# ENCYCLOPÆDIA BRITANNICA

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## *v15: MAX-NAP*

# ENCYCLOPÆDIA BRITANNICA

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"LET KNOWLEDGE GROW FROM MORE TO MORE
AND THUS BE HUMAN LIFE ENRICHED."

*A New Survey of Universal Knowledge*

# ENCYCLOPÆDIA BRITANNICA

Volume 15

MAXIMINUS *TO* NAPLES, KINGDOM OF

ENCYCLOPÆDIA BRITANNICA, INC.

*WILLIAM BENTON, PUBLISHER*

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# ENCYCLOPÆDIA BRITANNICA

## Volume 15

## MAXIMINUS *TO* NAPLES, KINGDOM OF

**MAXIMINUS, GAIUS GALERIUS VALERIUS** (d. 313), Roman emperor from A.D. 308 to 313, was a nephew of Galerius (*q.v.*) and originally called Daia. He started life as a shepherd but joining the army received rapid promotion, and on May 1, 305 was proclaimed *Caesar*, ruling Syria and Egypt under Galerius as *Augustus*. When Galerius made Licinius *Augustus* in 308 Maximinus also claimed and obtained the same title. On Galerius' death in 311 he occupied Asia Minor and in 313 he invaded Licinius' dominions in Thrace. He was, however, defeated at Tzurulum and retreated into Asia Minor, where he died of disease at Tarsus.

Maximinus was a persistent persecutor of the Christians. In 306 and again in 308 he ordered a general sacrifice to the pagan gods; recusants were mutilated and sent to the mines and quarries. In 311 he grudgingly accepted Galerius' edict of toleration, but soon began a new and more subtle attack on the Christians. Cities and provinces were encouraged to petition for the expulsion of Christians from their territories. The *Acts of Pilate* (an anti-Christian forgery) were taught in the schools and bogus confessions of sexual orgies practised at Christian services were publicized. At the same time Maximinus endeavoured to organize and revitalize paganism, appointing a chief priest to each city and a high priest to each province; the reform was clearly based on the Christian system of bishops and metropolitans. In the autumn of 312 he relented somewhat, ordering that persuasion rather than force should be used to induce Christians to conform, and shortly before his death in 313 he granted full toleration and the restoration of the confiscated property of the churches.

(A. H. M. J.)

**MAXIMINUS** (in English MAXIMIN), **GAIUS JULIUS VERUS,** Roman emperor from A.D. 235 to 238, was a Thracian. He is said to have been a shepherd before enlisting as a private soldier in the army, where his immense strength attracted the attention of the emperor Septimius Severus. Under Alexander Severus he held high command in the army of the Rhine. In March 235 Alexander was murdered and Maximin was proclaimed emperor by the Rhine army. His three years' reign was chiefly spent in campaigning on the Danube and the Rhine, and numerous milestones with his name upon them attest his energetic reconstruction of the roads. He made many enemies in Italy and the civilian provinces of the interior, especially among the landed aristocracy, whose taxes he collected more efficaciously than his predecessor.

In 238 a group of landowners in Africa killed the tax collectors and rebelled, proclaiming the aged Gordian (*q.v.*) as emperor. The revolt in Africa was quickly suppressed, but in Rome the senate deposed Maximin, established a council of senators to run the state, and raised a military force from the cities of Italy. Maximin and the army crossed the Alps and besieged Aquileia. The city resisted and after some months the soldiers killed Maximin and returned home. Meanwhile the pressure of the praetorian guards and the populace in Rome had compelled the senatorial council to proclaim first two elderly senators, Maximus and Balbinus, and later Gordian's grandson, Gordian III, as emperors. Gordian III emerged as Maximin's successor. (JN. R. M.)

**MAXIMS, LEGAL.** The term maxim is used by lawyers to refer to certain broad propositions (usually stated in a fixed Latin form) which have been in use since the 17th century or earlier. Some of them can be traced back to the law of Rome. Much more general in scope than ordinary rules of law, they commonly formulate a legal policy or ideal that judges are supposed to consider in deciding cases. Maxims do not normally have the dogmatic authority of statutes, but in California, for example, 35 have been incorporated into the civil code. Of these, the following are examples (a few Latin forms are given to indicate the differences in tone and meaning). "Anyone may waive the advantage of a law intended solely for his benefit. But a law established for a public reason cannot be contravened by a private agreement." (Thus an agreement not to plead the statute of limitations is binding, but an agreement not to plead that a certain contract constitutes an illegal restraint of trade is not.) "One must so use his own rights as not to infringe upon the rights of another": *sic utere tuo ut alienum non laedas* (thus the owner of land on the bank of a stream may make use of the water but must not dam it up or injure its quality). "He who consents to an act is not wronged by it": *volenti non fit injuria* (thus a father who connives at his daughter's seduction cannot recover damages from the seducer). "No one can take advantage of his own wrong." "He who takes the benefit must bear the burden." "The law

disregards trifles": *de minimis non curat lex* (thus an appellate court refused to reverse the lower court's judgment awarding nothing to the plaintiff although he was entitled to a judgment for six cents). "The greater includes the less" (thus, tender of a larger sum is a good tender of payment of a debt). "An interpretation which gives effect is preferred to one which makes void": *ut res magis valeat quam pereat*. "The law never requires impossibilities": *lex non cogit ad impossibilia* (thus an actress who becomes ill is excused from performing although her contract does not so state). "Where one of two innocent persons must suffer by the act of a third, he by whose negligence it happened must be the sufferer." "Between those who are equally in the right or in the wrong, the law does not interpose": *in aequali jure melior est conditio possidentis* (thus one who has entrusted his goods to another for an illegal purpose cannot recover them).

**History.**—With the expansion of commerce and industry in the 16th and 17th centuries English courts were called upon to decide many novel cases for which the rules of the medieval common law provided little or no assistance, and the judges felt a need for broad, authoritative principles to support their decisions. Francis Bacon composed a collection of 25 maxims of the common law (in Latin) with an elaborate commentary (in English) upon each. Edward Coke's writings were replete with similar Latin aphorisms, some borrowed from Roman law, others invented. Latin was apparently preferred for its dignified, formal sound as well as the implication of great learning and antiquity. Collections of maxims, usually followed by explanatory comments and references to illustrative cases, continued to appear during the next three centuries both in England and America. But with the accumulation of statutes, precedents and voluminous textbooks the maxims steadily declined in importance. Eventually they were criticized by the judges for what had once been considered their most valuable characteristic, their generality and vagueness. Although some of the ideas embodied in them retain considerable influence, the maxims themselves are now less often referred to.

Legal maxims have always appealed to those who believed that law consists (or ought to consist) of a coherent and logical system of rules. It is not surprising that Bacon, who advocated the codification of English law, should have composed a book of maxims or that David Dudley Field, an ardent codifier, should have included a collection of maxims in his civil code, adopted in California in 1872. The yearning for formal systematization of law which once made legal maxims popular now finds expression in England through textbooks in the form of codes and in the U.S. through restatements of the law.

BIBLIOGRAPHY.—H. Broom, *Selection of Legal Maxims* (1924); R. Pound, *Jurisprudence*, vol. 4, pp. 513–557 (1959); J. Smith, "Use of Maxims in Jurisprudence," *Harvard Law Review*, 9:13 (1895); *California Civil Code*, secs. 3509–43 (annotated ed., 1874). (MO. H.)

**MAXIM SILENCER.** The idea of using a muffler or silencer to reduce or eliminate the noise of the explosion in a firearm gained public prominence in 1908 with the invention by the American Hiram Percy Maxim of a device called after him the Maxim silencer. It consisted of a cylinder attached to the muzzle of a rifle or pistol. The cylinder contained a series of circular chambers separated from each other by thin steel baffles or partitions, each of which had a hole in it just large enough for the bullet to pass through. These holes were located in the line of the bore, and the series of holes formed in effect a continuation of the bore of the gun. When the powder gas issued at high speed from the bore, it expanded into these circular chambers and was momentarily trapped in them. It then passed out into the air through the same series of holes through which the bullet had just passed; but in the interval its pressure had been reduced enough to prevent it from impinging on the air with the violence that produces the sound of a gunshot.

Shortly after the invention of the Maxim silencer the U.S. army issued a limited number of silencer-equipped service rifles to be used by snipers, but it was found that they failed to accomplish their purpose of silencing the rifle. They eliminated the noise of the explosion but did not stop the sharp report made by the air wave generated by the bullet as it passed through the atmosphere with a velocity greater than the speed of sound. For this reason the army soon withdrew the silencers from service.

Besides the Maxim silencer, several other makes appeared on the market both in the United States and England. These were quite effective when used with low velocity ammunition (below the velocity of sound) in both rifles and automatic pistols of .22 rimfire calibre. Silencers do not work with revolvers because they cannot silence the noise of the gas escaping at high pressure through the gap between the front end of the cylinder and the rear end of the barrel.

The manufacture and sale of silencers in the United States came to an abrupt halt in 1932 with the passage of the National Firearms act, which required all silencers to be registered with the treasury department and imposed a tax of $200 on each transfer of a silencer.

Silencers were revived for military use during World War II by the Germans and the Soviets, both of whom produced special low-velocity cartridges for use with silencers. These cartridges used the regular military service bullet with a reduced powder charge that gave a muzzle velocity just below the speed of sound. In this way the bullet noise that had previously made silencers useless with military cartridges was eliminated.

One type of silencer used in World War II followed the basic principle of the Maxim silencer and contained a series of internal expansion chambers. A simpler type consisted of a cylindrical expansion tube that could be clamped onto the muzzle of the rifle. Its end was closed by thick rubber disks. The bullet passed through the rubber with ease but the gas was trapped inside the tube, from which it escaped into the air through vent holes drilled in the sides of the tube. It was necessary to replace the rubber disks after a certain number of shots but as the silencer-equipped rifles were used only for special purposes that presented no great problem. (J. S. HA.)

**MAXIMUS, SAINT** (THE CONFESSOR) (580–662), Byzantine monk, spiritual writer and opponent of the Monothelites, was born in Constantinople. At the age of 30 he became first secretary to the emperor Heraclius, but later became a monk at Chrysopolis (Scutari) and then at Cyzicus. After the Persian invasion in 626 he went to north Africa where he soon became famous as a determined adversary of Monotheletism (*see* MONOTHELITES). Pyrrhus, the deposed Monothelite patriarch of Constantinople, who had tried to win Maximus' support for the imperial edict known as the Ecthesis, forbidding any attempt to multiply the "energies" (wills) of Christ, was converted from his heresy by Maximus (645), who then became head of the resistance to the imperial Monothelites. Shortly afterward Maximus moved to Rome. In 653 he was arrested and exiled. In 662 he stood trial again, was mutilated and sent to Lazica, where he died on Aug. 13, his feast day in the west; his feast day is Jan. 21 in the east.

Maximus' teaching, which is essential to the understanding of Byzantine spirituality, interprets the mystical (*i.e.*, sacramental and dogmatic) tradition of the Eastern Church. He emphasizes the pure unrelated apophatic superessential nature of the divinity, and the multiple divine "energies" whereby God is communicable to man and reveals himself in creation. In Trinitarian theology Maximus summarizes the teaching of the Cappadocian Fathers on the person of Christ, and the procession of the Holy Spirit from the Father alone (not in his time a controversial issue). Among his important works are *Quaestiones ad Thalassium* (65 answers to difficult passages of Scripture), the *Ambigua* (an exegesis of the teaching of Gregory of Nazianzus), the *Mystagogia* (an interpretation of the liturgy), "Four Centuries on Charity" and a *Liber Asceticus*.

BIBLIOGRAPHY.—Works in J. P. Migne, *Patrologia Graeca*, vol. 90 (1860); Eng. trans. of *Liber asceticus* and "Centuries" with introduction by P. Sherwood (1955). *See* also P. Sherwood, *An Annotated Date List of the Works of Maximus* (1952) and *The Earlier Ambigua of St. Maximus* (1955). (A. O.)

**MAXIMUS,** the name of four Roman emperors.

MARCUS CLODIUS PUPIENUS MAXIMUS, joint emperor with Decimus Caelius Calvinus Balbinus (*q.v.*) during a few months of the year A.D. 238.

MAGNUS MAXIMUS (d. 388), usurping Roman emperor A.D. 383–388, was a Spaniard of poor family who became commander of the troops in Britain, where he operated successfully against the Picts and Scots. In the spring of 383, at a time when Gratian (*q.v.*) was repelling an Alamannic invasion in Raetia, Maximus was elevated to the purple by the British troops, who were dissatisfied with Gratian's rule. Maximus at once crossed to the continent. Gratian advanced as far as Paris to meet him, but Maximus managed to win over the emperor's troops. Gratian fled, but was overtaken and killed at Lyons on Aug. 25, 383. Maximus took up his residence at Trier, and in addition to Britain ruled over Gaul and Spain. He then entered into negotiations with Theodosius I, who feared for the safety of Valentinian II in Italy. Owing to the dangers which threatened his eastern frontier Theodosius wished to avoid war and hence recognized Maximus as emperor. Maximus also opened negotiations with Valentinian II and made an uneasy peace with him. At this time Maximus elevated his son Flavius Victor to be co-ruler with him, and his elevation was recognized by the other two emperors.

Maximus was an orthodox Christian. He summoned the leaders of the Priscillianists to Trier, where in 384 or 385 Priscillian (*q.v.*) and some of his followers were condemned to death and others to lifelong banishment. A council which Maximus held at Trier in 386 supported his strong measures and even urged him to persecute the Priscillianists in Spain. In the summer of 387 Maximus suddenly invaded Italy, finding the Alpine passes undefended. He hoped to capture Valentinian himself, but the latter escaped safely to Thessalonica. In spite of his occupation of Italy Maximus still hoped to keep the peace with Theodosius, but war broke out in 388. While Maximus himself remained in Aquileia, his troops, led by Andragathius, advanced to Siscia on the Sava and covered the river crossings there. Maximus hoped to win over the army of Theodosius, as he had already done that of Gratian; but only a few of the enemy's troops came over to him. Theodosius in fact won a victory near Siscia, and, although Maximus' army was rallied by his brother Marcellinus, it was decisively beaten again at Poetovio. Maximus threw himself on Theodosius' mercy, but was executed on Aug. 28, 388; his son Victor was also put to death.

MAXIMUS (d. 422), made emperor in Spain by the Roman general Gerontius, who had rebelled against the usurper Constantine in 409. After the defeat of Gerontius at Arelate (Arles) and his death in 411 Maximus renounced the imperial title and was permitted to join the Vandals in Spain. About 418 he rebelled again, but, failing in his attempt, was seized, carried into Italy and put to death by Honorius at Ravenna in 422.

PETRONIUS MAXIMUS (396–455), Western Roman emperor in 455, was born of a distinguished family in 396; at the age of 19 he had become count of the sacred largess, and at 24 prefect of the city, an office which he held again *c.* 433. After holding the consulship twice he became a patrician before the end of 445. Along with the eunuch Heraclius he helped to engineer the fall of Aetius (*q.v.*). Valentinian III was murdered on March 16, 455, and on the following day Maximus was proclaimed emperor. He forced Eudoxia, the widow of Valentinian, to marry him, and he engaged his son Palladius to marry her daughter Eudocia. But a Vandal fleet, said to have been invited by Eudoxia, was already threatening Rome, and on May 31 the Vandals were only six miles from the city. While Maximus was trying to escape from Rome, a stone was thrown at him by one of the enraged populace: he fell from his horse and was instantly torn limb from limb by the Romans, and his body was thrown into the Tiber. He had reigned for only two and a half months, and was not recognized as emperor by the Eastern government. His successor on the Western throne was Avitus.

*See* J. B. Bury, *History of the Later Roman Empire*, vol. i (1923); E. Stein, *Histoire du Bas-empire*, vol. i (1959). (X.; E. A. T.)

**MAXIMUS OF SMYRNA** (d. A.D. 371), a member of the Pergamene school of Neoplatonists founded by Aedesius (*q.v.*), made no important contributions to Greek philosophy but had a great reputation as a theurgic wonder-worker, his most spectacular achievement being the animating of a statue of Hecate. By his wonder-working he gained a great influence over the mind of the future Roman emperor Julian and became very powerful at court when Julian succeeded to the throne. His arrogant behaviour made him many enemies, and after Julian's death he was fined, tortured and eventually executed. (A. H. AG.)

**MAXTON, JAMES** (1885–1946), British politician and one of the leaders of left-wing socialism through the years between World Wars I and II, was born in Glasgow on June 22, 1885, the son of a schoolmaster. He was educated at Hutcheson's Grammar school and at the University of Glasgow. He was himself a teacher from 1906 to 1916 although he spent much of his time in propaganda for the Independent Labour party. After a year's imprisonment for a strong antiwar speech in 1916, Maxton later became a paid organizer for the I.L.P. He contested the Bridgeton division of Glasgow unsuccessfully in 1918, but in 1922 he was successful in the same constituency and continued to represent it in parliament until his death.

Maxton's role as a national politician was memorable for two things. He led the I.L.P. several times into a position of intransigent opposition to the moderate Labour line; and after the debacle of 1931 he severed relations between his small group of three members of parliament and the official Labour party. Secondly, he was one of the most attractive parliamentary orators of his generation, with a style that seemed even better suited to the house of commons than to his native Clydeside. This gave him a wide popularity which contrasted with the extremity of his views and was sometimes held to detract from his effectiveness. He died at Largs, Ayrshire, on July 23, 1946. His two principal books were *Lenin* (1932) and *If I Were a Dictator* (1935).

*See* J. McNair, *James Maxton, the Beloved Rebel* (1955). (R. J.)

**MAXWELL,** the name of a Scottish family, members of which have held the titles of earl of Morton, earl of Nithsdale, Lord Maxwell and Lord Herries. The name is taken probably from Maccuswell, or Maxwell, near Kelso, where the family migrated from England *c.* 1100 but it is best known in the southwest of Scotland. Sir John de Maxwell won fame by defending his castle of Carlaverock against Edward I in 1300; Sir Herbert (d. *c.* 1453) was made a lord of the Scottish parliament between 1441 and 1445; and his great-grandson John, 3rd Lord Maxwell, was killed at Flodden in 1513. John's son Robert (*c.* 1493–1546), 4th lord, was a member of the royal council under James V; he was also an extraordinary lord of session, high admiral and warden of the west marches, and was taken prisoner at Solway Moss in 1542. Robert's grandson, John (1553–93), 7th Lord Maxwell through his mother Beatrice, daughter of James Douglas, 3rd earl of Morton, became 4th earl of Morton in 1581, after the regent's execution. In 1586 the attainder of the late earl was reversed and Maxwell was deprived of his new title. He indulged in intrigue, went to Spain and made preparations to assist the invading Spaniards in 1588. His son John (*c.* 1583–1613), 9th lord, after a life of lawlessness, escaped from Scotland and was sentenced to death; having returned he was seized and beheaded in Edinburgh. In 1618 John's brother and heir, Robert (*c.* 1586–1646), was restored to the lordship of Maxwell, and in 1620 was created earl of Nithsdale, surrendering the claim to the earldom of Morton. He and his son Robert (1620–67), afterward 2nd earl, fought under the marquess of Montrose for Charles I during the Civil War. Robert died unmarried in Oct. 1667, when a cousin, John Maxwell, 7th Lord Herries (d. 1677), became 3rd earl. His grandson was William, 5th earl of Nithsdale (*q.v.*; 1676–1744). On his attainder in 1716, his titles became extinct, but his estates passed to his son William (d. 1776), whose descendant, William Constable-Maxwell (1804–76), regained the title of Lord Herries in 1858. Through his granddaughter Gwendolen the barony of Herries passed in 1945 to Bernard, 16th duke of Norfolk. Other distinguished branches of the family are the Maxwells of Calderwood, of Monreith, of Munches and of Pollok.

**MAXWELL, JAMES CLERK** (1831–1879), British physicist, remembered for his great researches in electricity, was descended from a well-known Scottish family, the Clerks of Penicuick, and was born in Edinburgh on Nov. 13, 1831. He was educated at the Edinburgh academy, at the University of Edin-

burgh and at Trinity college, Cambridge. In 1856, two years after graduating from Trinity with high honours, he took the chair of natural philosophy in Marischal college, Aberdeen. This post was followed by a professorship of physics and astronomy in King's college, London, which he held from 1860 to 1865, resigning to return to the family estate of Glenlair in Kirkcudbrightshire. His reputation, however, intruded upon the seclusion he desired, and in 1871 he reluctantly yielded to the urging of his friends and accepted the newly founded chair in experimental physics at Cambridge. Under his direct supervision there was erected the famous Cavendish laboratory, which from the beginning has been one of the major scientific workshops of the world. He died at Cambridge of cancer, the disease that had killed his mother 40 years earlier, on Nov. 5, 1879.

Maxwell was a born scientist. A persistently inquisitive little boy, he not only sought to discover how everything "doos" but made his own scientific toys before he was eight. In his 14th year he wrote a paper on a method for constructing perfect oval curves, which was read to the Royal Society of Edinburgh by James Forbes; when he was 18 and still a student at Edinburgh two of his papers, one on rolling curves, the other on the equilibrium of elastic solids, were published in the society's *Transactions*. During his two postgraduate years at Trinity he engaged in original mathematical research, designed his celebrated colour top (*see* COLOUR: *The Laws of Colour Mixture*), and did work in colour sensation for which he later won the Rumford medal of the Royal Society of London.

Perhaps the most significant activity of this period was his reading of Michael Faraday's *Experimental Researches*, which marked Maxwell's entrance upon the study of electricity; and before he left Trinity, he published his first major contribution to the subject, the beautiful paper "On Faraday's Lines of Force." (*See* ELECTROMAGNETIC WAVES: *Origin of Electric Wave Concept.*)

In 1859 he interrupted his electrical studies to write a brilliant paper explaining the motion and permanence of Saturn's rings. This essay won the Adams prize of the University of Cambridge and established him as a leader among mathematical physicists. The Saturn researches, having to do with the behaviour of a large mass of disconnected particles, excited his interest in the kinetic theory of gases, which raised the problem of describing the behaviour of vast assemblages of colliding molecules.

In this field he appeared as an experimenter (in measuring gaseous friction) as well as a mathematician. He conceived a mechanical picture which made it possible to account in precise quantitative terms for various properties—viscosity, diffusion, heat conduction—of a gas. The model has been criticized, and errors in Maxwell's reasoning have been discovered, yet his results which, as Sir James Jeans said, "ought to have been hopelessly wrong," turned out to be exactly right, and Maxwell's law of gases is in use to this day.

But his supreme achievement is in electricity. His first step, embodied in the Trinity paper, was to translate Faraday's ideas into mathematical notation. In his next paper, "On Physical Lines of Force," the main object was to devise a model which would provide a mechanical explanation of the interrelations and effects of electricity and magnetism. Like Faraday, Maxwell was opposed to the notion of "action at a distance." He applied his extraordinary imaginative powers to the development of Faraday's concept of the field and lines of force. Gradually he discarded the simple elements of his first models and erected a system involving the hypothetical "aether," a unique material medium whose physical stresses and motions could be made to account for all electric and magnetic phenomena. The laws of the system were formulated in his two famous sets of symmetrical equations, one of which expresses the continuous nature of electric and magnetic fields, the second the principle by which changes in one field produce changes in the other.

In the course of this labour he arrived at an epochal conclusion. Confirming by experiment the finding of Wilhelm Weber and Friedrich Kohlrausch that the velocity of an electric current through a wire is about the same as the velocity of light in empty space, he boldly asserted the identity of the two phenomena. "We can scarcely avoid the inference," he said, "that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena." The extension of the electromagnetic theory of light led to Heinrich Hertz's discovery of radio waves and to related advances in science and technology which have transformed the modern world. (*See* ELECTRICITY: *Electromagnetic Waves.*)

It is often said of Maxwell that he was the perfect pencil and paper theoretician, in contrast with Faraday, the great experimenter. This notion is a gross oversimplification. The fact is he combined a profound physical intuition, an exquisite feeling for the relationship of objects, with a formidable mathematical capacity to establish orderly connections among diverse phenomena. This blending of the concrete and the abstract was the chief characteristic of almost all his researches. A striking example of his skill with the concrete is found in the fact that the basic principles of modern colour photography were derived from an experiment made by Maxwell in 1861.

First broached in communications to the Royal society in 1864, Maxwell's electrical theory appeared in finished form in 1873 in his great *Treatise on Electricity and Magnetism*, one of the most splendid monuments ever raised by the genius of a single individual. Among his other writings are an admirable textbook, the *Theory of Heat* (1871), an excellent elementary treatise, *Matter and Motion* (1876), and a valuable edition, with copious original notes, of the *Electrical Researches of the Hon. Henry Cavendish*. His collected works, edited by W. D. Niven, were issued in 1890.

*See* also references under "Maxwell, James Clerk" in the Index.

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**MAY, PHIL** (PHILLIP WILLIAM) (1864–1903), English social and political caricaturist, was born on April 22, 1864, at Wortley, near Leeds. He was the son of an engineer who died when the child was nine years old. At the age of 12 May began to earn his living, working as timekeeper in a foundry, as a jockey and on the stage. When he was 16 he went to London, finally obtaining work as a designer with a theatrical costumer. He also drew posters and cartoons, and for about two years worked for the *St. Stephen's Review*. He went to Australia for his health and while there worked for three years for the *Sydney Bulletin*. In 1892 he returned to London and resumed his work for *St. Stephen's Review*.

May's studies of the London "guttersnipe" and the coster girl rapidly made him famous. His overflowing sense of fun, his sympathy with his subjects and his kindly wit were on a par with his artistic ability. There the extraordinary economy of line which was characteristic of his drawings was the result of a laborious process which involved numerous preliminary sketches. His later work included some excellent political portraits. He became a member of the staff of *Punch* in 1896 and in his later years his services were retained entirely for that magazine and for the *Graphic*. May died on Aug. 5, 1903. (H. Es.)

**MAY, THOMAS** (1595–1650), English poet, dramatist, translator and historian, who won a considerable reputation in his own day, and whose historical defense of the Long parliament continued to be read for a long time after his death, was born in 1595. He was the eldest son of Sir Thomas May of Sussex and, after graduating from Sidney Sussex college, Cambridge, in 1612, was destined for a legal career. He entered Gray's Inn in 1615, but abandoned law for literature, possibly because of a speech defect. In 1620 *The Heir*, his first dramatic work, was produced, after which he wrote one more comedy and three tragedies based on the lives of Antigone, Cleopatra and Agrippina. He turned also to translation; including Virgil, Martial and, his most important work in this field, Lucan's historical poem *Pharsalia*. The appearance of this edition in English verse in 1627 gained him considerable esteem and attracted the attention of Charles I himself, at whose request May composed verse histories of the reigns of Henry II and Edward III.

He received gifts from Charles but his greater expectations of pension or office were not fulfilled. This may have partly accounted for his increasing sympathy with the parliamentarians in their conflict with Charles. From 1646, as joint secretary "for the Parliaments" he was in effect their propagandist. His *History of the Parliament of England Which Began November the Third* (1647) and his *Breviary of the Parliament of England* (1650), although impartial in tone and presentation, and making use of the documents of both sides, were, in fact, skilful defenses of the parliamentary position. Unlike his namesake, who was arrested for sedition in 1649, with whom he has been confused, May enjoyed the confidence of parliament until his death in London on Nov. 13, 1650. He was buried in Westminster abbey, from which his body was removed after the Restoration.

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**MAY, WILLIAM** (d. 1560), English clergyman, was one of the most active supporters of the Reformation. Educated at Cambridge, he became a fellow of Trinity hall and in 1537 president of Queens' college. After being successively chancellor, vicar-general and prebendary of Ely, he was made dean of St. Paul's in 1546. His favourable report on the Cambridge colleges saved them from dissolution. He shared in the compilation of the Book of Common Prayer. He died on Aug. 8, 1560, the day of his election to the archbishopric of York. (G. HU.)

**MAY** (Lat. MAIUS), the fifth month of the modern calendar, has 31 days. As to the origin of the name the Romans were themselves uncertain, some deriving it from Maia, an obscure goddess to whom sacrifice was offered in this month, others from *maiores*, "elders," on the ground that this month honoured those of ripe years as June (from *iuniores*) honoured the young. Little is known of Maia, but probably both her name and that of the month had the original meaning of "increase," with reference to the growth of vegetation at this season. This interpretation fits with the importance attached later, in medieval and modern Europe, to the traditional May day celebrations, of which the origins are to be sought in pre-Christian agricultural rituals. Though there is wide variation in local usages, these celebrations commonly include the carrying in procession of trees, green branches or garlands, the appointment of a May king and May queen and the setting up of a May tree or Maypole. In Scotland and Ireland vestiges of old Celtic practices survived until the late 18th century in the custom of leaping over a fire or driving cattle between two fires (*see* BELTANE). Originally all such rites were intended to ensure fertility to the crops, and by extension also to cattle and humans, but in most cases this significance was gradually lost and the practices survived merely as popular festivities. A widespread superstition held that washing the face in the May day morning dew would beautify the skin.

In medieval and Tudor England, May day was a great public holiday. All classes of the people were up with the dawn and went "a-maying." Branches of trees and flowers were borne back in triumph to the towns and villages, the centre of the procession being occupied by the Maypole, gaily bedecked with ribbons and wreaths. Maypoles were usually set up for the day only, but in London and the larger towns were erected permanently. They were special eyesores to the Puritans. John Stubbes in his *Anatomy of Abuses* (1583) speaks of them as those "stinckyng idols" about which the people "leape and daunce, as the heathen did."

May day was designated as an international labour day by the International Socialist congress of 1889; in Communist countries and elsewhere it is the occasion for important left-wing political demonstrations. *See* LABOUR DAY. (F. R. WN.)

**MAY, ISLE OF,** an island of Fife, Scot., at the entrance to the Firth of Forth, 5 mi. S.E. of Crail and Anstruther. It is 1¼ mi. long, and measures at its widest about 400 yd. St. Adrian, a Hungarian missionary, settled there and was martyred by the Danes in the 9th century. In the 12th century David I built a Benedictine monastery (now in ruins) on the site of Adrian's grave, long a place of pilgrimage.

The population (7 in 1961) is made up of the lighthouse keepers and their families. The island is now a bird observatory and field station.

**MAYA** ("illusion") is a Sanskrit term used with reference to the phenomenal world by various Indian philosophical writers. It is especially characteristic of the monistic Vedanta of Shankara (*q.v.*; early 9th century A.D.), whose theory that the Absolute (*brahman*) was the sole reality naturally entailed the belief that the world was unreal. *Maya* is used both of the product—the world of multiplicity—and also of the cause, namely, that factor inherent in the universe which in a sense creates the latter and makes it appear real to us. The obvious logical difficulties in such a system were overcome by the assertion that the *maya* responsible for the world was neither real nor unreal, thus rendering the position unassailable by any logic which included among its axioms the law of the excluded middle (*see* THOUGHT, LAWS OF).

In the Vedas, *maya* is often the supernatural creative power of a deity. In nontechnical classical Sanskrit, the word can mean "deception," "trick," "illusion," the sleight of hand of the conjurer as well as sorcery considered to be genuine. In this sense it was used by the Buddhist idealist philosophers who, in denying the reality of the empirical world, compared the latter with a *maya*, a mirage, a dream, a reflection in a mirror. In Shankara's system, where *maya* is in a sense a cosmic factor, some modern writers have preferred translations such as "appearance" rather than "illusion"; and the older Vedic use of the word, rather than the meaning of mundane conjuring, may well have influenced the usage of the Vedanta writers. The theistic schools of Vedanta which criticized Shankara's monism tended to reject his theory of *maya*, although some applied the term to the creative potency of a personal deity, the created world, however, being accepted as real.

When used as a girl's name, Maya naturally means "bewitching" rather than "false." *See* also INDIAN PHILOSOPHY: *Six Systems: Vedanta.*

**MAYAGÜEZ,** Puerto Rico's third largest city, is located on the west coast of the island. Pop. (1960) 50,147. The town was founded in 1763 and because of its excellent harbour soon developed into the important shipping centre for the west end of the island. Sugar, coffee and tropical fruits are the main exports from the surrounding rural area. Previously the city was an important needlework centre; however, large industries, such as electronic products and canning factories, have been established with government help. Known over the island for its pure water supply, Mayagüez is the centre for the manufacturing of beer and soft drinks.

The land-grant College of Agriculture and Mechanical Arts, a division of the University of Puerto Rico, is located in the city. A student body of over 3,000 works toward degrees in engineering, agronomy, science and liberal arts. In conjunction with the Atomic Energy commission, a nuclear research centre, with an atomic reactor, has been established on campus to facilitate the granting of graduate degrees in nuclear technology. The U.S. department of agriculture maintains in Mayagüez one of its few experimental stations in tropical agriculture.

With several banks, a television station and several radio stations, a modern private hospital and numerous commercial establishments, Mayagüez is a prosperous and well-serviced community. Modern highways connect the city with Ponce on the south coast and San Juan on the north. Mayagüez has a commercial airport from which daily flights to the capital originate. (T. G. MS.)

**MAYA INDIANS,** a large group of American Indians speaking about a score of closely related languages and dialects of the Maya linguistic family and occupying a compact area in Central America. The name Maya is also applied to the civilization which the ancestors of these Indians evolved in pre-Columbian times. Finally, it is used in a narrower sense for the branch of the Maya inhabiting the Mexican state of Yucatán and for their language, now commonly called Yucatec to avoid confusion.

Maya-speaking Indians numbered in excess of 2,000,000 in the 1960s, more than 70% of whom lived in the highlands of Guatemala. They are short, dark-skinned and with straight black hair. The Yucatec Maya are among the most roundheaded people in

the world (average cephalic index nearly 86). Excavation reveals skulls of the same remarkable roundness.

## HISTORY

At the time of the Spanish conquest (*c.* 1540) the Maya occupied a rough quadrangle about 550 mi. from north to south and 350 mi. from east to west at its widest point. This embraced almost all of Guatemala, British Honduras, the western fringes of Honduras and El Salvador and in Mexico all Yucatán, Campeche and Quintana Roo, most of Tabasco and eastern Chiapas. The Huastec people, living in northern Veracruz and adjacent parts of Tamaulipas, far from the main Maya body, are Maya in speech but not in culture. This article does not deal with them.

The Maya region divides readily into three parts. The southern area comprises the mountainous parts of Guatemala and western El Salvador, a land of volcanoes, deep canyons, lakes and a temperate climate with appropriate fauna and flora. North of this lies the central area, embracing the southern half of the peninsula of Yucatán and the wider lowland base which supports it. This is a hot land of dense tropical forest and very heavy rainfall. The northern part of the peninsula of Yucatán forms the northern area, a plain of porous limestone with rivers and lakes only below its surface. Rainfall is much less here than in the central area, and in many places the thin soil fails to cover the limestone rock. As one travels northward, the surrounding forest changes to scrub.

The great achievements of the Maya were made, not in the southern area with its excellent climate and superior natural resources, but in the lowlands, particularly those of the central area, where the people expended so much effort in fighting the forest. The highland Maya formed a wealthy group throughout their history and some of their centres, notably Kaminaljuyu, Zaculeu and Utatlan, were large and important, but they had little or no part in the development of the hieroglyphic writing or of the distinctive styles of sculpture and architecture which bear the name of Maya. These are lowland contributions, particularly of the central area. The northern area shared in them, but with regional variations, and after the end of the classic period its development was quite distinct from that of the centre.

MAYA INDIAN CIVILIZATION SHOWING ARCHAEOLOGICAL SITES

Maya civilization, like the contemporary Mexican cultures of Teotihuacán, Monte Albán and La Venta, had its roots in the long development horizon known as the formative period. By about the beginning of the Christian era Maya culture was sufficiently differentiated from neighbouring cultures to be called Maya, and this marks the beginning of the classic period. The first three centuries, sometimes called protoclassic, mark the growth of the new culture, and then comes its great efflorescence from A.D. 300 to A.D. 900 (the "old empire" in the terminology of the 1930s). The abandonment of the great ceremonial centres (described below), completed by A.D. 900, marks the end of the classic period.

**The Classic Period.**—During this period the whole Maya lowland was dotted with large ceremonial centres, loosely termed cities, the building of which began in the formative period. These were not residential, but were used for religious ceremonies, and as markets, as courts of justice and of civil administration. They served the surrounding countryside, in which the people lived in small scattered settlements. Except on market days and the great religious festivals, the ceremonial centres were empty save perhaps for priests and novices who had retired there for the prolonged periods of fasting and continence which preceded the festivals. The total number of centres is unknown, for some of them are quite small and they may not yet be all discovered, but there are about 110 with hieroglyphic inscriptions, and very many more important centres which are without known texts or where only plain monuments were erected. Tikal, the largest known site, has its pyramids, "palaces" and courts concentrated in an area of about one square mile, but this is encircled by smaller, detached groups of structures covering much additional land.

Typical of all ceremonial centres are the courts flanked by pyramids and lower, many-roomed buildings before which stand the large stone shafts known as steles. Some of these are plain, but they are usually carved with representations of gods, priests and dignitaries who may represent rulers, and with hieroglyphic texts giving the date of their erection. Several hundred steles have been found (Calakmul has most with 103, of which one-quarter are plain), and they supply an excellent record of the spread of this custom, which appears to have had great prestige value. The earliest known stele carries a date equivalent to A.D. 292, and was found at Tikal, Guat., in 1959. The largest is a slender shaft at Quiriguá, 35 ft. high including the base and weighing 65 tons; its erection was a fine feat of engineering. (The dates used in this article are according to the Goodman-Martínez-Thompson correlation of the Maya and European calendars which has been accepted for many years by nearly all students on archaeological, astronomical and historical grounds. Early carbon-14 readings of wood taken from Maya buildings supported the Spinden correlation which places all Maya dates 260 years earlier in our calendar. Refinement of the carbon-14 technique has reversed this; subsequent readings of a long series of wood samples dated in terms of the Maya calendar agree completely with the Goodman-Martínez-Hernández-Thompson correlation.)

Buildings are usually of local stone (limestone in most districts), without windows and with a small doorway for each room. Some were flat-roofed with beams and mortar and others were thatched, but those of most importance were generally supplied with the corbeled or false vault, in which the two soffits are inclined inward until the gap between them is sufficiently narrow to be bridged by a line of capstones. The rooms thus vaulted are narrow, seldom more than 12 ft. wide. Frequently, a door in the back wall leads to a second room and there may even be a third room behind that. These inner rooms were most probably used only for storage, for they were unilluminated except by light filtering through the outer doorways, and the Maya are known to have covered these with curtains. The absence of chimneys and of hearths indicates that the buildings were never permanent residences, for which they are unsuitable. Scenes carved on their stone lintels and panels testify that high priests or rulers, seated on daises, held court and administered justice in them. From

knowledge of Aztec ritual it can be deduced that the people crowded the open courts to witness ceremonies performed before the temples, which were built on the tops of the pyramids. Specialized buildings included courts for the Maya to play their sacred ball game, sweat baths and, in Yucatán, ceremonial arches resembling the Roman triumphal arch. Important persons were often buried beneath buildings, which were frequently of perishable materials. The best-known centres of the classic period in the lowlands are Tikal; Palenque, Yaxchilán and Piedras Negras, famed for their beautiful sculpture; Copán for its situation and its sculpture; Uxmal, Labná and Sayil, for their fine buildings; Bonampak for its murals; and Quiriguá for its slender steles and carved boulders.

The abandonment of the ceremonial centres, a slow process spread over the whole 9th century, marked the end of the classic period. This abandonment appears to have been occasioned by a series of revolts on the part of the peasants against the ruling group, who worked them too hard. Influences from outside and alien religious concepts (one of the latest monuments at Copán is a feathered serpent god, symbol of a non-Maya cult) were probably important factors. The priest-ruler group appears to have been slain or driven out, after which the peasants, perhaps reduced in numbers, presumably continued their normal agricultural life under village headmen. There is archaeological evidence that they continued to visit the old centres as these gradually fell into ruin. Bodies were buried, accompanied by postclassic pottery, in partly collapsed buildings; fires were made on top of the soil and debris which accumulated on the floors of abandoned rooms, and huts were built in the courts. The central area was of little importance for the remaining six centuries of Maya history.

**The Mexican Period.**—The subsequent Mexican or postclassic period can be best followed in Yucatán, and strong influences from central Mexico appear even before the close of the classic period in various Yucatec cities, notably Uxmal and Kabah. But at Chichén-Itzá (*q.v.*), a city of some importance during the classic period, there is overwhelming evidence of the strong impact of a people deriving its culture unmistakably from Tula, the great Toltec capital 50 mi. N. of Mexico City. Resemblances in sculptured scenes, symbols and motifs, and in plans and decoration of buildings, are extraordinarily close; in addition, the emblems of the cults of Quetzalcoatl, Tezcatlipoca and other deities of Tula, as well as those of the great Toltec military order of jaguars and eagles, appear at Chichén-Itzá in overwhelming repetition. The new masters of the city constructed many buildings for their cults, adorning the walls with painted and carved scenes of their triumphs over the natives. Their success appears to have been partly due to their use of spear throwers and to an efficacious armour of quilted cotton.

There are good grounds for identifying these conquerors with the Itzá who figure greatly in Yucatec traditions, and for placing their subjugation of Chichén-Itzá between approximately A.D. 950 and A.D. 1000. During this period Maya and Mexican religious cults intermingled and a hybrid culture developed, but the cults of Quetzalcoatl and of the military orders were confined to the ruling class. By the time of the Spanish conquest both these cults, at one time supreme, were almost forgotten.

**The Mayapán Period.**—About A.D. 1200 Chichén-Itzá was overthrown by Hunac Ceel, and its rulers were driven out. The place continued as a centre of pilgrimage because of the renown of its cenote (a deep underground pool exposed by the collapse of the limestone crust above it), which was a shrine of the rain gods. Archaeological evidence confirms that Chichén-Itzá functioned only in this way during the remaining centuries of Maya history.

Hunac Ceel and his successors, the Cocom dynasty, established Mayapán as the capital of all Yucatán. This place, in contrast to the ceremonial centres of earlier times, was a true city. Surrounded by a defensive wall over five miles in circumference, it now contains over 4,000 mounds, nearly all of which once supported residences. The domination of Mayapán marked a serious retrogression in culture. Its sculpture is graceless and its architecture a crude copy of the style of Chichén-Itzá. Government was secular, and communal religion gave place to a militarism in which pride elevated ancestor worship to a dominant position among the aristocracy. The despotism of Mayapán was ended in 1450 by revolt and by the sacking and burning of the city, events fully confirmed by archaeological evidence. In the 90 years between the fall of Mayapán and the Spanish conquest, Yucatán divided into a dozen independent and warring states. Similar weak chiefdoms occupied much of the central area.

In the highlands of Guatemala, Mexican influence had been strong from early in the classic period onward, and the local nobilities, although Maya-speaking, claimed descent from Mexican invaders. Contemporaneously with the domination of Mayapán, the Quiché Maya attained ascendancy over much of the Guatemalan highlands and the Pacific littoral, but their power was curbed by a successful revolt of the Cakchiquel, so that at the time of the Spanish conquest there were various independent states speaking different languages and dialects of the Maya group such as Quiché, Cakchiquel, Mam and Pokomam.

**Mayan Culture.**—The outstanding intellectual achievements of the Maya were in the fields of hieroglyphics, astronomy and the calendar. Maya hieroglyphic writing is partly ideographic and partly phonetic, with much dependence on homophones (rebus writing). There are approximately 850 characters, most of which are of unknown meaning. Hieroglyphic texts were carved on stone monuments, on buildings, and on pieces of wood, jade and shell; they were also written in books, of which only three survive. One of these, the Dresden codex, contains accurate tables for predicting the dates of eclipses, although the Maya were unable to foretell which eclipses would be visible in their part of the world. Without even knowing that the moon revolved around the earth and the earth around the sun, they evolved a formula which in practice was: no solar eclipse if the new moon falls more than 18 days from node day (*i.e.*, the day when the sun intersects the moon's path). The Maya also learned the average synodical revolution of the planet Venus with extreme accuracy; their error was one day in 6,000 years, no mean success in view of the variation in length of this period. (For Maya achievement in handling time *see* CALENDAR: *Middle American Calendars;* CHRONOLOGY: *Pre-Columbian American.*)

In architecture the Maya were far ahead of any other people in the new world. As noted above, they failed to develop the true arch, using in its place the corbeled vault. This severely limited the width of their rooms, but this was perhaps no defect in the eyes of a priesthood which sought secrecy for many of its rites, and it gave to their buildings a massive solidity which was very impressive and which alone has preserved many of them from the destructive tropical forest. Equally impressive is the lofty grandeur of the temples atop their pyramids, a few standing about 200 ft. above natural ground level. Maya sculpture, usually in low relief, is now acclaimed as one of the great art styles of the world. The best work is on steles and lintels and, to a lesser extent, set in the upper façades of buildings. Little wood carving has survived, but it is of superb quality. Modeled stucco was widely used on the exteriors and sometimes on the interior walls of buildings. Plastered walls were sometimes decorated with paintings of life scenes, but some designs are geometric. The finest surviving murals completely cover the walls of three rooms at the comparatively small site of Bonampak, Chiapas. Executed in brilliant colours, they depict realistic scenes of battle, ceremonial dancing, arraignment of prisoners and sacrifice.

Lapidary work, particularly in jade, is of extremely high quality. No textiles except small, poorly preserved fragments have survived, but sculptures and murals give an idea of the sumptuous dress of persons of rank. Featherwork was very elaborate, with very effective use of the long tail feathers of the quetzal.

During the classic period the Maya had no metal. Copper and gold were quite rare even at the beginning of the 16th century. Tools were of wood, bone, stone and obsidian (volcanic glass). The bow and arrow were unknown until the Mexican period.

The seed beans of the cacao tree served as currency throughout Middle America. Cacao plantations were extensive in Tabasco, along the Bay of Honduras and on the Pacific coast and,

naturally, were a source of great wealth. Trade was widespread at all periods. The immense quantities of discarded obsidian blades encountered at every Maya site indicate a brisk commerce with the highlands, for there are no obsidian deposits in the lowlands. The much-valued jade was also imported by the lowland Maya (deposits of jade have been found in the Sierra de Minas, Guat.). Certain types of pottery had wide markets throughout Maya history. A pottery pipe found at Chichén-Itzá was made in northern Michoacán, Mex., not far short of 1,000 mi. away in a direct line and much farther by trail and coastal canoe; gold objects were brought from Panama, an even greater distance.

The Maya practised artificial deformation of the head, filed their teeth in various patterns and ornamented them also with inlaid disks of jade and hematite. Tattooing and scarification were common practices. Every conceivable method of disposing of the dead was used. The most spectacular burial is that found at Palenque, of a chief who lay full length, decked with massive necklaces, rings, bracelets and a mask of jade. The large mortuary chamber, in which he lay beneath a huge carved stone slab, was in the interior of a pyramid, to which led two flights of stairs, purposely blocked up in ancient times. The skeletal remains of persons presumably sacrificed at the funerary rites were by the entrance to the chamber. Cremation became common in the period immediately before the arrival of the Spaniards.

The basis of the Maya economy was maize, planted in fields temporarily wrested from the forest; the most important Maya deities were those connected with its growth. Chief of these were the rain gods, called Chacs; the moon, goddess of the soil, birth and fertility; the sun; and the maize god himself. The Chacs, like other Maya gods, are in a group of four, each associated with one of the four world directions, north, south, east and west, and with one of the colours, white, yellow, red and black, attributed to each. Maya cosmology envisaged the sky, supported by trees and by the upraised arms of the gods called Bacabs at the four points of the compass, as comprising 13 layers, the lowest of which was pictured as a celestial dragon decorated with the symbols of planets, stars, night and darkness. Beneath the earth were nine underworlds, in the lowest of which dwelt the death god. Throughout their history the Maya practised human sacrifice on a limited scale, usually by removal of the heart. Worshipers commonly drew blood from various parts of their bodies, particularly ears and tongue, to offer to the gods. (J. E. S. T.)

### MODERN COMMUNITIES

The modern Maya-speaking Indians occupy much the same territory as did their ancestors and retain surprisingly strongly their languages and their local Indian identities. Gone with the priests are the knowledge and the organization that developed the pre-Columbian civilization; only a part of the presumed tradition of the villagers of old remains, mixed with and changed by European elements. Thus, in western Guatemala the ancient calendar still governs the annual ceremonial cycle, but there is no long count or astronomy or means of notation. Thus, also, good colour and design and technique survive in textiles in Guatemala and Chiapas, but no frescoes or codices or the like, and no monumental architecture or stonework.

Except for a very few in the lowland forest along the Chiapas-Guatemala border, the modern Indians are part of the rural populations of Mexico, Guatemala (extending a little into Honduras) and British Honduras. The community unit in the lowlands is usually a village with its surrounding cornfields; in the highlands a town is surrounded by farms which "belong" to the town and its patron saint. Each of these social-political-religious units, though embedded in the larger economy, is the "world" to its Indians, who may continue for generations to "belong" to it even after migrating to another town or plantation.

The culture of the Indians inextricably mixes pre-Columbian Indian with European and modern elements; almost nothing in daily life is purely one or the other. Diet, for example, combines maize, beans, squash, turkey, chili and chocolate, prepared in Indian ways, with wheat bread, rice, sugar, lard, beef, pork, mutton, chicken and coffee brought by Europeans. Religion, folklore and social organization are compounds rather than mixtures. Thus Jesus often is a culture hero in a very local origin myth, and ancient gods reappear as Catholic *santos*. Also, Spanish-sounding town officials like *alcaldes*, *regidores* and *alguaciles*, and church officials like *sacristanes* and *mayordomos*, are combined in each community into a single age-grading and status organization with civil and religious functions which would not be recognized by either the nation or the church.

Each community has its distinct organization, culture and dialect, even "personality." Though not well off economically or in health, they tend to ignore or to resist efforts to incorporate them into the mainstreams of Mexican and Guatemalan national life. (S. Tx.)

**Languages.**—In the 1960s, more than 2,000,000 Maya Indians of Mexico, Guatemala, and British Honduras spoke one of 20 to 25 related languages. The languages ranged from those spoken by a few hundred to those spoken by several hundred thousand persons.

The Mayan language family probably had its origin in the highlands of northwestern Guatemala at the foot of the Cuchumatanes mountains and early split into a number of subfamilies. Of these, undoubtedly Huastec in its various subdialects and the various dialects of the Yucatec subgroup split off first from the highland Guatemala massif. Next to split off were the languages of the Gulf and Caribbean lowlands, the Chontal of Tabasco, the Chol of Tabasco and Chiapas, and the Chortí of Guatemala and Honduras. Next were the languages of the highlands of Chiapas, the Tzeltal and Tzotzil, and the Tojolabal. Those which remained behind became sharply differentiated; they are divided into Mamean (Mam, Aguacatec, Ixil), Quichean (Quiché, Cakchiquel, Tzutuhil) and Kekchían (Kekchí, Pokonchí, Pokomam). Languages such as Jacaltec, Solomeco and Kanjobal on the one hand, and Chuj on the other, form a bridge between Mamean and Tzeltalan and indicate the origin of Tzeltalan on the northern slopes of the Cuchumatanes.

Languages now extinct, such as Chicomuceltec, formerly spoken in the southeastern mountains of the Mexican state of Chiapas, may, because of its particularly close link with Huastec, indicate the point of origin for that now geographically distant language (spoken in eastern Mexico near Tampico). One of the Mayan languages, probably Yucatec, possibly Chontal-Chol-Chortí, was spoken by the vast majority of those priestly scribes who engraved the monuments and wrote the books which have been justly advanced as evidence of the high civilization of the Mayas. When such Maya hieroglyphic inscriptions have been completely deciphered, a great deal more will be known about Mayan origins and Mayan daily life. Although some speakers of Mayan languages are learning Spanish, large numbers still know no tongue other than their own native Mayan.

*See* CENTRAL AMERICA: *Anthropology;* MIDDLE AMERICA; INDIAN, LATIN-AMERICAN; *see* also references under "Maya Indians" in the Index. (N. A. McQ.)

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**MAYAKOVSKI, VLADIMIR VLADIMIROVICH** (1893–1930), an outstanding Russian poet of the Soviet period, was born July 7 (old style; 19, new style), 1893, in the Georgian village of Bagdadi (Mayakovski). The son of a gamekeeper, he became a revolutionary while still a schoolboy and worked in the revolutionary underground movement. In 1912 he began to publish verse and became a member of the Futurist movement in Russian poetry. Most notable of his prerevolutionary work is the long poem *Oblako v shtanakh* ("A Cloud in Trousers"; 1915). In 1917 he threw in his lot with the new Soviet state, spending much

time writing revolutionary slogans; and in 1923 founded a literary movement, *Lef,* intended to continue the principles of Futurism into the Soviet period. Mayakovski's tremendous feeling for rhythm, his use of brutal but effective slang and his dazzling stylistic originality make him a major Russian poet even when, as often, his subjects are trite. Besides his numerous lyrics and longer poems he wrote notable satirical plays, *Klop* (1928; Eng. trans. *The Bedbug,* 1961) and *Banya* ("The Bathhouse," 1929). A flamboyant figure who enjoyed bellowing out his verse to audiences of massed workers, he is also reported by close friends to have been sensitive and kindhearted. On April 14, 1930, he committed suicide in Moscow, possibly because of an unhappy love affair, combined with disillusionment about the results of the Revolution.

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**MAY APPLE** (*Podophyllum peltatum*), a North American plant of the barberry family (Berberidaceae), also called American mandrake, native to low woods from Quebec to Manitoba and southward to Florida and Texas. It is an erect, perennial herb, 12 to 18 in. high, which springs from a horizontal rootstock. The stem bears two large, shield-shaped, deeply lobed leaves, sometimes nearly a foot in diameter, in the axil between which rises in May a single stout-stalked, fragrant, white flower, about two inches broad, with six or more petals. The fruit, which ripens in July, is an oval, fleshy, yellow, edible berry about two inches long. In many districts the May apple is an abundant, conspicuous wild flower and it has many local names. Its poisonous rootstalk yields the powerful drug podophyllin.

JOHN H. GERARD

MAY APPLE (PODOPHYLLUM PELTATUM) SHOWING FRUIT AND ROOT SYSTEM

**MAY BEETLE** (JUNE BEETLE, JUNE BUG), any of the large, dark-brown beetles of the subfamily Melolonthinae of the scarab family (Scarabaeidae), especially *Phyllophaga* species. The larvae, white grubs with brown heads, are root pests of most cultivated crops and garden plants; the heavy-bodied adults, emerging in early summer, are often seen clumsily flying about lights in the evening. *See* BEETLE; CHAFER.

**MAYENNE, CHARLES DE LORRAINE,** DUC DE (1554–1611), the chief of the Holy League in France from 1589 to 1595, was born at Alençon, on March 26, 1554, the second son of François, duc de Guise (*see* GUISE, HOUSE OF). During the first religious wars in France, he took part in several actions against the Huguenots, including the battle of Moncontour (1569) and the siege of La Rochelle (1573). In 1573 he was created duc de Mayenne and a peer of France and accompanied the duc d'Anjou (later Henry III of France) to Poland. He married Henriette de Savoie-Villars in 1576. As governor of Burgundy, he raised that province in support of the League in 1585; but it was only after his brothers Henry, duc de Guise, and Louis, cardinal de Lorraine, had been assassinated (Dec. 1588) that he emerged as the leader of the Catholic party. Having raised an army in Burgundy, he went to Paris, where he was enthusiastically received, in Feb. 1589. A general council of the League was set up under his presidency, and he assumed the title of "lieutenant general of the state and crown of France." Instead of claiming the crown for himself after Henry III's assassination (Aug. 1589), Mayenne acclaimed the old cardinal de Bourbon as "Charles X" in opposition to the Huguenot claimant, Henry of Navarre (Henry IV of France). He tried to check the latter's advance on Paris but was defeated by him at Arques (Sept. 1589) and at Ivry (March 1590). After the cardinal de Bourbon's death (May 1590), he was faced with the problem of finding him a successor. He has truly been called "the solvent of the League" because of the measures that he took to curb its extremists, who supported the claim of the Spanish infanta Isabella to the French crown as a granddaughter of Henry II. In Dec. 1591 he had four members of the Council of the Sixteen in Paris executed for their part in the hanging of three moderates; and in Jan. 1593 he summoned a meeting of the estates-general in Paris, which upheld the principles of the Salic law of succession against Isabella's claim.

Mayenne continued to resist Henry of Navarre even after the latter had embraced the Catholic faith and gained control of Paris; but in Sept. 1595 he submitted. By the articles of Folembray (Jan. 1596) he was allowed to retain Chalon, Seurre and Soissons for six years, his followers were confirmed in the offices and honours which they had obtained from him, his own debts were settled up to 35,000 crowns, and his son was made governor of the Île-de-France. Thereafter he remained on excellent terms with Henry IV. Mayenne lacked the qualities of the Guises, being heavy in mind and body, but he was courageous and showed some sympathy for the sufferings of the poor. He died at Soissons on Oct. 3, 1611, and was succeeded by his eldest son, Henry (1578–1621), with whom the duchy became extinct. There is an edition of the *Correspondance du duc de Mayenne 1590–91* by C. Loriquet.

*See* M. Wilkinson, *A History of the League* (1929); H. Drouot, *Mayenne et la Bourgogne,* 2 vol. (1937). (R. J. K.)

**MAYENNE,** an inland *département* of northwestern France, formed in 1790 from the western part of the ancient province of Maine (*q.v.*), and bounded north by Manche and Orne, east by Sarthe, south by Maine-et-Loire, and west by Ille-et-Vilaine. Pop. (1962) 250,030. Area, 2,012 sq.mi. The *département* lies within the eastern part of the Armorican massif, and is built of granites and ancient grits and slates. The highest parts, in the Collines de Normandie on the north and northeast borders, rise above 1,000 ft., and the *département* consists of varied, hilly country, traversed from north to south across the general grain of the relief by the valley of the Mayenne river. The soils are usually rather heavy and lacking in lime and the agricultural colonization was late and slow. Fragments of woodland and heath still interrupt the farmland, which takes the form of a *bocage* of small, hedge-bounded fields. The farms are now largely under grass and fodder crops, and cattle rearing and dairying are the chief activities. Apple orchards are a ubiquitous feature of the landscape and cider is the local drink, the *département* lying north of the limit of cultivation of the vine. Although there are deposits of antimony near Laval, and roadstone, slates, and marble are quarried, there is little industrial activity and the *département* remains a rural backwater. The market towns, Mayenne, Laval and Château-Gontier, ranged along the Mayenne river in its passage across the *département*, are the centres of the three *arrondissements*. Évron, another market town, serves a district farther east. Laval, the largest town, situated in the centre of the *département*, and seat of the bishopric, is naturally the *préfecture*. Since the 1950s it has been the scene of some development of the manufacture of electrical apparatus. The *département* comes under the *académie* of Rennes for educational administration, and is served by the court of appeal at Angers.

Ste. Suzanne, a picturesque old fortified town, situated on a rocky promontory overlooking the Erve valley, preserves its shell of medieval walls and gates. The Romanesque cathedral at Laval (*q.v.*) is also noteworthy. (AR. E. S.)

**MAYENNE RIVER,** in northwestern France, is a tributary of the Sarthe, which it joins above Angers to form the Maine (*q.v.*), a tributary of the Loire. Rising at more than 1,000 ft. above sea level in the Collines de Normandie, the Mayenne flows south for 121 mi. across the Bocage Manceau, its valley forming the axis of the *département* to which it gives its name. The river basin lies within the area of the ancient rocks of the Armorican massif, and is a varied, hilly countryside of pastoral farming, with fragments of woodland and heath. Mayenne, Laval and Château-Gontier are market towns ranged along the river, which

is navigable for small craft well above Laval, as far as Brives near Mayenne. Its right-bank tributary, the Oudon, is navigable to Segré. (AR. E. S.)

**MAYER, JOHANN TOBIAS** (1723–1762), German astronomer whose lunar tables greatly assisted the accurate determination of longitude at sea, was born at Marbach, near Stuttgart, on Feb. 17, 1723. A self-taught mathematician, he had already published two original geometrical works when, in 1746, he entered the cartographic establishment founded by J. B. Homann at Nürnberg. Mayer published calculations of the libration and equatorial inclination of the Moon in the transactions of the Nürnberg cosmographic society, gaining a scientific reputation which led to his election to the chair of economy and mathematics at the University of Göttingen in 1751. He became superintendent of the university observatory in 1754, and worked there until his death at Göttingen on Feb. 20, 1762.

Mayer's lunar tables were published in the transactions of the Royal Society of Göttingen in 1755. In the same year he submitted to the British government an amended body of manuscript tables, which James Bradley found to be sufficiently accurate to determine the Moon's place to 75″, and consequently the longitude at sea to about half a degree. A London edition of the tables (1770), produced under the supervision of Nevil Maskelyne, also contained Mayer's method of determining longitude by lunar distances (which Maskelyne developed into a practical method challenged only by John Harrison's chronometer) as well as a formula for atmospheric refraction which applied a remarkably accurate correction for temperature. A finally revised version, corrected by Charles Mason and edited by Maskelyne, appeared in 1787. (O. J. E.)

**MAYER, JULIUS ROBERT VON** (1814–1878), German physician and physicist, was an independent a priori propounder of the first law of thermodynamics (*q.v.*) and applied that law to many cosmic and terrestrial phenomena. He was born at Heilbronn on Nov. 25, 1814, studied medicine at Tübingen, Munich and Paris, and after a journey to Java in 1840 as surgeon of a Dutch vessel took a medical post in Heilbronn. His first paper on heat, "Bemerkungen über die Kräfte der unbelebten Natur," appeared in 1842 in J. von Liebig's *Annalen der Chemie* (vol. 42), and in 1845 he published *Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel* ("Organic Motion in Its Relation to Metabolism").

Many scientists denied the priority of Mayer's ideas; this, plus the lack of appreciation accorded his work, and domestic grief, led to a suicide attempt. Entering a psychiatric hospital in 1851, he was later discharged. Mayer was made a member of the nobility in 1867 and died at Heilbronn on March 20, 1878. His papers were published as *Die Mechanik der Wärme* (1867; 3rd ed., 1893).

*See* O. Blüh, "Value of Inspiration: a Study on Julius Robert Mayer . . ," *Isis*, vol. 43 (1952).

**MAYER, MARIA GOEPPERT** (1906– ), U.S.-German physicist and co-winner, with J. H. D. Jensen and E. P. Wigner, of the 1963 Nobel prize for physics, was born June 28, 1906, in Kattowitz, Ger., the daughter of Maria (née Wolfe) and Friedrich Goeppert; her father was professor of pediatrics at Göttingen. In 1930, the same year she earned her Göttingen Ph.D. in theoretical physics under Max Born, she married U.S. chemical physicist Joseph E. Mayer, going with him to Johns Hopkins university, Baltimore, Md.; they had two children, Maria Ann and Peter Conrad. Under the influence of K. F. Herzfeld and her husband, with whom she wrote *Statistical Mechanics* (1940), her interests were in chemical physics. Turning to nuclear physics, she (and Jensen, working independently) explained the unusual stability of such atomic nuclei as those with 50, 82 and 126 protons or neutrons in terms of the theory (1949) for which the Nobel prize was awarded (*see* NUCLEUS: *Nuclear Structure and Nuclear Forces*). She and Jensen jointly wrote *Elementary Theory of Nuclear Shell Structure* (1955). In the period 1939 to 1945 Mrs. Mayer was at Columbia university and at Sarah Lawrence college, and worked on isotope separation for the atomic bomb project. From 1945 to 1960 she served at The University of Chicago and at Argonne National laboratory; after 1960 she and her husband were at the University of California. (J. E. MA.)

**"MAYFLOWER,"** the vessel that transported the Pilgrims from England to Plymouth, Mass., where they established the first permanent colony in New England in 1620. A former wineship, the "Mayflower" was chartered in England by London Adventurers for the epochal voyage. No picture or plan of the original vessel exists but a noted marine archaeologist, R. C. Anderson, constructed a model of the same size (180 tons) and of a type that was commonly used in that period. He conceived the original "Mayflower" to have been 90 ft. long, with a 64-ft. keel, 26-ft. beam and a hold 11 ft. deep. She was a square-rigged sailing ship steered by a whipstaff attached to the tiller and was armed with 12 cannon. Among the most prominent leaders of the Pilgrims on board were John Carver and William Bradford; another well-known member of the group was Capt. Myles Standish, who had been hired for his military knowledge.

The "Mayflower," with Christopher Jones as master, sailed from Southampton, Eng., on Aug. 15, 1620 (new style), accompanied by a smaller vessel, the "Speedwell," which had brought some of the group from Holland. The ships were twice forced to return to port (to Dartmouth the first time and to Plymouth the second time) because of serious leaking in the "Speedwell." The "Speedwell" was finally abandoned as unseaworthy and the "Mayflower" sailed alone on Sept. 16 (N.S.) from Plymouth after taking on some of the smaller vessel's provisions and passengers. There were 102 passengers and sundry crew members aboard the "Mayflower" during its historic voyage. The ship enjoyed a few days of smooth sailing but soon ran into "fierce storms" during which one of her main beams amidships was bowed and cracked. After serious consultation it was decided to repair the beam and continue the voyage. On Nov. 21, 1620 (N.S.), the "Mayflower" arrived at what is now Provincetown, Mass., on Cape Cod, having lost only one servant boy and one sailor during the 66-day voyage. One child, a boy, was born at sea to Elizabeth Hopkins and named Oceanus; another boy was born on the "Mayflower" while it was anchored at Cape Cod to Susanna White and was named Peregrine. Apparently because of a storm and rough seas, the colonists landed in Massachusetts instead of in the territory granted to the Virginia company as intended. The "Mayflower" deposited the settlers at Plymouth on Dec. 26, remained with them during the winter, and set sail for England on April 5, 1621 (N.S.), arriving there a month later. Little is known of her later history.

When the "Mayflower" reached Cape Cod the leaders feared a mutiny by some of the group. Before disembarking, therefore, they drew up a covenant, now known as the Mayflower Compact, here reproduced in modern spelling:

> In the Name of God, Amen. We, whose names are underwritten, the Loyal Subjects of our dread Sovereign Lord King James, by the Grace of God, of Great Britain, France, and Ireland, King, Defender of the Faith, etc. Having undertaken for the Glory of God, and the Advancement of the Christian Faith, and the Honour of our King and Country, a Voyage to plant the first colony in the northern Parts of Virginia; Do by these Presents, solemnly and mutually in the Presence of God and one another, covenant and combine ourselves together into a civil Body Politick, for our better Ordering and Preservation, and Furtherance of the Ends aforesaid; And by Virtue hereof do enact, constitute, and frame, such just and equal Laws, Ordinances, Acts, Constitutions, and Offices, from time to time, as shall be thought most meet and convenient for the general Good of the Colony; unto which we promise all due Submission and Obedience. In Witness whereof we have hereunto subscribed our names at Cape Cod the eleventh of November, in the Reign of our Sovereign Lord King James of England, France, and Ireland, the eighteenth and of Scotland, the fifty-fourth, Anno Domini, 1620.

The compact sanctioned, but did not construct, a frame of government and it bound the signers to obey whatever government should be established. Forty-one men, including all the adult masters and some servants aboard the vessel, signed the document on Nov. 21 (N.S.) in the cabin of the "Mayflower."

The Pilgrims had procured financial backing for their enterprise from a group of London merchants or Adventurers. They had previously failed to make satisfactory financial arrangements with the Virginia company. The Pilgrims and the Adventurers had drawn up an agreement by which the Adventurers were to furnish most of the money for ships, transportation and supplies, and the Pilgrims in turn were to receive a specified amount of stock in the

partnership in return for going in person and for any supplies they took with them. They were to establish a colony, and fish and trade for profits which were to be held in common. At the end of seven years the capital and profits were to be divided equally between the Adventurers who had stayed in London and the planters who had come to Plymouth. Disasters at sea and in financial dealings caused the dissolution of the partnership in 1624, and by 1627 the planters bargained with the Adventurers to buy them out for £1,800, a sum not fully paid for many years.

In 1957, 337 years after the "Mayflower" reached Massachusetts, a replica of the original ship celebrated the Pilgrims' crossing by attempting to duplicate the trip. Designed by an American, built in Brixham, Eng., and financed by funds from both countries, the well-publicized "Mayflower II" displaced 180 tons and was 90 ft. long, with a 25-ft. beam and 100-ft. mainmast. Unlike the original, she steered with a wheel, had an electrical generator and a two-way radio, and carried a crew of only 33 men. Sailing from Plymouth, Eng., on April 20, "Mayflower II" arrived off the Massachusetts coast after traveling 5,400 nautical miles in 53 days and was towed into harbour. The Elizabethan-garbed crew was greeted by a multitude of welcomers, a far cry from the wilderness encountered by the original ship.

*See* also MASSACHUSETTS: *History*.

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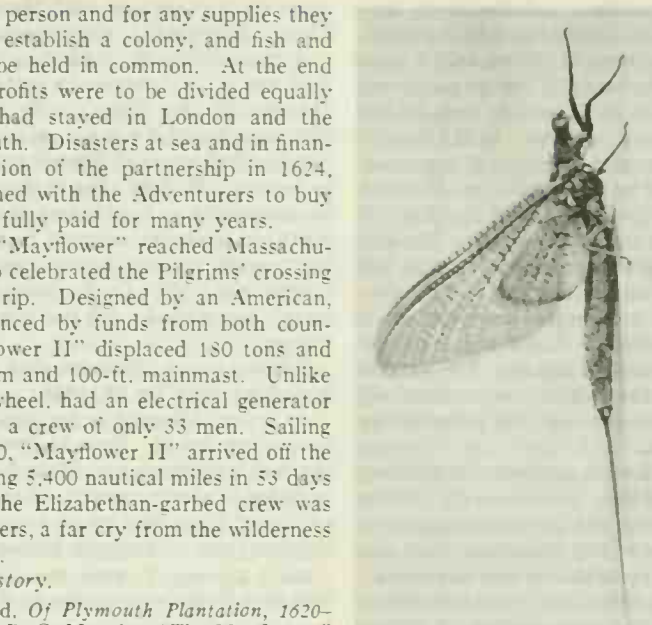
**MAY FLY,** common name for insects belonging to the order Ephemeroptera. Adult May flies are delicate, soft-bodied flying insects frequenting streams, rivers, ponds and lakes. They are readily recognized by their very short antennae; aborted mouth parts; triangular membranous wings, usually with many veins and cross veins, and with the hind pair greatly reduced or absent; and their two or three long taillike filaments. The common names shad fly or dayfly (in reference to the adult's short life span) have also been used for these insects.

Most species deposit the eggs on the surface of water, but some descend beneath the water to oviposit on submerged surfaces. The nymphs or naiads are found in fresh waters of all types and a few species enter brackish waters. They may be distinguished from other fresh-water insects by the greatly enlarged middle segment of the thorax (region behind the head); a single claw on each leg; and by the segmentally arranged gills on the abdomen.

The nymphs are very diverse. The most common types are minnowlike free-swimming forms, flattened forms which cling to rocks and crawling forms found in streams or on vegetation in ponds. A number of kinds burrow in the sandy bottoms of lakes and streams. The gills may be hidden under the abdomen or other protective covering such as a modified anterior pair of gills, elongated wing pads, flattened or spinous legs or extensions of the middle segment of the thorax.

The length of the life cycle may be as great as two or possibly three years, but in most species it lasts one year or less. The nymphal period in some species may be as short as 15 days, but in most it is usually six months to nearly a year, during which time more than 50 molts may occur.

When nymphal development is complete, the winged insect takes to the air after escaping through a dorsal split in the nymphal skin. This first winged stage, unique to May flies, is sexually immature and is called a subimago or dun; it also differs from the true imago or adult by its duller appearance, translucent wings and shorter appendages. The subimago usually comes to rest for a period of from a few minutes to two or three days, at which time the skin (pellicle) is cast off and the adult, imago or spinner emerges.



BY COURTESY OF THE (BRITISH) MUSEUM OF NATURAL HISTORY

MAY FLY (EPHEMERA VULGATA), A WELL-KNOWN FLY OF EUROPEAN TROUT STREAMS



JOHN H. GERARD

AMERICAN MAY FLY (HEXAGENIA)

The adult stage is very short lived; in some species less than two hours, but in most, one to three days. The adults do not feed, but may take some water. Most species execute aerial dances consisting of a fluttering ascent followed by a passive descent, repeated many times. During mid spring occasional mass flights may annoy man or impede automobile traffic with the slippery crushed bodies. May flies are attracted by light and often are seen in great clusters hanging on any solid object.

May flies are generally regarded as beneficial to man, and are eagerly devoured by fishes. A large percentage of all artificial trout flies are patterned after various species of May flies. May flies also serve as important food for other animals. The phenomenally high pheasant reproduction on some islands in Lake Erie has been attributed to the large amount of protein available to young pheasants feeding on adult May flies. In some parts of the world the aquatic stages are used by man for food.

About 1,800 species of May flies are known. There are more than 500 species known from North America, and additional species are being described every year. There are 48 species in the British Isles. Asia, South America and Africa seem to be particularly rich in undescribed forms.

*See* also references under "May Fly" in the Index.

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**MAY FOURTH MOVEMENT,** a term used to designate China's intellectual revolution and socio-political reform movement during the years 1917–21. The movement was directed toward national independence, emancipation of the individual and rebuilding of society under the banner of national salvation, modernization and new culture.

Faced with Japan's increasing influence in China after 1915, the Chinese developed strong patriotic sentiments. The young intellectuals, inspired by *New Youth*, a monthly magazine edited by Ch'en Tu-hsiu, promoted a vast agitation for reform known as the New Culture movement. In 1916 they launched an anti-Confucian campaign. From 1917 on they made considerable efforts to exalt western ideas, particularly science and democracy and ideas developed during and after the Renaissance. At the same time they attacked traditional Chinese ethics, philosophy, religion and social and political institutions. Liberalism, pragmatism, nationalism, anarchism and many varieties of socialism provided a stimulus. A new humanitarian, naturalistic and romantic literature in the vernacular style was proposed by Hu Shih. Ch'en and others to replace the old formalistic and didactic literature in the archaic, literary language.

The patriotic feelings and zeal for reform culminated in the incident of May 4, 1919, from which the movement took its name. More than 3,000 students from 13 colleges in Peking held a mass demonstration against the Chinese government's foreign policy and against the decision of the Paris peace conference to transfer the former German concessions in Shantung to Japan. In the demonstration the students burned the house of the minister of communications and assaulted China's minister to Japan, both pro-Japanese officials. In the following weeks the incident caused the death of a few students and the arrest of more than 1,000 others. The students in big cities called a general strike that lasted more than two months, and also protested in other ways. For one week, beginning June 5, merchants and workers in Shanghai and other cities went on strike in support of the students. There was a general surge of public opinion against the war lord regime. The government finally gave in; three pro-Japanese officials were dismissed, the cabinet resigned and China refused to sign the peace treaty with Germany.

In the months following the May Fourth incident, the students carried on their patriotic campaign all over the country by holding mass meetings, making public speeches and boycotting Japanese goods. With their publication of over 400 magazines they also vigorously spread "the tide of new thought and new literature." As a result of the movement the decline of the traditional ethics and family system was accelerated; the emancipation of women gathered momentum; a vernacular literature emerged; the press and popular education made progress; and, most important, the modern intelligentsia became a major factor in China's subsequent political developments. The movement also spurred the reorganization of the Kuomintang and the birth of the Chinese Communist party, and fostered some of the conditions favourable to a coalition between these parties for the overthrow of the Peking regime.

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**MAYHEM,** an old Anglo-French legal term signifying an assault whereby the injured person is deprived of a member proper for his defense in fight; *e.g.*, an arm, a leg, a fore-tooth, etc. The loss of an ear, jaw tooth, etc., was not mayhem. The most ancient punishment in English law was retaliative—*membrum pro membro*—but ultimately, at common law, fine and imprisonment. Various statutes were passed aimed at the offense of maiming and disfiguring, now dealt with by s. 18 of the Offences Against the Person act, 1861. Mayhem may also be the ground of a civil action in England as a form of trespass against the person.

In the United States, mayhem has been extended by statute to include "maim," which means to mutilate. It is punishable both as a felony and misdemeanour and also may be the ground for civil action. *See* also MAIMING.

**MAYMYO,** a town in Mandalay district of the Union of Burma. It takes its name from a Col. (later Maj. Gen.) James May of the 5th Bengal Infantry stationed there in 1886, and was the summer capital of Burma during the British administration. Pop. (1962 est.) 55,954. It lies at the head of a shallow valley about 3,450 ft. above sea level on the plateau 42 mi. E. of Mandalay by road. It is reached by rail and by air services from Rangoon (about 400 mi.). Maymyo's 17 sq.mi. were spaciously laid out with broad roads, lined with eucalyptus, silver oak and pine, and numerous large gardens are famed for their flowers, fruits and vegetables of temperate lands. Chrysanthemums are flown to many parts of Burma for floral offerings at the pagodas; strawberries are famous and are found growing with pineapples and coffee. The botanical gardens cover 350 ac. Though the government does not now leave Rangoon, the president maintains a summer residence at Maymyo, which is also a main training centre for army officers. The bazaar is a meeting place for the many varied peoples and products of the Shan state. (L. D. S.)

**MAYNARD, FRANÇOIS,** the common misspelling of the name of the French poet FRANÇOIS MAINARD (1582/83–1646), who invariably wrote it in the latter way. This Mainard, moreover, must not be confused with the advocate FRANÇOIS MÉNARD of Nîmes (1589–1631), also a poet.

Born at Toulouse in 1582 or 1583, François Mainard went to Paris and in 1605 obtained a post in the service of Queen Margaret (Marguerite de Valois). He then wrote his pastoral poem *Philandre,* but this was not printed till 1619. Meanwhile, in 1607, Mainard had attached himself to Malherbe, whose leading disciple he became. He held office in the presidial court of Aurillac (hence his designation as *le président Mainard*) from 1611 to 1628. Failing to win Richelieu's esteem, he spent many years in retirement in the country, though he was made a member of the Académie Française in 1634. On Richelieu's death he returned to Paris, but found that, while he still had a few admirers, literary fashion had changed.

Retiring again, Mainard died at St. Céré in Quercy and was buried there on Dec. 28, 1646.

As a poet Mainard is far inferior to Racan, with whose name his is often linked. Even his most praised epigrams are laboured. His real importance consists in his continuance of the Malherbian tradition of clarity, power and perfection of form. The collected edition of his works by G. Garrisson, 3 vol. (1885), mistakenly includes those of François Ménard.

*See* C. Drouhet, *Le Poète François Mainard* (1909); A. Adam, *Histoire de la littérature française au XVII^e siècle,* vol. i and ii (1948–51). (AE. A.)

**MAYNE, CUTHBERT** (1544–1577), the first seminary priest (*i.e.*, one of those trained on the continent rather than in England) to die in England for the Roman Catholic faith under Elizabeth I, was born of humble parentage at Youlston, near Barnstaple, Devon, and baptized on March 20, 1544. After attending St. Alban's hall, Oxford, he was ordained in the Church of England and appointed chaplain to St. John's college. There he became persuaded of the truth of the Roman Catholic religion, forsook his university career and went in 1573 to the English seminary newly founded by William Allen at Douai, being ordained as a Roman Catholic priest in 1575. In 1576 he returned to England to work among "his own people" in the west, settling in Francis Tregian's manor house at Golden, near Truro. There he passed as the steward, but pursued his priestly duties until his arrest in June 1577. After imprisonment for three months at Launceston he was tried there for high treason under an indictment which contained four principal charges, including the repudiation of the Act of Supremacy and the celebration of Mass. The judges disagreed, but he was sentenced to death; judges in London also disagreed, but the sentence was upheld by the privy council and carried out at Launceston on Nov. 29, 1577, after he had refused a reprieve if he would take the oath of royal supremacy. He was beatified by Leo XIII and his feast day is Nov. 29. Since 1920 an annual pilgrimage at Launceston has been attended by increasing numbers.

*See* R. A. McElroy, *Blessed Cuthbert Mayne* (1929); P. A. Boyan and G. R. Lamb, *Francis Tregian* (1955). (M. DR.)

**MAYNOOTH** (MAGH NUADHAD), a small town in County Kildare, Republic of Ireland, near the boundary of County Meath, 15 mi. W.N.W. of Dublin. Pop. (1961) 1,753. The Royal Catholic College of Maynooth (St. Patrick's college), founded in 1795 largely through the efforts of Edmund Burke, is the chief centre for the training of the Roman Catholic diocesan clergy of Ireland, and is an affiliated college of the National University of Ireland. The building, a Gothic structure by A. W. Pugin, was erected in 1845. Near the college stand the ruins of Maynooth castle, probably built by Maurice Fitzgerald in 1176. It was besieged in the reigns of Henry VIII and Edward VI, captured in 1647 and then dismantled.

**MAYO,** the name of a family of U.S. physicians associated with the Mayo clinic and the Mayo Foundation for Medical Education and Research at Rochester, Minn.

WILLIAM WORRALL MAYO (1819–1911) was born May 31, 1819, near Manchester, Eng. He attended Owens college and, after immigrating to the U.S. in 1845, studied medicine with a private physician in Lafayette, Ind. He then received degrees from Indiana Medical college at La Porte in 1850 and the University of Missouri, Columbia, in 1854. In 1863 he moved to Rochester.

With the opening there of St. Marys hospital on Oct. 1, 1889, Mayo and his two sons became responsible for care of the patients. After the father retired, the work was continued by the sons. He died in Rochester on March 6, 1911.

WILLIAM JAMES MAYO (1861–1939), older son of William Worrall Mayo, was born June 29, 1861, at Le Sueur, Minn. He received the M.D. degree in 1883 from the University of Michigan, Ann Arbor, and then engaged at Rochester in the private practice of medicine and surgery with his father and later with his brother. He and his younger brother, Charles Horace Mayo (*see* below), performed all the surgery at St. Marys hospital until about 1905. The co-operative group clinic, later known as the Mayo clinic, evolved from this surgical partnership of the two brothers. William James Mayo, who became a specialist in surgery of the stomach, remained active in surgery at the clinic until 1928 and in administration until 1933. From 1907 until his death he served on the board of regents of the University of Minnesota. He died in Rochester on July 28, 1939.

CHARLES HORACE MAYO (1865–1939), younger son of William Worrall Mayo, was born in Rochester on July 19, 1865 and died in Chicago, May 26, 1939. He received an M.D. degree from the Chicago Medical college (later part of Northwestern University Medical school) in 1888 and in the same year began the private practice of surgery with his father and brother. He originated modern procedures in goitre surgery and in neurosurgery. He retired from surgery at the clinic in 1930 and from administration in 1933. He was professor of surgery at the University of Minnesota Medical school in 1919–36 and at the University of Minnesota Graduate school in 1915–36. At one time he was a member of the advisory board of *Encyclopædia Britannica*. With his brother he alternated as chief consultant for all surgical services in the U.S. army during World War I, serving with the rank of colonel. After the war, each brother was commissioned a brigadier general in the medical corps reserve. Charles Horace's son, CHARLES WILLIAM (1898– ), was a surgeon and member of the board of governors of the Mayo clinic, chairman of the Mayo association and a member (chairman 1961– ) of the board of regents of the University of Minnesota.

The group began to grow in size in the early 1900s, when many young physicians began to apply for positions as interns and assistants. At the same time outstanding scientists in basic medical subjects were added to the clinic's training and research programs. In 1919 the Mayo brothers transferred property and capital to the Mayo Properties association, later called the Mayo association, a charitable and educational corporation having a perpetual charter. The Mayo clinic was changed from a partnership to a voluntary association of physicians and specialists in allied fields. In the early 1960s the clinic staff included about 350 staff physicians.

In 1915 the Mayo brothers gave $1,500,000 to the University of Minnesota to establish the Mayo Foundation for Medical Education and Research at Rochester in connection with the clinic. The foundation, which is part of the University of Minnesota graduate school, offers graduate training in medicine and related subjects. In 1934 the endowment was increased by $500,000; by the early 1960s it amounted to more than $3,250,000. At that time about 600 graduate physicians were attending as resident students.

*See* Helen B. Clapesattle, *The Doctors Mayo*, 2nd ed. condensed (1954). (T. E. K.)

**MAYO, HENRY THOMAS** (1856–1937), U.S. naval officer, was born in Burlington, Vt., on Dec. 8, 1856, and graduated from the United States Naval academy in 1876. Progressing through the grades, with varied sea and shore duties, he served on a number of coast surveys. He was created a rear admiral in June 1913, and in December he took over the fourth division of the Atlantic fleet, which he commanded during the 1914 dispute with Mexico which led to the seizure of Veracruz. Mayo was promoted in 1915 to command of the battleship squadron with the rank of vice-admiral, and a year later became admiral and commander of the Atlantic fleet, hoisting his flag on the battleship "Pennsylvania." During the entire period of World War I he held the vital post of commander in chief of the United States fleet, and on one extended journey inspected all naval activities in the European theatre of war from Scapa Flow to Trieste. When Mayo hauled down his admiral's flag on June 30, 1919, the combined fleet was again separated into the Atlantic and Pacific fleets. Mayo retired in 1920, was governor of the U.S. Naval home at Philadelphia, Pa., from 1924 to 1928, and died in Burlington on Feb. 23, 1937.

*See* D. W. Knox, *A History of the United States Navy* (1936). (W. B. CK.)

**MAYO, RICHARD SOUTHWELL BOURKE,** 6TH EARL OF (1822–1872), British statesman and viceroy of India. The son of Robert Bourke, 5th earl, he was born in Dublin, Ire., on Feb. 21, 1822, and educated at Trinity college, Dublin. After serving as chief secretary for Ireland in three administrations under the earl of Derby in 1852, 1858–59 and 1866–68, he went to India as viceroy in 1869, having succeeded to the earldom in 1867. The "masterly inactivity" of his predecessor, Lord John Lawrence, had failed to give confidence to Sher Ali Khan, the amir of Afghanistan, who wanted binding British support against both external attack and internal revolt. Mayo met him at Ambala, India, in 1869, but could only say that the government of India would try to strengthen his position and would view with severe displeasure any attempt to dethrone him. But the Russian occupation of Khiva in 1872 led Sher Ali to make a further appeal to Mayo's successor, Lord Northbrook. In social policy Mayo encouraged the chiefs and the Muslims in general to take to western education. In administrative policy his government initiated the decentralization of finance by giving the provinces greater control over local expenditure. His famous resolution on provincial finance in 1870 expressed the hope that this would "afford opportunities for the development of Self-government, for strengthening Municipal Institutions, and for the association of Natives and Europeans, to a greater extent than heretofore, in the administration of affairs." When on a visit of inspection to the penal settlement of Port Blair in the Andaman Islands, he was assassinated by a convict on Feb. 8, 1872.

*See* Sir W. W. Hunter, *Life of the Earl of Mayo*, 2 vol. (1875); and *The Earl of Mayo* in the "Rulers of India Series" (1891). (KE. A. B.)

**MAYO** (CONTAE MHUIGHEO), a westerly county of the Republic of Ireland, in the province of Connaught, is bounded on the north and west by the Atlantic ocean, northeast by Sligo, east by Roscommon, southeast and south by Galway. It is the third largest county in Ireland, with a land area of 2,084 sq.mi.

The coast, which is wild and broken, has many bays and inlets from Killala bay in the north to Killary harbour in the southwest. Westport and Ballina are the port towns. The most extensive islands are Achill Island (56.2 sq.mi.), the largest island off the Irish coast, Clare Island in Clew bay, and Inishturk near Killary harbour. The important lakes are Loughs Mask (10 mi. long), Conn, Cullen, Carrowmore and Carra. Stretching east and northeast from Lough Carrowmore is the largest expanse of bog in Ireland (200 sq.mi.). The principal rivers, famous for their salmon and white trout fishing, but not navigable, are the Moy which flows into Killala bay and the Errif which flows into Killary harbour. Nephin (2,646 ft.) and Croagh Patrick (2,510 ft.), which dominate the landscape, are typical quartzite summits. Muilrea (Mweelrea) to the north of Killary harbour, reaching a height of 2,675 ft., is the highest mountain in Connaught. East of Lough Mask are Carboniferous Limestone plains, and Clew bay, with its islets capped by glacial drifts, is a submerged part of the Carboniferous Limestone strata. To the north of the bay, Old Red Sandstone is evident from Achill to Lough Conn. The average yearly rainfall is 55 in.

The island of Inishglora is the biggest breeding colony of stormy petrels on the Irish coast. In the autumn and winter there is a variety of birds in the north and west but the district has been little surveyed by ornithologists. Mayo, notably lacking in woods, has not been botanically examined to the same degree as other counties. In the bleak baronies of Erris and Tirawley, across the north of the county, the Mediterranean heath (*Erica mediterranea*) is widespread. The feature plant of this great blanket bog is the fen-loving black bog-rush (*Schoenus nigricans*) and its presence

on an acid peat has aroused much interest among botanists. The great salad burnet (*Sanguisorba officinalis*) grows in profusion on the stony shores of Lough Conn and Lough Cullen.

The population of Mayo in 1961 was 123,330, a decline of 7.3% since 1956. There are three urban districts: Ballina (pop. [1961] 6,027), Castlebar (5,482) (*qq.v.*) and Westport (2,882), and seven rural districts.

Castlebar, the county town, is the headquarters of the county council, judiciary and government offices. The county is administered for local government purposes by a county manager and 31 councilors elected every five years. Seven members represent the county in *dáil éireann*, three from North Mayo and four from South Mayo. Ballina is the seat of the Roman Catholic bishop of Killala. Irish is the everyday language of many people in the area round Tourmakeady and in the extreme northwest. The village of Knock in the east is the most famous Irish shrine of the Virgin Mary; there are Sunday pilgrimages to it from May to October inclusive. Croagh Patrick is the scene of an annual national pilgrimage on the last Sunday of July. The county has literary associations with George Moore, the novelist, who was born at Moore hall which stood on the banks of Lough Carra.

The county is rich in Stone Age remains in the area round Cong in the south and Killala in the north. Saint Patrick is reputed to have founded churches at Killala, Turlough, Balla, Aughagower and Ballintubber and to have spent 40 days fasting on Croagh Patrick, on the shores of Clew bay. Mayo village was formerly the site of a celebrated monastery, university and episcopal see; the monastery was founded by St. Colman, who came with English monks from Lindisfarne, Northumberland. The district for a long time was known as "Mayo of the Saxons." There are round towers at Killala and Turlough and imperfect ones at Balla, Meelick and Aughagower. The last high king of Ireland, Ruaidri Ua Conchubair (Roderic or Rory O'Connor), died in 1198 in the former royal abbey of Cong, to which he had retired after the Norman invasion. Ballintubber abbey, Castlebar, founded in 1216 by the Augustinian Canons Regular is still in use as a church. There are widespread monastic ruins, of which the 15th-century Franciscan foundations of Rosserk and Moyne are among the finest. At the close of the 12th century the territory which now roughly coincides with the county of Mayo was granted by King John to William, brother of Hubert de Burgh. In the 14th century the land passed to a branch of the family known as MacWilliam Iochtar. Mayo however remained loosely subject to the Gaelic overlordship of O'Donnell, chief of Tyrconnell. The MacWilliams continued to exercise authority, which was regularized in 1603, when Theobald Burke of the MacWilliam Iochtar, surrendered his lands and received them back to hold with the title of Viscount Mayo (*see* CONNAUGHT). After the confiscation of Ulster in 1608 many Ulstermen settled on the north and west coasts. Their descendants still inhabit these areas. Large confiscations of property were made in 1586, 1641 and 1666. The Bingham family, later earls of Lucan, acquired considerable estates round Castlebar and north Mayo. The former seat of the earl of Lucan is now the Convent of Mercy, Castlebar. There are many ruins of small castles; that of Grace O'Malley at Carrigahooley, Newport, is well preserved. A French squadron under Gen. J. R. M. Humbert landed in Killala in 1798 and having captured Ballina and Castlebar advanced to Ballinamuck in Longford before being defeated.

In the rugged mountains of the north and west the farms are small and the bulk of the population supplements its earnings by migration to Great Britain. Store cattle (young unfinished meat animals) for the British market and sheep and pigs are raised extensively. The county is noted for its virus-free strawberry plants. Tourism is developing and the area is particularly attractive to fishermen and wildfowlers. Sea angling, game fishing and coarse fishing are available in great variety. The sea angling in Clew bay is of international fame and Achill Island is noted for its porbeagle and blue shark fisheries. Near Bangor Erris the Electricity Supply board, in conjunction with the Turf Development board, has erected a milled peat electricity generating station which feeds into the national grid. The Institute of Agriculture has established research stations at Glenamoy and Ballinrobe. There are small industries at Ballina (flour milling), Westport (clothing), Kiltimagh (spinning), Foxford (woolens), Castlebar (bacon), and Belmullet (toys). Race meetings are held twice yearly at Ballinrobe. Claremorris is the chief railway junction.

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**MAYOR.** The mayor is, in principle, the head of the government of a municipality. The English word "mayor" and the French word *maire* are derived from the Latin word *maior* meaning "greater," from which is also derived the expression *major domus*, one who is in charge of the management of a large, usually wealthy, household. In countries outside the English- or French-speaking worlds, the mayor is called by differently derived names: *alcalde* in Spanish, *Bürgermeister* in German, *bourgmestre* in Belgian and *sindaco* in Italian. As the official head of the government of a municipality, the mayor is almost invariably the chairman of the municipal council and of the council executive committee. In addition he has at least one and often all three of the following roles: chief executive officer, ceremonial figurehead and local agent of the central government. His role and importance in the local government structure thus depends largely on his relationship to the council and central government.

Though formally the mayor is the head of the government of the municipality, there are a number of countries where the power has shifted away from the mayor. This is a special phenomenon of the system in the United Kingdom where, with the rise of the influence of the popularly elected council, the power of the elected mayor has greatly diminished. In many municipalities in the United States, as well as in the United Kingdom and most of the Commonwealth countries, the office of the mayor has become virtually administratively impotent, although the prestige of the position is still great. This shifting of power from the mayor to the elected council has not so greatly affected the other countries which have elected councils and mayors. Many of these countries, however, do not have a long tradition of locally elected mayors.

In addition to the relationship between the council and the mayor, that between the mayor and the central government does much to determine his role. Originally, most mayors in Europe were appointed by the countries' central government. With the development of popularly elected councils, most mayors have taken on a dual role, serving not only as chief executive officer of the municipal administration, but also as agents of the central government charged with such functions as maintaining public security. Even after the local election of mayors developed, they continued this dual role in most countries except Switzerland, the Scandinavian and the English-speaking countries, and the Communist countries. The French mayor is probably the best-known example of a locally elected mayor whose duties as an agent of the central government greatly affect his role as a local chief executive.

Apart from Great Britain and certain other countries where most mayors are restricted to ceremonial functions, the mayor is almost universally the actual chief executive officer, the mainspring of the municipal administration and the focal point of policy. The mayor usually initiates policies and explains them to the council and to the public. As executive head of the municipal organization he is at the apex of a pyramidal administrative hierarchy, although frequently he has a second-in-command who is charged with the immediate general administrative supervision of the municipal departments.

As the representative and titular head of the municipality, the mayor welcomes visiting dignitaries, presides over civic gatherings and represents the municipality on public occasions.

Mayors may be appointed or elected. Up to the middle of the 19th century most mayors were appointed by the central government, but with the rise of the concept of representative government more and more countries adopted the practice of electing the mayor. In several the practice of appointing the mayor was abolished relatively recently: in France in 1875, in Denmark in 1919. Among countries where the mayor continued to be appointed, though for different reasons, were the Netherlands, Portugal and Spain, as well as many of the less-developed Asian countries.

Countries having an elected mayor can be considered in two groups: those in which the mayor is elected by the council and those in which he is popularly elected. In most European countries the mayor is elected by the council from among its members; usually he is the leader of the majority party or of one of the largest parties. In Switzerland, the United States, Canada and New Zealand most, if not all, mayors are popularly elected. These are countries where local government structures have been influenced by the concepts of popular democracy and the separation of powers, as expressed by Montesquieu. Most mayors in the Philippines and in Japan and a few in Latin-American republics are also popularly elected as a result of U.S. influence in these areas.

In the countries where the mayor is centrally appointed, as well as in those in which he is locally elected but is also an agent of the central government, he will almost invariably be the actual as well as the nominal head of the local government. In these countries, in general, there is hardly any tendency to shift power, either to the municipal council or to a professional administrative official.

The British mayor is only the nominal head of the government of the municipality. He is elected by the council, generally from among its members, for a one-year term. He is the chairman of the council and the titular figurehead of the borough, but he is not the borough's chief executive. Executive functions are carried out by the committees of the council, which work in collaboration with the individual departments and the clerk of the council. The role of mayor in Canada, Australia and New Zealand has been greatly influenced by the English model.

In the United States the role of the mayor is largely determined by the form of local government structure in his municipality. There are four main forms of local government. In the first and oldest, the so-called weak-mayor council form, descended from, and closely resembling, the British form, the mayor is the council chairman and the nominal, but not the actual, head of the municipal government. The second, the so-called strong-mayor council form of government, was a later development; in this the mayor is the actual chief executive as well as the titular figurehead. In most cases he is also the chairman of the council and often has the prerogative to veto actions of the council. Thirdly, the mayor of municipalities with the so-called council-manager system is the council chairman as well as the titular figurehead of the municipality; however, the manager is the chief executive. Fourthly, in the relatively few municipalities with the so-called commission form of government, each of the members of the commission heads a municipal department; the mayor is the chairman of the commission but has no more executive authority than any other commission member.

In the Danish, Norwegian and Icelandic municipalities, the council-elected mayor is chairman of the council, also chairman of the executive committee (when there is one) of the council; to a varying extent, he is also charged with the general supervision of the executive organs. In Sweden the local chief executive officer is the chairman of the council executive committee; another council-elected official serves as chairman of the council.

The Swiss mayor is popularly elected and presides over the municipal board as well as over the popular assembly composed of all the adult male voters. The Austrian mayor is elected by the council and presides over both the council and the board. He is also the chief executive officer of the municipal administration. The local government structure in the Federal Republic of Germany varies from *Land* to *Land*. In some municipalities the mayor resembles his Austrian counterpart; in others he is only the council chairman and titular figurehead, while a professional administrator is the chief executive officer.

In the Netherlands and Belgium the mayor is the council chairman, board chairman, ceremonial head and chief executive of a municipality. The appointments are made by the central government; however, in Belgium the royal appointment almost invariably is a ratification of the council's choice. In the Netherlands the mayor is usually an experienced administrator; although centrally appointed, he is a local official and above all an advocate and promoter of the local interests.

The French and Italian mayors are council-elected, preside over the council as well as over the board and are the chief executive officers of the municipal administrations. As agents of the central government they are directly under the head of the province (or *département*). The Spanish mayors are centrally appointed, preside over the council, if any, and are the chief executive officers as well as the heads of the local branches of the dominant national party. The Portuguese mayors are similar to their Spanish counterparts.

The mayors in Turkey, Tunisia, Iraq and Iran preside over the council and are strong chief executive officers. Those in Iraq are appointed by the central government; most of the others are locally elected, although in many cases their election must be ratified by the central government before they can assume office.

In India, Ceylon, Burma, Malaysia and the Sudan, the structure of local government has been influenced by the English model. However, in many cases, the locally elected mayor is both the council chairman and the chief executive officer. In others a central government official serves as council chairman and chief executive. In some municipalities the council chairman is elected locally, while the chief executive officer is a centrally appointed official.

In the Philippines and Japan, as noted above, the structure of local government reflects U.S. influence, the mayor in each country resembling the mayor in the strong-mayor council form of government in the United States. Japanese mayors and most of the Philippine mayors are popularly elected and preside over the council; the Japanese mayor, however, is the actual chief executive; the Philippine individual municipal departments are directly supervised by provincial or national officials.

Local government in many countries of Asia and Africa is in a rapid process of development, and the position of the mayor is consequently subject to change. *See* also CITY GOVERNMENT; CITY MANAGER. (S. Hs.; A. F. L.)

**MAYOR OF THE PALACE,** an official of the western European kingdoms of the 6th–8th centuries, whose status developed, under the Merovingian Franks, from that of an officer of the household to that of regent or viceroy. The great landowners of Roman imperial times had entrusted the administration of their domains to local managers or *majores*, over whom a *major domus* or mayor of the household was appointed to superintend the property as a whole. This system was taken over by the Merovingian kings, at whose court (*palatium*) the *major domus* came to be known also as *major palatii* or mayor of the palace. The early history of this functionary under the Merovingians is extremely obscure, but new functions and powers gradually accrued to him. The personnel of the court came under his authority; he advised the king on the appointment of counts and dukes; it was his duty to protect the *commendati* (persons who had been commended to the king) and the king's wards; and eventually he even assumed command of the royal army.

It was probably the long series of royal minorities following the murder of Sigebert of Austrasia in 575 and the death of Chilperic I of Neustria in 584 that enabled the mayors of the palace, as tutors of the young rulers, to gain control of the government—a control which they maintained when the kings came of age. This ascendancy, however, could not have been achieved without the support of the landowning aristocracy, which benefited from the king's liberalities and which supported the usurpations of the mayors so as to participate further in both the power and profits of government, obtaining countships and dukedoms and sending their sons to court as *commendati* for future preferment. The mayors for their part pursued varying policies toward the aristoc-

racy. Some, such as Flaochat in Burgundy and Erkinoald in Neustria, remained on good terms with it; but others, such as Ebroïn (*q.v.*) of Neustria and Burgundy, did the contrary. Ebroïn pursued his personal ambitions and private animosity against the great men of the realm and even against the clergy—as is shown by the tortures that he inflicted on Léger, bishop of Autun.

In the second quarter of the 7th century, Pepin I (Pepin of Landen; d. 640), as mayor of the palace, and Arnulf, bishop of Metz (d. *c.* 640), whose families were closely bound together by marriage, held power in Austrasia. Grimoald (d. 656), Pepin's son and successor, sought in turn to assure the succession to his son, but his aims were thwarted and as a result the family lost its ascendancy until 679, when Grimoald's nephew Pepin II (Pepin of Herstal; d. 714) became mayor. Conflict was inevitable between the ambitious and avaricious mayors of Austrasia and Neustria, and Pepin was defeated soon after his accession by the Neustrians under Ebroïn. In 680, however, Ebroïn was assassinated, and in 687 Pepin defeated the Neustrians at Tertry. From this time the three kingdoms of Neustria, Burgundy and Austrasia were united under the *de facto* rule of Pepin II as mayor of the palace. His son Charles Martel (d. 741) succeeded him and when Theuderic IV died in 737, Charles allowed the throne to remain vacant and divided the kingdom between his own sons Carloman (abdicated 747) and Pepin III (d. 768). In 743 these brothers placed Childeric III on the throne, but in 751 Pepin set him aside and had himself elected king, being the first king of the Carolingian dynasty. *See* CAROLINGIANS.

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**MAYOW, JOHN** (1640–1679), English chemist and physiologist who identified oxygen as a distinct atmospheric entity, was born in London, May 24, 1640. In 1658 he entered Wadham college, Oxford. He graduated in law (bachelor 1665; doctor 1670), but made medicine his profession. In 1678 he became a fellow of the Royal society. He died in London in Sept. 1679. The contents of his work, *Tractatus quinque Medico-Physici* (1674), which was translated into Dutch (1684), German (1799) and French (1840), show him to have been an investigator much in advance of his time. Mayow, who gives a remarkably correct anatomical description of the mechanism of respiration, preceded Joseph Priestley and A. L. Lavoisier by a century in recognizing the existence of oxygen, under the guise of his *spiritus nitro-aereus;* he perceived the part it plays in combustion and in increasing the weight of the calxes of metals as compared with metals themselves.

**MAYURBHANJ,** a district of northeast Orissa, India, formerly a princely state, merged with Orissa on Jan. 1, 1949, is bounded on the west and northwest by Bihar and on the northeast by West Bengal. Area 4,022 sq.mi.; pop. (1961) 1,204,043, the majority of whom depend on cultivation.

The district is mostly covered with deep forests and rugged hill ranges, the largest of which is Similipal, covering 600 sq.mi. (main peak Megasini, 3,823 ft.). There are many natural springs, and the chief river is the Burabalang. The district is rich in iron ore, the average annual yield being 2,000,000 tons from the mines of Badampahar, Gourumahishani and Suleipat. Other minerals are limestone, chromite, dolomite, kaolin, china clay and vanadium. Weaving, rope making and rice milling are well-known cottage industries.

Baripada, the district headquarters, was founded in about 1800. Pop. (1961) 20,301. The imposing palace of the former ruler now houses Maharaja Purna Chandra college affiliated to Utkal university. Baripada is connected by a narrow-gauge line with the Eastern railway at Rupsa in Balasore district. Other places of interest are Khiching, famous for historic monuments, and Haripur, with a ruined medieval fort. (MA. M.; N. K. S.)

**MAYWOOD, AUGUSTA** (b. 1825), the first American ballerina to achieve international renown, became prima ballerina at La Scala, Milan, when she was 23. Born Augusta Williams in New York city, she adopted the name of her stepfather, the theatrical manager Robert Campbell Maywood. Trained by Paul Hazard in Philadelphia, she made her debut there, Dec. 30, 1837, in Auber's opera-ballet *Le Dieu et la Bayadère*. Further study in Paris led to a debut at the Opéra in 1839. A brilliant dancer, she starred in Vienna, Lisbon and Milan in such ballets as *Giselle* and *La Sylphide*. She retired in 1862. (LN. ME.)

**MAYWOOD,** a village of Cook county, Ill., U.S., on the Des Plaines river, is 10 mi. W. of the Chicago loop. Founded in 1869 by Col. William Nichols of Vermont, it was incorporated as a village in 1881. Maywood is predominantly a residential community, with diverse municipal facilities, considerable business and industry and a continuing culture of its own within the Cook county metropolitan area. The village government was organized under a village manager in 1952. The manufacture of tin cans was initiated as a pioneering enterprise in the 1870s. Chief industries include can and carton production, bottled soft drinks and flexible metal tubing. There are many business and cultural organizations. Maywood is the site of the Chicago Lutheran Theological seminary, founded in 1891, and the Hines Memorial hospital for veterans. For comparative population figures *see* table in ILLINOIS: *Population.* (J. L. B.)

**MAZAGAN** (officially EL JADIDA, a contraction of *al brija al jadida,* "the new little port"), a port on the Atlantic coast of Morocco and the chief town of the region of the tribes of Doukkala, in the province of Casablanca, 68 mi. S.W. of Casablanca. It lies at the southern end of a sandy bay, south of the mouth of the Oum-er-Rbia. Pop. (1960) 40,302. The inhabitants are mainly Arabized Berbers from the surrounding tribes who have settled there because of the overcrowding of the country round. The port is small, covering only 17 ac. and containing two jetties and a wet dock, and is used for the export of agricultural produce (cereals, eggs and poultry) from Doukkala. The remarkable development of the sardine fishery along the coast after 1945 scarcely affected Mazagan. Once important, it was overtaken and surpassed as a port by Casablanca, Safi and Agadir. Its shipping is mainly coastal. There is some fish canning and salting, soapmaking and processing of palm fibres.

Founded by the Portuguese in 1502, Mazagan was the centre of their settlement in Morocco and the last place to be evacuated by them (1769). The Portuguese origin of the town can be seen in the walls, the gates surmounted by the escutcheons of the kings of Portugal, the castle and the tank (wrongly called the *salle d'armes*). The latter, the most remarkable building in Mazagan, served as a storehouse after the completion of the ramparts in 1541. The new town stretches to the north and south of the old town. (M. T.; A. AM.)

**MAZANDERAN** (MAZANDARAN), an *ostan* (province) of northern Iran bordering the Caspian sea. Its area has been subject to change in modern times; since 1961 it has consisted of the two historic provinces of Mazanderan and Gorgan combined with the outlying *shahrestan* (district) of Kashan (*q.v.*) on the interior highlands. At the same time a large part of the former *ostan,* south of the Elburz mountains, was formed into the separate general governorship of Semnan-Damghan (including Shahrud). The province is bounded west by Gilan, southwest by the Central *ostan* (Teheran), east by Khurasan; the Kashan district touches Isfahan and Luristan (Lorestan). The area of the *ostan* is approximately 20,386 sq.mi. Its population in 1956 was 1,334,433, of which approximately 165,000 lived in Kashan district. By 1964 the population had increased to an estimated 1,639,364. The capital of the *ostan* is Sari (pop. [1956] 26,278).

The northern section of the *ostan* consists of a lowland along the shores of the Caspian sea and an upland along the northern slopes of the Elburz mountains. The lowland is a narrow strip in the west, widening to 20 mi. in the east before it merges into the steppes of Gorgan. Marshy backlands dominate the plain along the coast which is closed by dunes, while extensive gravel fans fringe the mountains. The original luxuriant forest has largely given way to cropland and pastures, and elsewhere has become an almost impenetrable jungle of Christ's thorn and pomegranate because of deforestation. The climate is subtropical, humid through-

out the year, very hot in summer with only occasional frost spells in winter. Malaria, once dominant, was effectively controlled after World War II. Rice, cotton and wheat are the standard crops besides sugar beet, *kenaf* (a kind of hemp), citrus and other fruits. Silk production has declined.

The highland slopes rise abruptly in the west and more gently in the east. The forest cover (oak, walnut, box and the Persian "teak," *Parrotia persica*) has been largely destroyed by charcoal burning or commercial felling. The higher parts are mostly open land, cultivated and studded with villages partly derelict in winter, or providing extensive pasture for many flocks in summer. Mt. Demavend here dominates all neighbouring peaks in the Elburz range. Wild boar, deer and birds are numerous; the tiger, formerly found in the lowland, has disappeared. Cattle are usually humped; the buffalo is widely used as a draft animal. Mazanderan is still famous for its Arab or Turkmen horses. There are many rivers, including the Chalus, Heraz (Lar), Talar, Tajan and Neka, which are well stocked with trout, salmon and other fish.

The population is of Iranian stock with a large admixture of Turkic tribes (especially Turkmen), who dominate the Gorgan plains, and also of Kurds and other groups, Armenians and Russian emigrants.

The coastal plains and Gorgan belong to the most prosperous regions of Iran. They are connected with the interior by the Trans-Iranian railway and three motor roads. The coast, however, lacks good natural harbours. Since Babol Sar and Bandar-e Gaz were left dry by a recent recession of the Caspian sea, and Bandar-e Shah, the terminal of the railway, was completely silted up, there has been no outlet except for the artificially created little port of Now Shahr, north of Teheran, which cannot compare with Pahlavi farther west. Both Babol Sar and Now Shahr-Chalus have become seaside resorts.

Exports to the U.S.S.R. include rice, caviar, sturgeon, cotton and dried fruits but this trade is often hampered by the political situation. Industrialization, begun in the early 1930s and fostered by Reza Shah Pahlavi, includes several large textile mills. It has much benefited the towns Shahi (pop. [1956] 23,055), Behshahr (16,172) and Chalus (9,758). Older urban centres are the capital Sari (26,278), Babol (36,194), Amol (22,251) and Gorgan (28,380). Modern developments include several dams to improve irrigation.

The district of Kashan shares the natural and cultural features of the interior highlands. It is partly a sand-ridden desert and partly a rugged and barren mountain range, both with a limited number of partly prosperous, mostly declining villages. The town (46,000) was famous for its crafts. Though connected by railway with Qom and Teheran, it is not prosperous. (H. Bo.)

**MAZARIN, JULES** (Giulio Mazzarini) (1602–1661), cardinal and statesman, the Italian who shaped the destiny of France at the beginning of Louis XIV's reign, was born at Pescina in the Abruzzi on July 14, 1602. He was the eldest son of Pietro Mazzarini, a romanized Sicilian in the household of the constable Filippo Colonna. Educated by the Jesuits in Rome, he was sent at the age of 20 with the young Girolamo Colonna to Alcalá in Spain to study law for two years.

**The Diplomat of the Papacy.**—Giulio Mazzarini became a captain in a papal regiment in 1624, during the crisis over the Valtellina. In 1626 he was taken as secretary by G. F. Sacchetti, who in 1628 was appointed nuncio to the Spanish viceroy of Milan. During the War of the Mantuan Succession, Sacchetti's successor, the cardinal Antonio Barberini, sent him to negotiate with Cardinal Richelieu (*q.v.*) at Lyons in Jan. 1630. Soon afterward, at Casale in Montferrat, when the Spaniards and the French were about to join battle (Oct. 26, 1630), the young secretary rode out from the Spanish lines shouting "Peace, peace!" as if peace had been concluded; and in the ensuing talks he induced the Spaniards to raise their siege of Casale. He was rewarded by Pope Urban VIII with a Roman canonry (though he had only minor orders, never the priesthood); and early in 1631 he was sent by the pope on another mission to France. In 1632 he was engaged in negotiations between France and Savoy and received another Roman canonry. Appointed auditor of the papal legation in Avignon in 1633, he was made vice-legate of Avignon and nuncio extraordinary to France in 1634.

His nunciature in Paris enabled him to familiarize himself with the French government and court, but he failed to prevent the declaration of war against Spain in 1635 (*see* Thirty Years' War). He was recalled to Avignon early in 1636, but went back to Rome in November to act as France's unofficial representative. In 1636 he received the French nomination for a cardinalate, but the pro-Spanish faction in the curia was against him. Invited to enter France's service officially, he went to Paris in Dec. 1639.

**Richelieu's Protégé and Successor.**—The designation of Mazarin to be French plenipotentiary at Cologne for peace talks with the Habsburg powers (Jan. 1640) came to nothing; and from autumn 1640 to summer 1641 he was on a mission to the court of Savoy. He was later involved in preparations for the peace conference at Münster and on Dec. 16, 1641, was created cardinal.

When the conspiracy of Cinq-Mars was exposed, Mazarin dealt with the repentant duc de Bouillon and received the surrender of the latter's stronghold of Sedan (Sept. 1642). Then, on Dec. 4, 1642, Richelieu died, having recommended Mazarin to Louis XIII. Mazarin thus entered the king's council, to share the conduct of affairs with the comte de Chavigny (*see* Bouthillier) and with François Sublet de Noyers. Finally, on May 18, 1643, four days after Louis XIII's death, Anne (*q.v.*) of Austria, regent for the infant Louis XIV, declared Mazarin her principal minister.

It was most probably because of his mastery of diplomacy that Mazarin was chosen by Richelieu as his political heir. No one had better experience than Mazarin of the situation in Europe; no one was quicker witted or more tenacious. Mazarin, moreover, knew the channels through which Richelieu had worked in Paris and could apply his methods of obtaining money by farming taxes out, by the sale of offices and by new imposts.

The regent's confidence made Mazarin the most powerful member of the government. Some historians, arguing from appearances, have alleged without any real proof that Anne and Mazarin were secretly married or that they were lovers. Anyhow, their close political union meant that France was to remain under a *ministériat*, or rule by one principal minister. Yet whereas Richelieu had exercised uncontested authority with the consent of a king who was of age to rule, Mazarin was governing under a regency. Others, therefore, could now claim a right to examine the legality of the minister's actions; and the first to do so were the *parlements*, to whom royal edicts were sent for registration. Furthermore, Mazarin was a foreigner; and the family which followed in his wake, loaded with French honours, was not, like Richelieu's, a French one. In addition to his brother Michele, who was made archbishop of Aix in 1645, Mazarin had three Mancini nephews, five Mancini nieces and two Martinozzi nieces. Lastly, Mazarin was inclined to apply the methods of a diplomat to internal government: less imperious by nature than Richelieu and unable in his circumstances to bend everything to his will, he resorted to the undignified practice of playing Frenchmen off against each other.

**Foreign Affairs, 1643–48.**—After the suppression of the conspiracy of the Importants, led by the duc de Beaufort and by Madame de Chevreuse (*qq.v.*) in Sept. 1643, Mazarin for the next five years was chiefly concerned with negotiations to end the war against the Habsburg powers, Spain and Austria. He authorized Hugues de Lionne to mediate between the papacy and its opponents in the War of Castro or War of the Barberini (1642–44), so as to preserve France's potential allies in Italy; he promoted the Swedish-Danish peace of Brömsebro (1645), so that the Swedes could continue fighting in Germany; and by the truce of Ulm (March 1647), between France and Bavaria, he temporarily neutralized Austria's most important German ally. Before a general peace could be concluded, however, a delicate transaction of his was prematurely disclosed: he was offering a French withdrawal from Catalonia in exchange for the cession of the Spanish Netherlands. The Dutch took alarm at the prospect of having their French ally as an immediate neighbour and made a separate peace with Spain (Jan. 30, 1648). Spain could then reject Mazarin's terms.

Bavaria in Sept. 1647 had re-entered the war on the Holy Roman emperor Ferdinand III's side; but Turenne's victory at Zusmarshausen (May 1648) and Condé's at Lens (Aug. 1648), together with the Swedish invasion of Bohemia, induced Ferdinand's ambassadors to sign the peace of Westphalia (Oct. 1648). It has been argued that Mazarin, dismayed at contemporary events both in France and in England, renounced the prospect of completely defeating the emperor lest the authority of crowned heads should thereby be further endangered; but this argument fails to explain why, instead of making more efforts for a general peace when Spain wanted it, he staked everything on prolonging the Spanish war.

**The Fronde, 1648–53.**—The crisis of Mazarin's political life came with the Fronde (*q.v.*), which does not need to be described in detail here. After the first war of the Fronde (Jan.–March 1649), he tried for some months to steer a devious course between the rival factions. After the second (Jan. 1650–Feb. 1651), he went into exile at Brühl, in electoral Cologne, continuing however to direct royal policy by a clandestine correspondence. During the third Fronde war he returned to France in Dec. 1651 with a small army of his own to support the king, whereupon the *parlement* of Paris put a price of 5,000 *écus* on his head and decreed the sale of his unique library (which he had opened to the public in 1643). To facilitate the final settlement with Paris he withdrew again into exile in Aug. 1652, going via Sedan to Bouillon and then back to Sedan. On the king's triumphant return to Paris (Oct. 1652) he was promptly recalled, but he delayed his return till Feb. 1653, when he resumed his functions as chief minister. The victory over the Fronde cannot be ascribed to Mazarin alone, but he had played a great part in organizing the military resistance of the king's party against the rebels. The Frondeurs' pamphlets against him are collectively known as *mazarinades*.

**Foreign and Internal Affairs, 1653–61.**—With order restored in France, Mazarin could turn his attention again to diplomacy and to the war against Spain. For Germany, his concern was to prevent the Austrian Habsburgs from recovering a position of strength from which they could re-enter the war on behalf of their Spanish cousins. Thus, when the emperor Ferdinand III's elder son Ferdinand IV, king of the Romans, died prematurely in 1654, Mazarin began cautious attempts to promote the election of a Bavarian prince, or even of Louis XIV himself, instead of Ferdinand III's younger son Leopold. Though Leopold was at last elected emperor in July 1658, Mazarin was not dissatisfied with the restrictive covenant imposed by the electors, whereby the emperor expressly renounced any intention of helping the Spaniards against France; and for further security Mazarin organized the League of the Rhine in Aug. 1658 as a defensive alliance between France, Sweden, Cologne, Trier, Mainz, Münster, Palatinate-Neuburg, Hesse-Kassel and Brunswick-Lüneburg for the maintenance of the peace of Westphalia and of the new electoral covenant.

Meanwhile Mazarin had concluded a treaty of friendship (Nov. 1655) with the English Commonwealth, with which France had been waging an undeclared war. There followed a series of treaties (1657–58) for an Anglo-French alliance against Spain. The Spaniards were driven from northeastern France, though Dunkerque had to be given to the English. At last the peace of the Pyrenees, signed on Nov. 7, 1659, brought the Franco-Spanish war to an end.

The French withdrew from Franche-Comté but obtained Roussillon in the south and a considerable advance of their frontier in the Netherlands and toward Luxembourg. Moreover, it was stipulated that Louis XIV should marry the Spanish infanta Marie Thérèse of Austria, through whom he was later able to advance profitable claims on Spain's inheritance.

In internal affairs, despite the *parlements* and the provincial officeholders, the only way in which the royal government could control the secondary organs of administration was through commissioners or intendants (*see* INTENDANT). How Mazarin proceeded to re-establish the intendants after the Fronde is obscure; that he did so is certain. It was he also who trained the men who were to serve so well in the central government under Louis XIV's personal rule, Le Tellier, Colbert and Lionne, as well as the brilliant but less fortunate Fouquet.

Mazarin died of cancer at Vincennes on March 9, 1661, leaving an enormous fortune. His library, which he had reconstituted after its dispersal, is attached to the Bibliothèque Nationale in Paris, where his *carnets* (notebooks) are preserved. His letters for the period of his ministry were published by A. Chéruel and G. d'Avenel in nine volumes (1872–1906).

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**MAZAR-I-SHARIF,** capital of the province of Mazar-i-Sharif, is the fourth town of Afghanistan and the largest in Afghan Turkistan. It is situated 1,250 ft. above sea level on the extreme eastern edge of the Balkh oasis, 14 mi. E. of the ancient Balkh (*q.v.*; now called Wazirabad) and 35 mi. S. of the Amu-Darya (Oxus river). The population (1962 est. 41,706) includes a large number of Persian-speaking Tajiks (Tadzhiks), besides Turkic-speaking Uzbeks and some Pashtuns.

The focal point of Mazar-i-Sharif is the sacred ("blue") mosque and shrine to which the city owes its name ("holy tomb"). The tomb of Ali, the fourth caliph and son-in-law of the prophet Mohammed, is supposed to have been discovered there in the 15th (or, according to Afghan legend, in the 12th) century, although this claim is disputed by Najaf in Iraq, which is accepted as Ali's resting place by most Shi'ites. The impressive assemblage of these sacred buildings, with the two domes, minarets and courtyards, all covered with brilliant blue and turquoise tiles, has been much rebuilt (including new tiles) but is based on an original structure erected by the Timurids in 1480. The courtyards are full of white pigeons. Mazar-i-Sharif's growth and the corresponding decline of the much older city of Balkh date from the discovery of this tomb, which is venerated by all Muslims, especially Shi'ites. In the 1950s the old bazaars of the city and many smaller monuments were demolished to clear a large open space around the mosque and to make room for modern buildings.

A few miles southwest of Mazar-i-Sharif is Dehdadi, a large cantonment and military headquarters, with a military airport. Regular air services connect Mazar-i-Sharif with Kabul, Kunduz, Maimana and Herat. Roads link it with Kabul (about 390 mi. S.E.), west with Herat and north with the Amu-Darya ports of Pata Kesar (opposite Termez) and Kelif. The town is an important agricultural and trading centre (particularly for the lucrative karakul lambskin and carpet industries) and a transit point for Afghan-Soviet trade.

MAZAR-I-SHARIF PROVINCE, one of the major provinces of Afghanistan, stretches from the northern edge of the Koh-i-Baba range northward over the desert plains of Afghan Turkistan to the Amu-Darya and the Soviet frontier. Rivers run north from the mountains, watering the Balkh, Tashkurghan and other smaller oases, only to disappear in the sand before reaching the Amu-Darya. The climate is extremely hot and dusty in summer and vegetation is sparse. The population (1962 est.), 156,707, consists, in the country districts, mainly of Uzbeks, deposited there by the last great wave of nomadic Turkic peoples in the 16th century. Along the banks of the Amu-Darya, however, are patches of Turkmens, many of whom moved there when the Russians occupied their lands at the end of the 19th century. (For the history of Afghan Turkistan [Bactrian plain] *see* BACTRIA.) Numerous mounds testify to former greatness when the plains of Mazar-i-Sharif were irrigated and fertile. Now the Amu-Darya, having changed its course and level, can no longer be used for extensive irrigation. At Takht-i-Rustaum near the modern town of Haibak (Aibak) can be seen curious remains of the prosperous Buddhist period: a stone stupa cut into the rock and, nearby, large caves with ceilings sculpted in a lotus motif.

The main exports of the province are karakul skins and carpets, and pistachio nuts and almonds from the oases. Near the small

town of Darra-i-Suf in the inaccessible mountains in the south there are deposits of coal, but the problem is to transport the coal to where it can be used. The principal towns of the province, besides Mazar-i-Sharif, are Tashkurghan, Haibak, Wazirabad (Balkh) and Daulatabad. (X.)

**MAZATLÁN,** a Pacific port and resort called the "Pearl of the Pacific," in the Mexican state of Sinaloa, just south of the Tropic of Cancer. Diagonally opposite the tip of Lower California, Mazatlán is a chief communications link for that peninsula on the Mexican mainland. Pop. (1960) 75,751. The city, surrounded by coconut palms, is built along a peninsula overlooking Olas Altas bay and has a harbour that is dotted with large islands. After 1951 vessels of up to 10,000 tons were able to enter the harbour.

Accessible by railway, road and air, Mazatlán is a fishing and hunting region and a popular tourist resort. Exports include shrimp, minerals and fibres. (H. R. Hy.)

**MAZDAISM,** the religion of the *mazdayasna*, "worshipers of Ahura Mazda," another name of Zoroastrianism (*q.v.*).

**MAZDAKISM,** a dualistic religion which developed in Iran as an offshoot of Manichaeism (*q.v.*). Its founder appears to have been one Zaradust i Khuragan; a connection has been sought between him and a Persian, Bundos, who preached a divergent Manichaeism in Rome under Diocletian. The religion first came into prominence in the late 5th century A.D. under Mazdak i Bamdad, after whom, subsequently, it was generally named.

No Mazdakite books survive. Knowledge of the movement comes from brief notices in the Syrian chronicles of Joshua the Stylite and in Greek and Arabic histories; from the lost Sassanid royal chronicles (used by the poet Firdausi and Persian and Arab historians); from the lost Pahlavi romance the *Book of Mazdak;* and from a short account of its tenets given by Shahrastani.

According to Mazdakism, there exist two original principles, Good (or Light) and Evil (or Darkness). Light acts by free will and design; Darkness, blindly and by chance. By accident the two became mixed, producing the world. There are three Light elements: water, fire, earth. The god of Light, to be worshiped, is enthroned in paradise, having before him four powers—Perception, Intelligence, Memory and Joy. These rule over 7 "viziers" and 12 "spiritual beings." The 4 powers are united in man; the 7 and 12 control the world.

Man by his actions should seek to release the light in the world, through moral conduct and ascetic life. He may not kill, nor eat flesh. He is to be gentle, kind, hospitable, clement to foes. To encourage brotherly helpfulness and reduce causes of greed and strife, Mazdak sought to make property and women common. He converted to his faith King Kavadh I (488–531), who introduced social reforms inspired by its tenets. These appear to have involved some liberalizing of marriage laws and of measures concerning property. Kavadh thereby aroused the hostility of the nobles and Zoroastrian clergy and was deposed in 494. He regained his throne but thereafter was probably more cautious in his attitude to Mazdakism. Later he named as his successor not his eldest son, Kaus, an adherent of this faith, but his third son, Khosrau, an orthodox Zoroastrian. The communistic ideas associated with Mazdakism had spread, however, through the populace, leading to looting, seizure of land and abduction of women. The evidence for this lies largely in the stern measures taken by Khosrau to restore order. Khosrau had Mazdak and a large number of his adherents put to death, the literature of Mazdakism destroyed and its followers persecuted. The religion survived, however, in secret into Islamic times.

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**MAZE:** *see* Labyrinth.

**MAZEPA, IVAN STEPANOVICH** (1644?–1709), hetman of the Cossacks (*q.v.*) in the Russian Ukraine, remembered for his desertion from the Russians to the Swedes in the Northern War. He was born at Mazepintsy, near Bila Tserkva, his family's estate, probably in 1644. He served as a page at the court of the Polish king John Casimir, who later sent him to the west to complete his education. In 1663 he entered the service of Petro Doroshenko, the pro-Turkish hetman of the Ukraine on the right bank of the Dnieper; but in 1674, either from opportunism or from conviction, he transferred his allegiance to Ivan Samoilovich, the pro-Muscovite hetman of the left bank of the Dnieper, and disclosed to the Russians all that he knew about Doroshenko's plans. In 1687 he was himself acclaimed hetman.

Mazepa assisted the Russian statesman V. V. Golitsyn in his expedition against the Tatars in 1689. After Golitsyn's disgrace Mazepa saved his own head in Moscow with a diplomatic speech that won him the favour of the tsar Peter the Great. Peter, however, severely taxed Mazepa's loyalty and that of the Cossacks by sending them to new theatres of war and by setting them to new tasks. The treatment suffered by the civil population of the Ukraine at the hands of the Russian army was also hard to endure. Moreover, rumours were current of Peter's plans for the reform of the Cossack army and community.

In the summer of 1706 and in the spring of 1707 some of the Cossack leaders began to sympathize with Mazepa's mood of bitter discontent. It appears that from the outset of the Northern War in 1700 Mazepa had kept in intermittent touch with the pro-Swedish and anti-Russian party in Poland, represented by Stanislaw Leszczynski, the protégé of Charles XII of Sweden. Charles, Stanislaw and Mazepa intended that in the event of a Swedish victory the whole Ukraine should be joined to Poland on a federal basis, its ancient freedoms and privileges being guaranteed by Sweden.

In the summer of 1708, short of food and fodder, Charles XII turned south, expecting to find supplies and active military support in the Ukraine. In October events reached a critical pass: Mazepa's troops were urgently needed by the Russians in order to halt the Swedes, and his inactivity and absence were becoming suspect. The Desna river, which he crossed early in November with 5,000 men to join Charles, was Mazepa's Rubicon, but the gamble failed. By mid-December his army had dwindled to about 700 men; and the subsequent accession of the Zaporozhian Cossacks to the Swedish side only made good this loss. Neither the Cossack rank and file nor the officers nor even Mazepa's fellow conspirators were willing to support the Swedish king against the Russian tsar. Mazepa died on Sept. 2 (new style), 1709, at Bendery, in Moldavia, where he had been granted asylum by the Ottoman sultan Ahmed III after Peter's victory at Poltava.

Byron's version of the story that Mazepa in his youth was bound naked onto a wild horse and sent forth into the steppe by a jealous husband may owe something to the English poet's acquaintance with the Polish poet Adam Malczewski.

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**MAZOVIA** (Pol. Mazowsze), a historic territory in east-central Poland, comprising part of the Mazovia-Podlasia lowland in the basin of the middle Vistula and lower Bug rivers. The landscape is little varied, of postglacial character, in the eastern part densely forested; its soil for the most part is light, sandy, with occasional patches of clay and humus.

The name Mazovia appears in the 11th century, referring probably to the Plock-Ciechanow region only. In the early middle ages two other separate regions could be distinguished, namely the region of Sochaczew and the region of Grojec (formerly Grodziec) and Czersk. Ecclesiastically Mazovia was likewise divided (11th and 12th centuries): the northern part constituted the episcopal diocese of Plock, while the southern part, forming an archdeaconry, was an enclave under the bishop of Poznan.

Mazovia was incorporated into the Polish state in the first half of the 10th century. From 1138 it was one of the duchies of the Polish state. During the 13th and 14th centuries it was subdivided into several smaller duchies, with seats in Plock, Czersk, Warsaw, Rawa and Wizna. From 1350 onward the Polish crown began to reincorporate the various vassal Mazovian dukedoms on

the extinction of their reigning houses. This process was completed after the deaths of Stanislaw and Janusz, the last two Mazovian dukes of Warsaw, Ciechanow and Lomza (1524 and 1526). Subsequently the country was divided between the palatinates of Rawa, Plock and Mazowsze. Taken by Prussia in the 18th-century partitions of Poland, the whole of Mazovia was incorporated during the Napoleonic Wars in the duchy of Warsaw (1807–14). Thereafter it was part of Russian Poland till 1918. In restored Poland the greater part of Mazovia was comprised in the province (*wojewodztwo*) of Warsaw. After 1945 it was divided between the provinces of Warsaw and Bialystok.

A characteristic feature of the social structure of Mazovia was the numerous class of men who preserved their personal freedom, depended only on the duke and were summoned by him for military service. This was the origin of the large gentry class of Mazovia (in the 16th century up to 25% of the whole population). Of this class, 75% had no dependent peasants and worked the land themselves. In the 19th and 20th centuries the Mazovian village gentry supplied the cities and especially Warsaw with the energetic element from which the professional intelligentsia was largely recruited.

The historical and geographical divisions of Mazovia corresponded with the ethnic divisions. In the area of the oldest settlements, to the west of the rivers Wkra and Vistula, only one ethnic group survived, the so-called Ksiezacy in the region of Lowicz. In the area of Mazovian colonization, which started in the 13th century and continued over Podlasia and as far as Lithuania and Prussia until the 18th, the most interesting group is that of the Kurpie in the forest region around Ostroleka. (A. Gi.)

**MAZURKA** (Masurek), a Polish national dance in $\frac{3}{4}$ or $\frac{3}{8}$ time, the accent falling on the second beat of the measure. Danced in couples, it has more than 50 different steps, of which the most typical, also called *mazurka*, combines a skip and a slide. Characterized by stamping feet, clicking heels, and a proud carriage of the body, the mazurka was popular in western Europe as well as in Poland and Russia, in the late 19th century. It has been effectively introduced in *Coppélia, Swan Lake* and other ballets.

(Ln. Me.)

**MAZZINI, GIUSEPPE** (1805–1872), Italian patriot, the revolutionary prophet of the Risorgimento and of European nationalism, was born on June 22, 1805, in Genoa, a city then under French rule. His father was a doctor. A sickly and studious boy, Mazzini was taught at first by priests of Jansenist leanings and became strongly religious yet anticlerical. He went to Genoa university, studying chiefly law, but also philosophy and medicine, and graduated in 1827. His chief love was literature, and his early writings include essays on Goethe, Byron, Scott, Dante, Foscolo and Manzoni. His collected writings eventually numbered more than 100 volumes. But he early set aside his literary ambitions to devote his life to the unification of Italy.

As a youth Mazzini joined the clandestine Carbonari (*q.v.*). In Nov. 1830 he was imprisoned at Savona for three months by the government of Sardinia-Piedmont. Here he began to understand the "apostolate" (as he called it) which summoned him to political martyrdom. On his release he went into exile in France and settled at Marseilles. When Charles Albert became king of Sardinia-Piedmont in April 1831, Mazzini wrote a public letter urging him to lead Italy to independence. Mazzini also founded the organization called Giovine Italia ("Young Italy"), with the aim of achieving national independence; the means to be used were education and insurrection. Forced to leave Marseilles by the French government because of representations from Piedmont, he went eventually to Switzerland. From Geneva in 1833 he tried to instigate a mutiny in the Piedmontese army, but this only resulted in a dozen executions, and he and Giuseppe Garibaldi (*q.v.*) were sentenced to death. Again, in 1834, an insurrection in Savoy was planned; but this failed ignominiously. Mazzini was also involved in an obscure plot to assassinate Charles Albert, though later he denied this involvement. Having founded two more societies, Young Europe and Young Switzerland, he was expelled from Switzerland in 1836, again at Piedmont's request. As he moved surreptitiously from house to house, founding one ephemeral newspaper after another, always conspiring and firmly believing in the efficacy of popular insurrection, Mazzini's life began to take on a pattern that was to become familiar.

Exiled from many other states, Mazzini in Jan. 1837 arrived in London, where he was to live for most of his life. Poor though he was, he founded a school for Italian children and taught himself English so well that he was soon writing for the *Edinburgh*, the *Westminster* and other reviews. He became friendly with Thomas Carlyle, who on one occasion wrote to *The Times* that Mazzini was "a man of genius and virtue, one of those rare men . . . who are worthy to be called martyr souls." All the time Mazzini was waiting to start revolutions in Italy, sometimes editing several newspapers at once and smuggling them over the frontier; writing to Pope Pius IX in 1847 to urge him to lead the national movement; and keeping up a vast correspondence in order to educate a new generation of Italians. He was becoming the great prophet of nationalism: European federation and internal liberties were equally close to his heart, but national independence for all was first necessary, and he believed dogmatically that the frontiers of nations were easily defined and attained (for instance, he thought that there was a Scandinavian nation and an Alpine nation, but not a Portuguese or an Irish one).

Without doubt Mazzini's example and precept were behind the many insurrections which finally made Italian nationalism irresistible. Many of his friends were killed in these risings. His chief function in the Risorgimento was thus to create the martyrs who would help to make nationalism almost a religion. His constant iteration of a few simple themes did make many Italians conceive that a movement for national unification must be part of God's providence, and this created the will to sacrifice and the sheer foolhardiness without which nothing could have been achieved. Most of the national leaders went through a phase when he was their inspiration, even though most of them in the end found him too imperious, too dogmatic, too unrealistic in his belief that the ordinary citizens of Italy must be made to rebel and create a nation by popular effort. Cavour (*q.v.*) hated and feared Mazzini because Mazzini's revolution was incidentally a threat to monarchy and conservatism, but Cavour needed Mazzini time and again to ignite the spark which more cautious statesmen could later use to touch off their own more respectable revolution.

The Italian insurrections of 1848 brought Mazzini to Italy in April. At Milan he published a new journal, *L'Italia del Popolo*. When the Austrians recaptured Milan in August, Mazzini joined Garibaldi's volunteers, who were fighting a war of their own. In March 1849 Mazzini was elected a member of the triumvirate of the Roman republic after the flight of the pope. When Rome was invested by a French army, he not only organized a heroic resistance, but also kept remarkable order in the city for several months. At the end of June, Rome had to surrender. Mazzini for a time remained hidden, but the U.S. consul finally helped him to escape to London. This had been Mazzini's finest hour. His defense of Rome compared very favourably with the ignominious defeat of the Piedmontese army in the north and did much to convince Europe that Italian nationalism did not merely cover the dynastic ambition of a Charles Albert but represented a widespread feeling inside Italy. (*See* Italian Independence, Wars of; Italy: *History*).

Mazzini's success after 1849 was more limited. His chief ability had been as a prophet and educator, and in the new phase of positive action he was not a man to compromise with principles and act the opportunist like Cavour. He went on organizing revolutions—at Mantua in 1852, at Milan in Feb. 1853—but these were badly prepared and badly co-ordinated, and their failure helped to weaken his influence. Personally he became embittered and intractable. Many of his friends, Garibaldi among them, deserted him. In London, far away from the Italian scene, Mazzini could not recognize that ordinary people in Italy were not much interested in nationalism or republicanism. Others now saw that Italian unification could not be effected by Italy's own efforts, but only by outside assistance. Mazzini obstinately refused to accept this idea. In 1857 he traveled secretly to Italy to organize risings in Genoa, Leghorn and Naples—only to receive another

sentence of death from the Piedmontese courts. It seems that in 1856 Cavour had been ready to use Mazzini to stir up insurrections inside Austrian-controlled Italy, but by 1857 Mazzini was clearly too dangerous as well as too republican and democratic.

In Sept. 1858 Mazzini began a new journal in London, *Pensiero ed Azione*. Isolated though he was, it is surprising what political insight this magazine sometimes revealed and how often he knew diplomatic secrets long before others did. The moral elevation of his thought can be seen from his *Doveri dell'uomo* (1860), an ethical treatise which he dedicated to the workers of Italy. Mazzini repudiated socialism, for to him it was too materialistic, too much concerned with rights instead of duties, putting too much stress on class division instead of on the unifying virtues of nationalism. Mazzini aimed at the Italian working class, but he was far too religious and mystical to understand them; and to his infinite chagrin their manifest preference was for Bakunin's anarchism or Marx's socialism.

Mazzini strongly disliked the alliance that Cavour arranged with Napoleon III's French empire in 1859, for it not only tied Italy to something inherently illiberal but also meant that national unity was going to be imposed on Italy instead of won by Italians for themselves. Over the armistice of Villafranca between France and Austria in July 1859 he showed more realistic sense than Cavour himself; and in 1860 he certainly showed more readiness to co-operate with the monarchists than they with him. Cavour needed Mazzini as a kind of opposition scarecrow, in order to frighten both Napoleon and Victor Emmanuel II of Sardinia into accepting his own conservative revolution as the only way of avoiding something worse. Cavour tried to persuade Great Britain to expel Mazzini and employed French as well as Italian policemen to try to capture him. Nevertheless, on several occasions Mazzini came to Genoa without being caught. The dream of his life was now being realized, but it gave him no joy. Italy was being unified by the annexation of one province after another to Piedmont. Lombardy in 1859 was a gift of France, Venice in 1866 a gift of Prussia, handed over by Austria to France and then by France to Italy like so much merchandise. "I had thought to revive the soul of Italy," Mazzini said later, after the capture of Rome in 1870, "but all I find before me is its corpse."

In 1861 Italy officially had become a nation, but Mazzini was still in exile; and even after the sentence of death was removed from him in 1866 he could not bring himself to approve what had happened. Messina went on electing him to parliament, but he was not allowed to take his seat, for the rulers of the new state did not want fundamental controversies raised. Mazzini's last years were mainly divided between London and Lugano, with brief visits to Genoa and Milan. In 1870 he set out for Sicily, but one of his former friends informed the police and the government imprisoned him for several months in Gaeta. He died at Pisa on March 10, 1872, disguised as a Dr. Brown, a fugitive even in his own country.

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**MAZZUCHELLI, SAMUEL CHARLES** (1806–1864), Italian-American Dominican priest and missionary, was born at Milan on Nov. 4, 1806. He entered the Dominican order in 1823, and five years later embarked for the American missions, where he completed his theological studies and was ordained on Sept. 5, 1830. Mazzuchelli's first assignment was in the north and northwest regions of the Cincinnati diocese, with headquarters on Mackinac Island. When the diocese was divided in 1833, he was attached to Detroit; he continued his missionary activity in the north and also journeyed into Illinois and Iowa. Mazzuchelli became a prominent figure around Galena and Dubuque; the first bishop of Dubuque, Matthias Loras, appointed him vicar-general in 1837. He was also first chaplain to the first legislature of the territory of Wisconsin (1836), and in 1840 the legislature of the territory of Iowa convened in his as yet unconsecrated church at Burlington.

After a visit to Milan in 1843, Mazzuchelli returned to Galena with authorization to inaugurate a new Dominican province and to establish an order of Dominican sisters. Both projects were undertaken at Sinsinawa, Wis., but in Nov. 1849 he assigned the property and college to the Dominicans of Kentucky and moved to Benton, Wis., where he made a permanent home for the religious community of women. From 1853 until his death he devoted much of his time to the development of his parish, the schools and the direction of the Dominican sisters. He died at Benton on Feb. 23, 1864.

Mazzuchelli's *Memoirs Historical and Edifying of a Missionary Apostolic*, originally published in 1844, were translated and published in 1915.

*See* Soeur Rosemary Crepeau, O.P., *Un Apôtre dominicain aux États-Unis, le père Samuel Charles Gaetan Mazzuchelli* (1932); *Golden Bells in Convent Towers: the Story of Father Samuel and Saint Clara: 1854–1904* (1904). (F. G. MCM.)

**MBEYA REGION, TANGANYIKA,** established in Oct. 1963, following a reorganization of administrative units in Tanganyika, comprises Mbeya, Rungwe and Chunya districts, which previously belonged to the former Southern Highlands region. It is bounded west and north by Tabora region, north by Singida region, east by Iringa region and south by Nyasaland and Northern Rhodesia. Area 23,650 sq.mi. Pop. (1957) 540,978. The region includes the group of volcanic mountains between Lake Nyasa and Lake Rukwa (which lies in a dischargeless basin crossed by the region's western boundary), a part of the central plateau of Tanganyika and the Usangu plain or Buhoro flats (a former lake bed now drained by the Great Ruaha river and its tributaries). Rain falls mainly during December to April. The hot, dry plains contrast with the cool, moist highlands and the heavy rain (115 in.) north of Lake Nyasa. Regional headquarters are at Mbeya (pop. 6,932). The Nyakyusa are the largest among the many tribes. There has been European settlement in the highlands and Asian settlement (Balochi) in the Usangu plain. The principal cash crops are tea, coffee, pyrethrum, wheat and rice. Other occupations include the raising of livestock and timber and, on Lake Rukwa, fishing, crocodile hunting and salt production. Gold and pyrochlore are mined. (J. M. KE.)

**MBUNDU** (OVIMBUNDU), a tribe numbering over 1,000,000 in the 1960s and inhabiting the Benguela highlands in Angola (*q.v.*). Linguistically they belong to the western province of the southern Bantu. Physically they are of southern and central Bantu origin. The ruling families entered the highlands from the northeast in the 17th century, subduing and incorporating the indigenous cattle-keeping peoples. They divide into 22 chiefdoms, about half of which were tributary to a larger chiefdom prior to effective Portuguese occupation. Each chiefdom has a paramount chief, council and subchiefs.

The kinship system features double descent, land being inherited in the paternal, movable property in the maternal, line. Initiation "schools" exist for boys and girls of certain families only. Mbundu (under the names Mambari, Bihe or Bailundu) were formerly traders in the region bounded by the Great lakes, the Congo river and the Kalahari desert. Each trading caravan had a professional leader and diviner. Trade agreements linking the independent chiefdoms led to development of regional specialization; *e.g.*, metalwork in Viye, corn-meal production in Ciyaka and Bailundu. Large-scale trading activities declined with the arrival of European traders, the suppression of slave traffic and the construction of the Benguela railway in 1904.

Agriculture preponderates, main crops being maize (corn) and beans. Most Mbundu men and boys hunt but there are also professional hunters. Domestic animals include cows, sheep and goats; oxen are used for transport. Cattle are a measure of wealth, but few families own large herds. Beeswax was, and still is, an important item of trade.

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**Mc, M'** are alphabetized as MAC in this work.

**MDINA** (CITTA NOTABILE OR CITTA VECCHIA), a fortified city of Malta occupying a dominating rocky site 7 mi. W. of Valletta.

Pop. (1961 est.) 836. The city may have Neolithic origins; there are considerable Punic and Roman remains and the present name is Semitic (*medina*, "fortification"). Named Notabile in 1427 by the Castilian rulers, it was the Maltese capital until 1570 when Valletta (*q.v.*) was nearly completed; it was then referred to by the rulers as Città Vecchia ("old city"). Mdina retains intact its remarkable fortifications with a complete wall, and contains many 15th-, 16th- and 17th-century Maltese palaces. Its chief building is the cathedral church of Malta (restored after an earthquake in 1693) said to occupy the site of the house of the governor Publius who received the apostle Paul. Beneath Mdina and its almost contiguous modern neighbour Rabat occur catacombs, partly pre-Christian, showing early Christian burials. Some damage occurred by air attack during World War II but the city retains its Renaissance atmosphere. (W. B. Fr.)

**MEAD, GEORGE HERBERT** (1863–1931), U.S. philosopher, an important figure in both social psychology and the development of pragmatism, was born in South Hadley, Mass., on Feb. 27, 1863. He studied at Oberlin college and Harvard university. During 1891–94 he was instructor in philosophy and psychology at the University of Michigan. In 1894 he went to the University of Chicago, where he remained till his death on April 26, 1931.

To social psychology Mead's main contribution was his attempt to show how the human self arises in the process of social interaction. He thought that spoken language played a central role in this development. Through language the child can take the role of other persons and guide his behaviour in terms of the effect his contemplated behaviour will have upon others. Thus Mead's psychological approach was behaviouristic, though his behaviourism was rich enough to find a place for self-observation and for subjective events.

In philosophy, Mead was one of the major thinkers among the American pragmatists. In common with a number of his contemporaries, he was much influenced by the theory of relativity and the doctrine of emergence. His philosophy might be called objective relativism. Just as some objects are edible, but only in relation to a digestive system, so Mead thought of experience, life, consciousness, personality and value as objective properties of nature which emerge only under (and hence are relative to) specific sets of conditions. John Dewey acknowledged his own great indebtedness to Mead's philosophy.

Mead published no book. After his death his students edited four volumes from stenographic recordings and notes on his lectures and from unpublished papers: *The Philosophy of the Present* (1932); *Mind, Self, and Society* (1934); *Movements of Thought in the Nineteenth Century* (1936); *The Philosophy of the Act* (1938). (C. Ms.)

**MEAD, RICHARD** (1673–1754), English physician and collector of books, manuscripts and art objects, was born on Aug. 11, 1673, at Stepney, London. He studied at Utrecht and Leiden and in 1695 graduated in philosophy and physics at Padua, returning to London in 1696. His *Mechanical Account of Poisons* appeared in 1702 and in 1703 he was admitted to the Royal society, to whose *Transactions* he contributed in that year a paper on the parasitic nature of scabies. In the same year he was elected physician to St. Thomas' hospital. On the death of John Radcliffe in 1714 Mead became the recognized head of his profession; he attended Queen Anne on her deathbed and was physician to George II. Mead's library, the largest formed in his time, totaled 10,000 volumes. He died in London on Feb. 16, 1754.

**MEAD** (akin to *Madhu* in Sanskrit, meaning honey) is an alcoholic drink made by the fermentation of honey mixed with water; sometimes yeast is added to accelerate the fermentation. "Metheglin" (from the Welsh *meddyglyn*) should strictly only refer to spiced mead made with the addition of such spices and herbs as cloves, ginger, rosemary, hyssop and thyme; the terms are, however, sometimes interchanged. Mead can be light or rich, sweet or dry, or even sparkling; in the middle ages it was usually similar to a sparkling table wine.

Alcoholic drinks made from honey were common among the ancients and in the middle ages, particularly in northern countries where grape vines do not flourish; the *hydromel* of the Greeks and Romans was probably like the mead drunk by the Celts and Anglo-Saxons, although the Roman *mulsum* was not mead, but wine sweetened with honey. In Celtic and Anglo-Saxon literature, such as the writings of Taliesin, and in the *Mabinogion* and *Beowulf*, mead is the drink of kings and thanes. Chaucer's miller drank mead, but by the 14th century, spiced ale and pyment (a sweetened wine similar to *mulsum*) were superseding it. The rules which King Howel the Great laid down for making mead in the 10th century are proof that the Welsh took great interest in it; they favoured spiced mead and it was from the early 16th century (when the Tudors brought elements of Welsh culture into England) that the word "metheglin" was often used for plain and spiced mead alike. But mead, once the commonest alcoholic drink of England, had lost ground to ales and beers (since the earliest days of improved medieval agriculture) and also to wines (imported from Gascony for the rich, from the 12th century onward). Finally, when West Indian sugar began to be imported in quantity (from the 17th century), there was less incentive to keep bees, and the essential honey became scarcer. (C. C. H. F.)

**MEADE, GEORGE GORDON** (1815–1872), Union general of the American Civil War, was born Dec. 31, 1815, at Cadiz, Spain, where his father was a merchant. He graduated from West Point in 1835 and was commissioned in the artillery. After a year's service he resigned his commission and engaged in civilian surveying assignments, including work on the boundaries of Texas and Maine. Meade re-entered the army in 1842 as a second lieutenant of engineers, served with Generals Taylor and Scott in the Mexican War, and performed engineering duties in Delaware bay, in Florida and along the Great Lakes.

On Aug. 31, 1861, Meade was commissioned brigadier general of volunteers and assigned to command the 2nd brigade of the Pennsylvania reserves. He fought in the Peninsula campaign and was wounded at Frazier's Farm. After the second battle of Bull Run, Meade commanded his division and led the I corps temporarily when Gen. Joseph Hooker was incapacitated during the battle of Antietam. With the disastrous Union defeat at Fredericksburg he was assigned the V corps, which participated in the Chancellorsville campaign. There Meade urged a forceful attack, but the demoralized Hooker insisted upon withdrawal.

On June 28, 1863, Lincoln ordered the reluctant Meade to replace Hooker in command of the army of the Potomac and to defeat the invading Confederate army. From July 1–3 "the greatest battle ever waged in North America" was fought at Gettysburg (*q.v.*), and Meade completely repulsed Lee with great tactical skill. At the conclusion of his defensive victory, however, he failed to pursue vigorously, and Lee's army escaped.

Grant became general in chief of the Union armies in March 1864 and joined the army of the Potomac in field operations. Although Meade retained command until the end of the war, his independence of action was sharply curtailed. The relations between the two leaders were generally good, and Grant recommended Meade's promotion to major general in the regular army. Meade was respected by his associates but his irascible temper led him into frequent quarrels.

After the war Meade commanded successively the military division of the Atlantic, the department of the east, the 3rd military district (Georgia, Alabama, Florida), and the department of the south. He died of pneumonia on Nov. 6, 1872, in Philadelphia.

*See* George Meade, *Life and Letters of George Gordon Meade*, 2 vol. (1913); Freeman Cleaves, *Meade of Gettysburg* (1960); I. R. Pennypacker, *General Meade* (1901). (J. R. Co.)

**MEADOW BEAUTY,** the common name for several species of *Rhexia*, North American plants of the melastoma family (Melastomaceae). *Rhexia virginica*, called also deer grass and handsome Harry, is native to sandy marshes from Maine to Ontario and Iowa and southward to Florida and Texas. It is a rather stout, squarish-stemmed perennial about one foot high, with smooth, oval, light-green, three-ribbed, somewhat pointed leaves and handsome purplish magenta flowers, one to one and a half inches wide, blooming about midsummer. The floral parts consist of an urn-shaped calyx with a four-lobed limb; four broad, rounded petals; eight

stamens with golden anthers; and a single pistil with a four-celled ovary, which develops into a four-valved many-seeded pod (capsule). The pistil protrudes beyond the anthers, thereby ensuring cross-fertilization, which is effected by honeybees and other insects. In the southern states there are several allied species, among which are the Maryland (*R. mariana*) and the ciliate meadow beauty (*R. ciliosa*).

**MEADOW LARK,** the name for two species of *Sturnella*, well-known North American birds that, like the skylark of Europe, frequent meadows and sometimes sing on the wing. The eastern (*S. magna*) and the western (*S. neglecta*) species are very similar, both being about 11 in. long, with the back streaked brown and the breast yellow (paler in *S. neglecta*) with a black bib. Their white outer tail feathers are distinctive. Meadow larks are not related to the true larks (*see* LARK) but are aberrant members of the American family Icteridae, which includes the blackbirds and orioles. Both species have a musical song (richer in *S. neglecta*) and both build domed nests on the ground, among grass. A clutch consists of four to seven spotted eggs.

G. RONALD AUSTING FROM NATIONAL AUDUBON SOCIETY

EASTERN MEADOW LARK (STURNELLA MAGNA)

**MEADOW RUE,** the common name given to the numerous species of the genus *Thalictrum* of the buttercup family. A few species, comprising mostly tall perennial herbs with delicate dissected foliage and small flowers in usually large open terminal panicles, are grown as ornamentals, especially in the wild garden. They are of easy culture in well-drained loamy soil and are easily propagated by division of roots in early spring, and also by seeds. (J. M. Bl.)

**MEADVILLE,** a city and the seat of Crawford county, Pa., U.S., is on French creek, 40 mi. S. of Erie. The oldest settlement in northwestern Pennsylvania, it was founded by David Mead and other settlers from New England in 1788. The group founded Allegheny college (Methodist-Episcopal) in 1815, the oldest college west of the Allegheny mountains and north of the Ohio river. Incorporated as a borough in 1823 and as a city in 1866, Meadville became the commercial centre of a fertile dairy region. Oil and natural gas are found directly to the east. Near the turn of the century the manufacture of slide fasteners was started in the city which became the "home of the zipper"; it remains the major industry. Other manufactures include machine and hand tools, rayon and castings. For comparative population figures *see* table in PENNSYLVANIA: *Population.* (W. A. C.)

**MEAGHER, THOMAS FRANCIS** (1823–1867), Irish revolutionary leader, orator and Union officer in the American Civil War, was born in Waterford, Ire., on Aug. 23, 1823. He became a member of the Young Ireland party in 1845 and in 1847 was one of the founders of the Irish confederation. In July 1848 the confederation created a "war directory" of which Meagher was a member, and he and William Smith O'Brien traveled through Ireland arousing the countryside for a revolution against English rule. The attempt of 1848 proved abortive and Meagher was arrested in August. In October he was tried for high treason, found guilty and condemned to death. His sentence was commuted to life imprisonment in Van Diemen's Land (Tasmania).

Early in 1852 he escaped and in May reached New York city. He made a tour of U.S. cities as a popular lecturer, and then studied law and was admitted to the New York bar in 1855. He found himself a leader of the Irish element in New York city and edited several influential Irish journals. At the outbreak of the Civil War he was made captain of a company (which he had raised) in the 69th regiment of New York volunteers and fought at the first battle of Bull Run. He then organized an Irish brigade, of whose first regiment he was colonel until Feb. 3, 1862, when he was appointed to the command of this organization with the rank of brigadier general. After Chancellorsville, where his brigade was reduced to less than a regiment, Meagher resigned his commission, but on Dec. 23, 1863, his resignation was canceled, and he was assigned to the command of the military district of Etowah, with headquarters at Chattanooga.

At the close of the war Pres. Andrew Johnson appointed him secretary of Montana territory, and there, in the absence of the territorial governor, he acted as governor from Sept. 1866 until his accidental death in the Missouri river near Fort Benton, Mont., on July 1, 1867. Meagher's religion and his championship of President Johnson's principles of reconstruction made him unacceptable to the powerful vigilante organization that then ruled Montana, and in his efforts to dislodge the vigilantes from control he was unsuccessful.

**MEAL PLANNING:** *see* DIET AND DIETETICS; NUTRITION.

**MEALY BUG,** any of the small sap-sucking hemipterous insects of the family Pseudococcidae. World-wide in distribution, mealy bugs attack citrus trees and are pests on many ornamental, greenhouse and house plants. Most often seen are the ovoid, sluggish, mature females, each less than one-half inch long, consisting largely of a whitish cottony sac covering the body and several to many eggs or young. The females and "crawlers," the active young, tend to cluster along the veins and crevices on the undersides of leaves; the males are active two-winged fliers. Common among them are the citrus mealy bug (*Pseudococcus citri*) and the citrophilus mealy bug (*P. gahani*). Biological control has been effective against these pests in commercial plantings but organic insecticides are also used.

*See* also ENTOMOLOGY; HEMIPTERA; HOUSE PLANTS: *Control of Ailments.*

**MEALYWING,** the name applied to many species of small insects of the neuropteran family Coniopterygidae, so-called from their white, powdery covering. They are beneficial to man, since their larvae feed on plant pests such as aphids. *See* NEUROPTERA.

**MEAN.** In mathematics, mean is used as a synonym for average. (*See* also MEDIAN; STATISTICS.) In scientific work it is often useful to compute means for the purpose of summarizing data. For example, suppose a physicist finds in three repeated measurements that certain radioactive particles penetrate a radiation shield to depths of 1.251 ft., 1.256 ft. and 1.252 ft. He divides the sum of the measurements, 3.759, by the number of measurements, 3, to obtain an average of 1.253 ft. This particular average is called the arithmetic mean. More generally, the arithmetic mean of a set of $n$ numbers $x_1, x_2, \ldots, x_n$ is defined as the sum of the numbers divided by $n$. If we denote the arithmetic mean as $\bar{x}$, we have

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n}$$

The arithmetic mean represents a point about which the numbers balance. For example, if unit masses are placed on a line at points with co-ordinates $x_1, x_2, \ldots, x_n$, then the arithmetic mean is the co-ordinate of the centre of gravity of the system. For a system of particles having unequal masses, the centre of gravity is determined by a more general average, the weighted arithmetic mean. If each number $x_i$ is assigned a positive weight $w_i$, the weighted arithmetic mean is defined as the sum of the products $w_i x_i$ divided by the sum of the weights. In this case

$$\bar{x} = \frac{w_1 x_1 + w_2 x_2 + \cdots + w_n x_n}{w_1 + w_2 + \cdots + w_n}$$

In another application of the weighted arithmetic mean, suppose a motorist drives a distance of 120 mi. at a constant speed of 40 m.p.h. and returns over the same distance at a constant speed of 60 m.p.h. The arithmetic mean of the two speeds is not a reasonable measure of his average speed because he travels at 40 m.p.h. for three hours and at 60 m.p.h. for only two hours. The most reasonable definition of average speed here is total distance traveled divided by elapsed time. In this case he travels $3 \times 40$ mi. in one direction and $2 \times 60$ mi. in the other, for a

total of 240 mi. The elapsed time is 3 + 2, or 5 hours. Therefore the average speed for the trip is

$$\frac{3 \times 40 + 2 \times 60}{3 + 2} = \frac{240}{5} = 48 \text{ m.p.h.}$$

Thus, the average value, 48, is the weighted arithmetic mean of 40 and 60 with weights 3 and 2, respectively.

Weighted arithmetic means also apply in probability (*q.v.*). For example, suppose in a game of chance there is a probability $\frac{1}{4}$ of winning $8 and a probability $\frac{3}{4}$ of winning $4. A gambler wishes to decide how much he should pay to play this game. He may theorize that he has "$\frac{1}{4}$ claim" on the $8 and "$\frac{3}{4}$ claim" on the $4, for a "total claim" of $\frac{1}{4} \times 8 + \frac{3}{4} \times 4$, or $5, and decide to play only if the cost is $5 or less. The number 5 is the weighted arithmetic mean of 8 and 4 with weights $\frac{1}{4}$ and $\frac{3}{4}$, respectively, and is called the mathematical expectation of this particular game.

For a given set of data there are many possible averages one can define, depending on which features of the data are of interest. For example, suppose five squares are given, with sides 1, 1, 2, 5 and 7 in. Their average area is $(1^2 + 1^2 + 2^2 + 5^2 + 7^2)/5$, or 16 in.$^2$, the area of a square of side 4 in. The number 4 is the quadratic mean (or root mean square) of the numbers 1, 1, 2, 5, 7, and differs from their arithmetic mean, which is $3\frac{1}{5}$. In general, the quadratic mean of $n$ numbers $x_1, x_2, \ldots, x_n$ is the square root of the arithmetic mean of their squares,

$$\sqrt{(x_1^2 + x_2^2 + \cdots + x_n^2)/n}.$$

The arithmetic mean ($\bar{x}$) of $n$ numbers $x_1, x_2, \ldots, x_n$ gives no indication of how widely the data are spread or dispersed about the mean. A measure of the dispersion is provided by the quadratic mean of the $n$ differences $x_1 - \bar{x}, x_2 - \bar{x}, \ldots, x_n - \bar{x}$. This is called the standard deviation (*q.v.*) of $x_1, x_2, \ldots, x_n$.

The arithmetic and quadratic means are the special cases $p = 1$ and $p = 2$ of the $p$th-power mean, $M_p$, defined by the formula

$$M_p = \left(\frac{x_1^p + x_2^p + \cdots + x_n^p}{n}\right)^{1/p}$$

where $p$ may be any real number except zero. The case $p = -1$ is also called the harmonic mean. When the $x_i$ are not all equal, $M_p < M_q$ whenever $p < q$; in particular, the arithmetic mean is less than the quadratic mean. Weighted $p$th-power means are defined by

$$M_p = \left(\frac{w_1x_1^p + w_2x_2^p + \cdots + w_nx_n^p}{w_1 + w_2 + \cdots + w_n}\right)^{1/p}$$

If $\bar{x}$ is the arithmetic mean of $x_1$ and $x_2$, the three numbers $x_1, \bar{x}, x_2$ are in arithmetic progression. If $h$ is the harmonic mean of $x_1$ and $x_2$, the numbers $x_1, h, x_2$ are in harmonic progression. To find a number $g$ such that $x_1, g, x_2$ are in geometric progression, we require $x_1/g = g/x_2$, or $g^2 = x_1x_2$; hence $g = \sqrt{x_1x_2}$. This $g$ is called the geometric mean of $x_1$ and $x_2$. The geometric mean of $n$ numbers $x_1, x_2, \ldots, x_n$ is defined to be the $n$th root of their product; $g = \sqrt[n]{x_1x_2 \ldots x_n}$. It is related to the $p$th-power means by the inequalities $M_{-q} \leq g \leq M_p$ for all $p > 0$, $q > 0$. For the same data, the geometric mean never exceeds the arithmetic mean.

All the means discussed are special cases of a more general mean. If $f$ is a function having an inverse $f^{-1}$, the number

$$f^{-1}\left(\frac{f(x_1) + f(x_2) + \cdots + f(x_n)}{n}\right) \qquad (1)$$

is called the mean value of $x_1, x_2, \ldots, x_n$ associated with $f$. When $f(x) = x^p$ the inverse is $f^{-1}(x) = x^{1/p}$ and formula (1) gives the $p$th-power mean, $M_p$. When $f(x) = \log_e x$, the inverse is $f^{-1}(x) = e^x$ and formula (1) gives the geometric mean. Weights may also be introduced by using the weighted arithmetic mean of $f(x_1), f(x_2), \ldots, f(x_n)$ inside the large parentheses in formula (1).

If $f$ is continuous on an interval $a \leq x \leq b$, and if $A_n$ denotes the mean value computed from (1) for equally spaced points $x_k = a + k(b - a)/n$, $k = 1, 2, \ldots, n$, then as $n$ becomes infinite the mean values $A_n$ tend to a limit $c$ satisfying the equation

$$f(c) = \frac{1}{b - a}\int_a^b f(x)\,dx \qquad (2)$$

with $a < c < b$. The number $f(c)$ is the mean value of $f$ on the interval $a \leq x \leq b$. Figure 1 illustrates the geometric interpretation of equation (2). The rectangle of altitude $f(c)$ and base $b - a$ has the same area as the region between the graph of $f$ and the interval $a \leq x \leq b$. The mean-value theorem for integrals says that there is always a number $c$ satisfying (2).

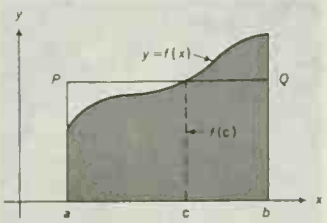


FIG. 1.—MEAN-VALUE THEOREM FOR INTEGRALS. THE AREA OF RECTANGLE ABQP IS EQUAL TO THAT OF THE SHADED REGION

When $f$ is the derivative of another function $g$, the integral in equation (2) is then equal to $g(b) - g(a)$ and equation (2) becomes

$$g'(c) = \frac{g(b) - g(a)}{b - a} \qquad (3)$$

with $a < c < b$. Equation (3) is illustrated in fig. 2. The tangent line at $C = [c,g(c)]$ is parallel to the chord joining the points $A = [a,g(a)]$ and $B = [b,g(b)]$. The mean-value theorem for derivatives states that there is always a number $c$ satisfying equation (3). (T. M. A.)

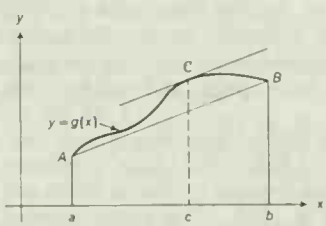


FIG. 2.—MEAN-VALUE THEOREM FOR DERIVATIVES. THE TANGENT LINE AT C IS PARALLEL TO THE CHORD AB

**MEANING.** The term "meaning" is used in many different senses. These may be divided into three principal types: (1) meaning as index or symptom of some occurrence; (2) meaning as intent or purpose of a deliberate action; (3) meaning as whatever is referred to, signified, or expressed by words or other symbols.

1. We use the term in the first of these three senses when we say that increased government spending means higher taxes; a falling barometer means rain; blushing means embarrassment; a certain kind of footprint in a slab of stone means that a dinosaur once walked there. In cases of this sort, the statement that one kind of fact or event, $A$, means another, $B$, is tantamount to the assertion that $B$ is often or always associated with $A$, so that an occurrence of $A$ affords more or less strong grounds for the presumption that $B$ has occurred or will occur. Here, then, $A$ means $B$ in the sense that $A$ is a symptom or an index for $B$.

2. The meaning of a deliberate act performed by an individual or a group—such as a specific move made by a chess player, or a decision arrived at by a planning board—is often construed as the purpose that the act is intended to serve; and individual or collective behaviour is then said to be meaningful insofar as it is governed by specifiable purposes. This second conception of meaning is sometimes extended, in a more or less metaphorical manner, to occurrences that do not in any clear sense constitute deliberate acts; this is the case, for example, when we speak of the meaning of history or the meaning of life.

3. The concept of meaning has its most important applications, however, in reference to the use and function of symbols; these may be words or more complex expressions—including sentences—of a spoken or written language, or such devices as flag or smoke signals, traffic lights, road markings, the sound signals produced by an air-raid warning siren, etc. Speaking very generally, the meaning of a symbol is whatever the symbol is intended or understood

to refer to or signify or express. The meaning of the "all clear" siren signal, for example, is at least twofold: it conveys the information that the immediate danger is over, and it transmits an order to return to normal activities. Similarly, a sentence or a passage consisting of several sentences may be the carrier of various meanings. Thus, (a) it may have cognitive meaning, *i.e.*, convey (true or false) information, as do, for example, the statements of mathematics and empirical science; (b) it may have directive meaning, *i.e.*, convey an order, request, or injunction, as do, for example, the Ten Commandments; (c) it may have emotive meaning, *i.e.*, express or evoke (rather than describe) a mood or attitude, as do some kinds of poetry; and (d) it may combine these and other kinds of meaning, as does, for example, a political speech or a newspaper editorial. The meaning of an expression will usually depend on, and vary with, the circumstances under which it is used and the psychological make-up of the individuals who produce it or take account of it (*e.g.*, the writer and his readers). That branch of semiotics, *i.e.*, the general theory of signs, which is concerned with the study of meaning in this broad sense is called pragmatics.

For the purposes of logic and of certain parts of linguistics—including the construction of dictionaries—it is useful to introduce a so-called semantical conception of meaning, which makes no explicit reference to the users of the symbols under study and construes the meaning of an expression simply as some object, attribute or other entity represented by that expression. (On this and some of the following points, *see* also SEMANTICS IN LOGIC.) Two kinds of semantical meaning are usually distinguished: reference or denotation, and sense or connotation. The expressions "the morning star" and "the evening star," for example, have the same reference; both refer to, or denote, the planet Venus. But they have different senses; *i.e.*, they refer to that planet by means of different characterizations. Similarly, the expressions "featherless biped" and "mammal endowed with speech" have the same reference, namely, all human beings; the class of the latter is said to constitute their extension. The two phrases have different senses, however; these are given by their intensions; *i.e.*, the attributes—namely, that of being a featherless biped and that of being a mammal endowed with speech, respectively—whereby each phrase characterizes the entities to which it refers. Some expressions, such as "the largest glacier on Sicily," have a sense but no reference; they refer, or apply, to nothing. Expressions that have the same sense, such as "grandfather" and "parent's father," are said to be synonymous; such expressions always have the same reference. A customary way of stating the meaning of a word or phrase is to give a definition that provides a synonym for it and thus exhibits its sense; and dictionaries often indicate the meaning, or meanings, of an expression by listing approximate synonyms for the principal linguistic contexts in which it occurs. Expressions which, like the word "meaning," have several distinct senses are called ambiguous.

A symbol which, like a hyphen or the words "it" and "very," has no sense in isolation, but may occur as a constituent of certain other expressions that do have sense, is said to be syncategorematic. Just what kinds of words or phrases may be said to have a sense in isolation is a matter of dispute in logic; and, indeed, some logicians hold that the very notion of sense—in contradistinction to that of reference—is so unclear and problematic as to make its value for precise logical and linguistic studies highly questionable.

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**MEASLES AND GERMAN MEASLES.** This article discusses two viral diseases: (1) measles, a normally mild illness of childhood that can lead to serious complications of the brain and lungs; and (2) German measles, sometimes known as three-day measles, which also usually is mild but is important since its occurrence during the first trimester of pregnancy may cause abortion, stillbirth or congenital defects.

**Measles.**—This disease, also called rubeola or morbilli, occurs throughout the world, with community outbreaks taking place about every two to four years. In each outbreak almost all persons who have not previously had the disease acquire it. An epidemic in a large city, therefore, will involve many thousands of cases. Usually the epidemics occur in late winter or early spring, although the disease may appear at any season. Measles commonly occurs in children but it may appear in older persons who have escaped it in early life. Infants are immune up to four or five months of age if the mother has had the disease. Immunity to measles following an attack is usually lifelong.

The causative agent of measles, isolated by J. F. Enders and T. C. Peebles in 1954, is considered to be a virus. Several research workers reported cultivation of the virus and reproduction of the disease in human beings by injection of a modified or attenuated virus. A vaccine developed by Enders and associates from attenuated measles virus was introduced in 1958. Side effects when the vaccine was administered alone were occasional fever and a very mild case of measles. These effects were largely eliminated when the vaccine was accompanied by an injection of gamma globulin (human immune globulin). The attenuated virus vaccine and a killed virus vaccine were licensed for manufacture in the U.S. in March 1963.

Measles is such a highly communicable disease that the slightest contact with an active case may infect a susceptible person. Infectivity is greatest just before the eruption appears and subsides as the rash fades. Uncomplicated measles is seldom fatal, and deaths attributed to measles usually have resulted from secondary bronchopneumonia caused by bacterial organisms getting into the inflamed bronchial tree. Complications caused by secondary bacterial infection will not spread measles.

*Symptoms.*—After exposure of susceptible persons to an active case, no symptoms appear for 10 or 11 days. At the end of this incubation period the patient develops fever, redness and watering of the eyes, profuse nasal discharge and congestion of the mucous membranes of the nose and throat—symptoms that are often mistaken for those of a severe cold. This period of invasion lasts from 48 to 96 hours. The fever increases with appearance of the rash, and the temperature may rise as high as 104° to 106° F. (40° to 41.11° C.) when the rash reaches its maximum. In the period of invasion and 24 to 36 hours before the rash develops, the disease can be diagnosed from the appearance in the mucous membranes of the mouth of typical spots, so-called Koplik spots, found most often opposite the first molar teeth or deep inside the lower lip. These are bluish-white specks of pinpoint size, surrounded by bright red areas about $\frac{1}{32}$ in. in diameter. When the Koplik spots appear, the patient should be put in bed and isolated to protect him against secondary infections and also to prevent the spread of measles to other susceptibles.

Before the appearance of the rash, experienced observers also can recognize the disease by a zone of congestion occurring in the lower eyelids. In addition, there is a considerable reddening and swelling of the eyelids, a great deal of tearing and often a sensitivity to light.

The rash almost always begins 14 days after exposure, 3 or 4 days after the onset of fever and 2 or 3 days after the appearance of Koplik spots. The eruption, which lasts four to seven days, is first noticed in the hairline, behind the ears, on the neck and over the forehead. It spreads downward, gradually covering the entire body. The individual lesions appear first as tiny red elevations that rapidly enlarge, increase in number and run together to produce a blotchy appearance. The patient complains of itching and burning of the skin. The face is puffy and is covered early with rash. There is a profuse discharge from the nose and a frequent harsh cough. The patient looks and feels miserable. After a day or two the rash becomes a deeper red and gradually fades; the temperature drops rapidly and the catarrhal symptoms disappear.

Pathological changes caused by the disease apparently are limited to the skin and the mucous membranes of the eyes, the throat, the bronchial tree and the intestinal tract.

In hemorrhagic or black measles the patient develops an extremely high fever and signs of shock, and the rash may be hemor-

rhagic from the seepage of blood into the areas of eruption.

*Complications.*—Measles lowers the resistance of the patient to secondary infections. Complications are commonly those of bacterial origin, including infections of the ears, sinuses and lungs. Laryngitis and bronchitis are characteristic features of the disease and should not be looked upon as complications. A common and dangerous complication is bronchopneumonia, which develops as the rash starts to fade. The patient does not improve; instead his fever continues and respiration becomes more rapid. The physical signs are those of a scattered or diffuse pneumonia. Without treatment the pneumonia may be fatal or may run a prolonged course of up to several weeks.

Measles also may cause a flare-up of pre-existing tuberculosis, which may have subsided or was apparently under control before the attack of measles. A rare (about 1 in 1,200–1,500 cases) but serious complication that may follow even mild cases is encephalitis. The rash may fade, but the patient in whom encephalitis develops continues to have fever and may have signs of involvement of the nervous system, such as stupor, muscular rigidity or convulsions.

*Diagnosis and Treatment.*—Measles must be differentiated from other disorders accompanied by an eruption. Roseola infantum is a disease seen in babies in which a measleslike rash appears after the child has had a high temperature for two or three days, but there is no fever at the time of the rash. Measles must also be differentiated from German measles (*see* below) and from eruptions following use of various drugs. Drugs that may produce rashes similar to measles are phenobarbital, diphenylhydantoin, the sulfonamides, phenolphthalein and penicillin. German measles can be differentiated from measles by the course of the disease and mildness of the symptoms. Sometimes scarlet fever, serum reactions and other rashes may, on certain sections of the body, look like measles.

The mortality rate due to measles declined steadily as improvements occurred in the health of children and infants and the effective treatment of complications became possible through the use of antibiotic and sulfonamide drugs. Isolation has not been effective in stopping the spread of the disease since infectivity is greatest before the disease usually is diagnosed. Nevertheless, isolation is sometimes required by public health laws from the time of diagnosis until the eruption has faded. Although 95% or more of the population sooner or later acquires measles, unnecessary exposure should be avoided, especially of persons in a run-down condition, those who have tuberculosis or those who have recently suffered an acute illness, especially an involvement of the respiratory tract.

Measles may be prevented after exposure if, early in the incubation period, gamma globulin from persons who previously have had the disease is injected intramuscularly into the persons to be protected. The protection usually lasts for several weeks. When given later in the incubation period, the same dosage will modify the severity of the disease.

There is no drug that is effective against measles. An antibiotic that is effective against a wide spectrum of bacteria or a sulfonamide drug given during the eruptive stage may prevent complications or curb those already in progress, and hence rob the disease of much of its danger.

The only treatment required is rest in bed, protection of the eyes, care of the bowels and sometimes steam inhalations to relieve irritation of the bronchial tree. The patient may be allowed water and food as required. An antipyretic drug such as aspirin may help control the temperature and render the patient more comfortable. There is no satisfactory drug treatment for measles encephalitis. Sedative drugs are indicated.

The measles virus is short-lived outside the body and will not persist for more than a few hours in the room that has been occupied by the patient if it is thoroughly exposed to light and air.

**German Measles.**—German measles, also called rubella or three-day measles, is an epidemic disease of mild course, quite distinct from real measles. It has a longer incubation period and is seldom followed by complications. Y. Hiro and S. Tasaka showed in 1938 that rubella is caused by a virus; the virus was isolated independently but concurrently in 1962 by investigators at the National Institute of Neurological Diseases and Blindness, the Harvard School of Public Health and the Walter Reed Army Institute of Research.

Rubella is acquired as the result of direct contact with a person who is ill with the disease. Infectivity is much lower than in measles. Although the disease may occur in young children, it is more commonly seen in older children or young adults. One attack of rubella apparently confers a lasting immunity, but there is no cross immunity between rubella and real measles. Many so-called second attacks of measles are actually German measles.

The period of incubation in rubella is 10 to 20 days, commonly 17 or 18 days. Usually the rash is the first sign noted. It is of a less intense colour than the rash in measles but has a similar blotchy appearance. It develops rapidly, often in one day, and fades just as rapidly two days later. There are no Koplik spots, little catarrh and little conjunctivitis. The temperature is seldom high and lasts only two or three days. Often there is no fever at all. Enlargement of the lymph glands in the neck, back of the ears and perhaps elsewhere in the body is characteristic. Complications are rare, although occasionally encephalitis may follow.

The most serious aspect of German measles is its effect on unborn babies if the mother acquires the disease during the first three months of pregnancy. Injury may occur in the unborn child in as many as 50% of these cases if infection occurs in the first month of pregnancy. Actually many other diseases in the mother probably have this type of effect on the unborn infant, but, because of the rash, German measles can be identified and its effect established. The baby may be born with faulty development of the eyes, heart or brain. German measles acquired by the mother later in pregnancy, *i.e.*, after the organs of the baby are completely formed, seems of little or no danger to the unborn infant.

German measles may be confused with scarlet fever because the rash on the second day may look like that of scarlet fever. Real measles (rubeola) is usually readily differentiated. German measles is such a mild disorder that little effort toward prophylaxis is needed. Obviously a woman who is in the early weeks of pregnancy should avoid exposure to German measles and, if exposure has occurred, she should be given gamma globulin in an effort to prevent the disease. No drug has a curative effect and no treatment is necessary except to keep the patient comfortable until the symptoms have subsided.

*See* also references under "Measles and German Measles" in the Index.

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(C. F. McK.)

**MEASURE, THEORY OF:** *see* INTEGRATION AND MEASURE; POINT SETS.

**MEASUREMENT,** the determination of the magnitude of anything in terms of a suitable unit. Such units may be quite arbitrary (*e.g.*, the pound, foot, second or degree centigrade) or may be derived from a combination of the arbitrary units (*e.g.*, pounds per cubic foot). The procedure adopted depends on the nature of the quantity to be measured and on the accuracy required. *See* METROLOGY; *see* also references under "Measurement" in the Index.

**MEASURING TOOLS:** *see* HAND TOOLS, HISTORY OF; METROLOGY; MICROMETER.

**MEAT** is the flesh or other edible parts of animals used for food, including not only the muscles and fat but also the tendons, ligaments and bones. It is valued as a complete protein food containing all the amino acids necessary for the human body. The fat of meat, which varies widely with the species, quality and cut, is a valuable source of energy and also influences the flavour, juiciness and tenderness of the lean. Parts such as livers, kidneys, hearts and other portions are excellent sources of vitamins and of essential minerals, easily assimilated by the human system. The meat industry from ancient times has been a primary source of leather and wool, and approximately 300 industrial and pharmaceutical preparations are obtained as by-products.

**Structure.**—*Muscle.*—Histologically, three types of muscles are recognized: (1) the nonstriated, chiefly associated with the digestive systems and referred to as involuntary muscle; (2) cardiac muscle, which is striated but involuntary; and (3) the striated or skeletal muscles, which are under the control of the will. The muscle consists of bundles of muscle cells held together by connective tissue, the size of the bundles varying in different muscles of the animal and in different species. The "grain" of the meat is determined by the size of the bundles and the connective tissue. The muscle fibres have a fine membrane forming an outer covering, the sarcolemma, which under certain conditions of freezing may become damaged, altering the structure of the meat.

*Connective Tissue.*—Two types of connective tissue materially influence quality in meat. Yellow fibre, of which the ligamentum nuchae is typical, is extremely tough, has little if any commercial value and is not made tender by cooking. The white connective tissue is composed largely of protein (collagen), which is softened and made tender by cooking, particularly in water or by steam.

*Fat.*—All meat contains fat. In the live animal, fat cells consist of small droplets of oil which, as fattening proceeds, increase both in number and size and thus, in combination with the relative proportions of connective tissue, affect the colour. To some extent, the fat will resemble the type of fat taken up in the feed. The species, breed and age of the animal also affect the colour of the fat; that of dairy cattle is usually yellower than that of beef cattle. "Marbling" fat is produced by the penetration of fat between the muscles and is a sign of quality. Such fat exerts an internal basting effect and introduces desirable fat-soluble flavours into the meat. Individual joints from a good beef carcass will show great variation in fat content from about 10% in the case of shin meat to 40% in boneless brisket.

*Bone.*—The percentage of bone in a beef carcass may vary from 10% in a fat beast to over 20% in a poor animal. Cartilage precedes the formation of bone structure and the degree of ossification provides a good indication of age in the carcass. Red bone marrow is found in unborn and newly born animals. In the round bones, red marrow diminishes after birth and is replaced by white fatty marrow.

**Tenderness.**—Tenderness in meat greatly influences palatability and is affected by structure which is, in turn, influenced by the age, sex and activity of the animal. The muscles subjected to greater strain such as those of the neck, legs and shoulders will develop thickened cell walls and denser connective tissue. The degree of fatness is another factor influencing the texture of meat.

**Composition.**—The most important constituent of muscle is protein, two main types being present: muscle cell proteins and connective tissue proteins. The amount of protein in the edible portion of meat is usually between 15% and 20% and is influenced by the fat content. As the proportion of fat increases the percentage of protein decreases.

The colour of meat is caused by muscle hemoglobin, a substance similar to, but not identical with, blood hemoglobin. Some muscles from the same animal will contain more hemoglobin than others and species vary in the amount present, *e.g.*, pork muscle contains less than beef and an older animal will contain more and consequently be darker than that of a young animal. On exposure to the air, hemoglobin is oxidized to form oxyhemoglobin; thus freshly cut beef will be a dark purplish-red but will brighten in colour, reaching its maximum brightness in a relatively short period. Alkalies, enzymes, acids and heat will bring about various decomposition changes in the hemoglobin. When cooking at about 150° F. (65° C.) oxyhemoglobin is coagulated and above this temperature hematin is formed, giving the characteristic gray-brown colour of well-done beef. In beef that has been matured this colour change will usually take place at a lower temperature. The colour in cured meats is usually "fixed" by the use of nitrates or nitrites or both in the brine or dry curing mixture.

The fat of a mammal always contains a certain amount of stearin, a fat rare anywhere else in nature, either in other animals or plants. At body temperature (about 100° F. [38° C.]) stearin is liquid but at normal atmospheric temperatures (60° F. [16° C.]) is solid; thus the amount present influences the firmness of the carcass fat. Mammalian fat also contains olein and palmitin in varying proportions, but these fats also occur in various plants and seeds. As palmitin acts as a solvent for carotene (the yellow colouring matter in green foods), animals with a high proportion of palmitin in their fat will, if fed on these foods, produce a yellower fat. Sheep, goats, buffalo, pigs and most breeds of cattle have little palmitin and can absorb only small quantities of carotene.

Volatile oils in the fat give fat and, to some extent, red muscle their attractive flavour and aroma. Thus well-marbled meat smells and tastes better than that lacking in fat. All meats contain water; fat-free beef muscle contains about 73% of water. The water content of a side of beef varies with the degree of fatness, which may be from 47% in very fat beef to over 65% in very poor beef.

Dried bone consists of organic and inorganic matter in the ratio of approximately 1:2. Toughness and elasticity is provided by the animal matter and hardness from the mineral matter. The organic matter (collagen) when boiled yields gelatin. Ox bone of average quality would have an analysis of phosphate of lime 57.35%, carbonate of lime 3.85%, phosphate of magnesia 2.05%, carbonate and chloride of sodium 2.45% and gelatin 33.30%.

**Digestibility.**—The value of a foodstuff depends upon the nutrients it contains; the extent to which these substances can be utilized in the body; and its palatability, because if it is unattractive it will probably not be eaten. Meat digests somewhat slowly but 95% of meat proteins and 96% of the fat is digested. Fats tend to retard the digestion of other foods, thus meat with a reasonable proportion of fat remains longer in the stomach, delaying hunger and giving "staying power." Extractives in meat cause a flow of saliva and gastric juices creating the desire to eat and ensuring ease of digestion. Less protein derived from animal sources is required than those of vegetable origin, as the degree of difference between animal and human protein is less than that between vegetable and human protein. These animal proteins are called first-class proteins and vegetable proteins, second-class proteins.

The nutritional composition of meat is shown in the table.

*Composition of Meats*
(Raw basis, 100 g., edible portion)

| | Beef side, medium fat | Veal side, medium fat (excluding kidney fat) | Lamb side, medium fat | Pork side, medium | Chicken total, edible | |
|---|---|---|---|---|---|---|
| | | | | | Broilers | Roasters |
| Water, % | 60 | 60 | 55.8 | 42 | 71.2 | 66 |
| Food energy, cal. | 273 | 190 | 317 | 457 | 151 | 200 |
| Protein, g. | 17.5 | 19.1 | 15.7 | 11.9 | 20.2 | 20.2 |
| Fat, g. | 22 | 12 | 27.7 | 45 | 7.2 | 12.6 |
| Ash, g. | 0.9 | 1 | 0.8 | 0.6 | 1.1 | 1 |
| Calcium, mg. | 10 | 11 | 9 | 7 | 14 | 14 |
| Phosphorus, mg. | 150 | 193 | 157 | 117 | 200 | 200 |
| Iron, mg. | 2.6 | 2.9 | 2.4 | 1.8 | 1.5 | 1.5 |
| Thiamine, mg. | 0.08 | 0.14 | 0.14 | 0.58 | 0.08 | 0.08 |
| Riboflavin, mg. | 0.16 | 0.25 | 0.20 | 0.14 | 0.16 | 0.16 |
| Niacin, mg. | 4.2 | 6.4 | 4.5 | 3.1 | 10.2 | 8 |

Source: Bernice K. Watt *et al.*, "Compositioo of Foods—Raw, Processed, Prepared," U.S. Department of Agriculture, *Agriculture Handbook No. 8* (June 1950).

**Consumption and Production.**—Meat consumption is greatest in those countries where much livestock is produced and where the human population is relatively low. High meat consumption is associated with a high standard of living and, broadly speaking, an increase in per capita national income will result in an increased demand for meat.

Major meat-producing countries are the United States, the U.S.S.R., Argentina, the Federal Republic of Germany, France, the United Kingdom, Brazil, New Zealand, Australia and Canada. Approximately 10% of world meat production is exported and of this about 75% is imported by the United Kingdom.

In normal times, Argentina has supplied about one-third of the total world meat trade, New Zealand about one-fifth, Australia about one-eighth and Denmark about one-twelfth. In value, meat is about as important as wheat. Meat trading in general has largely revolved around the government meat boards of New Zealand, Argentina and Australia, the ministry of food of the U.K. and the co-operatives of Denmark, with long-term government-to-government bilateral agreements, subject to periodic review and revision. Mixed systems of trading also exist.

**Preservation.**—Most beef, veal, mutton and lamb and their various cuts and edible offals are usually held at a temperature a little above that of the freezing point of meat, which is approximately 28.3° F. (−2° C.). For international trade, where prolonged shipment and storage make the handling of the fresh product impracticable, freezing is employed. There is a considerable export trade from the Argentine, Australia and New Zealand to the U.K. in chilled beef, transported at about 29.4° F. In cases where a longer period than about 40 days is involved, 10% of carbon dioxide gas may be introduced into the hold of the vessel to increase storage life.

Edible offals, fresh pork and veal are the most perishable. Good-quality, well-fatted beef and lamb keep relatively well at temperatures slightly above freezing. If cuts of meat, etc., are to be frozen, wrapping in moisture- and vapour-proof material will prevent "freezer burn" (dehydration). Rapid freezing to low temperatures is important to secure a high-quality product and quick-frozen products should be subsequently stored at 0–10° F. (−17° to −12° C.).

Preservation by drying is one of the oldest methods of preserving meat products. Biltong of Africa, charqui of South America and pemmican and jerked beef of North America are typical examples. Lean meat is required for the commercial production of dehydrated meat; *e.g.*, a very lean beast with a carcass weight of 480 lb. might have about 70 lb. of fat in and on the carcass and such a carcass would yield about 30% of its weight as dehydrated meat. A better-quality carcass would give a much lower yield because of the wastage of fat that would be involved.

Many pork and a few beef items are cured with salt, sugar, sodium or potassium nitrate or nitrite and may be smoked. Both fresh and cured meats may be canned in tins or placed in glass containers, followed by heat sterilization. For emergency use and military rations, meat may be ground, dehydrated and placed in cans or other containers.

**Carcass Yields.**—A typical 1,000-lb. choice-grade beef steer carcass gives a salable carcass of about 581–592 lb., with about 25% of edible offal and by-products (hide, tallow, etc.) and about 16% of waste. The meat carcass yield from pigs (including the head) will depend largely on the weight of the pig; small porkers yield about 65%, large fat pigs up to 80% and a good average for Wiltshire-type bacon pigs is around 72%. The yield from sheep and lambs will be influenced by the quantity and the condition of the fleece, an overall average being about 48% of the live weight.

**Ripening, Maturing or Aging.**—Well-finished beef is improved in tenderness and flavour if permitted to ripen for a period of 10–14 days at a temperature of 34°–36° F. A similar process is sometimes applied to mutton and lamb, although in this case the influence on tenderness is less marked. Enzymatic action and the development of lactic acid produce a tenderizing effect on the connective tissues and flavour changes take place with the ripening of the fat. Fat beef may be held for much longer periods until it develops a full flavour known as "high." With prolonged hanging some trimming of subcutaneous fat may be required to remove mold. A modern development is high-temperature maturing, when for a short period ultraviolet irradiation is frequently used to retard the growth of putrefactive organisms and molds. Fresh veal and pork are never aged.

**Inspection.**—In Europe the early responsibility for meat inspection was accepted by the guilds, who not only condemned meat unfit for human consumption but also exercised quality and price controls.

In most European countries, except England, and in the United States meat inspection is under the control of veterinary officers, frequently assisted by specialist lay meat inspectors. In England, with few exceptions, all food inspection is finally the responsibility of the medical officer of health.

In the U.S., congress enacted a law in 1906 providing for federal inspection of the domestic meat supply prepared for interstate trade; regulations were minutely detailed and the objectives high and, consequently, the purple stamp bearing the legend "U.S. Insp.d & P'S'D." established a world-wide standard for wholesomeness and inspection techniques. Duties of the inspection corps include inspecting the sanitation of the establishment; inspecting carcasses and internal organs of the animals after slaughter; inspecting meat processing and preparation of meat food products; destroying material condemned for food purposes; supervising application of the stamp or label indicating federal approval; and maintaining chemical, bacteriological, pathological and zoological laboratories to furnish inspectors with information needed in making proper decisions. A law passed by the 85th congress requiring that humane slaughter methods be used for all meats purchased by federal agencies added another task to those of the meat inspection service.

**The Meat Industry.**—The production of meat and its many by-products represents one of the world's leading economic activities. No other single industry occupies such an area of the earth's surface and it is mankind's most ancient industry.

Spearheads, knives and scrapers chipped from flint and obsidian, cave paintings and other discoveries by archaeologists indicate that man was a hunter for many thousand years before settling into the fixed community patterns necessitated by agriculture. Physically evolved to combine carnivorous and herbaceous foods in his diet, early man lived on meat, roots and wild fruits. Consequently, some animals were domesticated before the crops of the first crude farms evolved.

The dog, sheep, cow, horse and pig were all domestic meat animals as the human race progressed from Stone Age to Bronze Age. Certain religious tabus followed the pig, possibly traceable to an early Egyptian belief that pork was so delectable a food that it should be restricted to the gods. Egyptian high priests were permitted to eat it once each year during a religious ceremony. This tabu was adopted under various guises by most of the peoples of the African and Asiatic shores of the Mediterranean and persists in both Judaism and Islam. The Greeks and Romans liked pork, and the revelation claimed by St. Peter (Acts x) enabled Christians to incorporate it into their diet. Generally the sheep, the pig and the cow became the favourite meats of Christians, although specific tabus developed and still exist in some sects. The dog and the horse, developing into valuable "tools" of the cattle, sheep and pig herdsmen, became detached from the meat category. The trade of the butcher evolved from the habits of a stable agriculture and the development of urban life. From the work of the professional who processed animals into meats, hides and pelts, bone and hair, vessels of bloods, casings and waste, there developed the more specialized animal industries such as tanning, feltmaking, gluemaking and others.

The Worshipful Company of Butchers was referred to as the Butchers' guild in 1179, but was in existence prior to that date. A butchers' guild existed in Basel, Switz., in 1248 and marketable meat was defined by a Bishop Lutold. Prior to the development of refrigeration in the mid-19th century salt curing and smoking were the favoured forms of meat preservation. Sausages were known in Greece in Homer's time and forms of ham, bacon and

sausages were the meats carried and eaten on journeys in Eurasia. Various localities provided place names for particular meat products such as Bologna and Frankfurter sausage, Wiener schnitzel and Hamburg steak (hamburger).

Although the Spanish brought cattle, sheep, horses and pigs to their settlements in North America, little success was made in developing a meat trade; in California, where they established huge ranches, dried hides and tallow were the only export items prior to 1850. The professional meat industry reached America with the British colonists' entering of Virginia and New England in the early 17th century. The first meat-packing plant in America was founded by William Pynchon sometime in the 1640s on the east shore of the Connecticut river, 7 mi. S. of Springfield. Dried and salted pork and beef were exported to British plantations in the West Indies. The Pynchons are reputed to have developed or borrowed from the Indians a method of stall fattening cattle on hay and grains during the winter months. The herd of fat cattle John Pynchon drove from Springfield to Boston in the spring of 1655 is considered as the birth of the American fat-cattle industry. The post-Civil War depression in the south, coinciding with the U.S. army's need for beef provisions for forts and Indian reservations on the Great Plains, activated the Texan drives of Spanish "longhorn" cattle through Indian territory to Missouri and Kansas. This practice gave impetus to railroad construction west from Chicago to Dodge City, Kan., and other "cow towns" along the cattle trails. With Chicago's growth as the centre of the U.S. meat-packing industry, a position it long maintained, are associated the names of Gustavus Swift (*q.v.*) and J. Ogden Armour (*see* ARMOUR family), founders of the industry's two largest firms. Swift's experiments with refrigeration led to the development of the refrigerator car, which made possible the shipment of chilled fresh meats from coast to coast.

In Australia, New Zealand, Argentina, Paraguay and Brazil, similar changes were taking place, stimulated by the development of refrigeration. The first freezing works was probably established at Darling Harbour, Sydney, in 1861 and frozen meat was exported to London in 1880, after a voyage of 64 days. The first successful export of frozen meat from New Zealand arrived in London in 1882. In Argentina the first *frigorifico* was constructed in 1882 at San Nicolas on the Parana river and British and U.S. interests were soon established in the meat industry. Export of live cattle to the U.K. took place from the Río de la Plata up to about 1900, to be replaced with a rapidly increasing trade in chilled and frozen beef. A considerable import trade in Hereford, Aberdeen Angus and Shorthorn cattle and in pigs and sheep resulted in a rapid grading up of native stocks in the various meat-exporting countries.

For more detailed discussions of various kinds of meat *see* BEEF; LAMB AND MUTTON; PORK; BACON; HAM; SAUSAGE; for the cooking of meat *see* FOOD PREPARATION; *see* also references under "Meat" in the Index.

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For current statistics on production see *Britannica Book of the Year*.

(R. W. HO.; F. GE.)

**MEATH, HUGH DE LACY, 1ST LORD OF** (d. 1186), one of the Anglo-Norman justiciars of Ireland, went to Ireland with Henry II in 1171. He was granted (*c.* March 1172) the lordship of Meath for the service of 50 knights and was left as constable of Dublin and justiciar when Henry returned to England in April 1172. Hugh returned to England later in the same year; in 1173 he fought for Henry in Normandy, defending Verneuil. He was appointed to succeed William Fitz Audlin as procurator general of Ireland in 1177, but was removed from office in May 1181, perhaps because he had married a daughter of Roderic, king of Connaught, without seeking Henry's permission. Apparently restored during the winter of 1181–82, he was finally suspended from office in 1184. Henry's son John, who had been created lord of Ireland in 1177, visited Ireland in 1185 and subsequently complained that Hugh had intrigued against him.

According to Giraldus Cambrensis, Hugh was an able and resolute governor, but physically unprepossessing, swarthy, short and ill-proportioned. He built many castles in his territory; the construction of one, at Durrow, had involved the demolition of an ancient and venerated monastery. While inspecting the building on July 25, 1186, Hugh was decapitated by an assassin. His son Walter de Lacy (d. 1241) became second lord of Meath; a younger son Hugh (d. *c.* 1242) became 1st earl of Ulster (1205).

**MEATH** (CONTAE NA MIDHE: originally MIDE), a county of the Republic of Ireland, now in the province of Leinster, was at one time part of the Meath province, of which the last traces are the Roman Catholic and Protestant bishoprics centred at Mullingar and Trim respectively. It has an area of 903 sq.mi. and in 1961 had a population of 65,122. Crops and pasture cover 95% of the county and the only interruptions to the agricultural landscape are a few patches of woodland, some stretches of peat bog in the extreme southwest and small areas of hill pasture in the Slieve-na-Calliagh (a hill range of Silurian rocks generally 600–900 ft. high), in the extreme northwest. Part of County Meath is floored by Silurian and Ordovician strata, but most is of Carboniferous beds, particularly limestones: it is probable that the rock floor of County Meath is complexly folded, but it has been reduced to a peneplain at about 200 ft., with a gradual rise to 400 ft. The solid rock is rarely seen and the surface consists almost entirely of glacial drifts, of which some are as much as 100 ft. deep over the rock floor. In Meath there are some most attractive rivers, notably the Blackwater and the Boyne. Much of the Boyne valley consists of a gorge that has been cut through drift deposits and, less normally, through solid rock. There are many small streams in wide valleys which apparently carried glacial meltwaters. Many eskers and deep deposits of rich glacial loam extend over a great part of Meath and north Kildare, giving the area its rich agricultural and grazing land. This deep, workable soil favoured the easy erection of the many earthworks which give this area much archaeological interest. (*See* J. K. Charlesworth, *The Geology of Ireland*, 1953, p. 232.)

One of the most impressive of the archaeological remains is Newgrange tumulus, a vast Bronze Age burial place in the shape of a mound over a circular chamber entered by a passage walled with carved blocks of stone. Nearby are the two almost equally big tumuli of Dowth and Knowth. At Kells (*q.v.*) the priceless manuscript, the *Book of Kells* (in the library of Trinity college, Dublin), was inscribed during the 8th century. There are round towers at Kells and at Donaghmore, near Navan. The hill of Tara (*q.v.*) is the traditional seat of the high kings (*Ard Rí*) of Ireland.

Meath, the middle kingdom (*Midhe*, "middle"), originally consisted of the present Meath and Westmeath with parts of Cavan and Longford. The county came into existence in the 13th century and was defined as at present in the 16th century. When the Anglo-Norman invaders came to Ireland, the hereditary princes of Meath were the O'Melaghlins. In 1172 Henry II bestowed Meath as an earldom on Hugh de Lacy, his viceroy in Ireland. De Lacy reduced the natives, built strong castles at Trim, Kells and elsewhere and enfeoffed 18 baronies, creating an English territorial nobility which lasted into the 17th century. (*See* MEATH, HUGH DE LACY.) His heir, Walter, incurred the enmity of King John who drove him out, but he was restored at the accession of Henry III, as was his brother Hugh in the earldom of Ulster. Walter died in 1241 leaving only two daughters and the area lost its unity. As the English hold on Ireland deteriorated in the two subsequent centuries only part of Meath remained inside the pale and under direct rule from Dublin. Its northern boundary, west of Drogheda, was the scene of the battle of the Boyne (*q.v.*), when William III defeated James II in 1690.

An Uaimh (Navan *q.v.*), the county town (pop. 1961, 3,998), Ceanannus Mór (2,193) and Trim (1,366) are urban districts. There is a county council that meets at Navan, and a county man-

ager. Meath sends three members to *dáil Éireann*. The towns of Meath are mainly small market centres of Anglo-Norman origin: they have less than one-quarter of the county's population, but Drogheda, in County Louth, the port of the Boyne, serves a large area of Meath as a trading town. In the 19th century there was considerable barge traffic along the Boyne to Navan. This town has factories for clothing, farm tools, carpets and furniture. Kells has a boot-making factory and at Trim there is a factory where office supplies are made.

Agriculturally, Meath is well favoured, but the main specialization is grazing land for fattening cattle or keeping them as stores (young unfinished meat animals) for eventual export. The farms are generally large, averaging as much as 150 ac. in the east, but less toward the west. The normal practice is for the Meath farmers to buy up surplus stock from areas west of the Shannon, keep them for a time and then sell over half the dry cattle in the county that are over two years old. Many of the county's pastures are extremely rich: three-quarters of the whole farmed area is in permanent pasture, never plowed, and the remainder is divided fairly evenly between crops and hay. Over one-sixth is generally under crops: nearly 40,000 ac. being normally used for wheat and oats, about 10,000 ac. for barley and 6,000 to 8,500 ac. for potatoes. There is some sugar beet and other root and green crops. Among the farms there are a number of desmesnes of 30–40 ac., of which some have been taken over by "settlers of Irish speech" from the west. This plan of settling "congests" (so-named from the congested districts) was suggested by the Gaeltacht commission of the 1920s. It introduced a new social element into the rural life of Meath.

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**MEAUX,** a subprefecture of the *département* of Seine-et-Marne, France, is situated on the Paris–Metz road, 28 mi. (45 km.) E. of Paris, and on the Paris–Strasbourg railway. Pop. (1962) 21,960. The town is divided by the Marne river into two parts linked by bridges. The most noteworthy monuments are the Cathedral of St. Étienne, a Gothic structure begun early in the 13th century and containing statues and the tomb of J. B. Bossuet, bishop of Meaux from 1681 to 1704; the former Bishop's palace (12th to 17th centuries), housing the municipal museum and library (among the treasures of the latter is an illuminated manuscript of the *Roman de la Rose*) and with a garden laid out by Le Nôtre; the old chapter house, of the late 12th century, with a remarkable outside staircase; and the ramparts, some towers and walls of which date from the 4th century. There are pleasure gardens on the Marne.

The town's numerous industries include manufacture of carbon paper, metal stamping, screw cutting, a copper industry, knitting and printing. The region around Meaux is intensively cultivated, and wheat and sugar beets are grown on a large scale. The town has a barge port on the Marne.

Meaux was in existence in 58 B.C. It was taken by Clovis in the 5th century and was later included in the kingdom of Austrasia. The town received a charter in 1170. Henry V of England took it in 1422 after a memorable siege and a heroic resistance; it was retaken in 1439. The diocese of Meaux was the first in France to shelter the Reformers and was much fought over. Meaux also suffered from the St. Bartholomew's massacres of Huguenots in Aug. 1572. The town was occupied by the Prussians and the Russians in 1814 and again in July 1815 after Waterloo. On Sept. 5, 1914, during World War I, the retreating French army rallied before the gates of Meaux and repulsed the Germans. (R. PU.)

**MECCA** (Arabic MAKKAH, BAKKAH in ancient times and MACORABA in Ptolemy) is the birthplace of Mohammed, the foremost sacred city of Islam and capital of the Saudi Arabian province of Hejaz. Mecca owes its prosperity to the pilgrim trade (the annual influx of visitors may exceed 200,000), and local occupations are limited to catering and the manufacture of religious ornaments. The city lies about 45 mi. E. of Jidda, its seaport on the Red sea, with which it is connected by a tarmac road. The road follows the ancient pilgrim camel track from Jidda across the sandy coastal plain and through a broad band of arid hills into the wide, sandy and fertile valley of Wadi Fatimah, beyond which, at Ash Shumaysi, it passes into the foothills of the main Hejaz mountain range across the sandy valley of Wadi Sharif, a tributary of Wadi Fatimah, in which stand the two pillars (*'alamain*) marking the limit on that side of the *haram*, or sacred territory of Mecca. Beyond this point no non-Muslim is allowed to go, nor is the killing of any living creature allowed, except domestic animals required for food or sacrifice and criminals duly condemned to death by the *shari'al* court.

The limits of this sacred territory have never been exactly defined but pillars mark every point of entry into it. The territory forms a rough diamond, about 25 mi. long from Ash Shumaysi to Bazan near 'Arafat and about 12 mi. across from Tan'im on the Najd road to Bab Aqsa on the Yemen road. The pilgrim camp area on the plain of 'Arafat, beginning about 2 mi. E. of the Bazan pillars, is similarly marked out by pillars on the Mecca side and is limited on the farther side by a low ridge along the right bank of Wadi Nu'man.

Between the two tabu areas lies the valley of Wadi 'Aranah with the mosque of Namirah, where the noon prayers are said and a sermon preached on the day of pilgrimage before the pilgrims enter 'Arafat for the "standing" (*waqfa*) from 2 P.M. until sunset. In practice most of the pilgrims miss this part of the ceremony and remain in their tents on the 'Arafat plain; but the king and his entourage always camp by Namirah until the appropriate moment for entry into the "standing" area.

The Saudi Arabia government-controlled Radio Mecca broadcasts short-wave transmissions in Arabic, English, Malay and Urdu, in addition to its domestic Arabic service, with heavy emphasis on religious features.

**The City.**—Mecca is situated near the eastern end of the sacred territory. Ash Shumaysi, the western point of entry, is 14 mi. away, while Tan'im, on the east, is only 3 mi. distant. The main axis of the city is formed by the bed of the Wadi Ibrahim, running northeast to southwest, and becoming Wadi Misfala after passing the Great mosque (known as Al Haram). Many dry water courses, flooded only after heavy rain, join the main channel of the Wadi Ibrahim on both sides. The principal buildings of Mecca stand in one of these tributary gullies, Wadi Ajyad, and near its junction with Wadi Ibrahim. They consist of the ministry of the interior, the government press, the ministry of finance, the Egyptian hotel, the Isma'ili hostel and numerous private mansions. A project was launched in 1955 to enlarge and alter the construction of the Great mosque and to facilitate the circulation of the traffic.

From very early times the core of the city lay in the area immediately round the Great mosque, in which shops are mingled with religious edifices. Mecca seems never to have been surrounded by city walls and the mountains which dominate it at close quarters have always made defense difficult. The city has developed in modern times a number of flourishing residential suburbs with large houses and gardens, but the slum areas consist of tin shacks and wattle huts where the poor live crowded together in unsanitary conditions. The suburbs meanwhile continue to spread, chiefly along the Jidda road to the west, and consist of modern houses, blocks of flats and other amenities.

During World War II a census, made for the purpose of a fair distribution of bread and flour, showed a permanent population of 105,000. With the influx of settlers from other countries, the population (1962 est.) reached 250,000, in addition to which the city accommodates a floating population of about the same size during the pilgrimage. Formerly it was customary for pilgrims, especially from India and the Dutch East Indies, to spend six months in Hejaz, arriving in time to spend the month of Ramadan (*q.v.*) at Mecca, after which the interval between the fast and the pilgrimage would be spent in a visit to Medina (*q.v.*). In modern times more rapid means of transport have tended to shorten the pilgrims' visit, and the average sojourn is not much more than a month. During that time the accommodation problem is acute and expensive.

The main problem has always been water. Up to 1950, apart from wells of variable quality, the supply depended entirely on the aqueduct of Queen Zubaydah (wife of the Caliph Harun al-Rashid), an ancient subterranean *karez* channel restored or reactivated by her in 858. The water from this source frequently proved insufficient, and during the last years of King 'Abd al-'Aziz ibn Sa'ud (Ibn Saud; *q.v.*) the supply was reinforced and doubled by a new aqueduct emanating from 'Ayn Jadidah in Wadi Fatimah. The Zubaydah channel issues from the base of the main range at the head of Wadi Nu'man, whose bed has been raised 100 ft. in 1,100 years by the silt of seasonal floods. Advantage was not taken of excavation work in Mecca to study the stratification of the city area, which was exposed to heavy flooding at intervals through the ages until the damming and diversion of Wadi Ibrahim at a point above Ma'abida. The last great flood was experienced in King 'Abd al-'Aziz's jubilee year, 1950, when the courtyard of the Great mosque was flooded to a depth of seven feet. The kindred problem of sewage and drainage has caused anxiety at times as the main drain of the central area runs parallel with the aqueduct; but plans have been considered for ensuring against accidental pollution for the water supply.

The bathing of pilgrims in the reservoirs of Birkat 'Aun, Birkat Majid and Al Shuhada has introduced the snail-carried disease of schistosomiasis (bilharziasis) into the area, but suitable precautions have been taken to minimize this danger to public health. Mecca has three good hospitals, with competent doctors and nurses, mainly from Egypt and the Levant, for the service of both citizens and pilgrims.

The construction of a quarantine station near Jidda, in replacement of the former accommodation on the islands of the harbour, and of a modern pier with berths for ocean-going vessels has greatly increased the amenities of the pilgrimage; since 1926 motor transport has been provided and, since 1950, Jidda has a first-class airport. Air routes have been so devised as to avoid passing over Mecca, where there are no landing facilities. The lighting of the city is adequately furnished by a power station at Tan'im; the supply of gasoline and kerosene has been assured by the erection of large tanks between Al Hindawiya and Bi'r Bustan on the Jidda road.

V. K. ANTHONY (COLEMAN & HAYWARD)

THE KA'BA, SACRED SHRINE OF ISLAM IN THE COURTYARD OF THE GREAT MOSQUE AT MECCA

**The Temple.**—The heart of the temple of Mecca is a small stone building in the shape of a cube, the sides of which measure about 40 ft. and which is called by Muslims the Ka'ba (*q.v.*; "cube"). Muslims believe in the Old Testament narrative and claim that many of the events in the book of Genesis took place in Mecca. For example, Adam and Eve were separated after their eviction from the Garden of Eden but met again at 'Arafat, east of Mecca, and thenceforward lived there. The tomb of Eve is alleged to be at Jidda.

Muslim tradition further asserts that it was on the site of Mecca that Hagar and her son, Ishmael, nearly died of thirst. The well shown to Hagar by the angel was the well of Bi'r Zamzam, near the Ka'ba. Muslims also believe that Abraham visited Hagar at Mecca and took her son, Ishmael, to sacrifice him at Mina, east of Mecca. (Genesis alleges that Isaac, Abraham's younger son, was to have been the sacrifice and that the site was the temple area of Jerusalem). Islamic tradition, like Genesis, asserts that an angel prevented the sacrifice and indicated to Abraham a ram caught in a thicket as a substitute. Abraham, assisted by his son Ishmael, is believed to have subsequently built the Ka'ba, at the command of God, as a replica of God's house in heaven.

The Ka'ba has been several times destroyed by floods and by fire but appears always to have been rebuilt on the original plinth. The whole building is covered by a large embroidered cloth called the *kiswa* or garment, which is changed annually at the season of the pilgrimage. In the eastern corner of the Ka'ba and built into the masonry of the wall is the Black Stone of Mecca (*q.v.*), which is kissed by all pilgrims to the temple.

The Ka'ba was considered to be a place of pilgrimage by the idol-worshiping Arabs for several centuries before Islam. In the 6th century A.D. there appear to have been other similar ka'bas at several places in southeast Arabia but only that of Mecca has survived. All these ka'bas were places of pilgrimage and in all of them the rites included the ceremony of circumambulation, or walking seven times around the sacred building, as is still done by Muslim pilgrims to Mecca.

**The Pilgrimage.**—The pattern of the pilgrimage ceremonies was established for all time by the Prophet Mohammed, though of course there have been variations in the program from time to time according as the presiding authorities dealt with tradition strictly or perfunctorily. The traditional pattern was, however, re-established by Ibn Sa'ud on the basis of strict Hanbalite interpretation (*see* ISLAMIC LAW); and it may be well to state the *sine qua non* elements of the pilgrimage proper, which are (1) the assumption of the *ihram* garments (two white seamless sheets or towels, one wrapped round the loins and the other covering the upper body); (2) the *waqfa*, or "standing" (before God) on the plain of 'Arafat on the afternoon of the 9th of Dhul-Hijja; (3) the stoning (*rami*) of the "Great Devil" ('Aqabat al Kabir) early the following morning; (4) the descent to Mecca, then or after the feast days at choice, to perform the *tawaf* (circumambulation of the Ka'ba) and the *sa'i* or *sa'y* (running between Safa and Marwah seven times, beginning at the former and ending at the latter); and (5) shaving the head (snipping off a wisp of hair is sufficient) and resuming ordinary garments before returning to Mina for the sacrifice and feast days.

The pilgrim is of course bareheaded, though he may carry a parasol and wear sandals or shoes, during the performance of the first four of these requirements, of which the first three must be done at the proper time, while the fourth and fifth may be deferred till after the feast days, though a pilgrim remaining in the state of *ihram* must abstain from hunting, killing (except the sacrificial lamb or goat), the use of jewelry and perfume, personal adornment and sexual intercourse until his pilgrimage is complete. Apart from these essential requirements, the pilgrim should, without any actual obligation, endeavour as far as possible to conform with the practice of the prophet on the occasion of his only pilgrimage. On arrival from abroad or from a distance in the neighbourhood of the holy territory, he should bathe and don the pilgrim garb at one of the stations (*miqat*) prescribed for the purpose (Wadi Mahram, As Sayl al Kabir, Abyar 'Ali, Rabigh, Jidda or Al Lith). There or at his starting point he

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PILGRIMS ENCAMPED ON THE PLAIN OF 'ARAFAT OUTSIDE MECCA

should express his intention of making the pilgrimage and, on donning the *ihram*, he should say a prayer of two prostrations. From that moment, being in a state of ceremonial purity, he must refrain from all forbidden acts until he has performed the *'umra* or the *hajj*, as the case may be. The latter is the pilgrimage proper, which is obligatory for every Muslim once in his life, provided he is financially and otherwise capable of performing it. He or she may also perform it by proxy, appointing a relative or friend going on the pilgrimage to "stand" for him or her. The *'umra* (or "little pilgrimage") is incumbent on every person entering Mecca at any time, whether strangers or citizens returning home after an absence of any length. Such persons must assume the *ihram* at the appropriate *miqat* on their way to Mecca, and remain in that state until they have performed the *tawaf* and *sa'i*, after which they shave their heads and resume ordinary garments and the freedom of everyday life.

The *'umra* is also considered desirable and meritorious, though optional, in the case of persons residing in Mecca; in which case the citizen or visitor rides or drives out of Tan'im or the well of Ja'rana, performs the prescribed ablutions, dons the pilgrim garb, says a prayer of two prostrations (including the expression of intention to perform the *'umra*) and returns to the mosque for the rites of *tawaf* and *sa'i*.

The stringent program of the main pilgrimage (not very strictly adhered to by the mass of pilgrims, who find it more convenient to proceed to 'Arafat directly to avoid the pressure of traffic) requires the pilgrim to depart from Mecca after the afternoon prayer on the 8th of Dhul-Hijja, and to spend that night at Mina, performing at sunset the combined and shortened sunset and evening prayers, as prescribed for travelers at all times. On the morning of the 9th (the day of pilgrimage), when the sun has risen a spear's length above the enclosing hills, he leaves Mina, passes through Muzdalifa and the Bazan boundary pillars, and camps in the "free" territory of Wadi 'Aranah and the Namirah mosque. At the last he should attend the noon service and traditional sermon, after which he can proceed to 'Arafat for the "standing" from 2 P.M. until sunset. Then follows the rush (*daf'a* or *nafr*) to Muzdalifa, where the pilgrim performs the sunset prayer and the evening prayer, with a short interval between the two to permit the unsaddling of his camel (or in modern times the collection of his kit from his truck or car). The night should be spent there, and after the evening meal the little stones required for the stoning of the "devils" should be gathered from the bed of Wadi Muhassab, 49 stones in all for each pilgrim, who uses seven of them next morning on the "Great Devil" and 21 (seven against each of the three "devils" exemplified by three pillars marking spots where Ishmael was tempted) at or after noon on each of the two following days.

For this one night each year Muzdalifa is a brilliantly lighted city of tents, never seen in daylight since the pilgrims leave at dawn, after a second "standing" at the *mashhad* or minaret of Muzdalifa in the dark. In former times Muzdalifa was known as "the minaret without a mosque," just as Namirah was known as "the mosque without a minaret"; but neither description is now applicable, as reconstruction and additions have changed the appearance of both. There is also a royal palace at Muzdalifa for the accommodation of the king and his family, as there is also at Mina, which is a considerable town.

There the whole concourse of pilgrims assembles for the three days of the feast, some in ordinary garments if they have gone to Mecca for the *tawaf* and *sa'i*, but the great majority in *ihram*. The first day of the feast sees the sacrifice of animals, while the rest of the time is devoted to pageantry of various kinds (military parades and the like) and to mutual visits of congratulation on the completion of the pilgrimage, after which each man can add the word Hajji to his name.

In general it may be said that the traditional organization of the pilgrimage has remained intact. The substitution of motor and air transport for the camels, the improvement of the medical services, and a tighter governmental control of the operations of the money changers and others interested in the exploitation of the pilgrims have certainly tended to adjust the proceeding to modern requirements. But the cost of the pilgrimage to the pilgrim of today is substantially greater than it was of old, though the increase in all charges does little more than reflect the steadily decreasing value of money. Even the Bedouin, who strongly resented the intrusion of alien amenities, have found that they can earn more in a day as unskilled labourers than they did in a week or more in their traditional activities. The trend of the tribes away from the desert to the fringes of the many new towns in the course of development is perhaps an unhappy outcome of the westernization of Arabia.

Ibn Jubayr's description, in the 12th century A.D., of Mecca and its markets during the pilgrimage differs but little, if at all, from the accounts of the great European travelers of the 19th century: Domingo Badia y Leblich, known as 'Ali Bey al Abbasi (1807), J. L. Burckhardt (1814), Sir Richard F. Burton (1853), J. F. Keane (1877) and Christiaan Snouck Hurgronje (1885). And even in 1925, the first year of the pilgrimage under Ibn Sa'ud's auspices, Eldon Rutter found everything very much as it had been through the ages. It was in the following year that the first signs of modernization appeared with the introduction of motor traffic; and since then the pace of change has been ever more rapid.

**History.**—Mecca was a place of religious pilgrimage before the preaching of Islam (*see* above). In addition, it was an important commercial centre. In Roman and Byzantine times there was an active trade in eastern goods from India, east Africa and the far east to the Mediterranean countries. The products of the east were brought by sea to Aden where they were forwarded by camel caravan up the western shore of Arabia to Egypt, Damascus and Europe. Mecca was a principal staging-post on this caravan route and most of the Meccans were engaged in this trade.

Mohammed (*q.v.*) was born *c.* A.D. 570 in Mecca. At that time Abraha, the Christian Ethiopian governor of the Yemen, led an expedition against Mecca, which was, Muslims believe, miraculously saved from capture, possibly by an outbreak of smallpox in the Ethiopian army.

As a young man Mohammed more than once accompanied Mec-

can commercial caravans to Damascus. He began to preach in Mecca *c.* 613, but at first made few converts. In 622, as a result of increasing opposition in Mecca, the Prophet emigrated (*see* HEGIRA) with his supporters to the town of Yathrib (Medina). From this base he opened guerrilla hostilities against Mecca, intercepting and plundering the city's commercial caravans. At the same time the Prophet continued to preach to the people of Medina and the surrounding tribes. So successful were his methods that in 630 he was able to march on Mecca with 10,000 men and take the city. After its capture he declared the continuance of the pilgrimage, on the lines already established by the idol worshippers, to be a Muslim obligation. Mecca, however, was purged of idols and dedicated to the Only God.

Mohammed returned to Medina where he died two years later. As a result, Medina remained the political capital of Arabia under the Prophet's first three successors. As the Arab empire spread east and west to India and Spain, the number of pilgrims who visited Mecca increased enormously. The caravan trade, on which the Meccans had lived before Islam, lost its importance and thereafter Mecca lived almost entirely on the pilgrimage.

The city continued to be the religious heart of Islam but it never became a political capital. In 661 the government of the Arab empire moved from Medina to Damascus and, in spite of a few sporadic rebellions, the twin holy cities of Mecca and Medina faded into political insignificance. They retained immense religious prestige, however, and the caliphs of Damascus, and subsequently of Baghdad, continued to endow them with funds and to visit them on pilgrimage themselves.

With the weakening of the Abbasid caliphate, a heretical Muslim sect, the Karmatians, seized power in the Arabian peninsula. In 929 they seized Mecca and carried away the Black Stone, which was not returned until 20 years later, in a broken condition. In 907 and 925 the Karmatians attacked and exterminated the annual pilgrimage, resulting in its suspension for a number of years.

In 972 the Arab empire split into two parts, the Fatimid caliphate establishing itself in Egypt, while the Abbasid caliph continued to rule in Baghdad. Mecca and Medina became a bone of contention between the rival dynasties, acknowledging the supremacy sometimes of one and sometimes of the other. In spite of the efforts of the rival caliphs, the holy cities remained virtually independent. In 1258 the Baghdad caliphate was liquidated by the Mongols of Hulagu. The Fatimid caliphate had also disappeared. In 1269 the Mameluke sultan Baybars I of Egypt was able to establish effective control over Mecca, which remained under Egyptian suzerainty until 1517, when the Ottoman Turks achieved dominion over Egypt, Syria and the cities of Mecca and Medina.

The numerous descendants of the Prophet Mohammed all stem from Hasan and Husain (*q.v.*), the sons of his daughter Fatima by his cousin the caliph 'Ali. The descendants of Hasan, the elder, are known as *sharifs*, and are the traditional rulers of Mecca and Medina. Although the cities had to acknowledge in turn the suzerainty of Baghdad, Cairo and the Ottoman Turks, the *sharifs* in practice supplied the local semiautonomous rulers. The control of the holy cities did not pass in hereditary succession from father to son but the most prominent member of the sharifian clan was chosen. After the establishment of Ottoman rule the Sublime Porte normally recognized the senior representative of the sharifs as the prince of Mecca. As the leading Muslim government of the world from 1517 to World War I, the Turks spent considerable sums on the improvement of the caravan routes for pilgrims and on the repair and adornment of the holy places and the cities of Medina and Mecca.

The Turks showed little interest in Arabia as a whole, with the result that the sharifs of Mecca, while acknowledging Turkish supremacy, were able to build up considerable prestige and power for themselves among the desert tribes. A certain Mohammed ibn 'Abul-Wahhab, however, began, *c.* 1750, to preach a puritan religious revival in central Arabia. His adherents, known as Wahhabis, were as violent and fanatical as the Karmatians eight centuries earlier, though they differed from them in dogma. Mohammed, the preacher, allied himself with a tribal chief in central Arabia named Mohammed ibn Sa'ud, who offered his armed support to the new religious movement, thereby founding the Saudi dynasty.

In 1802 the Wahhabis attacked and captured Mecca, and Sharif Ghalib, the then ruler, retired to Jidda, but subsequently came to terms with the Wahhabis who, under Sa'ud ibn Sa'ud, grandson of Mohammed ibn Sa'ud, had established their control over most of Arabia. In 1811 the Sublime Porte commissioned Mohammed Ali (*q.v.*), governor of Egypt, to recover the holy cities. As a result of the campaign of 1811–15 the Wahhabis were driven out of Mecca and withdrew to central Arabia.

From that time until 1916 Mecca and Medina formed part of the Ottoman empire, as did the whole of the Hejaz. The Sublime Porte maintained a *wali* or governor in Mecca, and also exercised the right to appoint the sharifian ruler. Thus in theory Turkish rule was uncontested but in practice their authority could only be enforced in the principal towns, such as Mecca, Medina, Jidda and Yanbu', where they maintained garrisons and officials. In the open country and in the deserts the sharif actually exercised a considerable measure of independent control. The exact relationship between the power of the Turkish *wali* and that of the sharif varied from time to time with the personalities of the incumbents of the two offices.

At the beginning of the 20th century Sultan 'Abdul-Hamid II summoned the faithful of the Islamic world to subscribe to the construction of a railway from Damascus to the Holy Land. A German engineer, Meissner Pasha, formerly concerned with the project of the Berlin-Baghdad railway was commissioned to survey and construct the new line. By 1908 it had reached Medina, but all the blandishments of the Sublime Porte failed to shake the determination of the sharifs of Mecca to resist its extension to God's own city.

The reigning sharif, 'Aun al-Rafiq, had died in 1905 and Sharif 'Ali Pasha was recalled from exile in Egypt to take his place, in the hope that he would co-operate in the sultan's plans. He opposed them and was deposed, and the sharif appointed to succeed him died before taking up his post. 'Abdul-Hamid then turned to Husain ibn 'Ali (*q.v.*), long in honourable exile in Constantinople (Istanbul) and 60 years of age. It was a bold experiment and did not have the desired effect insofar as the railway was concerned. When World War I broke out Husain came to terms with the British government which, in return for his declaration of war against the Turks, recognized him as king of the Hejaz in 1916. Mecca, Jidda and At Ta'if, the principal centres of Turkish influence, soon fell to the sharifian forces provided with British arms and money. The railway was largely destroyed by Col. T. E. Lawrence and his Arab guerrillas and it has remained virtually out of commission in spite of intermittent efforts to restore it.

The negotiations between the sharif of Mecca and the British government in 1915–16 had recognized the right of all Arab elements in the peninsula to complete independence. King Husain had somewhat prematurely assumed the title of "king of the Arab countries," thus incurring the open hostility of Ibn Saud, the king of central Arabia. The British government engaged in an effort to secure an agreement between Husain and Ibn Saud; but the Kuwait conference of 1923–24 proved abortive. It was at this moment that Mustafa Kemal Atatürk decided to abolish the caliphate altogether. King Husain tried to seize the Prophet's mantle, but the reaction of the Muslim world to his assumption of the title of caliph was generally unfavourable. Ibn Saud then decided that the time had come for a final settlement with his rival.

In Sept. 1924 the Wahhabi armies fell upon At Ta'if, defeating the king's son, Amir 'Ali, at the battle of Hada. King Husain was forced by public opinion to abdicate and leave the Hejaz in favour of 'Ali; Mecca was occupied by the Wahhabis without opposition, and Ibn Saud entered the holy city in December, presiding over the pilgrimage for the first time in the summer of 1925. The sharifian dynasty thus came to an end, and the Wahhabi flag flew once more over the holy cities of Islam. From that time the history of Mecca was merged in the sphere of Saudi Arabia, with all its prestige as the metropolis of Islam intact in spite of the decline of its political significance in the international field.

With the termination of the once sovereign status of the sharifs

in Arabia, it seems appropriate to list those members of the clan who held the distinguished title of "amir of Mecca" as mediatized vassals of the Ottoman caliph-sultan from the conquest of the Hejaz by Mohammed 'Ali Pasha in the second decade of the 19th century until 1925, the year of the Wahhabi triumph: (1) 1788–1814, Sharif Ghalib ibn Musa'id ibn Muhsin, of the Dhawi Zaid clan; (2) 1814–27, interregnum of direct Turkish (Egyptian) rule; (3) 1827–51, Sharif Mohammed ibn 'Aun, of the Dhawi 'Aun clan; (4) 1851–56, Sharif 'Abdul-Muttalib ibn Ghalib, of Dhawi Zaid; (5) 1856–57, Sharif Mohammed ibn 'Aun, number (3) above; (6) 1857–77, Sharif 'Abdullah ibn Mohammed ibn 'Aun, son of the above; (7) 1877–80, Sharif Husain ibn Mohammed ibn 'Aun, brother of the above; (8) 1880–82, Sharif 'Abdul-Muttalib ibn Ghalib, number (4) above; (9) 1882–1905, Sharif 'Aun al-Rafiq ibn Mohammed ibn 'Aun, son of number (5) above; (10) 1905–08, Sharif 'Ali Pasha ibn 'Abdullah ibn Mohammed ibn 'Aun, son of number (6) above; (11) 1908, short interregnum; (12) 1908–24, Sharif Husain ibn 'Ali; and (13) 1924–25, Sharif 'Ali ibn Husain, son of the above and last of the sharifian rulers of the Hejaz. He abdicated his throne and left Jidda to the Wahhabis in Dec. 1925.

After 1925 certain puritan religious reforms were introduced into the holy cities in accordance with Wahhabi practice. The desert tribes, which had often robbed the pilgrims, were brought under control. The pilgrims could thereafter travel to the holy cities in safety but the dues which they were obliged to pay were increased. Moreover Ibn Saud had the power to ensure that the dues were paid. After the capture of Mecca he assumed the title of king. In 1926 100,000 Muslims visited Mecca and the fees collected from these pilgrims gave the king for the first time a substantial income. During the years before World War II the amenities available to the pilgrims were gradually improved and law and order reigned supreme. With the beginning of World War II the numbers of pilgrims inevitably decreased and for a time the Saudi government was in financial difficulties. The discovery of oil, however, soon brought money flowing into the government treasury.

This sudden flood of wealth in one of the poorest countries of the world led to a tragic lowering of morals. The strict puritanism of the Wahhabis was soon swept away. From the material point of view, however, the holy cities benefited. Water supplies, electric lighting, paved streets, modern buildings, blocks of flats and other civilized amenities replaced the picturesque and ramshackle but unsanitary buildings of the past. Instead of by long, weary hours on camelback, pilgrims were enabled to reach the Muslim holy land in modern airliners.

*See* also ARABIA; SAUDI ARABIA; HEJAZ; MOHAMMED; ISLAM; MEDINA; and references under "Mecca" in the Index.

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(H. ST. J. B. P.; J. H. GL.)

**MECHANICAL DRAWING:** *see* DRAWING, ENGINEERING.

**MECHANICAL MAN:** *see* ROBOT.

**MECHANICS,** the science concerned with the motion of bodies under the action of forces, including the special case in which a body remains at rest. This article discusses classical or Newtonian mechanics, in distinction to relativistic mechanics (*see* RELATIVITY) and quantum mechanics (*q.v.*). Of first concern in the problem of motion are the forces that bodies exert on each other; this leads to the study of such topics as gravitation, electricity and magnetism (*qq.v.*), according to the nature of the forces involved. Given the forces, we seek the manner in which bodies move under the action of forces; this is the subject matter of mechanics proper. For various reasons the study of gravitation is often included as a part of mechanics, although, at least from the classical point of view, it is a separate subject.

Historically, mechanics was the first of the exact sciences to be developed. Its internal beauty as a mathematical discipline, and its early remarkable success in accounting in quantitative detail for the motions of the moon, the earth and other planets, had enormous impact on philosophical thought and was an impetus for systematic development of science into the 20th century.

Three general realms of phenomena may be distinguished to which the principles of mechanics have been applied. The motions of such celestial bodies as stars, planets and satellites can be predicted with great accuracy thousands of years before they happen. The theory of relativity predicts some deviations from the motion according to Newtonian mechanics, but these are so small as to be observable only with very accurate techniques, except in problems involving all or a large portion of the detectable universe. As the second realm, ordinary objects on earth down to microscopic size (moving at speeds much lower than that of light) are properly described by Newtonian mechanics without significant corrections. The engineer who designs bridges or aircraft may use Newtonian mechanics with confidence. Examples of such applications may be found under AERODYNAMICS; BALLISTICS; ELASTICITY; MATERIALS, STRENGTH OF; and MECHANICS, FLUID. However, the forces in such cases are usually very complicated, and the beautifully precise calculations of celestial mechanics usually cannot be duplicated. The third realm of phenomena comprises the motion of particles of atomic and subatomic size. Although there were some limited early successes in describing the behaviour of atoms in terms of classical mechanics, these phenomena are properly treated in quantum mechanics.

Mechanics may be divided into three branches: statics, kinematics and kinetics. Statics deals with forces acting on and in a body at rest; kinematics describes the geometrically possible motions of a body or system of bodies; while kinetics deals with laws to predict the motion (from among all those possible) that will occur in a given situation. Kinematics and kinetics (sometimes also statics) are included under the term dynamics, in this sense a synonym for mechanics.

Alternatively, mechanics may be divided according to the kind of system studied. The simplest mechanical system is the particle, defined as a body so small that its dimensions and internal structure are of no consequence in the given problem. More complicated is the motion of a system of two or more particles that exert forces on each other and possibly undergo forces exerted by bodies outside of the system. In this discussion attention is confined to single particles and systems of particles.

A rigid body is one in which each point is always at a fixed distance from every other. The forces that can occur in such bodies at rest and the motions of rigid bodies as they undergo forces are treated under STATICS and DYNAMICS. The ideal concept of rigid body (as well as that of particle) is realized in practice only approximately, but often to a very high degree of precision. Thus the earth may be considered as a particle as it moves around the sun; it may be treated as a rigid body with reasonable accuracy in considering its rotation about its axis. Prediction of the shape of the earth from the principles of mechanics requires a study of its elastic and plastic properties. Matter (solid, liquid or gas), considered as composed of a very large number of particles moving according to the laws of mechanics, may be studied with statistical methods (*see* STATISTICAL MECHANICS).

This article begins with a historical outline of the development of the science of mechanics, including a nontechnical explanation of principles; it is organized as follows:

I. Historical Development
II. The Conservation Laws
III. Logical Foundations of Classical Mechanics
IV. The Breakdown of Newtonian Mechanics
V. Kinematics of a Particle
1. A Particle Moving in a Straight Line
2. A Particle Moving in a Plane
3. Displacement, Velocity and Acceleration as Vectors
4. A Particle Moving in Three Dimensions
5. Uniform Circular Motion
VI. Newton's Laws
1. Mathematical Formulation
2. Units of Measurement
VII. Statics of a Particle
1. The Composition of Forces
2. Analytical Composition of Forces
3. Equilibrium of a Particle Under Constraint
VIII. Kinetics of a Particle
1. Impulse and Momentum
2. Angular Momentum (Moment of Momentum)
3. Work and Energy
4. Planetary Motion
5. The Newtonian Principle of Relativity
IX. Systems of More Than One Particle
1. Conservation of Linear Momentum
2. Conservation of Angular Momentum
3. Work and Energy Relations
4. The Centre of Mass of a System of Particles
X. The Principle of Virtual Displacements
1. Application to a System of Particles
2. Imposition of Constraints
XI. Practical Application of Mechanics

## I. HISTORICAL DEVELOPMENT

Many of the principles of statics were known to the ancient Greeks (*see* PHYSICS: GENERAL SURVEY). The principles of levers, and of the statics of fluids, were developed systematically by Archimedes (*q.v.*) in the third century B.C. Dynamics, as an exact science of motion, however, owes its beginning to Galileo Galilei (*q.v.*; 17th century A.D.), who gave an account of the motion of falling bodies and of projectiles. Galileo's methods have since characterized the development of physical science. He had the genius to choose problems that were simple enough for him to solve, yet which were of fundamental importance in developing laws of mechanics. He developed a mathematical theory to permit precise calculations of motion. He recognized that the primary test of any theory is its agreement with, and accurate prediction of, experimental observations (*see* MOTION, PRINCIPLES AND LAWS OF).

Sir Isaac Newton (*q.v.*), who was born the year Galileo died, formulated three laws of motion that summarize, clarify and extend the principles introduced by Galileo. According to Newtonian mechanics, all bodies exert forces on each other; these forces determine their motion or state of rest. Newton's first two laws give the rule for determining motion when the forces acting on a particle are known. In modern terms the first law states that, if it undergoes no force, a particle (at rest or moving) will remain at rest or will continue to move with constant velocity in a straight line. By the second law the product of the mass and the acceleration of a particle equals the force that acts on the particle. Acceleration is the rate of change of velocity (which indicates changes in direction as well as speed). To formulate and solve the problem of the motion of a body according to Newton's laws of motion requires mathematical techniques for dealing with rates of change. The appropriate techniques are given by the calculus which was invented by Newton and G. W. Leibniz (*see* CALCULUS, DIFFERENTIAL AND INTEGRAL). Much effort of mathematicians in succeeding centuries was devoted to developing the calculus into an effective instrument for handling problems in dynamics.

Newton's first two laws generalize to all motion the principles applied by Galileo in his study of projectiles. The third law specifies a condition that must be met by the forces that act in motion: the force that one body exerts on another must always be equal in magnitude and opposite in direction to the force that the second body exerts on the first. This principle permits the derivation of general properties of motion in a mechanical system without further information about the forces.

The easiest interactions to visualize are the forces exerted between bodies in contact. Forces that arise from the distortion of solid materials in contact are the subject of the theory of elasticity; when they arise from the motion of fluids, they are the subject of hydrodynamics (or fluid mechanics). In every case, such forces are reducible to interactions among atoms. Although forces exerted at a distance are more difficult to visualize, it proved relatively easy to describe them mathematically; *e.g.*, the theories of gravitation and of electrodynamics (*see* ELECTRICITY).

Gravitational interactions were the first forces exerted at a distance to be reduced to a mathematical theory; they are the only significant forces acting between the planets and their satellites in the solar system. Many people had suggested that planets are held in their orbits by a force from the sun, similar to that which makes bodies fall to earth. By studying results of very detailed and precise astronomical observations, J. Kepler (*q.v.*) had formulated in three laws a mathematical description of the planetary orbits. Newton was able to calculate the acceleration of a planet from these laws and to show that it is directed toward the sun, is inversely proportional to the square of the planet's distance from the sun, and is independent of its mass. Newton's second law of motion then gives the force on the planet, while the third law implies an equal and opposite force exerted by each planet on the sun. This led to his law of universal gravitation: any two particles attract each other with a force proportional to the product of their masses and inversely proportional to the square of the distance between them. As a verification Newton found that the force given by the law of gravitation agreed with that calculated from the observed motion of earth's moon, within the accuracy of the empirical data.

Since then astronomical observations and mathematics have been refined to account not only for the sun's gravitational attraction but for the attractions of the planets on each other. In every case the calculations agree with the observations with astonishing precision, and establish that the Newtonian laws of motion and of gravitation usefully account for the motions of the planets and satellites. In the case of the orbit of the planet Mercury the discrepancy between Newtonian predictions and actual observation amounts only to about one degree of arc in 9,000 years; the general theory of relativity can account for the difference.

A complete mathematical theory of electric and magnetic interactions was formulated in the 19th century by J. C. Maxwell (*q.v.*), based on the research of many others, particularly M. Faraday (*q.v.*). The laws of electricity and magnetism form the subject of electrodynamics. In the meantime the development of mathematics by such men as C. F. Gauss, P. S. Laplace, J. L. Lagrange and Sir W. R. Hamilton (*qq.v.*) had provided more powerful methods of solving mechanical problems, and more refined ways of formulating the laws of mechanics. An important step in formulating any mechanical problem (and, in many cases, the key to the solution) lies in the proper choice of variables to describe positions and velocities of a system's parts. Lagrange and Hamilton discovered ways of formulating the laws of motion to permit great freedom in choosing these variables. The methods provide general ways of discovering constants of the motion; *i.e.*, quantities that are functions of the selected variables, but which remain constant during the motion. Such constants are of great general significance, and are very useful in the solution of mechanical problems. The methods (particularly Hamilton's) are applicable also to electricity and magnetism; and provide an elegant way of formulating laws of physics. For this reason, Hamilton's formulation is basic in the transition to the newer relativistic and quantum theories of the 20th century.

An important application of mechanics in the 19th century was to the explanation of the properties of matter (particularly gases) in terms of the motions of molecules (*see* KINETIC THEORY OF MATTER). The kinetic theory of gases, as developed by Maxwell, L. Boltzmann (*q.v.*) and others, accounted for the laws governing the relations among pressure, density and temperature in a perfect gas, for the viscosity and thermal conductivity of a gas, and in a qualitative way also for the behaviour of imperfect

gases, and of liquids and solids. These studies led to the development of statistical mechanics, from which J. W. Gibbs (*q.v.*) was able to deduce the laws of thermodynamics (*q.v.*) that describe the thermal behaviour of matter. To account in detail for the behaviour of matter, atoms and molecules are treated according to the laws of quantum mechanics; this is the subject of quantum statistical mechanics.

Perhaps classical mechanics reached its peak of development at the beginning of the 20th century with the work of H. Poincaré (*q.v.*) and others. By then powerful problem-solving methods and elegant general theorems about the behaviour of mechanical systems had been developed. Nevertheless a number of unsolved problems remained, most of which are still unsolved. One concerns the enduring stability of a system of three or more bodies (*e.g.*, the solar system) moving under mutual gravitational attraction. The motion of such a system can be predicted as far ahead and with any degree of accuracy as desired; but it is not known whether or under what conditions it will remain stable for all time. Will the planets continue to circle the sun forever in about the same orbits, or will they in some distant future be found in substantially different orbits? A related problem is the ergodic hypothesis (a basic assumption in classical statistical mechanics) according to which the parts of a mechanical system will (in general) eventually pass through all positions and velocities compatible with given values of the constants of the motion for the system. Despite the insight provided by the labours of many mathematicians, a complete proof (or disproof) of the ergodic hypothesis remained to be found in the 1960s.

The development of relativistic and quantum mechanics early in the 20th century turned the attention of most physicists and mathematicians away from classical mechanics. With the advent of artificial earth satellites and space probes, interest in classical orbit theory has revived, particularly in the practical problems of orbit calculation. New interest has also followed the development of particle accelerators (*see* ACCELERATORS, PARTICLE) in which individual electrically charged particles may make more than $10^9$ revolutions; and questions of the stability of the orbits of these particles are of great practical importance. Particle velocities in accelerators are usually so high that relativistic mechanics must be used, but the mathematical methods for finding the orbits are the same as in classical mechanics.

## II. THE CONSERVATION LAWS

Constants of motion have been mentioned that facilitate the solution of mechanical problems. Beyond their practical utility these quantities (which remain constant during motion) are found to have a deep and general significance, dimly perceived at the time of Newton, that has become increasingly clear. At Newton's time two quantities, now called linear momentum and kinetic energy, were recognized as being conserved (*i.e.*, as remaining constant) during the elastic collision of two bodies. Linear momentum for a particle is defined as the product of the particle's mass and velocity. (Momentum, like velocity, has a direction in space as well as a magnitude.) The linear momentum of a system is the sum of the momenta of its particles. That the linear momentum of a system of interacting bodies remains constant in the absence of external forces is a consequence of Newton's third law; this theorem is the law of conservation of linear momentum.

With the discovery that electric and magnetic forces do not act instantaneously, but are propagated with the speed of light, it became clear that the third law cannot apply at all times to the forces between rapidly moving charged bodies. In its primitive form as stated above, the law of conservation of linear momentum is not valid in such cases. To describe the propagation of electromagnetic forces, it is convenient to define an electromagnetic field that propagates outward from a charged body and acts on other bodies. It has been found possible to define an electromagnetic momentum associated with this field so that a conservation theorem of total linear momentum, of material bodies and the electromagnetic field, still holds. Similar remarks apply to other types of force field (*e.g.*, gravitation) that propagate with finite velocity between interacting bodies. The third law was originally introduced to provide for the conservation of momentum. Although the third law must be given up (or modified) in the case of rapidly moving charged bodies, the law of conservation of momentum still holds.

The kinetic energy of a particle is defined as half its mass times the square of its velocity. Under certain circumstances, the total kinetic energy of two bodies is conserved when they collide; when this is the case, it is said that the collision is elastic. Under the action of a force the kinetic energy of a moving body may change, but in some cases it is possible to define a quantity called potential energy (depending on the relative positions of the bodies in a mechanical system) so that the sum of the kinetic and potential energies remains constant. In this case, it is said that the forces are conservative. The frictional forces that act between colliding bodies, at moving contacts or in fluids in motion are not conservative; but it was discovered in the 19th century that whenever mechanical energy disappears through friction, a proportional amount of heat is developed. It is therefore possible to define heat energy so that the sum of kinetic, potential and heat energy is conserved even in the presence of frictional forces. According to the kinetic theory of matter, heat energy is simply the kinetic and potential energy associated with the random motions of atoms and molecules (*see* HEAT). It has been found possible to extend the concept of energy to all physical interactions; for example, by defining electromagnetic energy associated with electric and magnetic interactions, gravitational potential energy associated with gravitational interactions, and so on. This gives a general conservation law that the total energy in any isolated physical system remains constant.

The concepts of momentum and energy and their conservation thus extend throughout classical physics. With suitable modification they are valid also in relativistic and quantum physics. It is agreed always to define energy and momentum in such a way that they are conserved, and it is postulated that the laws of physics must be such that suitable definitions are always possible. The dynamical methods of Lagrange and Hamilton lead to an insight into the significance of the conservation laws. It can be shown that whenever a physical system exhibits a certain symmetry, which may be expressed by saying that the laws governing the interactions within the system are independent of some variable associated with the system, then there will be a corresponding quantity which is a constant of the motion as a consequence of that symmetry. Thus energy is the quantity corresponding to the variable time, and whenever the laws governing the interactions in a system are independent of the time, the energy is conserved. If the fundamental laws of physics do not change with time, it can be proved with the methods of Hamilton that there will be a certain quantity that remains constant. Energy may be defined as that quantity which remains constant as a consequence of the fact that the laws of physics are independent of the time. Likewise, the postulate of conservation of linear momentum is found to be equivalent to the statement that the laws of physics are the same in all parts of space. There is another fundamental quantity, the angular momentum (also called moment of momentum) that is conserved as a consequence of the fact that the laws of physics are independent of the orientation of a physical system in space.

## III. LOGICAL FOUNDATIONS OF CLASSICAL MECHANICS

One way of regarding theoretical mechanics is to visualize it as a purely abstract discipline. As such, it may legitimately be founded on any set of assumptions that is neither incomplete nor self-contradictory. These assumptions refer to the nature of the bodies and to their dynamical behaviour; if the rules of mathematics are followed correctly, a valid body of theory may be built up from them. In this way, theoretical mechanics may be developed as a branch of applied mathematics.

To begin a logical, mathematical development of mechanics, terminology must first be specified. Some terms (*e.g.*, position, time and mass) are taken as primitive or undefined. Others may be defined by using primitive or previously defined terms; for ex-

ample, velocity may be defined as time rate of change of position, and acceleration as time rate of change of velocity. When the terminology has been provided, a suitable set of initial assumptions or postulates is chosen from which the theorems of the theory can be deduced. Newton's three laws may be taken as postulates; however, other initial assumptions are also possible. Although it is probably possible to give a complete and rigorous logical development of classical mechanics as an abstract discipline after the manner of Euclidean geometry, this does not appear to have been carried out.

Mechanics is normally regarded as a branch of physics, in which case the mathematical development of the subject must be connected with the physical universe. This connection has two aspects, now recognized to be equally important. On the one hand, the theory must be experimentally verified and, if necessary, modified so that it correctly describes the behaviour of actual mechanical systems. This was already realized at the time of Galileo, and it is now generally recognized that (from the point of view of physical science at any rate) the usefulness of a theory lies in the agreement of its predictions with observational data. In principle, a theory may be tested by experimentally verifying its basic postulates. To verify directly each of Newton's three laws of motion with any precision is difficult even with modern experimental techniques, and it would have been practically impossible at the time of Galileo and Newton. A more practical method is to compare the quantitative predictions of the theory with results of experimental measurements. In the case of mechanics, the detailed agreement of observation with theoretical prediction, particularly in the motions of celestial bodies, is far more convincing than any direct experimental test of each of Newton's laws. This is not surprising, since the basic postulates are chosen for their logical simplicity, while investigators tend to choose tests of the theory where the most precise observations can be made and where the theory can be made to yield unambiguous quantitative predictions.

On the other hand, it is necessary to define the primitive terms used in mathematical theory by giving them physical meaning. This step logically precedes experimental verification. However the importance of this point was not recognized until long after the establishment of Newtonian mechanics as a useful theory, probably because the terms used were clear enough for practical purposes. Such concepts as time and distance seemed intuitively clear, and it was only with the advent of relativity and quantum mechanics that careful examination of their physical meaning became crucial; although the importance of physical meaning had already been emphasized in the writings of E. Mach (*q.v.*). Indeed these modern theories arise as much from fuzziness in classical concepts as from inaccuracies in classical laws.

Primarily, the primitive terms in the theory of mechanics are names of such physical quantities as distance and mass. They acquire physical meaning when they are given an operational definition: one that specifies how they are to be measured. Ideally, precise operational definitions should be given for every term needed before the construction of a physical theory is begun. Such a program faces insuperable practical and theoretical difficulties, however. For purposes of physics, it is perhaps enough to recognize that the meaning of such terms is contained in the way in which they are measured; a careful analysis of any particular aspect of the measurement operation may then wait until experiment or theory requires it.

The subject of kinematics requires the concepts of position, time, and the derived concepts of velocity and acceleration. Definitions of length and time interval must first be given. To measure length in an elementary way, the use of a ruler or tape measure can be specified more or less precisely. Physicists and astronomers can now measure a distance of $10^{-13}$ cm. or of 1,000,000,000 light years by methods that bear little resemblance to the tape measure, or to each other except that they involve extensive calculation based on elaborate theories and use data from complex and expensive instruments. A co-ordinate system (frame of reference) must be specified with respect to which the measurements are to be made. Newton did not offer a very satisfactory frame of reference within which velocities and accelerations are to be measured. Perhaps it is best to postulate that there is some reference system with respect to which the laws of motion are valid, leaving its determination to experiment. Such a frame of reference is called an inertial system. It is not difficult to show that the laws of motion will be equally valid in any other system moving with uniform velocity relative to the inertial system. This is called the Newtonian principle of relativity.

Mass is a typical physical quantity; Newton used the words quantity of matter to vaguely suggest a certain meaning for mass, but a precise operational definition is clearly required. First, a unit of mass is defined by specifying the mass of some standard body; the internationally adopted standard (made of platinum-iridium) is kept by the International Bureau of Weights and Measures at Sèvres, France, and is defined to have a mass of one kilogram. However, a standard body reproducible in any suitably equipped laboratory could also have been chosen; *e.g.*, a cubic centimetre of water at a standard temperature and pressure, or a hydrogen atom. Given such a standard, there are two basically different operations by which any mass may be measured. The most commonly used operation depends on the fact that mass appears in the law of gravitation. Thus the ratio of any mass to the standard is defined as the ratio of the gravitational forces acting on them; this is measured by a lever balance which directly compares the two forces. A scale that responds to a single force in terms of the compression or extension of a calibrated spring does not directly indicate relative mass; it measures weight (the gravitational force acting on a mass). Although its mass will be constant, a body will not have the same weight at different places on the earth, when orbiting in space or when resting on the moon. The lever balance would give the constant mass of a body anywhere on earth or on the moon, regardless of weight.

A second operation by which to measure mass is based on Newton's second law of motion. If a standard and an unknown mass are allowed to interact, the force on either is equal to the force on the other (by the third law); and their accelerations can be measured. The second law then asserts that the ratio of the two masses is the inverse of the ratio of their accelerations. Although far less convenient for practical use, this operational definition of mass is more fundamental since it is based directly on a law of motion.

From the point of view of Newtonian mechanics, there is no reason why these two different kinds of operations should give the same result. It hinges on the apparently accidental circumstance that the same quantity (mass) appears in both the law of motion and the law of gravitation. (In the law of electrical attraction between two bodies, another quantity [electrical charge] determines the magnitude of the force.) Two logically distinct quantities characterizing a body may be distinguished: the gravitational mass defined by the operation of the lever balance and the inertial mass defined by the operation of measuring acceleration. That these are always equal for any body is an experimental fact that has been verified to a precision of better than one part in 1,000,000,000.

The laws of motion refer to the behaviour of a particle, defined here as a body for which size and internal structure have no relevance for the mechanical problem at hand. If size (or structure) is relevant and these laws are used, then the body must be regarded as made up of particles to which the laws apply directly. Equations for the behaviour of the body then are derived from the laws governing the behaviour of its particles. For example, it is possible to define in any body a single point (the centre of mass) that moves like a particle with mass equal to that of the body and is acted on by a force equal to the total external force on the body. (That is, interactions among parts of the body are omitted. If rotation or distortion of the body is relevant, other equations must be deduced.) This justifies treating the body as a particle in problems where the internal structure is irrelevant, and in this respect Newtonian mechanics is logically consistent. However in the light of modern knowledge such a justification is not physically sound. Matter is made up of molecules that are composed of atoms, in turn composed of smaller particles. Even the elementary particles recognized by modern physics are not ideal

Newtonian particles because they have not only position and velocity, but also a spin and hence a kind of internal structure; their behaviour is described by quantum mechanics, not by classical mechanics (*see* PARTICLES, ELEMENTARY). Newtonian laws for a body of macroscopic size can be derived by applying the laws of quantum mechanics to its atoms. Or, a different set of basic postulates may be used; starting with the laws of conservation of linear and angular momentum, for example, equations of motion can be derived for any mechanical system, be it composed of rigid bodies, elastic solids, fluids or whatever. Beginning with the formulations of Lagrange or of Hamilton, the equations of motion can be written in terms of any suitable set of variables, again without the necessity of inquiring into the molecular structure of any mechanical system.

## IV. THE BREAKDOWN OF NEWTONIAN MECHANICS

Classical mechanics has proved to have an accuracy and a range of empirical validity far beyond the experimental evidence available at the time of Newton; however, the theory breaks down when applied to motions of very large or very small systems and to motions at very high speed. The difficulties run through all of classical physics and have given rise to relativity and to quantum mechanics which modify those classical laws that fail experimentally. These newer theories necessitate radical revisions in the conceptual structure of physics. Throughout classical physics it is assumed that the behaviour of measuring instruments is unaffected by their state of motion (as long as they are not too rapidly accelerated) and that in principle it is possible to devise instruments to measure physical quantities with as small an error as desired. Both assumptions fail; the first at very high velocities, and the second when very small magnitudes are to be measured. Their failure necessitates different operational definitions that lead to the conceptual structure of modern relativity and of quantum mechanics.

The Newtonian principle of relativity in classical mechanics was mentioned earlier. It was pointed out by Albert Einstein (*q.v.*) in 1905 that difficulties in accounting for observations of the behaviour of light and in the electromagnetic theory of moving matter could be resolved by postulating a principle of relativity for all of physics. His postulate of special relativity states that the laws of physics must be such that if they are valid in one reference frame, they are valid in any reference frame moving with constant velocity relative to the first. It has been found that all the laws of classical physics can be made compatible with this postulate. In the case of Newton's laws of motion, the small modifications required become important only at velocities comparable to that of light. It is now necessary to include in the operational definitions of most physical quantities the specification that the measuring instruments used are to be at rest relative to the selected frame of reference. Thus the definitions of distance and time, as well as velocity and acceleration, and most physical quantities, give these terms a meaning only relative to a particular frame of reference. Predictions of the special theory of relativity for phenomena involving high velocities have been amply confirmed by experiment.

Although the principle of relativity has a certain intuitive appeal, the postulate of the special theory only refers to motion at constant velocity relative to an inertial frame of reference. If motion with constant velocity has only a relative meaning, why should not the same apply to all motion? At first sight acceleration seems operationally definable independent of any reference frame. For example the occupants of a rapidly accelerating vehicle can detect the acceleration even without looking out the windows. But Einstein pointed out that (since the same mass appears in the laws of motion and of gravitation) these experiences could equally well be ascribed to the effects of gravitation. In fact, the equality of inertial and gravitational mass prohibits the direct verification of Newton's first law of motion, or the experimental discovery of an inertial frame of reference. With such equality, if a body on which no other force is acting does not move uniformly in a straight line, either the frame of reference is not inertial, or there is a gravitational force that produces the observed acceleration. Einstein proposed that the equality of inertial and gravitational mass (accidental from the point of view of Newtonian mechanics) is really a consequence of a fundamental principle of equivalence: no measurements that can be made locally can distinguish between the effects of a gravitational field and those of an accelerating frame of reference. This principle permits the postulate of general relativity: the laws of physics hold in any frame of reference. Einstein showed how to modify physical laws to make them compatible with this postulate. In all experimental tests yet devised the predictions of the general theory are very close to those of the classical and special theories. Nevertheless, when small differences have been predicted and detected, the test results have favoured the general theory.

Near the start of the 20th century it was found that light can behave like a wave motion or (under other conditions) like a stream of particles. Streams of particles also were found to exhibit wavelike properties. Quantum mechanics (growing from attempts to explain these results), particularly in its most modern forms, is a theory that unifies the theories of waves and of particles. In classical terms this is paradoxical, since a particle is localized in space, while a wave spreads continuously throughout a region. But W. K. Heisenberg (*q.v.*) showed that if there are limitations on the precision with which the position and velocity of a particle and the amplitude of a wave can be measured, then there is no way to make an absolute experimental distinction between particles and waves. Since the operational meaning of a physical term depends on how it is measured or observed, Heisenberg's idea (*see* UNCERTAINTY PRINCIPLE) makes possible the quantum theory in which particles and waves are two aspects of the same thing. At any given moment a physical quantity cannot in general be measured with arbitrary precision; logically it no longer can be represented by a single number, and a new kind of quantum mathematics is needed to describe phenomena. Thus far, all empirical results agree with quantum theory when the experiments can be performed and the necessary mathematical equations can be solved.

While relativity and quantum theory radically alter fundamental concepts, and are revolutionary in the philosophy of science, this does not mean that classical theories are to be discarded. Newtonian mechanics now gives even better agreement with observations in celestial mechanics than it did in the 18th and 19th centuries. To the extent that classical mechanics was experimentally confirmed, it still holds. One of the most powerful methods for the development of new theories is N. H. D. Bohr's (*q.v.*) correspondence principle: the predictions of any new theory must agree with the empirically verified predictions of older theories.

## V. KINEMATICS OF A PARTICLE

The mathematical development of mechanics begins with kinematics, the description of motion. Only the simple case of the kinematics of a point particle is discussed here. However, the extension to systems of more than one particle is readily made. What follows assumes an elementary grasp of the calculus.

**1. A Particle Moving in a Straight Line.**—In the simplest case of a particle moving in a straight line, the location of the particle is specified by its distance $x$ from some chosen fixed origin O on the line. As the particle moves, the value of $x$ changes, and the history of the motion is described by the function $x(t)$ which relates a value of $x$ to any instant $t$ in time (likewise measured from some chosen instant $t = 0$).

Suppose that at an instant $t_1$ the particle is at a distance $x_1$ from O, and at a later instant $t_2$ it has moved to the position $x_2$. The average velocity of the particle during the time interval from $t_1$ to $t_2$ is defined as

$$\frac{x_2 - x_1}{t_2 - t_1} = \frac{\delta x}{\delta t}$$

The average velocity does not indicate how the distance was traversed; it fails to show whether or not the particle stood still for any portion of the time interval $\delta t$, or moved quickly and then more slowly. Precise meaning is given to the notion of velocity at any instant $t$ by diminishing the interval $\delta t$ over which the average velocity is measured. The instantaneous velocity $v$ is then de-

fined as the limiting value approached by the average velocity as the time interval $\delta t$ is diminished toward zero. In symbols

$$v = \lim_{\delta t \to 0} \left( \frac{\delta x}{\delta t} \right) = \frac{dx}{dt} \tag{1}$$

In the language of the calculus, the velocity is found by differentiating the distance $x$ with respect to the time $t$.

Just as velocity specifies the rate at which the position $x$ is changing, acceleration is defined as the rate at which velocity is changing. If velocity at $t_1$ is $v_1$ and at $t_2$ it is $v_2$, the average acceleration during the time interval $\delta t$ is

$$\frac{v_2 - v_1}{t_2 - t_1} = \frac{\delta v}{\delta t}$$

As in the case of velocity, instantaneous acceleration $a$ is defined by diminishing the interval $\delta t$ toward zero:

$$a = \lim_{\delta t \to 0} \left( \frac{\delta v}{\delta t} \right) = \frac{dv}{dt} = \frac{d^2x}{dt^2} \tag{2}$$

The acceleration is the derivative of the velocity $v$ with respect to the time $t$; alternatively, it is the second derivative of the distance $x$ with respect to the time.

**2. A Particle Moving in a Plane.**—Now remove the restriction that the particle move in a single straight line, and consider motion in a plane; the extension to three-dimensional space will then be immediate. In space, position can no longer be described by a single distance $x$; direction of motion becomes important. Speed $s$ is merely magnitude of velocity without reference to direction; velocity $v$ specifies both magnitude and direction. That is, a particle moving east at 10 m.p.h. has the same speed but a different velocity from a particle moving north at 10 m.p.h.

To specify the position of a point in a plane it is convenient to construct perpendicular axes OX and OY as in fig. 1, and to measure its position relative to them. AB represents the path of a particle which at any instant $t$ is at some point P. The position P can be specified by the pair of distances $x$, $y$ measured along OX, OY from O to the projections $P_x$, $P_y$ of P on the axes. The history of the particle as it moves is specified by the pair of functions $x(t)$, $y(t)$.

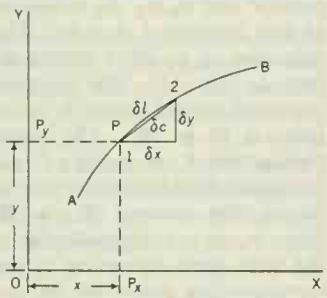

FIG. 1.—(SEE TEXT FOR EXPLANATION OF ALL FIGURES)

Suppose that, in the interval $\delta t = t_2 - t_1$, the particle moves from point 1 to point 2 in fig. 1, a distance $\delta l$ along the path AB. The average speed is

$$\frac{\delta l}{\delta t}$$

The average velocity is defined as directed along the chord 1, 2 and to be of magnitude

$$\frac{\delta c}{\delta t}$$

where $\delta c$ is the length of the chord. This could be represented by a line of length

$$\frac{\delta c}{\delta t}$$

drawn parallel to this chord. If this line were drawn, its projections on the axes OX, OY would be of lengths

$$\frac{\delta c}{\delta t} \cdot \frac{\delta x}{\delta c} = \frac{\delta x}{\delta t}$$

$$\frac{\delta c}{\delta t} \cdot \frac{\delta y}{\delta c} = \frac{\delta y}{\delta t}$$

respectively; the projections of the line that represents the average velocity of the particle at P themselves represent the average velocities of the projections $P_x$, $P_y$ on the axes OX, OY. If the interval $\delta t$ is now diminished the instantaneous speed $s$ (the magnitude of the instantaneous velocity) is defined as

$$s = \lim_{\delta t \to 0} \left( \frac{\delta c}{\delta t} \right) = \lim_{\delta t \to 0} \left( \frac{\delta l}{\delta t} \right) = \frac{dl}{dt}$$

The direction of the velocity will evidently be that of the tangent to the curve AB at the point P. Likewise the projections of the average velocity along the axes will approach the instantaneous velocities of the projections $P_x$, $P_y$. The velocity $v$ is said to have the components

$$v_x = \frac{dx}{dt} \text{ in the direction OX}$$

$$v_y = \frac{dy}{dt} \text{ in the direction OY}$$

In defining acceleration as rate of change of velocity, recognize that a change in velocity of a particle implies either an alteration of its speed or of its direction of motion, or both. It is again useful to think of a line with length and direction that represent the magnitude and direction of an instantaneous velocity.

Fig. 2(A) shows the axes X, Y and the path AB with points 1 and 2. The velocity at point 1 is $v_1$, directed along the tangent at 1. It is represented, to a suitable scale, by the line CD labeled $v_1$ in fig. 2(B); this line describes the velocity at time $t_1$. The line CE, labeled $v_2$, represents the velocity of the particle when it has reached point 2 at time $t_2$. The $x$ component of the velocity at 2 is evidently greater than that at 1 by the amount $\delta v_x$, given by the line FE in fig. 2(B). Similarly, the $y$ component of velocity at 2 is greater than that at 1 by the negative amount $\delta v_y$, shown as DF.

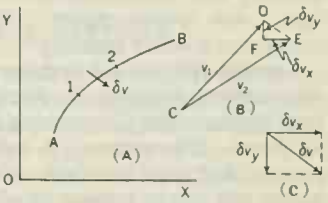

FIG. 2

These two changes of velocity parallel to the axes can be regarded as components of the total change of velocity and fig. 2(C) shows how the magnitude and direction of this change may be found. It is a line $\delta v$ that just fits across the gap DE in fig. 2(B). The change of velocity during the interval $\delta t$ is given then by the line DE, directed not along the curve AB but across it, as shown by the arrow in fig. 2(A). During its passage from 1 to 2, the point P is said to have an average acceleration

$$\frac{\delta v}{\delta t}$$

(where $\delta v$ denotes the change of velocity) in the direction of the arrow in fig. 2(A).

The instantaneous acceleration will have a magnitude

$$a = \lim_{\delta t \to 0} \left( \frac{\delta v}{\delta t} \right) = \frac{dv}{dt} \tag{3}$$

and will be in a direction given by the limiting direction of the velocity increment $\delta v$ in fig. 2(A) as $\delta t$ approaches zero; this direction will in general make some angle with the tangent to the path AB. By an argument similar to that given for the case of the velocity, the projections of the instantaneous acceleration along the directions OX, OY can be shown to be the accelerations of the projections $P_x$, $P_y$; these are the components of the acceleration. They are given by

$$a_x = \lim_{\delta t \to 0} \left( \frac{\delta v_x}{\delta t} \right) = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$

$$a_y = \lim_{\delta t \to 0} \left( \frac{\delta v_y}{\delta t} \right) = \frac{dv_y}{dt} = \frac{d^2y}{dt^2} \tag{4}$$

**3. Displacement, Velocity and Acceleration as Vectors.**—Suppose a particle moves from a point 1 to point 2 (fig. 3). The net change of position without reference to the manner of movement or path between the points is called the particle's displacement. The displacement can be shown as a line segment $l_1$ directed from 1 to 2, with length equal to the distance between. Such

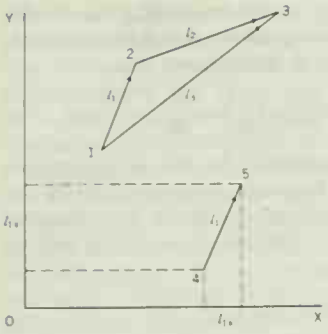

FIG. 3

quantities as displacement (with magnitude and direction in space) are called vectors. Note that the concept of vector refers only to magnitude and direction, and not to the location in space of the vector $l_1$.

Thus in fig. 3, the segment connecting points 4 and 5 has the same length and direction as that between points 1 and 2 and therefore corresponds to the same vector $l_1$. The projections on the axes OX, OY of the segment representing $l_1$ indicate the vector's components:

$$l_{1x} = x_5 - x_4 = x_2 - x_1$$
$$l_{1y} = y_5 - y_4 = y_2 - y_1$$

A vector may also be represented algebraically by the numerical values of its components.

When it is helpful the term scalar will be used to refer to a quantity with no associated direction, only a magnitude and perhaps a sign (plus or minus). Temperature, for example, may be considered a scalar quantity.

Suppose the particle next moves from point 2 to point 3. Its displacement vector $l_2$ is represented as shown in fig. 3. The total displacement $l_3$ in moving from point 1 to point 3 is a vector as shown. The vector $l_3$ is called the sum of $l_1$ and $l_2$, and the process illustrated by which $l_3$ is obtained from $l_1$ and $l_2$ is called vector addition in analogy to addition with ordinary numbers. If points 1, 2 and 3 are in a straight line, vector addition reduces to ordinary addition of the magnitudes. To add two vectors $l_1$ and $l_2$, place the segments representing them so that the final end of $l_1$ coincides with the initial end of $l_2$; the sum $l_3$ is then represented by the segment from the initial end of $l_1$ to the final end of $l_2$. This is often called the parallelogram rule because of the alternate construction (fig. 4) in which a parallelogram is formed with $l_1$ and $l_2$ as sides. Vector addition has many of the algebraic properties of ordinary addition (*see* VECTOR ANALYSIS). The rule (fig. 3) can be extended to the sum of any number of vectors. The component in any direction of the sum of any number of vectors is the sum of their components in that direction.

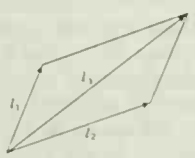

FIG. 4

Since velocity and acceleration have magnitude and direction, they are also vectors. Vector addition of velocities may be interpreted kinematically. Consider a point P with velocity $v_1$ relative to a frame of reference that is moving with velocity $v_2$. For example, a man walks with velocity $v_1$ across the deck of a ship that moves with velocity $v_2$ relative to the ocean. The resultant velocity $v_3$ of the man relative to the ocean is sought. In a time $\delta t$ the man achieves a displacement $\delta l_1$ with respect to the ship that would be his displacement relative to the ocean if the ship were still. In the same $\delta t$ the ship has a displacement $\delta l_2$ relative to the ocean; it would be the displacement of the man if he were standing still on deck. The total displacement $\delta l_3$ of the man relative to the ocean is the vector sum of $\delta l_1$ and $\delta l_2$. The average velocities during the interval $\delta t$ are

$$\frac{\delta l_1}{\delta t}, \frac{\delta l_2}{\delta t}, \frac{\delta l_3}{\delta t}$$

with the same directions as the respective displacements. If these velocities are represented by directed segments they will form a triangle (or parallelogram) similar to, and similarly oriented to, the triangle (or parallelogram) representing the addition of $\delta l_1$ and $\delta l_2$ that yields $\delta l_3$. By passing to the limit as $\delta t$ approaches zero, it can be concluded that $v_3$ is obtained by vector addition of $v_1$ and $v_2$. This is the law of composition of relative velocities. A similar result follows in the same way for the composition of accelerations, if a particle simultaneously undergoes two independent accelerations $a_1$ and $a_2$ its resultant acceleration $a_3$ is the vector sum of $a_1$ and $a_2$.

**4. A Particle Moving in Three Dimensions.**—The foregoing discussion may be extended immediately to a particle moving through three-dimensional space, although the diagrams become slightly more complicated. The reference frame now comprises any three mutually perpendicular axes OX, OY, OZ (fig. 5) convenient to the specific problem.

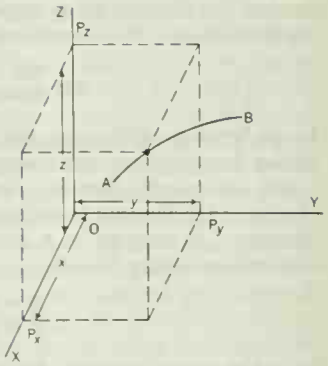

FIG. 5

The position of a particle is specified by three co-ordinates $x$, $y$, $z$. It can be shown that the velocity and acceleration are vectors with three components

$$v_x = \frac{dx}{dt}, v_y = \frac{dy}{dt}, v_z = \frac{dz}{dt} \tag{5}$$

$$a_x = \frac{dv_x}{dt}, a_y = \frac{dv_y}{dt}, a_z = \frac{dv_z}{dt}$$

Addition of vectors according to the triangle or parallelogram rule proceeds in precisely the same fashion in three dimensions, only now the triangle and parallelogram do not necessarily lie in the XY plane.

**5. Uniform Circular Motion.**—The special case of a particle moving with constant speed around a fixed circle is sufficiently important to be treated here. Let $s$ be the constant speed of the particle and $v_1$, $v_2$ the velocities at two instants $t$, $t + \delta t$. The velocities $v_1$, $v_2$ differ only in direction (fig. 6). The distance traversed around the circle in the interval $\delta t$ is $s\delta t$. The angle through which the radius $r$ (from the centre to the particle) moves during the interval $\delta t$, is $\delta\theta$. Since $v_1$, $v_2$ are perpendicular to the radii from the centre to the corresponding points on the circle, the angle between the directions of $v_1$ and $v_2$ is also $\delta\theta$ as shown in fig. 6(B), where $v_1$ and $v_2$ are represented by directed line segments. The velocity increment $\delta v$ must be added to the vector $v_1$ to reach $v_2$. Since $v_1$ and $v_2$ have equal magnitude the direction of $\delta v$ (in passing to the limit as $\delta\theta$ approaches zero) will approach that of a radius directed toward the centre of the circle. Since the triangles in fig. 6(A) and (B) are similar

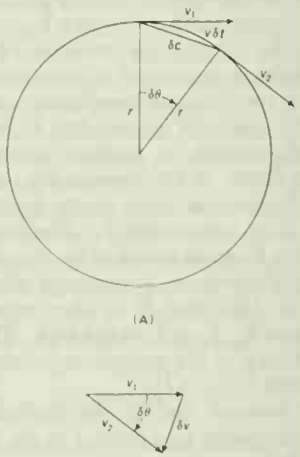

FIG. 6

$$\frac{\delta v}{s} = \frac{\delta c}{r}$$

the magnitude of the average acceleration during $\delta t$ is

$$\frac{\delta v}{\delta t} = \frac{s\delta c}{r\delta t} = \frac{s^2}{r}\frac{\delta c}{v\delta t}$$

The instantaneous acceleration is therefore

$$a = \lim_{\delta t \to 0} \frac{\delta v}{\delta t} = \frac{s^2}{r} \lim_{\delta t \to 0} \frac{\delta c}{v\delta t} = \frac{s^2}{r} \tag{6}$$

and is directed toward the centre of the circle.

## VI. NEWTON'S LAWS

**1. Mathematical Formulation.**—Newton's laws of motion (stated verbally earlier) can now be formulated mathematically. The second law is

$$f = ma \tag{7}$$

where $m$ is the mass of a particle, $f$ is the force acting on it and $a$ is its acceleration. Acceleration is a vector, mass is a scalar, and the product $ma$ is interpreted as a vector quantity in the same direction as $a$ and of magnitude $m$ times the magnitude of $a$. Equation (7) then implies that the force $f$ is a vector in the same direction and of the same magnitude as $ma$. This may also be expressed by writing the equation in terms of components along a suitable system of axes OX, OY, OZ:

$$\begin{aligned} f_x &= ma_x \\ f_y &= ma_y \\ f_z &= ma_z \end{aligned} \qquad (8)$$

In the case of a particle confined to a line (or plane) only one (or two) of these component equations is relevant.

For a particle that is acted on by no force, set $f = 0$ in equation (7); this implies that $a = 0$. With acceleration defined as the rate of change of velocity, zero acceleration implies constant velocity (magnitude and direction). Hence Newton's first law follows from his second as expressed in equation (7).

If the force components are known as functions of the time $t$, and perhaps also of the co-ordinates $x, y, z$ and of the velocity components, then equations (8) become three second-order differential equations to be solved for $x(t)$, $y(t)$, $z(t)$ (so called because the acceleration components are the second derivatives of the co-ordinates). Given $x, y, z$ and $v_x, v_y, v_z$ at an instant $t$, equations (8) determine the acceleration. If position, velocity and acceleration are known at $t$, the change in position and velocity during a brief interval $\delta t$ can be computed approximately by multiplying $\delta t$ by their rates of change; it is thus plausible that equations (8) permit the motion to be traced from a given position and velocity at some instant. This is indeed the case and a corresponding mathematical theorem can be proved.

If a particle interacts with one or more bodies, perhaps in several ways (*e.g.*, electrically and gravitationally), it may undergo several forces at once. If any force $f$ were acting alone, it would produce an acceleration given by equation (7). Since accelerations are combined by vector addition, the equation implies that the forces are to be combined in the same way to specify the total force $f$ related to the total acceleration $a$. (The system of triangles or parallelograms representing the addition of the various accelerations $a$ can equally well represent the composition of the various vectors $f$ if the scale of the diagram is simply changed by the factor $m$.)

For two or more interacting particles equation (7) is to be written separately for each particle. If any force $f$ exerted by a particle A on a particle B appears in the equation of motion for B, then Newton's third law implies that a corresponding force $-f$ exerted by B on A must appear in A's equation of motion. Here $f$ is a vector; $-f$ means a vector of equal magnitude but oppositely directed.

**2. Units of Measurement.**—Thus far little has been said about the units in which such quantities as $f$ and $a$ are to be measured. When an unfamiliar quantity appears in an equation, the unit in which it is to be measured may be determined from the equation if units for all other quantities in the equation have been defined. All equations of quantities with previously defined units can be checked for dimensional consistency in the same way.

The fundamental units of length and time may be chosen arbitrarily. Equation (1) then implies that a particle has unit velocity when it moves a unit of distance in unit time. If the foot and the second are selected as units of distance and time, the unit of velocity is the foot per second (ft./sec.); and equation (2) implies that the unit of acceleration is the foot per second, per second (ft./sec.$^2$). Equations (3) to (6) will be found consistent with these units.

Equation (7) contains two more quantities ($f$ and $m$); the unit for one of these may be chosen arbitrarily (if no other equation is known that requires consistency). Usually the unit of mass is chosen; then equation (7) implies that the unit force is one that will impart unit acceleration to a unit mass. If the unit of mass is the pound, as in the foot-pound-second (F.P.S.) system, the unit of force is the pound-foot per second per second (lb.-ft./sec.$^2$), also called the poundal.

Many systems of units are used in different countries and situations. The accompanying table shows the names given to units for mechanical quantities under three systems in common use (*see* PHYSICAL UNITS).

| System of Units | Length | Mass | Time | Force |
|---|---|---|---|---|
| F.P.S. | foot | pound | second | poundal |
| C.G.S. | centimetre | gram | second | dyne |
| M.K.S. | metre | kilogram | second | newton |

It is common, particularly in engineering practice, to use a unit of force known as the pound weight or pound force or (rather confusingly) simply the pound. A force of 1 lb. weight is exerted on a mass of 1 lb. by earth's gravitation and is found to be 32.174 poundals when measured at the National Physical laboratory, Teddington, Eng. When exerted on a mass of 1 lb., a force of 1 lb. weight thus produces an acceleration of 32.174 ft./sec.$^2$ If a unit of mass equal to 32.174 lb. is used, it will acquire an acceleration of 1 ft./sec.$^2$ when acted on by a force of 1 lb. weight. This system of units is frequently used by engineers, the unit of mass being called the slug.

## VII. STATICS OF A PARTICLE

Statics refers to the conditions under which a body will remain at rest, the size of the body being of no consequence. While the statics of a particle is of somewhat limited technical importance, it is a significant exercise in the logic of classical mechanics.

**1. The Composition of Forces.**—By Newton's first law the condition under which a particle will remain at rest is that no force shall act on it. This condition is met when the simultaneous action of several forces on a particle produces a sum (or resultant) of zero.

The sum of the forces that act on a particle are found by repeated application of the rule for vector addition illustrated in fig. 3. Suppose one of the forces is represented by the line $AF_1$ in fig. 7, and a second force by $F_1$ $R_1$. Then their vector sum (resultant) is represented by the line $AR_1$, to which may be added a third force represented by $R_1$ $R_2$.

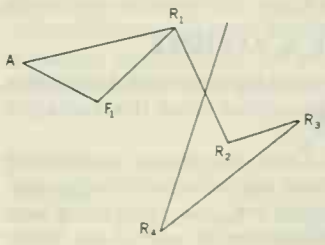

FIG. 7

This process may be repeated for other forces; the successive resultants would be given by lines connecting $AR_1$, $AR_2$, $AR_3$, . . . . (The figure need not lie in a plane.) The condition of equilibrium is that the sum of the forces shall vanish so that the last point found in this way coincides with A. Thus, if $AF_1$, $F_1R_1$, $R_1R_2$, $R_2R_3$, . . . were drawn to represent forces acting to produce a zero resultant they would form the sides of a closed polygon. This is called the polygon of forces; there is no necessity to follow any particular order in taking the component forces.

**2. Analytical Composition of Forces.**—In practice it is often convenient to use an algebraic rather than graphic method of adding forces, particularly when the polygon of forces is not confined to a plane. For this purpose, a rectangular system of axes OXYZ is chosen, and each force is represented by its three components along these axes. Fig. 8 shows the components $(f_1)_x$, $(f_1)_y$, $(f_1)_z$ of a force represented by the line $AF_1$. Note that a given component, say $(f_1)_x$, is to be taken as a number equal in magnitude to the projection of the line $AF_1$ on the corresponding axis, and positive or negative according to whether the projection of point $F_1$ lies

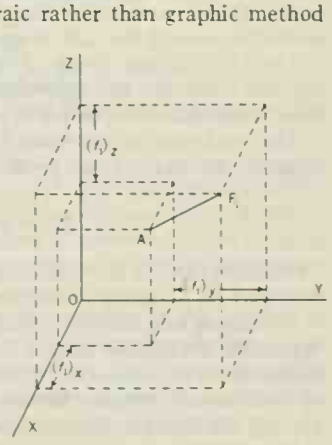

FIG. 8

farther from or closer to the origin than the projection of the point A. The component $(f_1)_x$ is given by the product of the length of $AF_1$ and the cosine of the angle between $AF_1$ and a line through A parallel to the axis OX.

The components of the resultant zero force are the sums of the components of the individual forces, as noted earlier, so that the condition of equilibrium may be stated in the form

$$\begin{aligned}(f_1)_x + (f_2)_x + (f_3)_x + \cdots + (f_n)_x &= 0\\ (f_1)_y + (f_2)_y + (f_3)_y + \cdots + (f_n)_y &= 0\\ (f_1)_z + (f_2)_z + (f_3)_z + \cdots + (f_n)_z &= 0\end{aligned} \tag{9}$$

**3. Equilibrium of a Particle Under Constraint.**—In problems involving the statics of a particle, it is common for the body to be constrained in some way. If it lies on a horizontal table, for instance, the possibility of movement downward is precluded. The forces exerted on the particle by constraints of this sort must be included in determining the state of equilibrium. Thus it is commonly necessary to know the postulated properties of the constraint.

By a smooth constraint is meant a surface (or, possibly, a curve) that can only exert a force normal to itself at the position of the particle. In practice, the force will usually be oblique to the surface but it can be resolved into one component normal to the surface and one that is tangential to it. The latter is termed the force of friction.

An empirical law often attributed to C. A. de Coulomb (1781) but known to Leonardo da Vinci (1452–1519) and rediscovered by G. Amontons (1699) (*qq.v.*) is usually assumed to govern the magnitude of a force of friction. The law states that equilibrium can be maintained at a constraining surface if the magnitude of the force of friction $F$ needed for equilibrium is not greater than a certain number $\mu$ (the coefficient of friction) multiplied by the normal component of force $N$. In symbols the law is given as

$$F \not> \mu N \tag{10}$$

## VIII. KINETICS OF A PARTICLE

Having noted the particular case in which both sides of equation (7) are zero, now consider the wider subject when this limitation is removed.

**1. Impulse and Momentum.**—Linear momentum was defined earlier as $mv$, the product of the mass and velocity of a particle. It is a vector quantity with components $mv_x$, $mv_y$, $mv_z$ along axes OX, OY, OZ. When the term momentum is used alone, linear momentum is always understood.

Consider the motion of a particle along a straight line represented by axis OX. The first of equations (8) will govern the motion; the second and third imply that the force components $f_y$ and $f_z$ are zero. Since $m$ is constant, the equation may be rewritten in the form

$$f_x = \frac{d}{dt}(mv_x)$$

In words, the force is equal to the time rate of change of momentum. This is essentially the form in which Newton originally stated his second law. It is equivalent to the form of equations (7) or (8). In the theory of relativity, $m$ is no longer constant, the two forms are not equivalent, and it is the rate of change of momentum that must be taken equal to the force.

The total effect of the force $f_x$ during a time interval $t_B - t_A$ is found by integrating this result to give

$$\int_{t_A}^{t_B} f_x dt = (mv_x)_B - (mv_x)_A \tag{11}$$

The integral on the left side of equation (11) is called the impulse delivered by $f_x$ during the interval $t_B - t_A$.

In the case of a particle moving in space, the same mathematical operations are applied to each equation (8) to obtain three results analogous to equation (11) which state that the three components of the (vector) impulse delivered by the force during the interval $t_B - t_A$ are equal to the corresponding components of the change in momentum.

**2. Angular Momentum (Moment of Momentum).**—An important concept in mechanics is that of angular momentum, also called moment of momentum. Let the resultant velocity of a particle moving along a path AB be $v$, such that two of its components $v_x$ and $v_y$ may be compounded to give the velocity $q$ in the plane OXY (fig. 9). Consider the projection of the motion of the particle on this plane, as it would be seen by an observer looking down parallel to the axis ZO. Let the distance between the line containing the $q$ vector and the origin O be denoted by $p$. The product of the component $mq$ of the momentum and the distance $p$ is called the moment of momentum of the particle about the fixed axis OZ. By a suitable choice of axes, the line about which the moment of momentum is calculated may have any position and direction; it is only necessary that it be fixed.

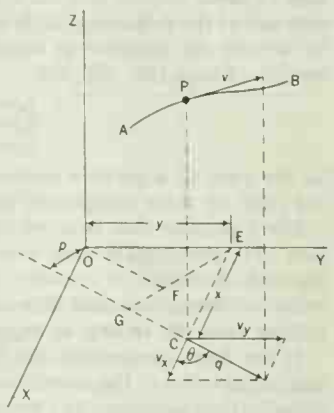

FIG. 9

From fig. 9 it may be seen that

$$\begin{aligned}m(xv_y - yv_x) &= mq(x\sin\theta - y\cos\theta)\\ &= mq(\mathrm{EG} - \mathrm{EF})\\ &= mqp\end{aligned}$$

In words, the moment of the momentum about OZ is equal to the sum of the moments about this axis of the components of momentum. The rate of change of moment of momentum is thus

$$\begin{aligned}m\frac{d}{dt}(xv_y - yv_x) &= m\left[\left(x\frac{dv_y}{dt} + v_y\frac{dx}{dt}\right) - \left(y\frac{dv_x}{dt} + v_x\frac{dy}{dt}\right)\right]\\ &= m[(xa_y + v_yv_x) - (ya_x + v_xv_y)]\\ &= m(xa_y - ya_x)\end{aligned}$$

since $m$ is a constant.

The components $a_x$ and $a_y$ of the acceleration of P are associated with components $f_x$ and $f_y$ of applied force in accordance with equations (8). Therefore the rate of change of the moment of momentum about OZ is given by

$$\frac{d}{dt}(mqp) = xf_y - yf_x \tag{12}$$

The right-hand side of equation (12) can be interpreted by analogy with the moment of momentum; the quantity $xf_y - yf_x$ is obtained if $mv_x$ and $mv_y$ are replaced by $f_x$ and $f_y$ in the expression $m(xv_y - yv_x)$. But $m(xv_y - yv_x)$ is the moment about OZ of the total momentum.

In the same way, therefore, $xf_y - yf_x$ is the moment about OZ of the total applied force. This may be visualized by thinking of the vectors of fig. 9 as representing forces instead of velocities, remembering that in general the force applied to the particle P will not be tangential to the path AB. The moment of the applied force about OZ is equal to the sum of the moments of its components about this axis by the argument applied previously to momentum.

The moment of momentum of P about OZ is shown by equation (12) to be of constant magnitude if the moment (about the same axis) of the applied force is zero. This circumstance arises if the force is itself zero, if the line of action of the force intersects the axis OZ or if the force is parallel to the axis so that $f_z$ is its only nonzero component.

**3. Work and Energy.**—The concept of momentum was seen to introduce the notion of the time effect of a force. Now to examine the space effect; by analogy with equation (11), evaluate the quantity

$$\int_{x_A}^{x_B} f_x dx$$

Start again from equations (8). Consider first the motion of a

particle in the direction of the OX axis under the influence of a force $f_x$. The acceleration is

$$a_x = \frac{dv_x}{dt} = \frac{dv_x}{dx}\frac{dx}{dt} = v_x\frac{dv_x}{dx} = \tfrac{1}{2}\frac{d(v_x^2)}{dx}$$

so that

$$f_x = \frac{m}{2}\frac{d(v_x^2)}{dx}$$

But, since $m$ is a constant, this may be written

$$f_x = \frac{d}{dx}(\tfrac{1}{2}mv_x^2)$$

so that the required integration may be performed. That is, if the particle moves from a point A for which $x = x_A$ to a point B where $x = x_B$, then

$$\int_{x_A}^{x_B} f_x dx = (\tfrac{1}{2}mv_x^2)_B - (\tfrac{1}{2}mv_x^2)_A$$

The integral in this equation (the space effect) is referred to as the work done by $f_x$ over the specified displacement $(x_B - x_A)$; it is equal to the increase of the quantity $\frac{1}{2}mv_x^2$.

The theory can be extended without difficulty to motion in three dimensions. Corresponding to this result for motion along OX, the following results may be found for motion along OY and OZ:

$$\int_{y_A}^{y_B} f_y dy = (\tfrac{1}{2}mv_y^2)_B - (\tfrac{1}{2}mv_y^2)_A$$

$$\int_{z_A}^{z_B} f_z dz = (\tfrac{1}{2}mv_z^2)_B - (\tfrac{1}{2}mv_z^2)_A$$

If $v_x$, $v_y$ and $v_z$ are the three orthogonal components of a total velocity $v$ of magnitude $s$, an application of the so-called Pythagorean theorem to the parallelepiped of vectors shows that

$$v_x^2 + v_y^2 + v_z^2 = s^2$$

It follows, by addition of the three work equations, that if a particle moves from a point A$(x_A, y_A, z_A)$ to a point B $(x_B, y_B, z_B)$

$$\int_A^B (f_x dx + f_y dy + f_z dz) = (\tfrac{1}{2}ms^2)_B - (\tfrac{1}{2}ms^2)_A \qquad (13)$$

where $\frac{1}{2}ms^2$ is called the kinetic energy.

By extending the definition of work, this term can be made to cover the integral in equation (13) so that the increase of the kinetic energy is still a measure of the work done on the particle by the applied force. The necessity for extending the definition of work arises because the general motion of a particle is such that displacement does not necessarily occur in the direction of the resultant applied force. Suppose (fig. 10) that the particle moves the short distance $\delta l$ between points 1 and 2 on its path from A to B; this portion of the path is shown in a plane chosen to contain both the short arc 1,2 and the line containing the force vector which may be supposed to emanate from the particle P and which is drawn for the instant when P is at 1. If $\delta l$ is very small, the force $f$ will remain sensibly constant in magnitude and direction during the journey from 1 to 2. If $\delta x$, $\delta y$, $\delta z$ are the projections of $\delta l$ on the axes OX, OY, OZ and $f_x$, $f_y$, $f_z$ are the corresponding components of $f$, it may be shown that

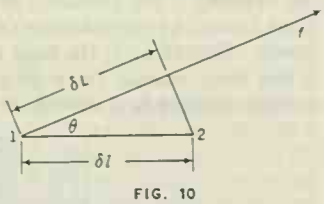

FIG. 10

$$f_x\delta x + f_y\delta y + f_z\delta z = f\delta l\cos\theta = f\delta L$$

where $\delta L$ and $\theta$ have the meanings indicated in the figure. That is, the product of the force and the resolved part of the small displacement in the direction of the force is a measure of the work done as P proceeds from 1 to 2. Now pass to the limit and sum up the small contributions to the work done, so that

$$\int_A^B f\,dL = (\tfrac{1}{2}ms^2)_B - (\tfrac{1}{2}ms^2)_A \qquad (14)$$

This integral defines the total work done during the motion of the particle from point A to point B.

**4. Planetary Motion.**—As an illustration of the foregoing principles consider a particle of small mass $m$ moving under a force arising from its gravitational interaction with a particle of large mass $M$. Particle $m$ might be a planet and $M$, the sun; or $m$ might be the moon or an artificial earth satellite and $M$, the earth. By Newton's third law the two interacting masses exert equal and opposite forces on each other, so that by equation (7) the respective accelerations are inversely proportional to the masses. Assume $M$ so large that its acceleration may be neglected. The particle $M$ is then at rest (or moving uniformly) and its position is a suitable choice for the origin O of the co-ordinate system.

The force of attraction exerted by $M$ on $m$ is given by the law of gravitation, and may be written

$$f = \frac{GMm}{r^2} \qquad (15)$$

where $r$ is the distance between the particles and $G$ is a constant of proportionality (the gravitational constant). If $M$ is the mass of the earth, the quantity $GM$ may be evaluated in terms of the radius $R$ of the earth and the acceleration $g$ (about 32 ft./sec.$^2$) of a body falling near the earth's surface. Substitution from equation (15) in equation (7) yields the equation of motion of such a falling body

$$\frac{GM\mu}{R^2} = \mu g$$

where $\mu$ is the mass of the falling body; this is readily solved for

$$GM = gR^2 \qquad (16$$

Note that it has been assumed here that the mass $M$ may be regarded as if it were concentrated at the centre of the earth. To the extent that the earth is spherical, this assumption may be proved by mathematical argument.

Consider particle $m$ to be moving in a circle about $M$. Its acceleration toward $M$ is then given by equation (6) which may be substituted, together with equation (15), in equation (7) to obtain

$$\frac{GMm}{r^2} = \frac{ms^2}{r}$$

The period $T$ required for one revolution of the particle is

$$T = \frac{2\pi r}{s}$$

so that the above equation of motion can be solved for

$$T^2 = \frac{4\pi^2}{GM}r^3$$

For the motion of a planet around the sun, this equation expresses J. Kepler's (*q.v.*) third law of planetary motion, from which the law of gravitation was originally deduced. For the moon (or any earth satellite) equation (16) may be used to get a relation between the period $T$ and the radius of the orbit:

$$T^2 = \frac{4\pi^2}{gR^2}r^3$$

This equation was tested by Newton for the case of the moon. For a low-altitude earth satellite, $r$ and $R$ are nearly equal and the equation indicates $T$ to be about 90 minutes.

It may be shown that the solution of equations (7) or (8) with the force given by equation (15) yields (besides circular orbits) orbits in the form of ellipses, hyperbolas or parabolas. A partial solution of the more general problem is presented below in order to show how the conservation of energy and of angular momentum are useful in this case.

If the axis OX passes through the position of the particle at some initial instant $t_0$, and the axis OZ is perpendicular to the initial velocity vector, then neither velocity, force nor acceleration has a component along OZ; it is evident that the last of equations (8) may be satisfied by setting $z(t) = 0$ for all time, so that the motion is confined to the XY plane.

Since the force is directed toward the origin, its moment about any axis through the origin is zero, and hence the angular momentum (in particular, about the axis OZ) is a constant of the motion

$$m(xv_y - yv_x) = L \tag{17}$$

where the constant $L$ may be found by substituting the initial values of position and velocity.

The work done by the force $f$ when the particle moves through a small displacement $\delta l$ is

$$f\delta l \cos\theta = f\delta r$$

where $\theta$ is the angle between the direction of $\delta l$ and the radius $r$ from the origin, and $\delta r$ is the change in radius. Substitute from equation (15) and calculate the work done during the interval $t_B - t_A$

$$\int_A^B f dr = \int_{r_A}^{r_B} \left(-\frac{GMm}{r^2}\right) dr = \frac{GMm}{r_A} - \frac{GMm}{r_B}$$

where the negative sign is introduced because the force is directed toward the origin and its component along the radial direction is therefore negative. If this result is used in equation (14) it is found after rearranging that

$$(\tfrac{1}{2}ms^2)_B - \frac{GMm}{r_B} = (\tfrac{1}{2}ms^2)_A - \frac{GMm}{r_A}$$

The second term in each member of this equation is called the potential energy. It is concluded that the sum of kinetic and potential energies is a constant of the motion:

$$\tfrac{1}{2}ms^2 - \frac{GMm}{r} = E \tag{18}$$

where the constant $E$ can again be found by substituting the initial values of $s$ and $r$.

Equations (17) and (18) can be used to obtain a complete solution for the orbit. Consider the problem of finding the distance of closest approach of a planet to the sun (perihelion distance) or of a satellite to the earth (perigee distance). At perihelion or perigee, the velocity is evidently perpendicular to the radius, so that the moment of the momentum is simply

$$msr = L$$

Solve for the speed $s$ and substitute in equation (18) to find the quadratic equation

$$\frac{L^2}{2m}\left(\frac{1}{r}\right)^2 - GMm\left(\frac{1}{r}\right) - E = 0$$

with the solution

$$\frac{1}{r} = \frac{GMm^2}{L^2} \pm \sqrt{\left(\frac{GMm^2}{L^2}\right)^2 + \frac{Em}{L^2}}$$

It may be noticed that the mass $m$ actually drops out of all these equations, since both $L$ and $E$ are proportional to $m$; and a knowledge of $m$ is not necessary for finding the orbit. The equations apply equally to the radius $r$ at the point of maximum distance from the origin (aphelion or apogee). If the total energy $E$ is negative, the last equation above will have two positive roots for $1/r$ which evidently correspond to perihelion (perigee) and aphelion (apogee). If $E$ is not negative, there is only one positive root, and the orbit in this case cannot be an ellipse; it must be a hyperbola or parabola, the latter corresponding to the case $E = 0$ which separates the closed orbits (ellipses) with a maximum and minimum value of radius from the open orbits with no maximum radius.

For the hyperbolic or parabolic orbits, which represent a body that escapes to infinite distance from the mass $M$, the single minimum radius is given by the positive root of the last equation. Note that a test has been derived for determining if any observed body will have an elliptical orbit or will escape from the earth or the sun; it is determined whether $E$ (calculated from equation [18]) is negative or positive.

**5. The Newtonian Principle of Relativity.**—Consider a particle moving along a fixed straight line, taken to be the axis OX. Its equation of motion is

$$f = m\frac{d^2x}{dt^2}$$

The force $f$ has only an $x$ component. Now introduce a moving origin O′, and a co-ordinate $x'$ that measures the distance from O′ to the particle $m$. If $h$ is the distance from O to O′, then

$$x = x' + h$$

Substitute into the equation of motion and rearrange terms to obtain

$$f - m\frac{d^2h}{dt^2} = m\frac{d^2x'}{dt^2} \tag{19}$$

Now if O′ is moving with constant velocity, its acceleration is zero so that the second term on the left vanishes. The equation of motion in terms of $x'$ relative to a uniformly moving origin of co-ordinates has then the same form as the equation in terms of $x$ relative to the original stationary origin O. This result is readily extended to the three-dimensional case, and to the equations of motion of a system of particles. This is the Newtonian principle of relativity in classical mechanics.

If O′ is accelerated, the second term on the left in equation (19) does not vanish; the equation then has the form of Newton's law of motion, but with an extra term added to the force. This extra term is called a fictitious force because it appears in the equation as a force, but it does not arise from the interaction of $m$ with other bodies, but rather from the motion of the co-ordinate system. Note however that (like the gravitational force) it is proportional to the mass. If rotations of the co-ordinate system also are included, other kinds of fictitious forces also appear (centrifugal and Coriolis forces; *see* FORCE). In the general theory of relativity, which treats all co-ordinate systems as equally legitimate, these forces are not fictitious, but are real forces that are part of the gravitational force. Of course, to maintain this interpretation it must be shown how to relate them to the relative positions and motions of other bodies. (The statement is sometimes put the other way around; *i.e.*, it must be shown that gravitational forces also are associated with the geometrical and kinematical properties of the co-ordinate system.)

## IX. SYSTEMS OF MORE THAN ONE PARTICLE

It is essential to be clear about the makeup of any specific system of more than one particle. For example, the system may be defined by means of a suitable bounding surface. It will be necessary to distinguish between internal forces (that arise from interactions among the system's particles) and external forces (that stem from interactions with particles [or bodies] not included in the system). The particles, with masses $m_1, m_2, \ldots$, have positions located by co-ordinates $(x_1, y_1, z_1)$, $(x_2, y_2, z_2)$, . . ., respectively. Denote by $f_1$ the total external force on particle 1, and by $f_1'$ the total internal force on particle 1, so that its equations of motion, relative to a chosen set of axes OXYZ, are

$$\begin{aligned}(f_x)_1 + (f_x')_1 &= m_1(a_x)_1\\ (f_y)_1 + (f_y')_1 &= m_1(a_y)_1\\ (f_z)_1 + (f_z')_1 &= m_1(a_z)_1\end{aligned} \tag{20}$$

Similar sets of equations may be written for the other particles.

**1. Conservation of Linear Momentum.**—For any particle of mass $m$,

$$ma_x = \frac{d}{dt}(mv_x)$$

Now add all of the equations (20) for the $x$-motion of all of the particles, and likewise for the y- and $z$-motions:

$$\begin{aligned}\Sigma\frac{d}{dt}(mv_x) &= \Sigma f_x + \Sigma f_x'\\ \Sigma\frac{d}{dt}(mv_y) &= \Sigma f_y + \Sigma f_y'\\ \Sigma\frac{d}{dt}(mv_z) &= \Sigma f_z + \Sigma f_z'\end{aligned}$$

where the symbol $\Sigma$ is to be interpreted as meaning "the sum of all terms like this, a typical one."

By Newton's third law, however, the internal forces between the particles exist in equal and opposite pairs so that the sum of their components in any direction must vanish; that is

$$\Sigma f'_x = 0; \Sigma f'_y = 0; \Sigma f'_z = 0$$

Using this result in the right members of the previous equations (and since the sum of the derivatives is the derivative of the sum), they may be rewritten as

$$\begin{aligned} \frac{d}{dt}\Sigma\, mv_x &= \Sigma f_x \\ \frac{d}{dt}\Sigma\, mv_y &= \Sigma f_y \\ \frac{d}{dt}\Sigma\, mv_z &= \Sigma f_z \end{aligned} \tag{21}$$

These equations state that the time rate of change of each component of the total linear momentum is equal to the corresponding component of the total external force.

If the total external force (or its component in any direction) is zero, then equations (21) imply that the total linear momentum (or its component in that direction) will remain constant. This is known as the principle of conservation of linear momentum. One outcome of this principle may be noted immediately. If two bodies collide, then the sum of their total momenta remains constant. This is because their interaction can only cause equal and opposite forces to act between pairs of particles. These forces, being internal to the system comprising the two bodies, can therefore produce no increment of total momentum.

**2. Conservation of Angular Momentum.**—The rate of change of the angular momentum of a particle of mass $m$ about the axis OZ is equal to the moment about that axis of the total force acting on the particle, according to equation (12), which may be written

$$\frac{d}{dt}(mxv_y - myv_x) = x(f_y + f'_y) - y(f_x + f'_x)$$

Three equations of this sort can be written for each individual particle since the same procedure may be used for axes OX or OY.

Imagine that the three equations like the last are written for each particle and that they are then added. In this way it is found that

$$\begin{aligned} \Sigma\frac{d}{dt}(mxv_y - myv_x) &= \Sigma\,(xf_y - yf_x) + \Sigma\,(xf'_y - yf'_x) \\ \Sigma\frac{d}{dt}(myv_z - mzv_y) &= \Sigma\,(yf_z - zf_y) + \Sigma\,(yf'_z - zf'_y) \\ \Sigma\frac{d}{dt}(mzv_x - mxv_z) &= \Sigma\,(zf_x - xf_z) + \Sigma\,(zf'_x - xf'_z) \end{aligned}$$

The expression

$$\Sigma\,(xf'_y - yf'_x)$$

is the sum of the moments about the axis OZ of the internal forces of the aggregate. These forces, however, occur in pairs of which the members are equal in magnitude, colinear and opposite in direction. The moment of one member of such a pair is thus equal and opposite to that of the other so that the total effect of the sum is zero. The above equations can therefore be written in the simpler form

$$\begin{aligned} \frac{d}{dt}\Sigma\, m\,(xv_y - yv_x) &= \Sigma\,(xf_y - yf_x) \\ \frac{d}{dt}\Sigma\, m\,(yv_z - zv_y) &= \Sigma\,(yf_z - zf_y) \\ \frac{d}{dt}\Sigma\, m\,(zv_x - xv_z) &= \Sigma\,(zf_x - xf_z) \end{aligned} \tag{22}$$

Equations (22) state that the rate of change of the total angular momentum about any fixed axis is equal to the sum of the moments of the external forces about that axis.

The principle of conservation of angular momentum can now be stated. If the sum of the moments of the external forces about a fixed axis is zero, then the total angular momentum of the aggregate of particles about that axis is constant.

**3. Work and Energy Relations.**—When a single particle moves from one position to another, the total work done on it is equal to its increase of kinetic energy. If that particle is one of an aggregate, the forces acting on it will in general be both external and internal. It follows from equation (13) that, for the particle,

$$\Delta(\tfrac{1}{2}mv^2) = \int(fx + f'x)dx + \int(fy + f'y)dy + \int(fz + f'z)dz$$

In words, the increase of the kinetic energy is equal to the total work of the external and internal forces during the displacements in the $x$, $y$ and $z$ directions (so that appropriate limits are implied on the integrals).

If equations such as this are now added for all the particles, it is found that

$$\begin{aligned} &\Delta\Sigma(\tfrac{1}{2}mv^2) = \\ &\Sigma\,\{\int(f_x + f'_x)dx + \int(f_y + f'_y)dy + \int(f_z + f'_z)dz\} \end{aligned} \tag{23}$$

That is, the increase in the total kinetic energy of all the particles is equal to the work done by all forces as the system moves from one configuration to another.

The notion of work done by the external forces acting on a system provides a link between mechanics and the more general subject of thermodynamics. The thermodynamic state of a body, isolated as before by a chosen boundary, is determined by the values of the properties (such as temperature) of its parts whereas its mechanical state is determined merely by the motions or configurations of its parts.

In mechanics, external forces are conceived as acting on this system (*i.e.*, on the body) which can do work; this work is done on the system and may be thought of as crossing the bounding surface. In thermodynamics (*q.v.*) heat is also conceived as being able to cross this surface.

Let the heat flow into the system be $Q$ and the work done on it by the external forces be $W$, both processes being measured over some given period. The first law of thermodynamics states (in effect) that

$$Q + W = \Delta E \tag{24}$$

where $\Delta E$ represents the gain of total internal energy of the system. This increase of $E$ may be manifested in several ways, one of which is an increase of kinetic energy. Its value will, in general, change as a result of work done against internal forces. Thus, in mechanics, it can be said that account is merely taken of $W$ on the left hand side of equation (24) and certain forms of internal energy $E$ on the right. This being so, the reservation is made that the theory may be incomplete since no account is taken of heat flows and extraneous forms of internal energy. For instance, if a piece of metal is struck repeatedly, its temperature is found to rise with the result that heat flows out of the body; under these circumstances, it is not possible to account completely, in equation (23), for all the work done by the external forces.

The concept of work done by internal and external forces is of fundamental importance in all branches of applied mechanics. An important extension of the concept is dealt with in the next section.

**4. The Centre of Mass of a System of Particles.**—Let the total mass of a system of particles

$$\Sigma m = m_1 + m_2 + \ldots$$

be denoted by $M$ and let $\bar{x}$ be defined by the equation

$$M\bar{x} = m_1x_1 + m_2x_2 + \ldots = \Sigma mx$$

In just the same way, quantities $\bar{y}$ and $\bar{z}$ can be defined, so that

$$\begin{aligned} \bar{x} &= \frac{\Sigma mx}{M} \\ \bar{y} &= \frac{\Sigma my}{M} \\ \bar{z} &= \frac{\Sigma mz}{M} \end{aligned} \tag{25}$$

If equations (25) are differentiated with respect to time, it is found that

$$M\frac{d\bar{x}}{dt} = \Sigma m\frac{dx}{dt} = \Sigma mv_x$$
$$M\frac{d\bar{y}}{dt} = \Sigma m\frac{dy}{dt} = \Sigma mv_y$$
$$M\frac{d\bar{z}}{dt} = \Sigma m\frac{dz}{dt} = \Sigma mv_z$$

That is, the total momentum of the system in any of the directions OX, OY, OZ is precisely that of a hypothetical particle of mass $M$ (the total mass) and which occupies the position defined by the co-ordinates $(\bar{x}, \bar{y}, \bar{z})$. This position is termed the centre of mass of the system. This notion of the total mass as concentrated at the centre of mass is useful in a great many applications in the engineering sciences.

Another differentiation of these equations reveals that

$$M\frac{d^2\bar{x}}{dt^2} = \Sigma m\frac{d^2x}{dt^2} = \Sigma ma_x$$
$$M\frac{d^2\bar{y}}{dt^2} = \Sigma m\frac{d^2y}{dt^2} = \Sigma ma_y$$
$$M\frac{d^2\bar{z}}{dt^2} = \Sigma m\frac{d^2z}{dt^2} = \Sigma ma_z$$

and these results permit equations (21) to be rewritten in a more compact form. To do this, let the sums of all the external forces acting on the system be denoted by

$$F_x = \Sigma f_x$$
$$F_y = \Sigma f_y$$
$$F_z = \Sigma f_z$$

It now follows that

$$F_x = M\frac{d^2\bar{x}}{dt^2}$$
$$F_y = M\frac{d^2\bar{y}}{dt^2} \qquad (26)$$
$$F_z = M\frac{d^2\bar{z}}{dt^2}$$

The idea of the mass of the system as concentrated at its centre of mass can now be taken a stage further. For equations (26) are precisely those of the hypothetical particle when it is imagined as being acted on by the resultant of all the external forces, these forces all being supposed to act in their correct directions on the hypothetical particle.

An immediate deduction can be made from this. If a system is acted on by external forces which are such that the sums of their components in the directions OX, OY, OZ are all zero, then the centre of mass of that system must either be at rest or moving with uniform velocity in accordance with Newton's first law. A special case of this arises with a system of particles that is entirely free from external forces.

Since the centre of mass is defined by the co-ordinates $\bar{x}, \bar{y}, \bar{z}$, the co-ordinates of any particle within the system can be measured relative to that point. For instance, the position of the particle $m_1$ may be specified either as $x_1, y_1, z_1$ or by the co-ordinates

$$\bar{x} + \xi_1, \bar{y} + \eta_1, \bar{z} + \zeta_1$$

That is, if a set of axes, parallel to OX, OY, OZ, were erected with the centre of mass as origin, then the corresponding co-ordinates of $m_1$ would be $\xi_1, \eta_1, \zeta_1$. From the definitions of $\bar{x}, \bar{y}, \bar{z}$ it follows that

$$\Sigma m\xi, \Sigma m\eta, \Sigma m\zeta$$

together with their derivatives, must be zero.

If $\bar{x} + \xi$, $\bar{y} + \eta$, $\bar{z} + \zeta$ are substituted for $x$, $y$, $z$ in the expressions for the moments of momentum about the fixed axes, it is found that they give

$$\Sigma m(xv_y - yv_x) =$$
$$M\left(\bar{x}\frac{d\bar{y}}{dt} - \bar{y}\frac{d\bar{x}}{dt}\right) + \Sigma m\left(\xi\frac{d\eta}{dt} - \eta\frac{d\xi}{dt}\right)$$

$$\Sigma m(yv_z - zv_y) =$$
$$M\left(\bar{y}\frac{d\bar{z}}{dt} - \bar{z}\frac{d\bar{y}}{dt}\right) + \Sigma m\left(\eta\frac{d\zeta}{dt} - \zeta\frac{d\eta}{dt}\right) \qquad (27)$$

$$\Sigma m(zv_x - xv_z) =$$
$$M\left(\bar{z}\frac{d\bar{x}}{dt} - \bar{x}\frac{d\bar{z}}{dt}\right) + \Sigma m\left(\zeta\frac{d\xi}{dt} - \xi\frac{d\zeta}{dt}\right)$$

for the axes OZ, OX, OY respectively.

Consider the first of these results. The quantity

$$M\left(\bar{x}\frac{d\bar{y}}{dt} - \bar{y}\frac{d\bar{x}}{dt}\right)$$

is the moment about OZ of the momentum of a single particle of mass equal to the total mass and which lies at the centre of mass. Again, by analogy with the expression on the left-hand side,

$$\Sigma m\left(\xi\frac{d\eta}{dt} - \eta\frac{d\xi}{dt}\right)$$

and the corresponding expressions in the latter two equations (27) are the moments of momentum calculated relative to a co-ordinate system O$\Xi$ HZ whose origin O is at the centre of mass (and moves with it) and whose axes remain parallel to the corresponding axes OXYZ. If the aggregate of particles comprises a single body (not necessarily rigid, or even solid), then the motion of the centre of mass, given by $\bar{x}(t)$, $\bar{y}(t)$, $\bar{z}(t)$ may be called the orbital motion; and the motion represented by $\xi_1, \eta_1, \zeta_1, \xi_2, \ldots$ may be referred to as the internal motion. The above argument then shows that the angular momentum can be resolved into two parts: an orbital part and a part associated with the internal motion. The internal part of the angular momentum is often called the spin.

Let the new expressions $\bar{x} + \xi$, etc., be substituted for the $x$, $y$ and $z$ co-ordinates in equations (22). If the equations are then simplified in the light of the foregoing remarks, they reduce to

$$\frac{d}{dt}\Sigma m\left(\xi\frac{d\eta}{dt} - \eta\frac{d\xi}{dt}\right) = \Sigma(\xi f_y - \eta f_x)$$
$$\frac{d}{dt}\Sigma m\left(\eta\frac{d\zeta}{dt} - \zeta\frac{d\eta}{dt}\right) = \Sigma(\eta f_z - \zeta f_y) \qquad (28)$$
$$\frac{d}{dt}\Sigma m\left(\zeta\frac{d\xi}{dt} - \xi\frac{d\zeta}{dt}\right) = \Sigma(\zeta f_x - \xi f_z)$$

These equations state that the rate of change of any component of the spin angular momentum is equal to the total moment of the external forces about the corresponding axis (through the centre of mass). In a similar way the kinetic energy of an aggregate of particles may be resolved into an orbital and an internal part. The kinetic energy of the system is

$$\Sigma\tfrac{1}{2}m\left\{\left[\frac{d}{dt}(\bar{x} + \xi)\right]^2 + \left[\frac{d}{dt}(\bar{y} + \eta)\right]^2 + \left[\frac{d}{dt}(\bar{z} + \zeta)\right]^2\right\} = T \text{ (say)}$$

If this expression is now simplified by the previous method, it is found that the kinetic energy reduces to

$$T = \tfrac{1}{2}M\left[\left(\frac{d\bar{x}}{dt}\right)^2 + \left(\frac{d\bar{y}}{dt}\right)^2 + \left(\frac{d\bar{z}}{dt}\right)^2\right]$$
$$+ \Sigma\tfrac{1}{2}m\left[\left(\frac{d\xi}{dt}\right)^2 + \left(\frac{d\eta}{dt}\right)^2 + \left(\frac{d\zeta}{dt}\right)^2\right] \qquad (29)$$

The kinetic energy of a system of particles is therefore equal to that of the hypothetical particle $M$ which is placed at the centre of mass plus the kinetic energy of the particles as it would be calculated by an observer moving with the centre of mass.

The practical significance of a centre of mass is most apparent in the theory of solid bodies. This is demonstrated in the article on dynamics and it will be found to have additional significance in the science of statics.

## X. THE PRINCIPLE OF VIRTUAL DISPLACEMENTS

In considering the mechanics of collections of particles, certain general results (such as the principle of conservation of linear momentum) furnish a basis for the study of the mechanics of various types of body. Another principle of mechanics serves the same purpose; it is that of virtual displacements. This principle is sometimes regarded as axiomatic, but it will be explained by reference to the foregoing theory.

The principle of virtual displacements is concerned essentially with systems of particles in equilibrium; that is, with statics. But this does not preclude its use in dynamics; for it is possible, by invoking D'Alembert's principle (*see* DYNAMICS), to solve dynamical problems by the methods of statics.

**1. Application to a System of Particles.**—The validity of equations (20) is not impaired if they are multiplied throughout by some numerical factor. Thus if the particle $m_1$ is in static equilibrium, they give

$$\begin{aligned} a_1[(f_x)_1 + (f'_x)_1] &= 0 \\ b_1[(f_y)_1 + (f'_y)_1] &= 0 \\ c_1[(f_z)_1 + (f'_z)_1] &= 0 \end{aligned}$$

Similar equations may be written in sets of three for each of the other particles. If these equations are added for an aggregate of particles at rest they give

$$\begin{aligned} \Sigma[a(f_x + f'_x)] &= 0 \\ \Sigma[b(f_y + f'_y)] &= 0 \\ \Sigma[c(f_z + f'_z)] &= 0 \end{aligned} \qquad (30)$$

The numbers $a, b, c$ can be regarded as components of displacement. Thus $a_1$, $b_1$ and $c_1$ can be thought of as displacements of the particle of mass $m_1$ in the directions OX, OY and OZ respectively. These displacements are not to be confused with the actual displacements of which the body is capable because the changes of the force components which usually accompany a change of position are not considered. They are therefore referred to as virtual displacements.

Equations (30) show that the total work done by external forces plus the total work done by internal forces is nil for any arbitrary virtual displacement of the constituent particles, if the system is in equilibrium. Conversely, it can be deduced that a system of particles is in equilibrium if the total work done by all external and internal forces is nil during any arbitrary virtual displacement.

It may seem unnecessarily complicated to use this last result as a criterion of equilibrium instead of the equations

$$\begin{aligned} f_x + f'_x &= 0 \\ f_y + f'_y &= 0 \\ f_z + f'_z &= 0 \end{aligned}$$

relating to each particle separately. The purpose of doing so becomes more apparent, however, if the concept of constraints is introduced. In fact, the principle of virtual displacements is one of the most powerful tools of applied mechanics, being notably useful in structural analysis.

**2. Imposition of Constraints.**—To establish, by the method of virtual displacements, that a system of discrete particles is in equilibrium it is necessary to consider a number of arbitrary displacements, the number being dependent on the number of particles. If there are $n$ particles, then $3n$ independent virtual displacements must be examined.

Normally, however, problems do not present themselves in this form because constraints exist between particles. Suppose for instance that a body may be regarded as rigid. That is, constraints are imposed on the constituent particles so as to fix their relative positions. Virtual displacements of the particles can be chosen to conform with these constraints, so that the relative positions of the particles remain unaltered. (Some writers prefer to reserve the adjective virtual for displacements of this restricted type.) But if this is the case, and there is no rotation, the work of the internal forces is zero because

$$\Sigma a f'_x = \Sigma b f'_y = \Sigma c f'_z = 0$$

The principle of virtual displacements for a single rigid body then states that the work of the external forces in a virtual displacement that does not involve rotation from a position of equilibrium must be zero.

As a simple example consider the equilibrium of a pencil (assumed rigid and resting on a horizontal table). The pencil is subject to the reaction $R$ of the table and to the attraction $W$ of the earth (its weight) and is known to be in equilibrium. If the pencil were to be pressed down onto the surface, the reactive force would increase to compensate for the added downward thrust; only a slight depression of the surface would account for a large increase of $R$.

If, in contrast, the displacement is virtual and of magnitude $a$, the forces $R$ and $W$ remain constant and the virtual work is $Wa - Ra = 0$. Since $a$ is not zero, then $W$ and $R$ are of equal magnitude in the equilibrium position.

Some idea of the importance of this principle can be seen when the methods of statics are applied to several connected bodies, as in a mechanism. The entire mechanism can be regarded as a collection of particles so that the theory of the preceding section still holds. The forces between adjoining bodies are internal to the system and, in the absence of friction, may even be such as to do no work during a virtual displacement of the whole. In this case there is no need to determine the forces between individual parts when examining the equilibrium condition of the whole mechanism by the method of virtual displacements; this would be necessary, on the other hand, if the equilibrium of the various component bodies had to be analyzed separately and then the conditions examined by which they fit together. It is usually convenient to make the virtual displacements small in problems of this sort.

## XI. PRACTICAL APPLICATION OF MECHANICS

Principles governing the motion of bodies have been deduced from Newton's laws by considering the bodies as aggregates of particles. Now suppose that, in applying the principles, bodies are treated as if they were continuous.

The ways in which the principles of mechanics can best be applied depend upon the nature of the system concerned. For instance, fluids have no characteristic shape so that the methods of fluid mechanics differ somewhat from those of solid mechanics. However, to gain some idea of how analytical mechanics is applied, consider the mechanics of solid bodies.

The assumption that bodies may be regarded as continuous leads to the concept of stress. Suppose that a body B (fig. 11) has a distribution of force (that is, of surface traction) applied to its bounding surface. Consider a small area $\delta A$ of this surface and suppose that a resultant force $\delta F$ acts on it. In general this force will not be normal to the surface so that it can be resolved into components $\delta F_n$ and $\delta F_t$ which are normal and tangential to $\delta A$ respectively. The ratios

$$\frac{\delta F_n}{\delta A} \text{ and } \frac{\delta F_t}{\delta A}$$

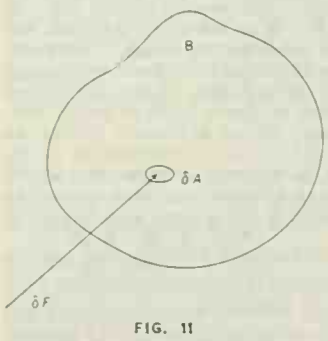

FIG. 11

are referred to as the average normal stress and average shear stress respectively at the point of the surface of B where $\delta A$ is selected. Taking $\delta A$ indefinitely small the definitions of normal stress $\sigma$ and shear stress $\tau$ are given by

$$\sigma = \lim_{\delta A \to 0}\left(\frac{\delta F_n}{\delta A}\right), \quad \tau = \lim_{\delta A \to 0}\frac{\delta F_t}{\delta A} \qquad (31)$$

The body B of fig. 11 is determined entirely by the position of the chosen bounding surface. This surface can, in fact, isolate complete components, assemblies of components, or parts of components. Thus, for example, it is possible to discuss the mechanics of a vibrating bridge composed of many members, of

a single member taken from the bridge or of a portion of the bridge that is imagined as being cut from the remainder by severing several of the members.

Imagine an actual body A to be separated into parts B and C in this way. The distribution of force acting on B at the cut must evidently be applied by C. The stresses at any point of the cut are internal to the entire system A and a knowledge of their numerical values may be of technical importance in calculations of strength. Thus it is sometimes necessary to investigate the distribution of force acting at one of these imaginary divisions. The systems B and C (which, together, form A) each must satisfy such conditions as those of equations (21) and (22), no matter where the division of A is made; these are sometimes called conditions of equilibrium.

All bodies found in nature can be distorted. To some extent, this will usually influence the conditions under which the bodies move, or remain at rest under the influence of external forces. Very often, however, the effect is small and can be disregarded, the body being considered rigid.

The assumption of rigidity in mechanics permits great simplification of the general equations that have been derived for a system of particles. In fact, the momentum equations (21) and (22), or (26) and (28), become sufficient completely to determine the motion of a rigid body. Further, the kinetic energy of a rigid body, like its momentum, is not influenced by the internal forces.

*See* also references under "Mechanics" in the Index.

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**MECHANICS, FLUID,** is the branch of engineering science dealing with the motion of fluids and the conditions governing such motion. The general term mechanics includes both kinematics and dynamics. Kinematics, which deals with the geometry of motion, is concerned with how fluids move; dynamics, with the forces involved in the motion. Sometimes a particular phase of fluid mechanics is given a particular name. The word hydraulics may refer to the study of some liquid, such as water or oil; pneumatics, to the study of compressed air; and hydrodynamics, to the purely theoretical study of some type of flow, such as that of an incompressible fluid.

FIG. 1—FORCES ACTING ON TWO PLATES JOINED BY A PIN

A fluid is a substance which cannot sustain tangential or shear forces when in static equilibrium. This property of action under shear forces distinguishes between the solid and fluid states. Fig. 1 illustrates two plates joined by a solid pin, bolt or rivet. The two parallel forces tend to slide one plate with respect to the other; these are shear forces. For small forces the solid pin or bolt sustains shear forces in static equilibrium. If a fluid such as water, oil or air were substituted for the solid pin, there would be relative motion of the plates, even for extremely small forces. The fluid could not sustain the shear forces and keep a static equilibrium. Fluids are usually divided into two subclasses: liquids and gases. A liquid occupies a definite volume independent of the dimensions of the container which holds it. A gas, however, expands to fill any container in which it is placed. In a liquid the spacing between molecules is closer than in a gas.

In many cases liquids may be regarded as incompressible. In some cases, however, the compressibility of a liquid is important and cannot be neglected. In most cases gases are regarded as compressible. In some cases the pressure change and velocity are so small that the gas may be regarded as incompressible.

It is customary in fluid mechanics to regard fluids as continuous media. Actually, gases and liquids consist of molecules and atoms. Fluid properties and actions are directly related to molecular behaviour. In most cases of flow, however, the mean free path of the molecule is small in comparison with the distances involved; thus the flow actions can be studied by reference to bulk properties.

**Historical Background.**—Edme Mariotte, a priest and one of the founders of the French Academy, by his interest in the ornamental waterworks at Versailles was stimulated to make some of the first important contributions to the study of fluid friction. His *Traité du mouvement des eaux et des autres corps fluides* appeared in 1686, one year before the publication of Isaac Newton's *Principia.* In this treatise, Mariotte dealt with the theory and practice of hydrodynamics, offering not only mathematical formulas but experimental data on such problems as the measurement of the strength of water pipes. Mariotte devised the hydrodynamic technique by which a model is held stationary in a stream of fluid and the drag is measured by a weighing instrument.

Newton, analyzing the phenomenon later known as the internal friction of fluids, used the term attrition to identify it. In *Hydrodynamics* (Dover Publications, Inc., New York, 1956), by H. L. Dryden, F. D. Murnaghan and H. L. Bateman, Bateman points out: "The use of the word attrition has now gone out of fashion in this country, and the word friction is generally used instead. The use of the word friction is, perhaps, unfortunate because, in the first place, the laws of fluid friction are quite different from those of solid friction, and secondly, because there are really two types of internal friction in a fluid, the molar and the molecular." (Molar friction is characteristic when the motion of the fluid is irregular or turbulent. Molecular friction is characteristic when the motion of the fluid is of the steady type described as streamline or laminar flow.)

Daniel Bernoulli, who made important contributions to modern hydrodynamics, constructed his theories around the concept of a continuous fluid supposedly having no viscosity. For the "ideal" fluid he established the Bernoulli equation, a mathematical interpretation of the law of the conservation of energy. The equation, published in his *Hydrodynamica* in 1738, offers a method of calculating the potential energy in motion of fluids.

The mathematical formulas of Bernoulli and others, to gauge the resistance of a theoretical ideal or perfect fluid, have been productive of results remarkably close to those observed in actual fluids under experimental conditions. In this connection, Theodore von Kármán says in *Fluid Mechanics and Statistical Methods in Engineering,* p. 26 (University of Pennsylvania Press, Philadelphia, 1941): "One of the most surprising developments in modern fluid mechanics is the successful application of the theory of potential motion of ideal incompressible fluids to the actual flow of air around airfoils and streamlined bodies. A few decades ago the potential theory was considered as a purely mathematical discussion."

The following discussion is divided into two main parts. The first section, *Basic Relations,* covers laws and features that hold in any case of flow; the second, *Applications,* deals with special

cases of flow, and shows applications of the basic relations.

*See* also AERODYNAMICS; HYDRAULICS, APPLIED.

## BASIC RELATIONS

**Definitions.**—The specific weight $w$ of a fluid is defined as weight per unit volume. Specific weight depends on the particular fluid, the pressure and the temperature. Water at 14.7 lb. per square inch absolute and 59° F. (15° C.) has a specific weight of about 62.4 lb. per cubic foot. Air at 14.7 lb. per square inch absolute and 59° F. has a specific weight of 0.0765 lb. per cubic foot.

A path line is a line made by a single particle as it moves over a period of time. The trace made by a single carbon particle as it leaves a smokestack, for example, would be a path line. A streamline is a line that gives the fluid velocity direction at each point along the line. Imagine a group of particles at an instant in a body of flowing fluid. Imagine that a straight line is drawn at each point showing the direction of the instantaneous velocity at each point. A continuous curve tangent to each of these straight lines would be a streamline. Steady flow is defined as a flow in which the velocity, pressure, specific weight and other such characteristics at a point do not change with time. Streamlines and path lines are identical in steady flow.

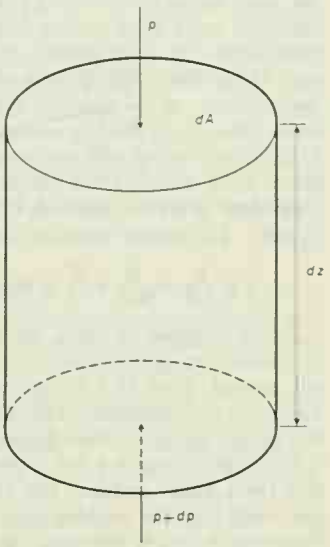


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FIG. 2.—INFINITESIMAL ELEMENT IN A STATIC FLUID

**Fluid Statics.**—Statics refers to a study of the conditions under which a body or a particle remains at rest. The state of rest may be regarded as a special case of motion. If a body or particle is at rest with a certain set of forces, the forces are said to be in equilibrium or the body is said to be in static equilibrium.

Imagine a body of any static fluid. Picture an infinitesimal element in this fluid, as illustrated by fig. 2; $dA$ is an infinitesimal area, $dz$ is a change in vertical distance $z$, with $z$ measured positively upward, $p$ is the pressure on the top surface and $p + dp$ is the pressure on the bottom surface, the pressure increase $dp$ being due solely to the fluid weight. The weight of the element is $wdzdA$. Balancing forces in a vertical direction gives

$$dpdA = -wdzdA$$

$$dp = -wdz \qquad (1)$$

The minus sign indicates that the pressure decreases with an increase in height. Equation (1) is the basic equation of fluid statics. It shows that the pressure decreases in the upward direction, the decrement per unit length being equal to the weight per unit volume. The pressure change $dp$ is zero when $dz$ is zero; the pressure is constant over any horizontal plane in a static fluid. Equation (1) can be used for any fluid and any application in statics.

**Buoyancy.**—When a body is completely or partly immersed in a static fluid, every part of the surface in contact with the fluid is pressed on by the fluid; the pressure is greater on the parts more deeply immersed. The resultant of all the forces exerted by the fluid pressure is an upward, buoyant or lift force.

The fluid pressure on each part of the surface of the body is independent of the body material. Imagine the body, or as much of it as is immersed, to be replaced by fluid of the type surrounding the body. This substituted fluid will experience the pressures that acted on the immersed body; the substituted fluid will be at rest. Therefore, the resultant upward force on the substituted fluid will equal its weight, and will act vertically through its centre of gravity.

Thus, following Archimedes' principle, a body immersed in a fluid is acted upon by a buoyant or lift force equal to the weight of the displaced fluid. This static lift force acts through the centre of buoyancy, which is the centre of gravity of the displaced volume.

There are various applications of Archimedes' principle. The volume of any solid body can be determined by measuring its apparent loss of weight when the body is completely immersed in a liquid of known specific weight. Let $W_2$ be the weight of the body in the liquid, let $W_1$ be the weight of the body in air, let $w$ be the specific weight of the liquid and $V$ the volume of the body. The buoyant force of the liquid equals $W_1 - W_2$, or $wV$. Thus the volume can be found from the relation $V = (W_1 - W_2)/w$.

Another application is the hydrometer, a convenient instrument for measuring the specific weight of a liquid. The usual hydrometer has a hollow glass chamber, weighted at the bottom, with a graduated stem at the top. When placed in liquid, the hydrometer sinks until it displaces its own weight of liquid. If the hydrometer is properly calibrated, the specific gravity of the liquid can be read directly where the stem projects through the liquid surface. The specific gravity is defined as the ratio between the specific weight of a substance divided by the specific weight of some standard substance, as water

Imagine a body at rest partly or completely immersed in a static fluid. There are two forces acting on this body; the downward force of the body weight and the upward buoyant force. The body weight acts vertically downward through the centre of gravity of the body, whereas the buoyant force acts vertically upward through the centre of buoyancy. The term static stability refers to the initial tendency of the body to move away or to return to the equilibrium condition after a disturbance.

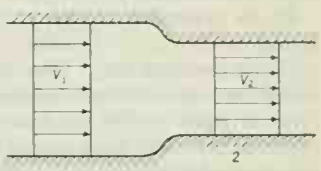


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FIG. 3.—FLOW CHANNEL

A body is statically stable when there is an initial tendency to return the body toward its equilibrium position after being slightly displaced. The equilibrium of a completely immersed body is stable when the centre of buoyancy is above the centre of gravity. If such a body is tilted, forces are developed which tend to swing the body back to its original position. Examples of such bodies are submarines and balloons.

A body is unstable if it continues moving away from the balanced state after being slightly displaced. A partly immersed body, as a marine vessel, may be unstable.

**Equation of Continuity.**—Fig. 3 illustrates the steady flow through a channel. At section 1 the area is $A_1$, the velocity at each point over the area is $V_1$ and the specific weight is $w_1$. At section 2 the area is $A_2$, the velocity at each point over the area is $V_2$ and the specific weight is $w_2$. The general physical law of the conservation of matter gives the so-called equation of continuity

$$A_1V_1w_1 = A_2V_2w_2 \qquad (2)$$

If the area $A$ is in square feet, the velocity $V$ in feet per second and the specific weight $w$ in pounds per cubic foot, then the product $AVw$ is in pounds per second; this is weight rate of flow. For steady flow, with no destruction or creation of matter, the weight rate entering must equal the weight rate leaving. For liquids and gases which can be regarded as incompressible, $w$ is constant and equation (2) takes the special form

$$A_1V_1 = A_2V_2 \qquad (3)$$

If the area $A$ is in square feet and the velocity $V$ in feet per second, then the product $AV$ is in cubic feet per second. This product is volume rate of flow.

**Dynamic or Momentum Equation.**—Let $m$ represent the mass of a body, $F$ the net or resultant of the external forces acting on a body, $V$ the instantaneous linear velocity, $t$ time and $dV/dt$ the acceleration. Then a basic relation in both solid-body and fluid mechanics is the dynamic equation

$$F = m\frac{dV}{dt} \qquad (4)$$

In one set of units, a force of one pound acting on a mass of one slug accelerates the mass one foot per second each second; this relation might be considered a definition of the unit slug. In another set of units, a force of one dyne acting on a mass of one gram accelerates the mass one centimetre per second each second. Equation (4) can be put in an alternate form. The product $mV$ is called linear momentum. Then

$$F = \frac{d}{dt}(mV) \tag{5}$$

Force equals the time rate of change in linear momentum.

Fig. 4 illustrates the steady flow of a jet or stream of fluid from a fixed nozzle. The stream strikes a fixed vane or blade and is deflected. The velocity of the fluid before striking the fixed vane is $V_1$, the velocity after leaving the vane is $V_2$. The force $F$ of the vane on the fluid is in the same direction as the vector difference $V_2 - V_1$. Let $\Delta t$ represent the time interval in which the mass $m$ has its velocity changed from $V_1$ to $V_2$. Then the dynamic equation becomes

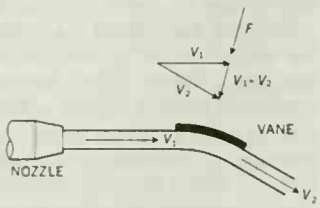

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FIG. 4.—JET AND VANE ACTION

$$F = \frac{m}{\Delta t}(V_2 - V_1) \tag{6}$$

Force equals mass rate of flow times velocity change.

In the preceding discussion the net force $F$ is an external force acting on the fluid. In some treatments it is convenient to deal with the inertia force. The inertia force refers to the resistance of an inert mass to acceleration. The magnitude of the inertia force is equal to the product of particle mass and the particle acceleration. The direction of the inertia force is opposite to the direction of the particle acceleration.

**Density.**—A body of mass $m$ has a weight of $mg$, where $g$ is the gravitational acceleration. In one set of units $g$ is usually taken as 32.2 ft. per second per second. In another set of units $g$ is usually taken as 981 cm. per second per second. Density $\rho$ is defined as mass per unit volume; $\rho$ could be expressed in slugs per cubic foot or in grams per cubic centimetre. The relation between density and specific weight $w$ is

$$\rho = \frac{w}{g} \tag{7}$$

Air at 59° F. and 14.7 lb. per square inch absolute has a density of 0.002378 slug per cubic foot.

**Energy Equation.**—The technical term "work" is defined as the product of a force times displacement, with the force acting in the direction of the displacement. Work may be expressed in such units as foot-pounds or centimetre-dynes. The energy of a body is defined as the capacity of the body for doing work. A body may have energy because of a variety of states or conditions of the body. The potential energy of a body is the energy of that body due to its position. A body of weight $W$ at a height $z$ above some arbitrary datum has potential energy equal to $Wz$ with respect to that datum. If the body were moved to a lower level, potential energy could be converted into work. Consider a body of mass $m$ moving with the velocity $V$ with respect to some reference, as the earth. This body has a certain kinetic energy; it has the capacity to do work against forces which change its motion. Application of the dynamic equation shows that the kinetic energy is $\frac{1}{2}mV^2$; if the body were brought to rest, the amount $\frac{1}{2}mV^2$ would be available for conversion to work. The internal or intrinsic energy of a substance is thermal energy stored within the substance, and is due to the spacing and activity of the molecules. Heat or heat transfer is defined as thermal energy in transition as a result of a temperature difference between two bodies. A unit of quantity of heat is the British thermal unit, B.T.U. This is defined as the heat which must be transferred to raise the temperature of one pound of water one degree Fahrenheit. Measurements indicate that 1 B.T.U. is approximately equal to 778 ft.lb.; this quantity is sometimes called the heat equivalent of work.

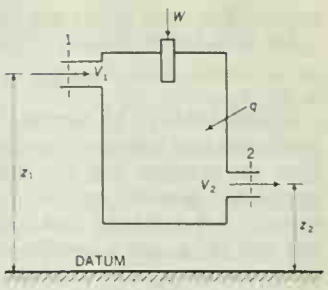

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FIG. 5.—NOTATION FOR ENERGY EQUATION

Fig. 5 shows the notation for the steady flow of any fluid through any apparatus. Fluid enters at section 1 and leaves at section 2. An energy balance will be made for unit weight of fluid passing through. An accounting of energy and work shows that the heat added to the fluid plus the total work done on the fluid must equal the total gain in energy of the fluid. Let $q$ represent the heat transfer to the fluid, $p$ the pressure, $w$ the specific weight, $W$ the net mechanical shaft work done on the fluid by external machines, $u$ the internal energy, $V$ the linear velocity at each point over a section, $z$ the elevation above some datum, $g$ the gravitational acceleration and $J$ the heat equivalent of work. Subscript 1 refers to inlet; subscript 2 refers to exit. The energy equation then becomes

$$q + \frac{p_1}{w_1 J} - \frac{p_2}{w_2 J} + \frac{W}{J} = u_2 - u_1 + \frac{V_2^2 - V_1^2}{2gJ} + \frac{z_2 - z_1}{J} \tag{8}$$

As an example of units, let us take $q$ in B.T.U. per pound, $p$ in pounds per square foot, $w$ in pounds per cubic foot, $V$ in feet per second, $g$ as 32.2 ft. per second per second and $z$ in feet. Then $J$ is approximately 778, and each term in equation (8) is in B.T.U. per pound of fluid flowing from section 1 to section 2.

Work $W$ is positive for a pump, fan or compressor and negative for a fluid turbine. The term $p_1/w_1$ is called flow work, or the work done in pushing unit weight of fluid across the inlet. The term $p_2/w_2$ is the work done in pushing unit weight of fluid across the exit.

In some cases it is convenient to regroup certain terms. The term enthalpy $h$ is defined as

$$h = u + \frac{p}{wJ}$$

Enthalpy is simply a quantity established by arbitrary definition for the sake of convenience. Equation (8) can be written in the alternate form

$$q + \frac{w}{J} = h_2 - h_1 + \frac{V_2^2 - V_1^2}{2gJ} + \frac{z_2 - z_1}{J} \tag{9}$$

In an adiabatic process no heat is added or removed from the fluid; this means that $q = 0$. Consider the special case of an adiabatic process, no shaft work, no change in internal energy and an incompressible fluid with a constant specific weight $w$. Then equation (8) can be written

$$\frac{p_2}{w} + \frac{V_2^2}{2g} + z_2 = \frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 \tag{10}$$

Equation (10) is sometimes called Bernoulli's equation.

**Viscosity or Internal Friction.**—In some cases it is permissible to assume that the fluid has no friction, or resistance to relative motion. In other cases friction must be taken into account. Consider any fluid between the two parallel plates in fig. 6. The lower plate is stationary, while the upper plate moves with the velocity $V$. A thin layer of fluid adheres to the lower plate; the velocity of this fluid layer is zero. A thin layer of fluid adheres to the upper plate; this fluid layer has the velocity $V$. $R$ is the shear force required to maintain the flow, to slide the different layers relative to each other. The force $R$ overcomes the internal fluid resistance due to the action of the molecules. In this so-called laminar flow the fluid flows in parallel layers or laminae; only the molecules cross from layer to layer of

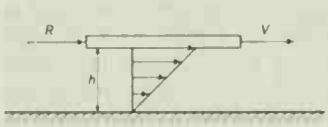

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FIG. 6.—FLOW BETWEEN PARALLEL PLATES, WITH LOWER PLATE STATIONARY

fluid. The absolute or dynamic viscosity of the fluid $\mu$ is defined as the ratio

$$\mu = \frac{\text{shear stress}}{\text{rate of shear strain}} \tag{11}$$

The shear stress is the force $R$ divided by the area of the plate in contact with the fluid. The rate of shearing strain is $V/h$, where $h$ is the distance between plates.

The units of dynamic viscosity can be determined by reference to equation (11). Dynamic viscosity can be expressed in the following units: pound-seconds per square foot; dyne-seconds per square centimetre; slugs per foot-second; and grams per centimetre-second. The poise is defined as

$$1 \text{ poise} = \frac{1 \text{ dyne-second}}{\text{square centimetre}} = \frac{1 \text{ gram}}{\text{centimetre-second}}$$

A conversion from one set of units to another is

$$1 \text{ poise} = 2.089 \times 10^{-3} \frac{\text{slug}}{\text{foot-second}}$$

Kinematic viscosity $\nu$ is the ratio of dynamic viscosity to density

$$\nu = \frac{\mu}{\rho} \tag{12}$$

Kinematic viscosity can be expressed in feet squared per second or centimetres squared per second. One centimetre squared per second is sometimes called a stoke. Table I shows some viscosity values at 59° F. and 14.7 lb. per square inch absolute.

TABLE 1.—*Some Viscosity Values*

| Fluid | Dynamic viscosity slugs/ft.sec. | Kinematic viscosity $(ft.)^2/sec.$ |
|---|---|---|
| Air | $0.0373 \times 10^{-5}$ | $1.57 \times 10^{-4}$ |
| Water | $2.391 \times 10^{-5}$ | $1.233 \times 10^{-5}$ |
| Castor oil | $3160 \times 10^{-5}$ | $1.692 \times 10^{-3}$ |

**Dimensional Analysis.**—Many flow phenomena are so complicated that a purely mathematical solution is impossible, incomplete or impractical, and it is necessary to resort to experimental measurements. Dimensional analysis (*q.v.*) and dynamic similarity are two tools which have proved very helpful in the organization, correlation and interpretation of experimental data. The present section will cover dimensional analysis; the next, dynamic similarity. Dimensional analysis is a mathematical method useful in determining a convenient arrangement of variables in a physical relation and in planning systematic experiments. The first step is to list all the variables involved. This step may be the result of experience or judgment. The actual dimensional analysis, the next step, can be made by following a formal procedure.

Let the letter $L$ represent the dimensional symbol for length, $M$ the dimensional symbol for mass, $F$ the dimensional symbol for force and $T$ the dimensional symbol for time. If length is selected arbitrarily as the primary or fundamental dimension of space, then units of area and volume can be devised as derived or secondary units. Area can be represented by the dimensional symbol $L^2$; volume can be represented by the dimensional symbol $L^3$. If time is selected arbitrarily as a primary dimension, then linear velocity can be taken as a derived or secondary unit. The dimensional symbol for linear velocity is $LT^{-1}$; in a similar fashion, the dimensional symbol for acceleration is $LT^{-2}$. The selection of force or mass as a primary dimension is solely a matter of convenience; either one could be selected. If one is selected, then the other becomes a derived or secondary dimension. Since force equals mass times acceleration, the dimensional relation between force and mass can be written as

$$F = MLT^{-2} \quad \text{or} \quad M = FT^2L^{-1}$$

This treatment will deal solely with physical equations which are dimensionally homogeneous. All the terms of a dimensionally homogeneous equation have the same dimensions. It is most convenient to have a physical equation arranged with the variables in dimensionless groups or combinations. Buckingham's $\pi$ theorem can be used to organize variables in the smallest number of significant groups. This theorem is particularly useful when the number of variables is large.

Let $A_1, A_2, A_3, \ldots A_n$ be $n$ physical quantities which are involved in some physical phenomenon. Examples of these physical quantities are pressure, velocity, viscosity and density. Let $m$ represent the number of all the primary or fundamental units (such as force, length and time) involved in this group of physical quantities. The functional relation between these quantities, or the physical equation, can be written as

$$f(A_1, A_2, A_3, \ldots A_n) = 0$$

which means that some function involving all the variables equals zero. Buckingham's $\pi$ theorem states that the foregoing relation can be written alternately as

$$\phi(\pi_1, \pi_2, \ldots \pi_{n-m}) = 0$$

where each $\pi$ is an independent dimensionless product of some of the $A$'s. The number of the terms in the physical equation has been reduced from $n$ to $n - m$. For example, if there are five variables in a case ($n$ is 5), and there are three fundamental units ($m$ is 3), the physical equation has $5 - 3 = 2$ dimensionless ratios.

As an illustration, consider a case in which there are three primary dimensions, as mass, length and time. In this case, $m = 3$, and the maximum number of independent dimensionless products can be obtained by expressing the products in the form

$$\pi_1 = A_1^{x_1} A_2^{y_1} A_3^{z_1} A_4$$
$$\pi_2 = A_1^{x_2} A_2^{y_2} A_3^{z_2} A_5$$
$$\cdots\cdots\cdots$$
$$\pi_{n-m} = A_1^{x_{n-m}} A_2^{y_{n-m}} A_3^{z_{n-m}} A_n$$

There will be $m + 1$ variables in each term; only one variable need be changed from term to term. In each product there are three unknown exponents. A consideration of the three primary dimensions, $M$, $L$ and $T$, yields three separate equations. A simultaneous solution of these three equations gives numerical values for the three exponents. For example, in the $\pi$ product, the values $x_1$, $y_1$ and $z_1$ can be determined from the following three conditions: all the length dimensions must cancel out; all the mass dimensions must cancel out; and all the time dimensions must cancel out.

**Dynamic Similarity.**—In order to obtain information about the flow around or through a structure or machine called the original or prototype, it is often convenient and economical to experiment with a copy or model of the prototype. The model may be smaller than, larger than or equal in size to the prototype. Tests with models provide an advantage in research and design which cannot be obtained from theoretical calculations alone.

The flow around the model is similar to the flow around the prototype if the model is geometrically similar to the prototype and if the streamline pattern around the model is similar to the streamline pattern around the prototype. Considering corresponding points with respect to the bodies, the velocity direction in one flow must be the same as the velocity direction in the other flow. The velocity direction at any point in a flow field is determined by the ratio of the forces acting on the fluid at a point. Therefore dynamic similarity between model flow and prototype flow is realized when the ratio of the forces acting at a point in the model flow is the same as the ratio of forces acting at a corresponding point in the prototype flow.

**Reynolds Number.**—There are various cases of flow in which three types of forces predominate: viscous (or shear force due to viscosity or internal friction of fluid); inertia; and pressure. Examples are completely enclosed flows, as in pipes, fans, pumps and turbines. Further examples are flows in which bodies are fully immersed in a fluid, as vehicles, submarines, aircraft and structures. If there are only three forces involved, specifying two of the three forces automatically specifies the third force because the three forces are in equilibrium. Thus, a significant pair of forces can be taken as viscous and inertia. Similarity between model and prototype is realized if, at points similarly located with respect to the bodies, the ratios of the inertia forces to the viscous forces are the same.

The product of mass times acceleration is proportional to

$$(\text{volume})(\text{density})(\text{velocity/time})$$

Thus the inertia force is proportional to

$$\frac{l^3\rho V}{t} = l^2\rho V^2$$

where $V$ is some typical velocity (as the average velocity in a pipe or the velocity of a vehicle), $l$ is some characteristic length (as pipe diameter) and $\rho$ is density. The viscous force (*see* equation [11]) is proportional to $\mu Vl$. Then the dimensionless ratio (inertia force)/(viscous force) is proportional to

$$\frac{l^2\rho V^2}{\mu Vl} = \frac{\rho Vl}{\mu}$$

The dimensionless ratio $\rho Vl/\mu$ is commonly called the Reynolds number. If viscous, inertia and pressure forces determine the flow for a prototype, then dynamic similarity between model and prototype is realized when the Reynolds number for the model equals the Reynolds number for the prototype. The experimental data for various flows are expressed as a function of the Reynolds number.

**Froude's Number.**—There are various cases of flow which involve inertia, gravity and pressure forces. Examples are flows in open channels and the surface waves produced by a ship or seaplane hull. If there are only three forces involved, specifying two of the three forces automatically specifies the third force. A significant pair of forces can be taken as inertia and gravity. A model of a ship will produce the same shape of surface waves as the prototype ship if the ratio of inertia force to gravity force is the same at similarly located points with respect to the prototype and the model. The gravity force equals the mass times the gravitational acceleration $g$. The gravity force is proportional to $\rho gl^3$, where $l$ is some typical length, as the length of a ship. The ratio (inertia force)/(gravity force) is proportional to

$$\frac{\rho l^2 V^2}{\rho l^3 g} = \frac{V^2}{lg} = \frac{V}{\sqrt{lg}}$$

The ratio $V/\sqrt{lg}$ is frequently called Froude's number.

**Weber's Number.**—Surface tension is a molecular property of liquids which produces certain phenomena at liquid surfaces. By liquid surfaces is meant surfaces of separation, such as that between water and air. Surface tension $\sigma$ can be expressed in such units as dynes per centimetre or pounds per foot. There are various cases of flow which involve surface tension, inertia and pressure forces. Examples are the formation of drops in liquid jets and the action of bubbles rising in a liquid. A significant pair of forces can be taken as surface tension and inertia forces. The surface tension force is proportional to $\sigma l$. The ratio (inertia force)/(surface tension force) is proportional to

$$\frac{\rho l^2 V^2}{\sigma l} = \frac{\rho l V^2}{\sigma}$$

The ratio $\rho lV^2/\sigma$ or the square root of this ratio is sometimes called Weber's number.

**Other Dimensionless Numbers.**—The foregoing sections dealt with certain force ratios. Other force ratios could be devised, depending on the forces determining the particular flow.

**Laminar and Turbulent Flow.**—There are two different types of flow—laminar and turbulent. In laminar flow the fluid moves in laminae, or layers. In turbulent flow secondary irregular motions and velocity fluctuations are superimposed on the main or average flow. A common occurrence showing these types of flow is found in the rising column of smoke from a cigarette or cigar lying on an ash tray in a quiet room. For some distance the smoke rises in smooth filaments which may weave around but do not lose their identity; this flow is laminar. The filaments suddenly break up into a confused eddying motion at some distance above the cigarette; this flow is turbulent. The transition between laminar and turbulent flow moves closer to the cigarette when the air in the room is disturbed.

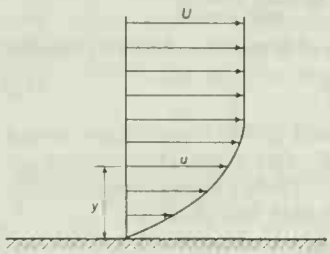
Imagine a fluid along a fixed surface or solid boundary, as shown in fig. 7. There is a thin layer of fluid which adheres to the surface and thus has zero velocity with respect to the fixed surface. At some distance away from the plate, in the $y$-direction, the fluid has the constant velocity $U$. There is a region, normal to the wall, in which there is a velocity variation from $u = 0$ to $u = U$. This region is called the boundary layer.

Consider the state of flow at a distance from the wall, in the boundary layer, where the indicated velocity is $u$. If the flow is laminar the shear stress $T$ is given by the expression

$$T = \mu \frac{du}{dy}$$

where $du/dy$ is the velocity gradient, or change in $u$ with respect to $y$. This shear is due only to molecular action; there is no transfer of fluid masses between adjacent layers.

If the flow is turbulent, however, there is molecular friction plus an additional interaction due to the momentum transfer of fluid masses between adjacent layers. The term turbulence implies irregular fluctuations, not a regular motion. For the case shown in fig. 7, if the flow were turbulent, $u$ would be the average or mean velocity at a point; velocity fluctuations would be superimposed on this mean velocity.



BY COURTESY OF R. C. BINDER

FIG. 7.—BOUNDARY LAYER

The exact nature of the mechanism of turbulent flow has not been completely established. Some concepts have been established, however, which provide some guide in studying turbulent flow.

For turbulent flow the total shear stress $T$ can be written as

$$T = (\mu + \epsilon)\frac{du}{dy}$$

where $\epsilon$ has the dimensions of dynamic viscosity; $\epsilon$ is variously called exchange coefficient and eddy viscosity. There is also the concept of eddy stresses. Referring to fig. 7, let $u'$ represent the velocity fluctuation in the direction of the main flow, and let $v'$ be the velocity fluctuation in the $y$-direction. Then a momentum study shows that the total shear stress can be written as

$$T = \mu \frac{du}{dy} - \rho\,\overline{u'v'}$$

where the bar over $u'v'$ denotes the time mean value of the product.

Another concept is that of mixing length. For molecular motion there is defined a term, mean free path of the molecule, which means the average distance a molecule travels between collisions. Mixing length is similar to mean free path. In the turbulent exchange the fluid masses displaced perpendicularly to the direction of the mean flow carry momentum over a certain length perpendicular to the mean flow. The mixing length is defined as the average distance perpendicular to the main flow covered by the mixing particle. The total shear stress is then

$$T = \mu \frac{du}{dy} + \rho L^2 \left|\frac{du}{dy}\right| \frac{du}{dy}$$

where $\left|\frac{du}{dy}\right|$ is the absolute magnitude of the velocity gradient, and $L$ is the mixing length. The mixing length is determined indirectly from measurements of velocity distribution. The mixing length can be expressed in the form

$$L = k \left| \frac{\frac{du}{dy}}{\frac{d^2u}{dy^2}} \right|$$

where $k$ is a universal numerical constant determined experimentally, and $\frac{d^2u}{dy^2}$ is the change in $\frac{du}{dy}$ with respect to $y$.

**Momentum Study of Boundary Layer.**—Fig. 8 illustrates two-dimensional flow along a surface; in this case the flow is identical in planes parallel to the plane of the figure. Upstream from the leading edge of the plate, the uniform velocity is $U$. The

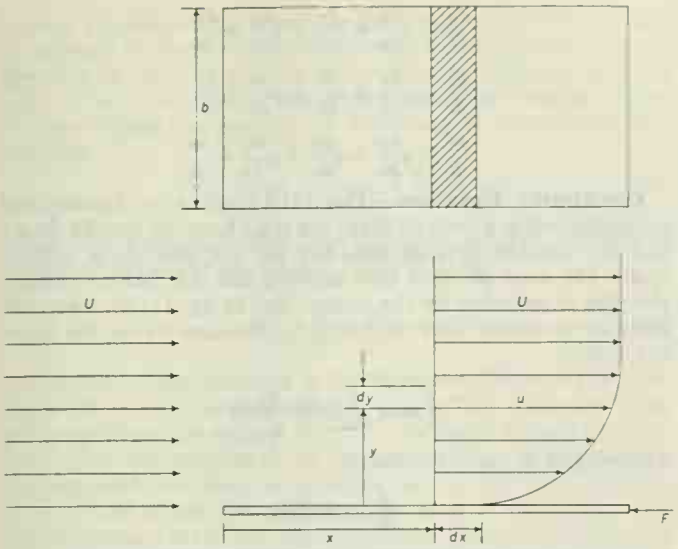


FIG. 8.—FLOW ALONG A SURFACE

indicated force $F$ parallel to $U$ is called a skin-friction force. If the fluid were frictionless, then $F$ would be zero. With real fluids, however, $F$ is definitely not zero.

Let $b$ represent the width of the plate perpendicular to the plane of flow. Picture the flow through the area $bdy$. The mass rate of flow through this area is $\rho ubdy$. Ahead of the plate the fluid velocity is $U$; at the section, a distance $x$ from the leading edge, the fluid velocity is $u$. The case will be taken in which there is no change in static pressure in the direction of flow. If $p$ is static pressure and $x$ is the distance along the plate, then the pressure gradient $dp/dx$ is zero for this case. The force $dF$ acting on the fluid equals the mass rate of flow times the velocity change, or

$$dF = \rho ubdy(U - u) \tag{13}$$

At section $x$ there is a velocity variation normal to the plate. At $x = 0$, the velocity distribution is uniform. The total force of the plate on the fluid is then

$$F = b\int_0^\infty \rho u(U - u)dy \tag{14}$$

Theoretically speaking, the integral should be taken from zero to infinity. For practical purposes, however, it is accurate enough to integrate from zero to some finite distance $\delta$; $\delta$ is so selected that the velocity defect $(U - u)$ is very small for values of $y$ greater than $\delta$. The distance $\delta$ is called the disturbance thickness of the boundary layer. It is the region in which the major part of the velocity variation occurs. Then equation (14) can be written as

$$F = b\int_0^\delta \rho u(U - u)dy \tag{15}$$

If the velocity distribution as a function of $y$ at section $x$ is known, this functional relation can be put in equation (15), the integration carried out and the friction force $F$ calculated.

**Separation.**—Let $p$ represent the static pressure at a point and let $x$ be a distance measured positive in the direction of flow. The passage between streamlines may be such that the velocity of the fluid is increased in the direction of flow and the pressure is reduced. In this case, the pressure gradient $dp/dx$ is negative. Such streamlines may be formed in the flow around a body, such as a turbine blade or some craft. Such streamlines may be formed by a solid wall, in which case the device may be called a nozzle. Nozzles are found in various applications in fluid machines, ejectors, propulsion systems, rockets and some fluid meters. For an incompressible fluid, a nozzle-type channel is formed by converging streamlines. The fluid is accelerated in the converging passage and some of the pressure energy is converted into velocity or kinetic energy. In general, this conversion is a stable process and can be made with low losses.

The passage between streamlines can be such that the velocity of fluid is decreased in the direction of flow and the pressure is increased. In this case, the pressure gradient $dp/dx$ is positive; sometimes this gradient is called adverse. Such streamlines may be found in the flow around a body, such as a compressor blade or a ship's hull. These streamlines may be formed by a solid wall; in this case, the passage may be called a diffuser. Diffusers are found in various applications, such as machines involving a pressure rise, propulsion systems, Venturi meters and piping systems. For an incompressible fluid, a diffuser-type channel is formed by diverging streamlines. Flow in a diffuser is one of the most common, most important and most troublesome problems in practice. The energy conversion in a diffuser is more difficult than the reverse conversion in a nozzle.

Fig. 9 illustrates the boundary layers at successive points along the wall in a diffuser-type channel. At section A there is a certain velocity distribution in the boundary layer. A boundary layer with flow toward the right could be maintained if all the kinetic energy were available for conversion. However, some kinetic energy is dissipated into unavailable thermal energy, with the result that the velocity in the boundary layer is less than what it would be without friction. At point B the flow velocity is reduced. At point C the velocity distribution curve is normal to the wall. Point C is the so-called point of separation. Separation of the main flow from a surface is accompanied by a reversal in direction of the flow very close to the surface behind the separation point and by the formation of a wake in which the velocity is much reduced. At D the fluid stream has separated from the wall and an eddy is formed. The formation of eddies represents further

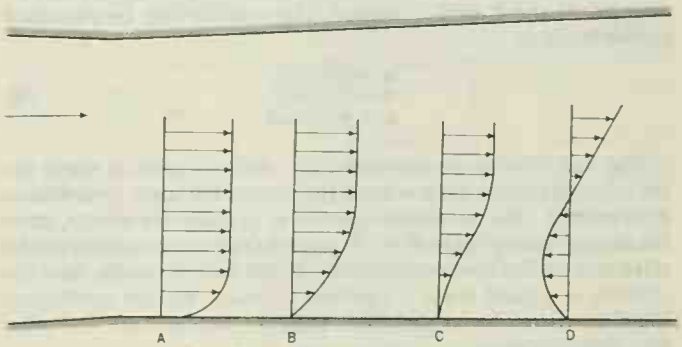


FIG. 9.—BOUNDARY LAYERS IN A DIFFUSER

dissipation of available into unavailable energy.

Thus flow in a diffuser passage may be an unstable, inefficient process, accompanied by large energy losses and appreciable eddying regions. If the streamlines around a body form a diffuser channel, there may be a marked separation and an eddying wake. For lifting vanes, such as airfoils, separation is associated with the so-called stall. The stall represents a drop in lift and an increase in resistance as compared with the case in which there is no separation and consequently no stall.

**Types of Flow.**—Picture flow along a surface, as illustrated in fig. 8. At the leading edge of the plate ($x = 0$) the boundary layer thickness is zero. At successive positions along the plate the boundary layer grows in thickness. At small values of $x$ the flow in the boundary layer is laminar. Picture the case in which there is a turbulent flow at high values of $x$. This means that there is a transition region along the plate, in which the flow changes from laminar to turbulent. There are certain characteristic flow phenomena which are found in various fluid machines, the flow around different bodies and the flow in many channels. The flow pattern may be simple or complex. A study of these characteristic phenomena is very useful in gaining a general understanding of flow. These characteristic phenomena are listed as: (1) formation of boundary layers; (2) laminar flow; (3) turbulent flow; (4) transition from laminar to turbulent flow; and (5) separation.

There are various possibilities. In some cases the entire flow around a body or through a channel may be laminar. The flow in other cases may be laminar or turbulent with a transition region. In some cases the laminar flow may separate. In still other cases the turbulent boundary layer may separate.

## FLOW IN THREE DIMENSIONS

In some cases the flow can be studied by using one-dimensional relations, such as the equation of continuity (2) and the energy equation (8). In other cases, however, it is necessary to take into account the three-dimensional aspects of the flow.

**Methods of Describing Motion.**—Two methods of describing motion have been established. The Lagrangian method (after J. L. Lagrange) gives a description of the behaviour of individual fluid particles. A description of the velocities of individual fluid particles would be an example of the Lagrangian method. Similar descriptions could be given for displacements, accelerations and other characteristics. The Eulerian method (after L. Euler) gives a description of the velocity, pressure and other characteristics at certain points or at a section in the fluid. The Eulerian method is the more familiar and common. Fig. 3 is an example of the Eulerian method. In this example, it is not known just what particles pass section 1 or section 2, but the description gives the velocity distribution at each of these sections.

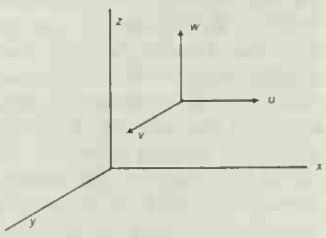


FIG. 10.—CO-ORDINATE SYSTEM

Let $x$, $y$ and $z$ represent the rectangular space co-ordinates and $t$ time. Let $V$ represent the resultant linear velocity at any point in a body of fluid, $u$ the $x$-component of the resultant velocity $V$, $v$ the $y$-component and $w$ the $z$-component. The notation is illustrated in fig. 10. As an example of the Eulerian method, the velocity can be expressed symbolically as

$$\begin{aligned} u &= f_1(x,y,z,t) \\ v &= f_2(x,y,z,t) \\ w &= f_3(x,y,z,t) \end{aligned} \tag{16}$$

The first relation in equation (16) can be stated in words as: the velocity component $u$ is some function of the space co-ordinates $x$, $y$, $z$ and $t$. For a certain value of $x$, $y$, $z$ and the time $t$, there is a corresponding value of $u$. Equation (16) is a general symbolic statement of the velocity relation. If the flow is steady, then the velocity at a point is not a function of time. Similar expressions could be written for acceleration, pressure, temperature and other flow characteristics.

**Velocity and Acceleration.**—In the most general case of fluid movement the resultant velocity $V$ is a function of both the distance $s$ along a streamline and the time $t$, that is

$$V = f(s,t) \tag{17}$$

The velocity changes from point to point in space in one instant of time, and also from moment to moment of time at any one point in space. Thus the total derivative $dV$ can be written

$$dV = \frac{\partial V}{\partial s}\,ds + \frac{\partial V}{\partial t}\,dt \tag{18}$$

Note that the partial differential quotient is taken with respect to one variable only, keeping all other variables constant. For example, $\partial V/\partial s$ is the derivative of $V$ with respect to $s$ only, with time $t$ constant.

Acceleration is defined as the time rate of change in velocity. Thus the total acceleration $dV/dt$ is

$$\frac{dV}{dt} = \frac{\partial V}{\partial s}\frac{ds}{dt} + \frac{\partial V}{\partial t} = V\frac{\partial V}{\partial s} + \frac{\partial V}{\partial t} \tag{19}$$

The term $\partial V/\partial t$ is frequently called the local acceleration and the term $V\partial V/\partial s$ is called the convective acceleration. The local acceleration represents the change in the local velocity with respect to time at a fixed point. If the flow is steady, then $\partial V/\partial t = 0$.

Velocity and acceleration are vector quantities; each has both a magnitude and a direction. In some cases, it is convenient to deal with components of the resultant vector. Differentiation of equation (16) gives the corresponding components of the resultant or total acceleration

$$\begin{aligned} \frac{du}{dt} &= u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} + \frac{\partial u}{\partial t} \\ \frac{dv}{dt} &= u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} + \frac{\partial v}{\partial t} \\ \frac{dw}{dt} &= u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} + \frac{\partial w}{\partial t} \end{aligned} \tag{20}$$

**Continuity Equation.**—Fig. 11(A) shows an infinitesimal parallelepiped in a body of fluid; the sides have the lengths $dx$, $dy$ and $dz$. Consider first the mass flow per unit time in the $x$-direction. The mass per unit time entering the left face is $\rho u dy dz$; this flow is indicated by the vector "In" in fig. 11(A). As indicated by the vector "Out" in fig. 11(A), the mass leaving the opposite face is

$$\left[\rho u + \frac{\partial}{\partial x}(\rho u)dx\right]dydz$$

The net gain in the $x$-direction is

$$\frac{\partial}{\partial x}(\rho u)dxdydz$$

Calculating in a similar manner for the other directions gives the gain

$$\left[\frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\rho w)\right]dxdydz$$

The above expression considers only a space variation. In the most general case, there is also a time variation or gain

$$\frac{\partial}{\partial t}(\rho)dxdydz$$

The mass rate of flow across the closed boundary surface from

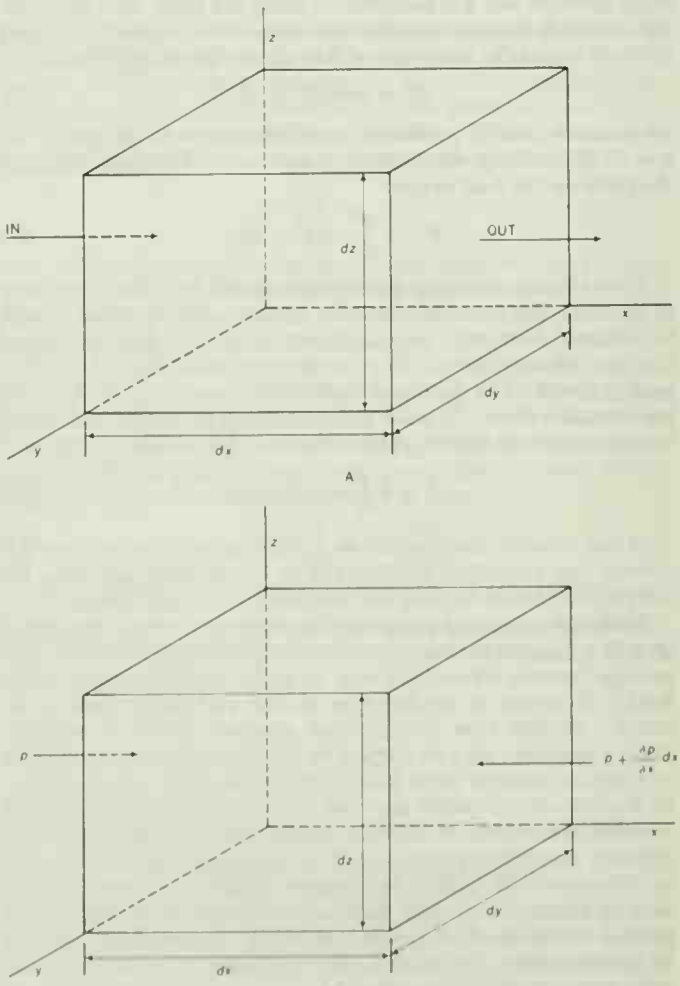


FIG. 11.—INFINITESIMAL PARALLELEPIPED OF FLUID

without to inward must equal the mass rate of flow from within to outward if there is to be no creation or destruction of mass. If inflow is taken as positive and outflow as negative, then the total or net mass rate of flow across the closed boundary must be zero. Thus the equation of continuity in three dimensions becomes

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\rho w) = 0 \qquad (21)$$

If the fluid is incompressible ($\rho$ is constant), then the equation of continuity takes the special and common form

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \qquad (22)$$

**Dynamic Equation for a Frictionless Fluid.**—The foregoing relations are purely kinematic; that is, they refer only to the geometry of motion without regard to the forces causing that motion. The next relation to be derived is simply a statement in mathematical form that the resultant force acting on a small element of fluid equals the product of the mass of the element and the acceleration involved. Note that both force and acceleration are vector quantities. The following derivation is limited to flow with no friction (this assumes that the dynamic viscosity of the fluid is zero). Fig. 11(B) shows an infinitesimal parallelepiped in a body of fluid; the sides have the lengths $dx$, $dy$ and $dz$. Imagine first the forces acting on this element in the $x$-direction. The pressure on the left face is $p$; the pressure force acting on the left face is $pdydz$. The pressure on the right face is

$$p + \frac{\partial p}{\partial x}dx$$

The pressure force on the right face is

$$\left[p + \frac{\partial p}{\partial x}dx\right]dydz$$

The net pressure force acting on the element in the positive $x$-direction is

$$-\frac{\partial p}{\partial x}dxdydz$$

Imagine that some force other than that due to static pressure is acting on the fluid; such a force might be a gravity force. The attraction of the earth is an example of a body force. A body force is proportional to the volume or mass of fluid. A pressure force is proportional to area. Let $P$, $Q$ and $R$ represent the $x$-, $y$- and $z$-components, respectively, of the body force per unit mass. Then the total force acting on the element in the positive $x$-direction is

$$\left[P\rho + \frac{\partial p}{\partial x}\right]dxdydz$$

Since force equals mass times acceleration, the dynamic relation for the $x$-direction becomes

$$\left[P\rho - \frac{\partial p}{\partial x}\right]dxdydz = \rho dxdydz\frac{du}{dt}$$
$$P\rho - \frac{\partial p}{\partial x} = \rho\frac{du}{dt} \qquad (23)$$

where $du/dt$ is the $x$-component of the total acceleration. Equations for the $y$- and $z$-directions can be derived in a similar fashion. The final set of dynamic equations for the three directions is thus

$$P\rho - \frac{\partial p}{\partial x} = \rho\frac{du}{dt}$$
$$Q\rho - \frac{\partial p}{\partial y} = \rho\frac{dv}{dt} \qquad (24)$$
$$R\rho - \frac{\partial p}{\partial z} = \rho\frac{dw}{dt}$$

The above equations are sometimes called Euler's hydrodynamic equations. The total acceleration in equation (24) can be expressed in the form given by equation (20).

**Steady Flow of a Frictionless Fluid.**—A general objective in fluid mechanics is to map out the velocity and pressure distribution in the field or region of a flowing fluid. Knowledge of the pressure distribution around a body is helpful in determining the total force of the fluid on the body. For example, in investigations of pumps, fans, compressors and turbines, the force acting between a fluid and a blade may be determined with the help of a pressure-distribution study. The velocity and pressure distributions around a body or along a channel are useful in studies of energy transfer.

Various means are used in determining the pressure distribution around a body or along a channel. One direct method is to make measurements on the actual body or channel, or the prototype. Sometimes it is more convenient to make measurements on a geometrically similar model of the body or channel. A body may be tested in a wind tunnel or a water tunnel. In each case pressure openings along a surface can be connected to suitable manometers or pressure gauges to find the pressure distribution.

In some cases it may be difficult and expensive to make an experimental investigation. The expense and difficulty of a test may not be warranted. Then there is this question: Can the velocity and pressure distribution be calculated analytically?

The general problem of fluid flow around a body or through a channel is divided into two parts. In one part is the study of the field or region of flow close to the surface (of the body or channel) in which there is a marked velocity change from zero at the surface to a velocity greater than zero at some distance from the surface; this is the region of the boundary layer. Viscosity plays a major role in boundary layer flow. In the other part is the study of the flow outside the boundary layer, in a region where the fluid is regarded as having no viscosity or internal friction. Some treatment of boundary layer flow has been given in the previous paragraphs. The following will give some treatment of frictionless flow.

Consider frictionless flow of an incompressible fluid without any body forces. Assume two-dimensional flow in the $x$-$y$ plane; this means that the flow is identical in parallel planes. The basic equations available for studying this flow are the equation of continuity and the dynamic equations. For the case under consideration, equation (21) and equation (24) reduce to

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \qquad (25)$$
$$-\frac{\partial p}{\partial x} = \rho\frac{du}{dt} \qquad (26)$$
$$-\frac{\partial p}{\partial y} = \rho\frac{du}{dt} \qquad (27)$$

The resultant velocity $V$ at any point in the fluid has the components $u$ and $v$. Multiplying both sides of equation (26) by $dx$, multiplying both sides of equation (27) by $dy$, adding the resulting equations and integrating gives the result

$$p + \tfrac{1}{2}\rho V^2 = \text{constant} \qquad (28)$$

This equation is sometimes called Bernoulli's equation. Equation (28) brings out an important feature. If the velocity at each point in the field is known, an application of equation (28) gives the pressure at each point. Thus attention is frequently focused on determining the velocity distribution in the field of flow.

**Velocity Potential and Stream Function.**—Potential functions have been established for expediting the analytical study of velocity fields. One type of function is called a velocity potential. Let $\phi$ represent velocity potential; $\phi$ is a scalar quantity which is some function of $x$ and $y$, and is defined by the relations

$$u = \frac{\partial \phi}{\partial x} \qquad v = \frac{\partial \phi}{\partial y} \qquad (29)$$

where $u$ is the $x$-component of the resultant velocity and $v$ is the $y$-component of the resultant velocity.

The feet and second units will be employed to illustrate a few examples. If the velocity potential for a certain flow is $\phi_1 = 20x$, then $u$ is 20 ft. per second ($u = \partial\phi/\partial x$). The velocity is 20 ft. per second in the $x$-direction for all points in the field of flow. If the velocity potential for another flow is $\phi_2 = 10y$, then $v$ is 10

ft. per second; the velocity at all points is 10 ft. per second in the y-direction. These two flows can be superposed or combined mathematically by simply adding the two potential functions. An algebraic addition of two potential functions is equivalent to a vector addition of velocities. The potential function $\phi = \phi_1 + \phi_2$ represents the combined flow pattern. This simple example illustrates the convenience of potential functions.

Using the equation of continuity with the velocity potential gives the relation

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0 \tag{30}$$

Equation (30) is commonly called the Laplace equation. This equation must be satisfied for all flows, in order to satisfy the equation of continuity.

The stream function $\psi$ is a scalar quantity which is a function of $x$ and $y$, and defined so that

$$u = \frac{\partial\psi}{\partial y} \qquad v = -\frac{\partial\psi}{\partial x} \tag{31}$$

For the function $\phi$ the total derivative can be written as

$$d\phi = \frac{\partial\phi}{\partial x}dx + \frac{\partial\phi}{\partial y}dy = u\,dx + v\,dy \tag{32}$$

An equipotential line is defined as a line along which the function $\phi$ is constant. Along this line $d\phi = 0$, and equation (32) gives

$$\frac{dy}{dx} = -\frac{u}{v} \tag{33}$$

Equation (33) gives the slope of the equipotential line.

For the function $\psi$ the total derivative can be written as

$$d\psi = \frac{\partial\psi}{\partial x}dx + \frac{\partial\psi}{\partial y}dy = -v\,dx + u\,dy \tag{34}$$

For a line along which the stream function is constant, $d\psi = 0$, and equation (34) gives

$$\frac{dy}{dx} = \frac{v}{u} \tag{35}$$

Equation (35) gives the slope of a curve which is tangent to the resultant velocity at a point. A line of constant $\psi$ is thus a streamline. A comparison of equations (33) and (35) shows that, at each point in the field, the equipotential line is perpendicular to the streamline.

The general problem is to map out the velocity or pressure distribution in the field or region of a flowing fluid. If the velocity at each point in the field is known, then an application of the dynamic or energy equation yields the pressure at each point. Thus, the first problem is to determine the velocity field. In order to determine the velocity field, we can start with certain elementary types of flows, as (1) a rectilinear flow in which all the streamlines are parallel; (2) a radial flow, a source or sink, in which all the streamlines are radial; and (3) a circular or vortex flow, in which all the streamlines are concentric circles. Basic relations for each of these elementary types of flow can be established. Then, using these elementary types as building blocks, various combination flows can be formed.

The velocity potential and the stream function can be determined for these types of elementary flow. Once these basic flows are established, then various combinations of flow can be determined analytically in a simple manner. For example, a source flow, a sink flow and a rectilinear flow can be combined to give the flow around a circular cylinder. This is a case of a practically important flow.

## APPLICATIONS

**Flow in a Curved Path.**—Imagine the flow between two concentric streamlines as indicated in fig. 12. The tangential linear velocity is $V$, the radius of curvature is $R$. The element has a height $dR$, and an average area $dA$ along the curved surface. The mass of the element is $\rho dRdA$; the radial acceleration is $V^2/R$. The pressure on the element varies from $p$ to $p + dp$ as the radius varies from $R$ to $R + dR$. Since force equals mass times acceleration,

$$dpdA = \rho\frac{V^2}{R}dRdA$$

$$dp = \rho\frac{V^2}{R}dR \tag{36}$$

In curved flow the pressure increases with radius.

A vortex is a flow in which the streamlines are concentric circles. There are two types of vortex motions: the forced vortex (one with a torque acting) and the free vortex (one with no torque acting).

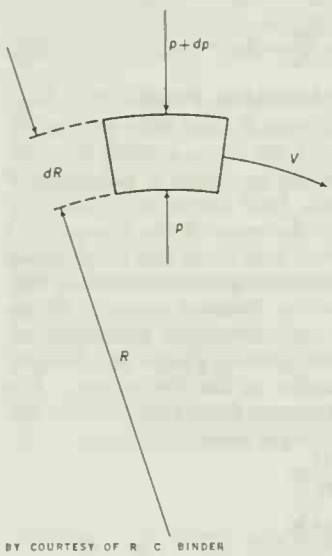


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FIG. 12.—FLOW IN A CURVED PATH

Picture a vertical cylinder containing liquid rotating about a central vertical axis. The liquid rotates like a solid body if there is no motion relative to the container; this motion can be realized with vanes in the cylinder. Such a flow is called a forced vortex; there is an external torque acting on the fluid. Let $\omega$ represent the angular speed of the vessel (in radians per unit time), and $R$ the radial distance to any point. The linear velocity $V$ at any point is given by the relation $V = R\omega$. Application of equation (36) to this type of flow shows a parabolic pressure distribution with respect to radius.

As brought out by equation (5) the force $F$ acting on a body equals the time rate of change in linear momentum

$$F = \frac{d}{dt}(mV)$$

Picture a body of mass $m$ moving at a radius $R$ about an axis of rotation, with $V$ the tangential linear velocity of the body. The foregoing momentum equation can be extended by the multiplication of each side of the equation by $R$ to give the torque $T$

$$T = FR = \frac{d}{dt}(mRV) \tag{37}$$

The product $mRV$ is called the moment of momentum or angular momentum. In words, torque equals the time rate of change in angular momentum.

Picture a frictionless fluid moving in a circular path with no torque applied. For this free vortex,

$$\frac{d}{dt}(mRV) = 0$$

Integration gives the relation $RV = K$, or

$$V = K/R \tag{38}$$

where $K$ is some constant. In a free vortex the velocity decreases as the radius increases.

A forced vortex might be found in the runner portion of a centrifugal pump. A free vortex might be found in the casing, or volute, outside the rotating impeller of a centrifugal pump.

**Incompressible Flow in Pipes.**—A wide variety of applications involves the flow of some fluid through a pipe. There are almost as many miles of pipe as there are of railroads.

For pipe flow a Reynolds number is defined as

$$N = \rho\frac{VD}{\mu} \tag{39}$$

where $\rho$ is the density of the fluid, $D$ is the inside diameter of the pipe, $\mu$ is the dynamic viscosity of the fluid and $V$ is the average velocity. Experiments show that the stable form of motion for pipe flow is normally laminar for $N$ less than 2,000. Below

$N = 2{,}000$ an initially turbulent flow, with its irregular mixing motion, cannot be maintained indefinitely. For the usual conditions, the pipe flow is turbulent for values of $N$ above about 3,000. In the transition range $N = 2{,}000$ to $N = 3{,}000$ there are various possible conditions, depending upon the initial disturbances, the pipe entrance and the pipe roughness.

Let $h$ represent the head loss in the pipe length $l$; $h$ has the dimensions of energy loss per unit weight, or the net dimension of a length; $h$ might be expressed in such units as foot-pounds energy loss per pound of fluid flowing, or $h$ might be expressed in feet of fluid flowing. It is customary to express the lost head $h$ in the form

$$h = f \frac{l}{D} \frac{V^2}{2g} \tag{40}$$

where $V$ is average velocity, $g$ is gravitational acceleration and $f$ is a dimensionless friction coefficient. The ratio $l/D$ is dimensionless. The factor $V^2/2g$ is sometimes called a velocity head; it can be expressed as foot-pounds per pound of fluid, or it can be expressed as feet of fluid.

For usual velocities, many measurements have established the fact that the friction coefficient depends only on the Reynolds number of the flow and the geometry of the inner pipe surface. For circular pipes the geometry of the conduit can be expressed in terms of a factor called the relative roughness of the pipe. Thus for circular pipes the friction factor $f$ is a function of the relative roughness and the Reynolds number.

Fig. 13 shows a plot of friction factors as a function of Reynolds numbers, using logarithmic scales. For $N$ below 2,000, for laminar flow, there is a single curve. For turbulent flow there are various curves, depending on the roughness. Each curve is for a certain relative roughness $e/D$, where $e$ is the absolute roughness (a length

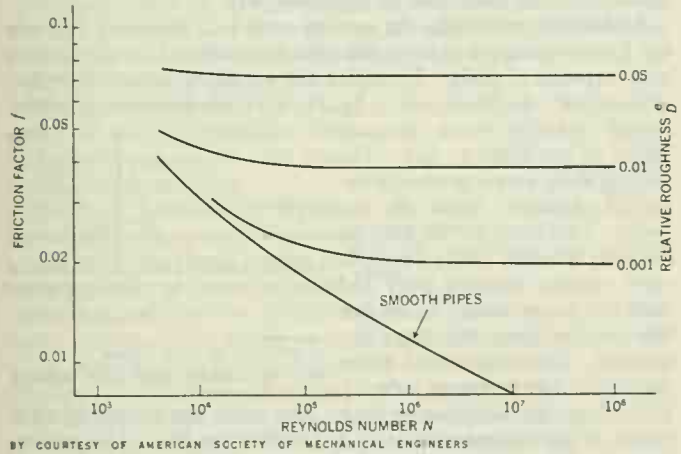


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FIG. 13.—FRICTION FACTORS FOR FLOW IN CIRCULAR PIPES

dimension) and $D$ is the inside pipe diameter; $e/D$ is a dimensionless ratio; any set of consistent units could be used. Table II gives typical roughness values.

TABLE II.—*Absolute Roughness Values for Pipes*

| Pipe | Absolute roughness $e$ (feet) |
|---|---|
| Commercial steel | 0.00015 |
| Asphalted cast iron | 0.0004 |
| Galvanized iron | 0.0005 |
| Cast iron | 0.00085 |
| Concrete | 0.001 to 0.01 |
| Riveted steel | 0.003 to 0.03 |

One common type of problem is to determine the pressure drop for a given pipe length, pipe diameter, dynamic viscosity, density and velocity. For this type of problem, the Reynolds number can be calculated, and then the friction factor determined from fig. 13. The head loss $h$ can be calculated by equation (40). The pressure drop can be found by using the energy equation (8). This equation gives, for the head loss,

$$h = \frac{p_1 - p_2}{w} + z_1 - z_2 \tag{41}$$

If the pipe is horizontal, then the pressure drop is

$$p_1 - p_2 = wh \tag{42}$$

*Laminar Flow in Circular Pipes.*—For fully developed laminar flow in circular pipes, many experiments have shown that $f = 64/N$. For this type of flow the pressure drop in a horizontal pipe of length $l$ becomes

$$p_1 - p_2 = w \frac{64}{N} \frac{l}{D} \frac{V^2}{2g} = \frac{32 \mu l V}{D^2} \tag{43}$$

Equation (43) is sometimes called the Hagen-Poiseuille law.

**Fluid Meters.**—Force, time and length are quantities which can be measured very accurately. It is good technique to refer all derived measurements, as velocity, volume rate of flow and pressure, as directly as possible to the established and easily available standards of force, length and time. For example, in order to determine the rate of flow of a liquid from a pipe or pump, high accuracy can be obtained by weighing the discharge during a measured time interval. In some cases, convenience and economy, however, may require the use of secondary instruments whose accuracy depends solely on a calibration or assumed coefficients.

The Pitot tube is a device for measuring linear velocity. As illustrated in fig. 14, $V_0$ is the velocity and $p_0$ is the static pressure some distance ahead of the simple Pitot tube. The flowing fluid is brought to rest at the nose or stagnation point of the instrument. The static fluid inside the Pitot tube can be connected to some pressure gauge, to give a measurement of the total or stagnation pressure $p_s$. Applying the energy equation for incompressible frictionless flow, equation (10), gives

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FIG. 14.—PITOT TUBE

$$\frac{p_0}{w} + \frac{V_0^2}{2g} = \frac{p_s}{w}$$

$$V_0 = \sqrt{\frac{2g(p_s - p_0)}{w}} \tag{44}$$

Thus, if we know $p_s$, $p_0$ and $w$, the velocity $V_0$ can be calculated by equation (44). Various special shapes of Pitot tubes can be constructed. Equation (44), however, is the basic relation involved.

The Venturi meter, the flow nozzle and the orifice meter are instruments used for measuring and controlling the volume rate of flow. As shown in fig. 15, the Venturi meter (named after G. B. Venturi) consists of a Venturi tube (the flow channel) and some form of pressure gauge or gauges for measuring differential pressure. The flow channel has a converging portion, a throat (section of smallest area) and a diverging portion. The converging portion serves to increase the velocity of the fluid and to reduce the static pressure. Thus a pressure difference between inlet and throat is developed; this pressure difference is correlated with the rate of flow through the meter. The diverging portion serves to lower the velocity and increase the pressure. Different proportions and different arrangements of pressure gauges are used in practice. The term "flow nozzle" usually refers to a nozzle placed in or at the end of a pipe for purposes of measuring rate of flow. Fig. 16 illustrates the flow nozzle. The flow nozzle resembles a Venturi meter without a diverging portion.

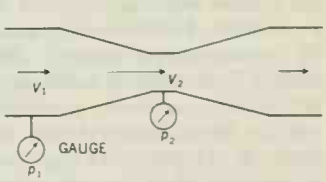


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FIG. 15.—VENTURI METER

The orifice is probably one of the oldest and most common devices for controlling and measuring the flow of fluids. Fig. 17 illustrates an orifice meter. A thin plate, with a hole in it, is mounted in a pipe. The orifice plate may be clamped between flanges. Pressure connections or pressure taps are made at holes

on both sides of the plate. The inlet edge of the orifice opening may be sharp. Different sizes of holes, different locations of pressure taps and different types of pressure gauges are used.

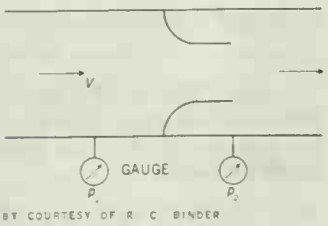

FIG. 16.—FLOW NOZZLE

The form of the basic flow equation is the same for the Venturi meter, the flow nozzle and the orifice meter. *See* fig. 15 for the notation. The area at section 1 is $A_1$, the velocity at each point over section 1 is $V_1$, the pressure at section 1 is $p_1$ and $w$ is the specific weight. Similar terms apply for section 2. For incompressible steady flow with no friction, the energy equation becomes

$$\frac{p_1}{w} + \frac{V_1^2}{2g} = \frac{p_2}{w} + \frac{V_2^2}{2g} \tag{45}$$

Using the continuity equation $A_1V_1 = A_2V_2$ with equation (45) gives the ideal volume rate of flow $Q$ with no friction loss

$$\text{ideal } Q = A_2V_2 = \frac{A_2}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}} \sqrt{\frac{2g(p_1 - p_2)}{w}} \tag{46}$$

A measurement of the pressure difference along with the areas provides a measurement of volume rate of flow. The actual volume rate $Q$ is expressed as $Q = CA_2V_2$, where $C$ is a dimensionless discharge coefficient. The best technique is to determine $C$ experimentally for each meter installation. Sometimes this is not possible, and then discharge coefficients must be assumed.

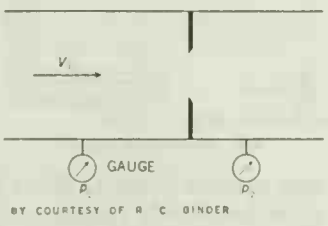

FIG. 17.—ORIFICE METER

Sometimes the volume rate is expressed in the form

$$\text{actual } Q = KA_2\sqrt{\frac{2g(p_1 - p_2)}{w}} \tag{47}$$

where $K$ is a flow coefficient

$$K = \frac{C}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}} \tag{48}$$

Discharge and flow coefficients are usually correlated with Reynolds numbers for the meter installation.

A weir is sometimes used for the measurement and control of the flow of water in an open channel, that is, a channel with the water surface open to atmospheric pressure. As indicated in fig. 18, there is a distance $H$ of the undisturbed water level above the upper edge or crest of the weir. This height $H$ is correlated with the volume rate of flow. The measurement of $H$ should be made accurately. In one method, a sharp conical point or hook is moved by a micrometer screw. The hook is first entirely submerged in the water, screwed up until it touches the surface, and then the height $H$ observed. The opening in the weir plate through which water flows may be rectangular, triangular or semicircular. The best plan is to calibrate the weir in place, under the same conditions for which it is to be used.

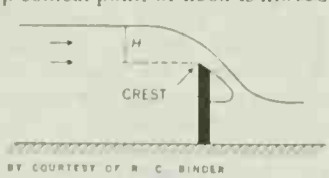

FIG. 18.—WEIR

There are various mechanical devices which consist primarily of a rotating element whose angular speed of rotation is correlated with the linear velocity of flow. Such devices can be calibrated by insertion in a stream of known velocity or by moving the device at a known speed through a body of stationary fluid. When used in air such devices are frequently called anemometers; when used in water, current meters. The rotating member may consist of a series of vanes (as in a windmill) or a series of cups mounted on a shaft held in bearings. The rotating shaft is connected to some sort of revolution counter; an observation is made of the number of revolutions during a measured time interval.

Hot-wire anemometers have been devised for measuring linear velocity and velocity fluctuations. In the hot-wire anemometer there is a wire (such as platinum) of very small diameter mounted on a probe. This probe is held in the fluid stream to be studied. An electric current is passed through the wire. The heated wire cools when exposed to the fluid flow, and its electrical resistance changes. The linear velocity of flow is correlated with electrical measurements. Since rapidly changing electrical signals can be measured, fluid velocity fluctuations can be measured.

The salt-velocity method of measuring water flow in a conduit depends on the fact that salt in solution increases the electrical conductivity of the water. Salt is introduced into the conduit at some point. Various electrodes are arranged along the conduit. The flow of the salt solution is recorded by electrical instruments, and the time for the salt solution to travel a certain distance is measured. The velocity of flow and the volume rate of flow are calculated from these data and the dimensions of the conduit.

A viscometer is an instrument for measuring the dynamic viscosity of a fluid. Probably the best method for measuring the dynamic viscosity of a fluid is the capillary-tube method. A measurement is made of the flow through a capillary or a tube of very small inside bore. If the flow is laminar, the Hagen-Poiseuille law, equation (43), can be arranged in the form

$$\mu = \frac{(p_1 - p_2)\,D^2}{32\,l\,V} \tag{49}$$

If measurements are made of the pressure drop, the inside diameter $D$, the length $l$ and the average velocity $V$, then the dynamic viscosity can be calculated by equation (49).

**Resistance or Drag.**—In various cases it is necessary to study the forces acting on a body completely immersed in a relatively large expanse of fluid. Examples are airplanes, automobiles and submarines. As illustrated in fig. 19, let $V$ be the uniform, undisturbed velocity some distance ahead of the body at rest. The flowing fluid exerts a certain resultant dynamic force on the body. This force of the fluid on the body depends only on the relative velocity between body and fluid. It is customary to resolve this resultant force into two components. One component along the line of the upstream velocity $V$ is called the resistance or drag. The other component at right angles to the upstream velocity $V$ is called the lift. This section discusses drag; the next will discuss lift. The total resistance or drag may be divided into separate contributions, as skin-friction drag and pressure drag.

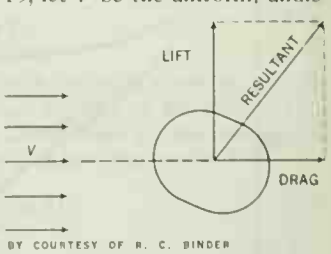

FIG. 19.—DRAG AND LIFT FORCES

Fig. 7 indicates a surface parallel to the flowing fluid. If the fluid had no viscosity or internal friction, the fluid would slip over the surface with the uniform velocity $U$; no drag would result. With real viscous fluids, on the other hand, there is a boundary layer as indicated by the velocity variation in fig. 7. Shear stresses are developed in the boundary layer because adjacent layers of fluid move with different velocities. A force is necessary to hold the surface in the stream, to overcome the skin-friction drag. Pressure drag is the contribution resulting from pressure differences over the surface of the body. The flow in front of a blunt body is different from the flow behind the body. Behind the body there may be an eddying wake with a low pressure. In front of the body the pressure may be high; this pressure difference contributes to the drag.

It is customary to express the total drag force $D$ as

$$D = C_D \frac{\rho V^2}{2} \text{ (area)} \tag{50}$$

where $C_D$ is a dimensionless ratio called the drag coefficient and $\rho$ is the density of the fluid. The product $\rho V^2/2$ is a pressure. The

area in the drag relation depends on the body under consideration. For spheres and cylinders the area may be the projected area normal to the upstream flow. In organizing data, it is customary to express the drag coefficient as a function of Reynolds number $\rho V l/\mu$ where $l$ is some characteristic length of the body. Drag coefficients can be measured by means of models in air streams and water streams.

**Dynamic Lift.**—The lift force illustrated in fig. 19 is a dynamic lift due to the flow of the fluid. Dynamic lift is different from buoyant lift. Buoyant lift is a force which can act vertically upward on a body in a stationary or static fluid; this buoyant lift equals the weight of the fluid displaced by the volume of the body.

Dynamic lift is obtained by making the flow unsymmetrical about a line parallel to the approach velocity $V$ (*see* fig. 19). An unsymmetrical flow pattern can be obtained by making the body unsymmetrical, or by tilting a plate with respect to the upstream flow. Twirling a ball causes an unsymmetrical flow because of boundary layer effects. The curve of a tennis ball, a baseball or a golf ball is a familiar example of a dynamic lift action; the spinning of the ball around an axis through the ball is necessary in order to produce the curve.

Fig. 20 shows certain conventions employed in discussing lifting vanes or sections. The geometric chord $c$ is the length of an arbitrary reference line usually established by the designer of the section. The angle $A$ between the chord and the direction of the upstream flow is called the angle of attack.

It is customary to express the lift force $L$ in the form

$$L = C_L \frac{\rho V^2}{2} (\text{area}) \tag{51}$$

where $C_L$ is a dimensionless lift coefficient. The area in equation (51) is usually taken as the projected chord area.

In many cases of lifting vanes, the lift coefficient increases, reaches a maximum and then drops as the angle of attack increases from a low value. The stall of a lifting vane is reached when the angle of attack is greater than that of the maximum lift coefficient. At the stall condition the fluid separates from the vane and forms an eddying wake.

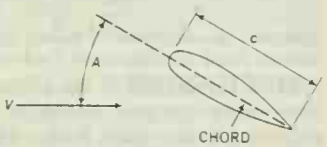


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FIG. 20.—NOTATION FOR LIFTING VANE

**Flow of Liquids in Open Channels.**—An open channel is one in which the liquid stream is not completely enclosed by solid boundaries and thus has a free surface subjected only to atmospheric pressure. The flow in an open channel depends on the slope of the liquid surface and the slope of the channel bottom. Natural streams, rivers, sewers and tunnels are examples of open channels. It is difficult to obtain reliable experimental data on the flow in open channels. Thus the treatment of open channel flow is somewhat more empirical than that of other aspects of fluid mechanics, such as that of pipe flow.

The word stage is sometimes used in place of depth; either word refers to the vertical height of liquid in a channel. Steady flow refers to flow in which the characteristics at a point do not change with time. Flow in an open channel is uniform when the depth, velocity, slope and other such features remain constant from section to section. Uniform flow should not be confused with steady flow.

The term hydraulic radius or hydraulic mean depth $R$ is defined as

$$R = \frac{\text{cross-sectional area}}{\text{wetted perimeter}}$$

The cross-sectional area is the area normal to the flowing fluid. The wetted perimeter is the length of solid boundary in contact with the fluid; the wetted perimeter does not include the distance across the free surface.

Consider steady uniform flow. Let $S$ represent the slope or the change in elevation $h$ (of either the bottom of the channel or the free liquid surface) divided by the length $l$ of the channel; $S = h/l$. Let $V$ represent fluid velocity. Then the following relation is commonly used

$$V = C\sqrt{RS} \tag{52}$$

where $C$ is a coefficient given by the relation

$$C = \frac{1.49}{n} R^{1/6} \tag{53}$$

where $n$ is a roughness factor. Some average values of $n$ are given in Table III.

TABLE III.—*Some Values of* n

| Nature of surface | $n$ |
|---|---|
| Planed wood | 0.012 |
| Brick | 0.016 |
| Gravel | 0.028 |
| Cast iron | 0.014 |

The term specific energy is used in different studies of open channel flow. Specific energy $E$ is defined as the energy per unit weight of the flowing fluid with respect to a line passing through the bottom of the channel,

$$E = y + \frac{V^2}{2g} \tag{54}$$

where $y$ is depth. The specific energy equals the sum of the depth and the velocity head.

Consider liquid at rest at a depth $y$ in a relatively shallow channel. Let $c_w$ represent the velocity of propagation of a small surface wave. This velocity is given by the relation

$$c_w = \sqrt{gy} \tag{55}$$

where $g$ is gravitational acceleration.

Next, consider flow in an open channel. So-called critical flow refers to a flow in which the liquid velocity $V$ equals the wave velocity $c_w$. If a wave were started it could not progress upstream because the two velocities are equal. In tranquil or subcritical flow, the liquid velocity is less than $c_w$. In subcritical flow the small surface waves would travel upstream. In rapid or supercritical flow the liquid velocity is greater than $c_w$. In supercritical flow small surface waves would be swept downstream. If a body, such as a boat, moves through water with a velocity greater than $c_w$, a bow wave is formed in front of the body.

Under certain circumstances the flow at a depth less than the critical may suddenly change to a flow at a certain depth greater than the critical. With this depth increase there is a corresponding velocity decrease. This phenomenon, which may take place in a relatively short distance, in which flow passes abruptly from the rapid to the tranquil state, is called the hydraulic jump. This jump may be found in the flow over rocks and other objects in streams, and in storm drains. The hydraulic jump is similar to the sudden expansion in a pipe, or a rapid increase in flow area, with a corresponding decrease in velocity.

**Cavitation.**—If a liquid flows through a stationary passage or a machine, there may be an unfavourable change in performance as operating conditions vary. There may be a dangerous erosion or pitting of metal parts, and a loss in energy. In many cases these effects have been attributed to a phenomenon called cavitation.

Cavitation refers to an alternate formation and collapse of vapour bubbles. If, at some point in the normal water flow, the fluid pressure equals the vapour pressure at the temperature of the fluid, the liquid will vaporize; a cavity or void will form. If the fluid pressure fluctuates slightly above and below the vapour pressure, there will be an alternate formation and collapse of vapour bubbles; this can pit metal parts and result in a loss in energy of the flowing fluid.

**Compressible Flow.**—Density variations may have an appreciable effect on the flow. The flow of gas through various machines, the motion of some craft at high velocities and the motion of projectiles are some examples of many in which the compressibility of the fluid exerts an influence. The specific heat of a substance is the amount of heat required to change the temperature of unit weight of the substance one degree. A parameter of importance is the ratio

$$k = \frac{\text{specific heat at constant pressure}}{\text{specific heat at constant volume}}$$

For air, carbon monoxide, hydrogen and oxygen, $k$ is about 1.4. For carbon dioxide $k$ is 1.3. If a volume of fluid $v$ under a pressure $p$ were decreased in volume by $dv$, the increase in pressure would be $dp$. The bulk modulus $E$ is defined as the ratio

$$E = -\frac{dp}{dv/v} \tag{56}$$

The negative sign in equation (56) indicates a decrease in volume for a positive increase in pressure. $E$ is about 300,000 lb. per square inch for water at ordinary conditions. For a gas following a constant-temperature or isothermal process, $E = p$, where $p$ is the particular gas pressure. For a gas following a frictionless adiabatic process, $E = kp$. In a perfectly rigid and incompressible substance an impulse is transmitted instantaneously from one element to another. In an elastic or compressible substance, however, the transmission of an impulse is retarded by the inertia of the displaced elements. In some cases the time of travel of an impulse may be short or difficult to observe if the distance of travel is short. In other cases the time of travel may be noticeable if the distance is large. Thunder, for example, is heard some time after the lightning is seen if the observer is some distance away from the storm.

The velocity of propagation of a small pressure wave or small pressure disturbance is variously called the velocity of sound, sonic velocity or acoustic velocity. This velocity $c$ is given by the expression

$$c = \sqrt{\frac{E}{\rho}} \tag{57}$$

where $E$ is the bulk modulus of the fluid, and $\rho$ is the density of the fluid. For gases, the relation becomes

$$c = \sqrt{\frac{kp}{\rho}} \tag{58}$$

For air at 14.7 lb. per square inch absolute and 59° F., $c$ is about 1,120 ft. per second. Consider the flow of some compressible fluid in which the predominating forces are inertia, pressure and elastic. A significant pair is inertia force and elastic force. The inertia force is proportional to $\rho l^2 V^2$ where $V$ is some characteristic velocity, $l$ is some characteristic length and $\rho$ is density. The elastic force is proportional to $El^2$, where $E$ is the bulk modulus. Then the ratio (inertia force)/(elastic force) is proportional to

$$\frac{\rho l^2 V^2}{El^2} = \frac{V^2}{c^2}$$

The ratio $M = V/c$ is commonly called Mach number, after E. Mach. If inertia, elastic and pressure forces determine the flow for a prototype, then the model flow is similar to the prototype flow if the model Mach number is equal to the prototype Mach number. Compressible flow data are frequently correlated as a function of Mach number.

Flow at a Mach number less than 1 is subsonic; flow at a Mach number greater than 1 is supersonic. Subsonic flow differs from supersonic flow in various respects.

Imagine a converging channel, that is, one in which the area decreases in the direction of flow. For continuous subsonic flow the velocity increases in the direction of flow, the pressure decreases in the direction of flow; the channel is called a nozzle. For continuous supersonic flow the velocity decreases in the direction of flow, the pressure rises in the direction of flow; the channel is called a diffuser.

Imagine a diverging channel, that is, one in which the area increases in the direction of flow. For continuous subsonic flow the velocity decreases in the direction of flow, the pressure rises in the direction of flow, the channel is a diffuser. For continuous supersonic flow the velocity increases in the direction of flow, the pressure decreases in the direction of flow, the channel is a nozzle.

In compressible flow there are some cases of sharp or abrupt changes in pressure. In a sound wave, for example, across the wave (in a very short distance) there is a very small change in pressure. In some cases, in a very short distance (a small fraction of an inch) there may be a very large pressure change; this pressure change may be called a compression shock or a shock wave.

Picture a craft moving steadily through air at a subsonic speed. A sound wave or a pressure signal travels ahead at sound velocity minus craft velocity with respect to the craft. A sound or pressure signal travels backward at a speed equal to the sum of craft velocity and sound velocity with respect to the craft. The distribution of sound signals is not symmetrical. Each point in the immediate vicinity of the body, however, is reached by a signal.

Picture next a craft moving through air at supersonic speed. It travels faster than the pressure signal. Thus at the nose of the craft there is a bow wave, across which there is a pressure change.

There are features associated with the propagation of a pressure wave through a compressible fluid that are similar to those involved in the travel of a slight disturbance at the free surface of a liquid. Critical flow in an open channel is analogous to sonic flow in a compressible fluid. Supercritical flow in an open channel is analogous to supersonic flow in a compressible fluid. A similar analogy holds for subcritical and subsonic flows.

The hydraulic jump in open channel flow is analogous to the compression shock in compressible flow. Before the jump the liquid moves with a high velocity at a low depth; behind the hydraulic jump the liquid moves with a low velocity at a high depth. Before the compression shock the gas moves with a high velocity at a low density (low pressure); behind the shock the gas moves with a low velocity at a high density (high pressure).

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**MECHANISM** is the general name for the view that natural phenomena can and should be explained by reference to matter and motion and their laws. Historically the term has acquired somewhat different senses in different contexts, according to the other view which it is intended to contradict. In the 17th century the "mechanical philosophy" was revived, partly under the influence of Greek atomism, as an alternative to Aristotle's qualitative physics in keeping with the newly developing science of mechanics. "Give me extension and motion and I will remake the world," Descartes wrote; "the universe is a machine in which everything happens by figure and motion"; and Robert Boyle expressed the "tenets of mechanical philosophy" as consisting in explaining physical phenomena by means of "little bodies variously figured and moved." The upholders of this philosophy were mainly concerned with the elimination from science of such notions as "substantial forms," "occult qualities," "hypostatical principles," etc., which could not be related to the new mathematical methods in use and which, so far from being explanations, were declared merely to put a stop to all further inquiry. Among the important problems to which 17th-century mechanism gave rise are those involved in the distinction made by Galileo (and by Locke) between primary and secondary qualities, in the Cartesian dualism of mind and a purely mechanical body and in the question, discussed by Boyle, whether "mechanical" could be combined with teleological explanations or with the assumption that Nature has "designs." Descartes' view of the body as a machine—and of animals as nothing but machines—had a profound effect upon the history of physiology. It was advanced in opposition to the alternative Aristotelian view of animals as organisms, and it stimulated the tendency to look for explanations of living processes in terms of physics and chemistry. Later developments in biology led to the view, taken for instance by Kant, that, while physicochemical modes of explanation must be pursued as far as possible, these were inadequate to account for the whole of the facts of life. The methods of physiology have perforce led to the pursuit of mechani-

cal explanations in this sense, but biologists since the 18th century have differed sharply in their conceptions of the ultimate nature of living things: at one extreme is the view, held for instance by Lamettrie, by Theodor Schwann, by Jacques Loeb and by some 20th-century students of biochemistry and of cybernetics that there is no aspect of living organisms that cannot be explained by the laws of inorganic nature; at the other extreme is the form of vitalism which asserts that there is in each living thing a kind of entelechy or directive vital principle. *See* also EMERGENCE.

(A. C. CE.)

**MECHELEN** (Fr. MALINES), a city in the province of Antwerp, Belg., is situated on the Dyle river, 24 km. (15 mi.) N.N.E. of Brussels on the Antwerp-Brussels railway line. Pop. (1961) 64,772.

The older part of the city, which is oval in shape, was formerly surrounded by fortifications, but these were replaced by wide boulevards, leaving only the 13th-century Brussels gate. The cathedral of St. Rombold (Rumoldus; Fr. Rombaut), standing on the north side of the market place, is a 13th- to 15th-century building with an impressive tower and a 49-bell carillon. Inside are a series of paintings illustrating the life of St. Rombold and a Crucifixion by Van Dyck. Also at the market place are the town hall by Rombaut Keldermans (1526) and two buildings which formerly served as the town hall, one, from the 13th–15th centuries, housing the post office, and the other, dating from the end of the 14th century, containing the archives. Nearby is the 14th-century cloth hall. Other notable buildings are St. John's church (15th century) with an "Adoration of the Magi" by Rubens; the early Renaissance palace built by Margaret of Austria, used since 1796 as the law courts; and Our Lady's hospital, with 16th-century fenced gardens. In the church of Our Lady Across the Dyle is Rubens' "Miraculous Draught of Fishes." The Stadsmuseum contains exhibits of paintings and sculpture, as well as local antiquities. In the diocesan museum are mementos of Désiré Cardinal Mercier, who was archbishop of Mechelen during World War I. The old manor house, De Zalm, is now a museum of handicrafts, while the Coeckelbergh convent is a folklore museum.

Mechelen was long renowned for its lace manufacture. Among its chief industries are furniture- and tapestry-making, brewing and various handicrafts. It is one of western Europe's principal vegetable markets, and there is a large state railway works. The town is well served by rail and road communications.

St. Rombold is said to have come to Mechelen in 756, but the town's importance dates from the 11th century, when it belonged to the prince-bishops of Liège. It passed to the Burgundians in the 14th century and Philip the Good made it the seat of the grand council, the supreme court of the Low Countries, in 1473. The city's period of greatest prosperity was under Margaret of Austria, regent of the Netherlands from 1507 to 1530, who held a brilliant court there. Mechelen was then capital of the Netherlands and a centre of culture. In 1559 Mechelen was made the see of the only Belgian archbishopric. The city suffered greatly during the wars of the 16th, 17th and 18th centuries and was captured several times by the Spanish, English and French. It was seriously damaged during World Wars I and II. (R. J. C. DE R.)

**MECKLENBURG,** a former *Land* of the German *Reich*, extending for about 100 mi. along the coast of the Baltic sea from the Bight of Lübeck to the isthmus of the Darss peninsula, with a hinterland stretching southward to the lower Elbe river in the west and over the sources of the Havel in the east. The *Land* had a total area of 6,069 sq.mi. before the short-lived territorial rearrangements of 1945, and it had the lowest density of population among all the German *Länder* (less than 150 per square mile in 1939). Schwerin was the capital. Mecklenburg's territory was divided in 1952 between the *Bezirke* of Rostock, Schwerin and Neubrandenburg (*qq.v.*) under the German Democratic Republic.

Most of Mecklenburg is drained into the Baltic, the Warnow being the most important of the country's own rivers; but small areas in the southwest and south belong to the Elbe system. Central Mecklenburg is traversed from west to east by a plateau of late-morainic, hilly country covered by fertile soil and beech forests and studded by more than 600 lakes, the largest lake being that of Müritz in the south (45 sq.mi.). Southwestern Mecklenburg, between the plateau and the Elbe, has poor sandy soils, pine forests and marshy valleys. In the north the plain has mainly good clay soils. Along the coast, steep cliffs alternate with beaches and dunes; and in the northeast there is a short stretch belonging to the so-called Boddenküste, where areas under seawater lie behind a chain of dunes. The economy is based on agriculture.

**History.**—Early in the 7th century A.D. the Germanic population was displaced by Slavs—the Obodrites (*q.v.*) in the west and the Lutycy (Lyutichi) or Veleti in the east. These Slavs remained pagan and independent till the 12th century, when the victory of Henry the Lion, duke of Saxony, over the Obodrite prince Niklot in 1160 brought the country into the political and cultural orbit of Germany. Christianity spread rapidly as towns and monasteries were founded and German peasants settled. Niklot's son Przybyslaw (Pribislav), having accepted Christian baptism, became a vassal of the Saxon duke in 1167 and was enfiefed with his former own lands, though Henry granted parts of the country to the newly founded bishoprics of Ratzeburg (1154; on the western frontier) and Schwerin (1160), as well as to the new countship of Schwerin. From Przybyslaw the reigning house of Mecklenburg descended.

Przybyslaw's great-grandsons, in a series of partitions effected from 1229, founded four separate hereditary lines: Mecklenburg (named after Mikilinborg, the dynastic stronghold, south of Wismar), Rostock, Güstrow (or Werle) and Parchim; but the Mecklenburg line in 1436 absorbed the whole inheritance. Mecklenburg moreover acquired the lordship of Stargard (on the Linde river to the southeast) from Brandenburg through a marriage of 1292 and the countship of Schwerin by purchase in 1358. In 1348 the German king Charles IV raised the princes of Mecklenburg to the rank of dukes in "immediate" vassalage to the emperor. A division (from 1352) between the line of Mecklenburg-Schwerin and that of Mecklenburg-Stargard ended with the latter's extinction in 1471.

The University of Rostock was founded in 1419. With the Reformation, a Lutheran church was established in 1549. Territorial divisions between Mecklenburg-Schwerin (the west) and Mecklenburg-Güstrow (the east) recurred throughout the 16th century; and the same division was again made in 1621 between the brothers Adolf Frederick I (Schwerin; d. 1658) and John Albert II (Güstrow; d. 1635). Under this arrangement, Rostock was held in common by the two duchies. In the Thirty Years' War the two dukes allied themselves with Christian IV of Denmark and were overthrown (1627) by Wallenstein, who was then enfiefed with Mecklenburg in their place; but the Swedish invasion of Germany restored them in 1631. At the peace of Westphalia (1648), Wismar, Neukloster and the island of Poel had to be ceded to Sweden, which occupied them till 1803; but Mecklenburg received in compensation the secularized bishoprics of Ratzeburg and Schwerin. The extinction of the Güstrow line reunited Mecklenburg in 1695.

For centuries the estates of Mecklenburg had resisted the dukes, and it was their opposition which prevented the development of princely absolutism in Mecklenburg. The estates, moreover, continued to meet in common even after the final splitting of the country by the treaty of Hamburg (1701). By this treaty the duchy of Mecklenburg-Schwerin had the main body of the territory, while the duchy of Mecklenburg-Strelitz was to consist of two parts, namely the lordship of Stargard, with the capital Neustrelitz, in the southeast and the principality of Ratzeburg in the northwest. During the Great Northern War, Charles Leopold, duke of Mecklenburg-Schwerin from 1713, invited Russian troops into his duchy, which was subsequently occupied by Hanoverian forces in charge of the Roman empire (1719) and administered, from 1728 to the duke's death in 1747, by an imperial commission. In 1755 Charles Leopold's successor Christian Louis II concluded an *Erbvergleich* or "hereditary compromise" with the estates, perpetuating the medieval constitution whereby the government was shared between the dukes, the landowners and the towns, without any representation of the lesser people.

Both duchies joined the Confederation of the Rhine in 1808 and were recognized as grand duchies and as members of the German confederation in 1815. On Prussia's side in the Seven Weeks' War

(1866), they subsequently joined the North German confederation. From 1871 they were member-states of the German empire. The grand dukes tried repeatedly to introduce democratic reforms, but were frustrated by the estates.

After the revolution of 1918, free states of the German *Reich* under parliamentary democracy took the place of the grand duchies, through the fundamental law of Mecklenburg-Strelitz (Jan. 29, 1919) and the constitution of Mecklenburg-Schwerin (May 17, 1920). Under the Nazi regime the two states were merged into a single *Land* Mecklenburg as from Jan. 1, 1934. At the end of World War II, Mecklenburg fell under Soviet occupation. In July 1945 the part of Hanover lying east of the Elbe (the district of Neuhaus, with 30 parishes) was transferred to Mecklenburg; on Aug. 1, 1945, Vorpommern and the island of Rügen were also added; and there were minor adjustments of the frontier with Schleswig-Holstein southeast of Lübeck. Land reforms broke up the large properties which had dominated agriculture. A self-governing autonomous *Land*, Mecklenburg (temporarily Mecklenburg-Vorpommern) became part of the German Democratic Republic in 1949 but was dissolved into *Bezirke* by the administrative reorganization of July 1952.

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**MECKLENBURG DECLARATION OF INDEPENDENCE,** the name given to certain resolutions drawn up by a committee of American patriots in Mecklenburg county, N.C., in 1775. News of the conflict at Lexington and Concord on April 19, 1775, which marked the beginning of the American Revolution, reached the southern colonies early in May. In the frontier North Carolina county of Mecklenburg a local patriot committee met on May 31, and passed strongly worded resolves that annulled the authority of Great Britain. The committee then proceeded to form a temporary government for the county. The resolves were later transmitted to the North Carolina delegates in the second continental congress. The authenticity of these radical resolves cannot be doubted, although no contemporary copy of the document has ever been found as the records of the committee were destroyed by fire in 1800. In that year, John McNitt Alexander, then 67 years old, wrote down what he recalled of the meeting of May 1775.

In April 1819 the *Raleigh Register* published a document supposed to have been passed by the Mecklenburg committee on May 20, 1775. In the second of five resolves the citizens declared that "the political bands which have connected us to the Mother Country . . ." were dissolved. The authenticity of this declaration of independence has been in dispute since the date of publication. Whether or not a committee met in Charlotte, N.C., on May 20, 1775, cannot be proved or disproved. The text of the resolves alleged to have been passed there is not credible. The documents are printed in William L. Saunders, *The Colonial Records of North Carolina*, ix, 1263, 1282. *See* also G. W. Graham, *The Mecklenburg Declaration of Independence* (1905), which accepts the resolves as authentic, and William H. Hoyt, *The Mecklenburg Declaration of Independence* (1907), which rejects them. (BR. C.)

**MECOPTERA,** a small order of mostly winged insects best represented by the scorpion flies, the large family Panorpidae. Included also in the order are the tiny, blackish snow scorpion flies, family Boreidae, and the craneflylike hanging flies, family Bittacidae. *See* SCORPION FLY; INSECT: *Classification: Mecoptera*.

**MEDAK,** a town and district of Andhra Pradesh, India. The town (pop. [1961] 15,891) lies 45 mi. N.N.W. of Hyderabad. The 16th-century fort, built by the raja of Warangal, stands about 300 ft. high above the surrounding country. Medak has the largest Christian mission and church in the state. Handloom weaving is the main cottage industry. The Central railway serves the town.

MEDAK DISTRICT (area 3,711 sq.mi.) had a population of 1,227,361 in 1961. The rock formation is Archean, and the district is almost wholly composed of pink and gray granites, giving rise to brownish sandy soils. Annual rainfall is from 30 to 35 in., and there are numerous tanks or reservoirs; irrigation is mostly by wells and tanks. The main crops are jowar, rice, pulses and oil seeds. Sangareddi, the district headquarters, is a trading town and noted for the manufacture of silk cloth, brass and silverware. Siddipet is well known for its blankets and silk and cotton fabrics. (S. AH.)

**MEDALS AND DECORATIONS.** Man has always wished to distinguish himself from his fellows by some outward sign. In ancient Greece and Rome the laurel wreath was used for this purpose; in the days of chivalry the coloured shield and plumed helmet were employed. Over the centuries the medal has become the universal mark by which services are rewarded and participation in certain events indicated. In monarchies most awards are made in the name of the sovereign; in other countries they are made in the name of the government.

Orders of knighthood, of which the higher classes confer nobility or the accolade of knighthood and the lower ones designations such as commander, officer, member, etc., are dealt with in the article KNIGHTHOOD, CHIVALRY AND ORDERS. Their insignia are chiefly silver and enamel stars worn on the breast, enameled gold or silver badges attached to a broad ribbon over the shoulder or round the neck and smaller badges worn on the left breast with other decorations and medals.

Decorations awarded for gallantry include the British Victoria cross and George cross, the U.S. medal of honor and the French *médaille militaire;* there are also medals for long service, medals to commemorate coronations, jubilees, participation in wars, humane actions, the saving of life, services to the community and innumerable others.

The insignia vary considerably in size and value. The Victoria cross and the medal of honor are made of bronze, the *médaille militaire* has a gilt and enamel design, while others are of solid gold or silver.

Additional awards of the same decoration can be signified by the addition of bars of metal worn transversely across the ribbon, or by oak-leaf clusters, roses, palms, stars and other devices. Some countries (the U.S.S.R. for example) simply repeat the original award in full, thus enabling a holder to wear four or five replicas of the same badge. (*See* NUMISMATICS.)

Decorations in their entirety are worn only with full dress or on ceremonial occasions. At other times strips of the ribbons only are arranged on the left breast in a strictly regulated order with the highest decoration in the top row and nearest the centre of the coat. With evening dress, miniature (half-size) decorations are worn. In some countries full-size awards may be worn in two or more rows, the metal portions of the top row obscuring the ribbons of the second row; the more usual arrangement, however, is to have all the medals on the same bar but overlapped, the senior one being shown in full.

### UNITED STATES

The foremost military U.S. decoration, the medal of honor, instituted in 1861 for the navy and 1862 for the army, was at first confined to enlisted men, officers being admitted later. It is given only for "courage above and beyond the call of duty." The medal is worn round the neck and has a badge, which for the army is in the form of a five-pointed bronze and enamel star resting on a wreath suspended from a bar bearing the word "Valor," on which sits an eagle with outspread wings. The centre of the medal shows the head of Minerva; the ribbon is pale blue and is decorated with a pattern of 13 white stars just above the eagle. The naval design is a bronze five-pointed star suspended from an anchor. Its centre device is an allegory representing Minerva repulsing Discord. The ribbon is approximately the same as for the army. Undress ribbons show only five stars and second awards are represented by an oak-leaf cluster for the army and a gold star for the navy.

In succession follow the distinguished-service cross and the distinguished-service medal for the army, the navy cross and the distinguished-service medal for the navy and the distinguished-flying cross for the air force. The silver star, the bronze star and the air medal are lesser awards for gallantry, while the soldier's medal and the navy and marine corps medal reward services in peacetime or "heroism not involving actual conflict with the enemy."

# MEDALS AND DECORATIONS

MEDAL OF HONOR (ARMY)

MEDAL OF HONOR (NAVY)

DISTINGUISHED SERVICE CROSS (ARMY)

NAVY CROSS

DISTINGUISHED SERVICE MEDAL

SILVER STAR

DISTINGUISHED FLYING CROSS

LEGION OF MERIT

THE SOLDIER'S MEDAL

NAVY AND MARINE CORPS MEDAL

BRONZE STAR

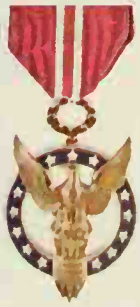
AIR MEDAL

PURPLE HEART

ASIATIC-PACIFIC CAMPAIGN MEDAL

ARMY OF OCCUPATION MEDAL

PRESIDENTIAL MEDAL OF FREEDOM



MEDAL FOR MERIT

UNITED STATES MEDALS AND DECORATIONS

BY COURTESY OF (BOTTOM ROW CENTRE) U.S. GOVERNMENT (OTHERS) SMITHSONIAN INSTITUTION

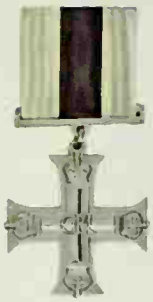
# MEDALS AND DECORATIONS

DISTINGUISHED SERVICE ORDER

DISTINGUISHED CONDUCT MEDAL

VICTORIA CROSS

DISTINGUISHED SERVICE MEDAL



MILITARY CROSS

BRITISH EMPIRE MEDAL

1939-45 STAR

DISTINGUISHED FLYING CROSS

WAR MEDAL, 1939-45

DEFENCE MEDAL

CANADIAN VOLUNTEER SERVICE MEDAL

AUSTRALIAN SERVICE MEDAL

QUEEN ELIZABETH II CORONATION MEDAL

NEW ZEALAND WAR SERVICE MEDAL

KOREA MEDAL

ORDER OF LIBERATION (FRANCE)

CROIX DE GUERRE (FRANCE)

ACADEMIC PALMS (FRANCE)

CROSS OF VALOUR (POLAND)

SERVICE MEDAL WITH "KOREA" CLASP (UNITED NATIONS)

BRITISH, COMMONWEALTH, UNITED NATIONS AND EUROPEAN MEDALS

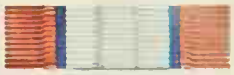
BY COURTESY OF JAMES C. RICH, RICH COIN GALLERIES, NEW YORK CITY. PHOTOGRAPHED ESPECIALLY FOR ENCYCLOPAEDIA BRITANNICA, INC.

# MEDALS AND DECORATIONS

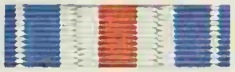
MEDAL OF HONOR

DISTINGUISHED SERVICE CROSS

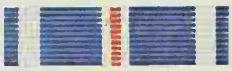
NAVY CROSS


DISTINGUISHED SERVICE MEDAL (ARMY)

DISTINGUISHED SERVICE MEDAL (NAVY)


SILVER STAR

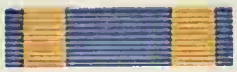
LEGION OF MERIT

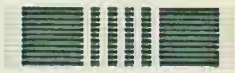

DISTINGUISHED FLYING CROSS

SOLDIER'S MEDAL

NAVY AND MARINE CORPS MEDAL

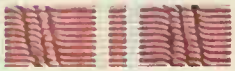
BRONZE STAR MEDAL

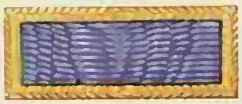

AIR MEDAL


COMMENDATION RIBBON WITH METAL PENDANT (ARMY OR AIR FORCE)

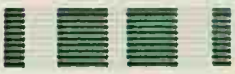
NAVY COMMENDATION RIBBON

PURPLE HEART


MEDAL FOR MERIT


DISTINGUISHED UNIT COMMENDATION BADGE

NATIONAL SECURITY MEDAL


COAST GUARD COMMENDATION RIBBON

PRESIDENTIAL UNIT CITATION (NAVY)

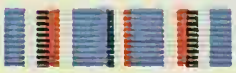
GOLD LIFE-SAVING MEDAL

SILVER LIFE-SAVING MEDAL

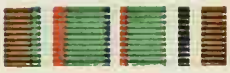
MERCHANT MARINE DISTINGUISHED SERVICE MEDAL

ARMY OF OCCUPATION MEDAL, 1918-23

AMERICAN DEFENSE SERVICE MEDAL

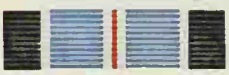

AMERICAN CAMPAIGN MEDAL

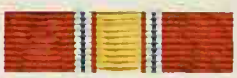
ASIATIC-PACIFIC CAMPAIGN MEDAL


EUROPEAN AFRICAN MIDDLE EASTERN CAMPAIGN

VICTORY MEDAL, WORLD WAR II

OCCUPATION MEDAL GERMANY AND JAPAN, WORLD WAR II

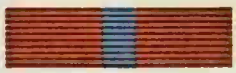

HUMANE ACTION MEDAL (BERLIN AIRLIFT) 1948-49

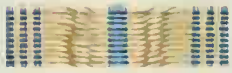

NATIONAL DEFENSE SERVICE MEDAL, 1953

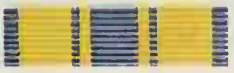
KOREAN SERVICE MEDAL

ARMY GOOD CONDUCT MEDAL

NAVY GOOD CONDUCT MEDAL


MARINE CORPS GOOD CONDUCT MEDAL


ARMED FORCES RESERVE MEDAL


AIR FORCE COMMENDATION MEDAL

ANTARCTIC EXPEDITION MEDAL, 1939-41

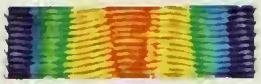
RIBBONS OF UNITED STATES DECORATIONS

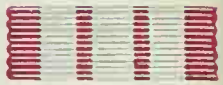
DRAWN FOR ENCYCLOPÆDIA BRITANNICA, INC. BY GEORGE ARMSTRONG

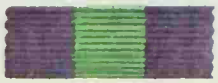
# MEDALS AND DECORATIONS

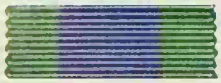
1914-15 STAR

BRITISH WAR MEDAL, 1914-18

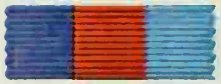

VICTORY MEDAL, 1914-18


NAVAL GENERAL SERVICE MEDAL, 1915


GENERAL SERVICE MEDAL ARMY AND ROYAL AIR FORCE, 1918


INDIA GENERAL SERVICE MEDAL, 1908

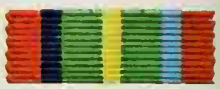
INDIA GENERAL SERVICE MEDAL, 1936

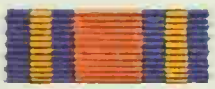

1939-45 STAR

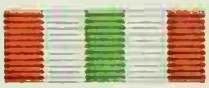
ATLANTIC STAR, 1939-45

AIR CREW EUROPE STAR, 1939-44

AFRICA STAR, 1940-43


PACIFIC STAR, 1941

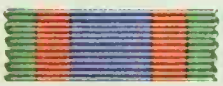

BURMA STAR, 1941-44


ITALY STAR, 1943-45

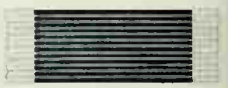
FRANCE AND GERMANY STAR, 1944-45

DEFENCE MEDAL, 1939-45

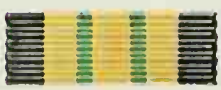
1939-45 WAR MEDAL

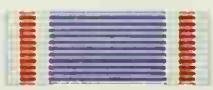

CANADIAN VOLUNTEER SERVICE, 1943

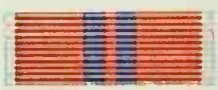
AUSTRALIAN SERVICE, 1939-45

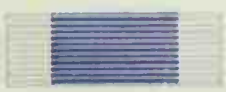

NEW ZEALAND WAR SERVICE, 1935-45

KOREA MEDAL

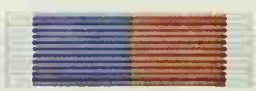

AFRICA GENERAL SERVICE, 1902

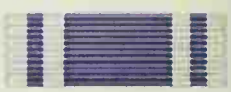

KING GEORGE VI CORONATION, 1937


QUEEN ELIZABETH II CORONATION, 1953

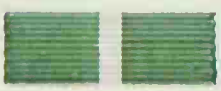

NAVAL LONG SERVICE

ARMY LONG SERVICE

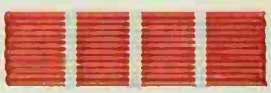

ROYAL AIR FORCE LONG SERVICE


POLICE LONG SERVICE

INDIA SERVICE, 1939-45


PAKISTAN MEDAL

INDIAN INDEPENDENCE


CANADIAN FORCES DECORATION FOR LONG SERVICE

BRITISH MEDALS AND OVERSEAS DECORATIONS

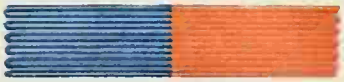
DRAWN FOR ENCYCLOPÆDIA BRITANNICA, INC. BY GEORGE ARMSTRONG

# MEDALS AND DECORATIONS

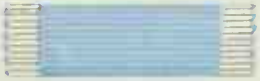
VICTORIA CROSS

GEORGE CROSS

ORDER OF THE BATH



ORDER OF MERIT



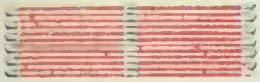
ORDER OF THE STAR OF INDIA

ORDER OF ST. MICHAEL AND ST. GEORGE

ORDER OF THE INDIAN EMPIRE

ORDER OF THE CROWN OF INDIA

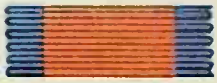
ROYAL VICTORIAN ORDER



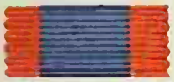
ORDER OF THE BRITISH EMPIRE (MILITARY)

ORDER OF THE BRITISH EMPIRE (CIVIL)

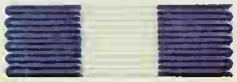
ORDER OF THE COMPANIONS OF HONOUR



DISTINGUISHED SERVICE ORDER



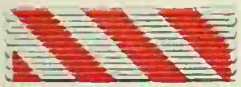
ROYAL RED CROSS



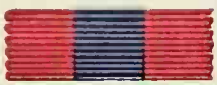
DISTINGUISHED SERVICE CROSS

MILITARY CROSS

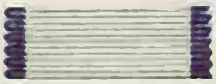
DISTINGUISHED FLYING CROSS



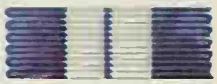
AIR FORCE CROSS



DISTINGUISHED CONDUCT MEDAL



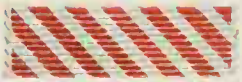
CONSPICUOUS GALLANTRY MEDAL



DISTINGUISHED SERVICE MEDAL

MILITARY MEDAL

DISTINGUISHED FLYING MEDAL



AIR FORCE MEDAL

GEORGE MEDAL

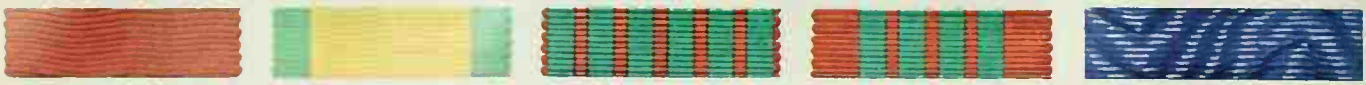
EDWARD MEDAL

RIBBONS FOR BRITISH DECORATIONS

DRAWN FOR ENCYCLOPÆDIA BRITANNICA, INC. BY GEORGE ARMSTRONG

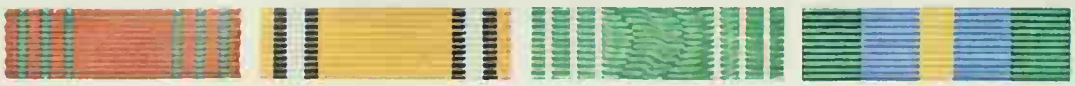
# MEDALS AND DECORATIONS

## FRANCE



LEGION OF HONOUR | MÉDAILLE MILITAIRE | CROIX DE GUERRE | CROIX DE GUERRE (WORLD WAR II) | ACADEMIC PALMS

## BELGIUM

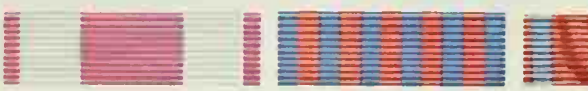


CROIX DE GUERRE, 1941 | WAR COMMEMORATION | MARITIME MEDAL | ABYSSINIA, 1941

## U.S.S.R.

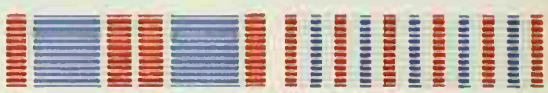
GOLD STAR | ORDER OF LENIN | ORDER OF THE RED BANNER | CAPTURE OF BERLIN

## POLAND



CROSS OF VALOUR | MONTE CASSINO | CROSS OF MERIT

## CZECHOSLOVAKIA



MEDAL FOR VALOUR | WAR CROSS, 1939

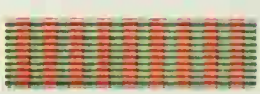
## UNITED NATIONS

SERVICE MEDAL (KOREA)

## NETHERLANDS

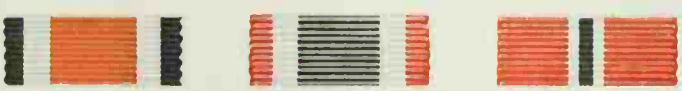
BRONZE LION | BRONZE CROSS

## ITALY



WAR MEDAL, 1940-43

## GERMANY



IRON CROSS WORLD WAR II | WAR MERIT WORLD WAR II | WINTER OFFENSIVE IN EAST, 1941-42

## DENMARK

PARTICIPATION IN WAR, 1940-45

## NORWAY

FREEDOM CROSS

RIBBONS FOR EUROPEAN AND UNITED NATIONS DECORATIONS

RIBBON FOR ENCYCLOPÆDIA BRITANNICA, INC. BY GEORGE ARMSTRONG

The legion of merit is the only U.S. decoration which has distinct ranks. Members of the armed forces of other countries can be admitted in the grades of chief commander, commander, officer and legionnaire but U.S. citizens receive only the lowest grade. The basic badge is a five-armed, ball-tipped, double-pointed white cross resting on a green wreath, the arms having red edges and the centre being blue with 13 white stars.

The purple heart was originally founded by George Washington in 1782 for bravery. The device consisted of a purple heart-shaped piece of cloth edged with silver braid. Only three were actually awarded and two specimens still exist. The 200th anniversary of Washington's birth was chosen for the revival of this award and on Feb. 22, 1932, a new purple heart was instituted. Its principal purpose now is to award recognition to those who have been wounded or killed in the service of their country. The decoration consists of a purple, heart-shaped badge with light bronze edges. Between the top of the heart and the ribbon are Washington's arms (two bars below three stars) and the ribbon is purple with narrow white edges.

The medal for merit was established in 1942 for award to civilians of the United States and its allies for exceptionally meritorious service or courageous acts in the furtherance of the war effort. The device is an eagle with upspread wings on a blue white-starred ring and the ribbon is claret with two central white stripes. In what might be called a lower category is the medal of freedom, which is more widely distributed (ribbon, red with four white central stripes). It was authorized in 1952 for meritorious service by civilians in time of war or national emergency.

In 1953 the national security medal was created for meritorious service in intelligence activities related to national security. It is a blue 16-pointed compass rose surrounded by a red oval bearing the words "United States of America National Security," the whole within a gold wreath. It hangs from its ribbon by an eagle with upstretched wings and the ribbon is yellow with blue edges and transverse blue "stepped" stripes.

The equivalent of the British system of "mentioned in dispatches" in the United States is the award of medals called "commendations" and there are separate ones for the army (from the ribbon of which hangs a hexagonal pendant showing an eagle), the navy, coast guard and air force.

Campaign medals (then called badges) were first issued about 1904, although one or two medals commemorating specific events had come out earlier. They ranged from the Civil War medal to awards for the Indian campaigns and the Spanish-American War. Later there were medals for service in Mexico, Nicaragua, Haiti and Dominica. World War I was commemorated solely by the victory medal to which bars could be added. Two naval medals signifying service in China and on the Yangtze river in the 1930s bring the history of U.S. medals up to World War II.

For service during the period before the actual declaration of hostilities in 1941, the American defense service medal was instituted, to the ribbon of which could be added a letter *A* in bronze for service in the Atlantic. The women's army corps service medal was given to all women who had served in the corps during 1917–18 and who rejoined in World War II.

For the purpose of the award of campaign medals the world was divided into three areas: the American, the Asiatic-Pacific, and the European, African and middle eastern. Medals were given to all who served specified periods in the different parts, with bronze stars to mark engagements and an arrowhead to indicate a landing on an open beach or by parachute. Subsequently a victory medal was added and the armies of occupation in Germany and Japan received the army of occupation medal (as they had done during the occupation of Germany after World War I).

After the end of World War II, the Berlin air lift of 1948–49 was commemorated by the humane action medal; another medal was issued for service in Korea while a general medal under the title of the national defense service medal appeared in 1953. An armed forces reserve medal was authorized in 1950 for those who completed ten years of service in the reserves.

All the states and territories issue their own crosses and medals, principally to reward long service in their national guard contingents, but sometimes in connection with floods, riots, etc., and occasionally to supplement the valour and campaign medals given by the federal government.

Numerous private societies and contingents of the reserve officers training corps have their own awards, many being merely membership badges such as those of the Veterans of Foreign Wars and the Daughters of the American Revolution. The Society of the Cincinnati, which is composed entirely of direct descendants of officers of the Continental army, has as its badge an eagle suspended from a pale blue, white-edged ribbon and can be worn with uniform, when it takes precedence over all awards except the medal of honor.

Two ancillary services of the U.S. armed forces issued their own decorations—the merchant marine and the coast and geodetic survey. The former had a distinguished service medal, a meritorious service medal, a defense bar and American, Asiatic and European bars, together with "gallant ship" and combat bars, the one bearing a small silver sea horse emblem for a second award and the other a silver star to indicate an "abandon ship" operation. The ribbon of the defense bar is very distinctive, having a black centre shading to red, pink and white each side, bounded by narrow green edges. The coast and geodetic survey uses its own distinguished-service medal, meritorious service medal, long service, defense, Atlantic and Pacific war zone bars.

In 1945 the medal of freedom was established for award to anyone other than a member of the U.S. armed forces who, on or after Dec. 7, 1941, had performed a meritorious act or service that had aided the United States or any of its allies in the prosecution of a war. The executive order creating the medal was amended in 1952 so that the medal of freedom could be awarded for a meritorious act or service in the interest of the security of the United States or its allies, not necessarily in time of war. In Feb. 1963 Pres. John F. Kennedy changed the name of the medal to "presidential medal of freedom" and broadened its scope to include meritorious contributions to the security or national interests of the United States, world peace, or cultural or other significant public or private endeavours. Thereafter the presidential medal of freedom was considered the nation's highest civilian award.

### GREAT BRITAIN

The pre-eminent decoration for valour is the Victoria cross, founded by Queen Victoria in 1856 as an award open to all ranks of the army and navy without distinction who distinguished themselves by gallantry of an outstanding nature. The conditions of warfare changed so considerably in the succeeding 100 years that, whereas in 1856 the saving of a comrade's life under fire or the capture of a standard was sufficient to earn the Victoria cross, during World War II a much higher degree of self-sacrifice was required, as was shown by the number of Victoria crosses posthumously awarded. In all by 1957, 1,343 crosses had been awarded, to which must be added three bars for second awards, making a total of 1,346 in all. The decoration is in the form of a cross pattée bearing the royal crest (a lion standing on a crown) above a scroll inscribed "For Valour." The 1½-in.-wide ribbon is described in the statutes as red, but is actually a dull crimson. The crosses are individually forged and are made from guns captured from the Russians in the Crimean War.

The second highest British award, the George cross, which was instituted in 1940 by King George VI, may be given only for "acts of the greatest heroism or of the most conspicuous courage in circumstances of extreme danger." The cross is silver, plain, bearing in the centre a representation of St. George slaying the dragon, surrounded by the words "For Gallantry." The ribbon is 1½ in. wide and of garter blue.

For the Distinguished Service Order *see* KNIGHTHOOD, CHIVALRY AND ORDERS. The distinguished service cross and the military cross are lower decorations for army and navy officers, while the distinguished flying cross and the air force cross are reserved for R.A.F. officers.

For other ranks there is a series of medals roughly comparable with the above, including the conspicuous gallantry medal and the distinguished service medal for the navy, the distinguished con-

duct medal and the military medal for the army and the distinguished flying medal and the air force medal for the air force. The George medal is analogous to the George cross, but the standard required is not so high (both incidentally may be awarded to civilians).

A medal frequently given for gallantry and for numerous other services is the British empire medal, which is allied to the Order of the British Empire. Its ribbon is pink with gray edges, with an additional stripe of gray in the centre for the military division. The Edward medal is rarely awarded now, but at one time it was used to reward lifesaving in mines and industrial plants, a high degree of gallantry being required. The Albert medal, the queen's police medal and the queen's fire service medal are awarded for gallantry or distinguished service. The Royal Humane society's silver and bronze medals are well known; its Stanhope gold medal is awarded annually for the bravest deed of lifesaving of the year.

Great Britain and the United States easily lead the field in the number of types of award for gallantry and war service. Britain was probably the first country to produce war decorations which could be worn. Some of the recipients of commemorative medals in the 16th and 17th centuries used a thin chain to suspend their medals round their necks. The "ark in flood" medal (so called from its design) issued by Queen Elizabeth I to commemorate the defeat of the Spanish Armada in 1588 and the medals proposed by Charles I in his royal warrant of 1643 may be quoted as examples of early decorations.

The first English campaign medal for both officers and men was the one issued by parliament in 1650 to mark the victory over the royalists at the battle of Dunbar. It bore the portrait of Cromwell (in spite of his protests) on one side and a representation of the house of commons on the other. It has no loop at the top for suspension. Few medals were issued until the end of the 18th century, when naval gold medals for admirals and captains appeared and with them one of the first references to a medal ribbon, appropriately enough in blue and white, the colours selected for the first naval uniforms. About the same time the Honourable East India company began to issue various awards for native soldiers. The early Indian medals were probably worn round the neck from a yellow cord. As there was no general award made to the rank and file after the battle of the Nile (1798), Alexander Davison, Nelson's prize agent, presented a medal to every man who took part. His example was followed by Matthew Boulton, of the Soho mint, Birmingham, who in 1805 gave a medal to all ranks present at the battle of Trafalgar.

During the Peninsular War an army order authorized gold medals to be awarded to officers not below the rank of lieutenant colonel or battalion commander who had taken part in the major operations of Roleia (Roliça), Vimeiro, Corunna and Talavera, and the order was extended to cover other battles. As many officers became entitled to more than one medal it was decided in 1813 that only one medal would be awarded, with two clasps for second and third operations, while on the fourth operation a gold cross would be substituted, bearing the battle names on the arms. Clasps could be added to this and the duke of Wellington obtained the largest individual number of clasps (nine) awarded to anyone.

The first modern war medal awarded to all ranks alike was the Waterloo medal (1815). Although issued in the reign of George III, it bore the effigy of the prince regent and used the ribbon of the army gold cross, red with blue edges.

The East India company issued a series of campaign medals for service in India. After much agitation and against the wishes of the duke of Wellington the British government instituted in 1848 a military general service medal for award to survivors of campaigns which took place during 1801–14. A similar medal for those who took part in naval operations from 1793 to 1840 appeared also. A medal for service in India covering the years 1799–1826 was struck by the East India company in 1851 in imitation.

After the Crimean War and the Indian mutiny, campaign medals multiplied and the device of general service medals was adopted to cover a series of campaigns, each marked by an appropriate bar.

World War I created problems of a new character—the large number of troops involved, the numerous fronts on which the war was waged and the periods of time spent on each. During the war a star was awarded to those who went to certain areas before the end of 1915, a separate issue, the 1914 star (commonly known as the Mons star), being given to those who landed in France before Nov. 23, 1914. A general issue of the British war medal covered the majority of men who served during 1914–18 and those who went overseas received also the victory medal, an award common to all the Allied nations.

World War II presented even greater difficulties. Two stars, the 1939–43 star and the Africa star were authorized as interim awards in 1943 and were later extended to cover the years 1939–45. The other stars issued at the end of the war, each covering a specific area, were the Pacific star, Atlantic star, Burma star, air crew Europe star, Italy star and France and Germany star. In addition there were the defense medal (for home defense and noncombatant areas) and the war medal, given to all who served at least one month.

The naval general service medal (1915) was awarded with appropriate bars for operations after World War II in Palestine, the far east, Malaya, Cyprus and Suez and also for mine sweeping. The general service medal (1918) was given to soldiers and airmen for postwar service in various places. The Mau Mau rising in Kenya occasioned the reissue of the Africa general service medal of 1902, with Queen Elizabeth II's head and the bar Kenya. The Korea medal bears the head of Queen Elizabeth II on the obverse and Hercules slaying the hydra on the reverse.

A large number of British medals are awarded for long service in the various regular, territorial and volunteer forces and the police and fire brigades now have official medals to replace those previously given by some individual forces. The Order of St. John of Jerusalem awards a lifesaving medal and a long service medal, while the British Red Cross society has the voluntary medical service medal. Among other decorations may be mentioned the various polar medals, having appropriately white ribbons, and given to members of polar expeditions.

The royal observer corps has a long service medal as do the officers and instructors of the cadet forces (sea, army and air), the ribbon of which is ingeniously constructed from the territorial efficiency medal with the addition of narrow stripes of dark blue, red and light blue placed between the green centre and yellow edges. The medal suitably bears the torch of education. Coronation and jubilee medals have been issued since the reign of Queen Victoria and the latest, Queen Elizabeth II's coronation medal, is silver, rimless and bears her crowned effigy on the obverse and her cipher and the date June 2, 1953, on the reverse.

The queen's medal for chiefs and the badge of honour are awarded to non-European dignitaries in the commonwealth and consist of circular or oval silver-gilt, silver or bronze medals bearing the queen's effigy and title on the obverse and a suitable design and territorial name on the reverse.

### FRANCE

The *médaille militaire*, instituted in 1852, is conferred upon high-ranking officers in the army and navy and other ranks in the services for distinguished conduct in action.

For the *Légion d'Honneur*, *see* KNIGHTHOOD, CHIVALRY AND ORDERS. The *croix de guerre*, established in 1915, is awarded to all ranks for individual feats of arms mentioned in dispatches, and may also be won by officers and men of allied armies. A new ribbon was issued to commemorate service in World War II. In 1940 Gen. Charles de Gaulle created the *ordre de la libération* to reward distinguished service in the cause of the liberation of France. It could be awarded to civilians as well as to servicemen. The decoration has a sword on a shield, surmounted by a black Lorraine cross (ribbon, green with black edges and two narrow black stripes). Other decorations issued during and after World War II include a medal for those who took part in the resistance movement and another for those who were interned or deported during the resistance.

An interesting feature of World War II was the creation of decorations by the Vichy government. These included the *francis-*

*que gallique*, a small badge consisting of a double-headed ax protruding from a marshal's baton, a *croix de guerre* (ribbon, green with seven black stripes), the *croix des combattants 1939–40* (ribbon, black with four pale blue stripes) and another *croix de guerre* for the volunteers who fought against the Soviet Union (ribbon, green with black edges and seven black lines).

There are numerous awards given to civilians for various services, among which may be named the following: the *ordre de mérite agricole*, the *ordre de mérite commercial*, the *ordre de palmes académiques* and the *ordre de mérite civil*. Numerous societies add their quota to the decorations worn in France and there are many medals for lifesaving, social work, etc.

The cross for military valour was issued in 1956 to cover military operations in peacetime. Medals were struck for the wars in Indochina and Korea. Another was awarded for service in north Africa, to which bars were added for Morocco, Algeria and Tunisia. The Suez operation of 1956 was marked by the reissue of the orient medal of 1919, with a suitable bar.

### GERMANY

For the order *pour le mérite* see KNIGHTHOOD, CHIVALRY AND ORDERS.

The iron cross was instituted in 1813 as a reward for distinguished service in the War of Liberation. It was revived for the Franco-German War of 1870–71 and was again issued for service in World Wars I and II. The cross is a Maltese cross of cast iron edged with silver. On the upper arm is a crown, on the lower link is the date of the campaign. Eight grades were created, the senior of which are with oak leaves, oak leaves with swords, oak leaves with swords and brilliants and grand cross of the iron cross. The grand cross, double the size of the ordinary cross, is worn round the neck, and is awarded solely for the winning of an important battle or equivalent exploit. It was awarded in World War II only once—to Hermann Göring for the air force's part in the campaign in France in 1940.

Before 1918 there were at least 20 separate states awarding decorations in Germany. Under the Weimar republic awards all over the country were forbidden and only gradually revived, and after a time the wearing of the old types of decoration was permitted. A Red Cross decoration was instituted and quite widely distributed. Under the Nazi regime the long service medal (the lowest class for only four years' service) was reinstituted, with its familiar cornflower blue ribbon. One of Hindenburg's last acts was to approve of commemoration crosses for World War I, making use of the same ribbons as were employed with the medals for the victorious campaign against France during 1870–71.

For the Olympic games in Berlin in 1936 both a cross and a medal were struck and to reward members of the Nazi party who took part in some of the incidents before his rise to power Hitler created the so-called blood order in 1934. The ribbon, red with narrow black and white edges, was used again in different proportions for the 1939 iron cross, which bore a swastika at its centre.

In World War II Germany created only one medal for a military campaign as such, that for the "winter war in the east," the invasion of the Soviet Union in 1941. For the other theatres of war there were "shields," small metal plaques worn on the arm, including the Crimea shield, the Lapland shield, the Kuban shield, etc. A different type of badge with oak leaves outstretched on either side of a centrepiece, worn on the breast, was awarded to participants in bombing raids, tank actions, close combat fighting, etc., while for the navy the badge consisted of various types of ship within an oval. Other decorations of the Nazi period include the order of merit of the German eagle, intended only for foreigners, and the *Deutsches Kreuz*. The war merit cross, instituted as an inferior award to the iron cross, was awarded mostly to civilians for special effort and achievement in running the war machine and for courage under bombing. Soldiers also occasionally received it. It had second class, first class and knight's cross.

Under the Federal Republic of Germany a series of lifesaving and fire-brigade medals were instituted, while the Red Cross decoration was revived. The order of merit of the Federal Republic has eight classes from grand cross to medal, the universal ribbon being red with black and gold edges. In 1957 the *Bundesrat* passed a law approving the wearing of decorations gained in World War II providing that the swastika was removed.

### U.S.S.R.

The order of Lenin (1930) may be awarded to individual citizens or collective bodies for special services rendered to the regime. The badge has a circular portrait of Lenin framed in a gold wreath of ears of rye. Numerous orders awarded during World War II for military and naval merit include those named after such national heroes as Kutuzov, Suvorov, Alexander Nevsky, etc. The order of glory is given for valour in battle and the gold star for outstanding feats contributing to the honour and material development of the U.S.S.R. The order of victory is the highest decoration for senior army officers and is given for an outstandingly successful military operation. It comprises an elaborate five-pointed star decorated with diamonds.

A series of medals was created to commemorate service in the various theatres of war including medals for partisans, for the defense of Leningrad, Moscow, Sevastopol, Stalingrad, the Soviet arctic, Odessa and the Caucasus. Decorations were awarded for the liberation of towns in adjacent countries (Warsaw, Prague, Belgrade), and for the capture of cities in enemy countries (Budapest, Vienna, Berlin, Königsberg). There were general medals for the victories over Germany and Japan.

Later medals were awarded for: frontier defense (1951), distinguished service in the preservation of public order (1952), the restoration of the coal mines in the Don basin (1947), the restoration of the heavy industry of the south (1948). Medals are issued for 20, 30 and 40 years' service in the army (the equivalent of long service medals) and for civilians there are medals for valiant labour and for labour distinction. Widely distributed medals commemorate the 800th anniversary of the foundation of Moscow (1947) and the 250th anniversary of the creation of St. Petersburg (Leningrad) (1957).

### OTHER COUNTRIES

**Australia.**—The Australia service medal was created in 1949 for those who served during World War II. The obverse bears the sovereign's effigy, while the reverse shows the Australian coat of arms and the words "The Australia Service Medal, 1939–45."

**Belgium.**—The *décoration militaire* (1902) is awarded to ranks of the armed forces for acts of courage or distinguished service. The *croix de guerre* (1915) is an award given for acts of courage on the field of battle or for long service at the front. Various orders were founded to give recognition for services in the Congo. Several new decorations were created to commemorate the period of German occupation during World War II.

**Canada.**—The Canada medal was instituted in 1943 for award to Canadians and others for "meritorious service above and beyond the faithful performance of duties." It was the first distinctively Canadian decoration and was awarded to civilians or to members of the armed services. The silver prototype bore the effigy of King George VI on the obverse and a crowned shield of the arms of Canada surrounded by a maple leaf wreath on the reverse. The ribbon is equal thirds of red-white-red. The Canadian forces decoration (1950), awarded to all members of the Canadian forces after 12 years' service, is a silver-gilt decagonal medal. For service during World War II the Canadian volunteer service medal was issued. It is silver with the Canadian coat-of-arms on the reverse and on the obverse seven marching figures representing the branches of the service.

**Ceylon.**—Ceylon marked the establishment of its armed forces by the institution of the Ceylon armed forces inauguration medal.

**India.**—The principal decorations are military: the Param Vir Chakra is awarded for outstanding bravery in the face of the enemy, the Maha Vir Chakra for acts of gallantry in the face of the enemy and the Vir Chakra for gallantry. All these awards were instituted in 1950. The Indian independence medal was founded by the Indian government to commemorate the attainment of sovereignty by India. The first campaign medal instituted by the

president of India was the general service medal.

**Italy.**—Until World War I Italian medals were not numerous but since then a spate of more or less unofficial ones has made it difficult to assess their value adequately. The blue-ribboned medal for military valour, founded in 1833 in gold, silver and bronze, has always held a high place, the gold medal being very rarely awarded. World War I was commemorated by the general service medal. The Fascist regime produced numerous awards and there were decorations for those who took part in the Abyssinian war and the Spanish civil war. During World War II there were medals for the campaigns in France, Africa, Greece, Yugoslavia and the Soviet Union. Recent orders include the order of merit of the Italian republic and the order of military merit of Italy, which replaces the military order of Savoy.

**Netherlands.**—Decorations established in World War II include the *Bronzen Kruis*, the *Bronzen Leeuw*, the *Kruis voor Verdienste* and the *Vliegerkruis*. A resistance cross, the *Verzetskruis*, was founded in 1946.

**New Zealand.**—The New Zealand government issued a war service medal for service during World War II and also presented to the widows and mothers of those who died on active service the silver memorial cross.

**Pakistan.**—In commemoration of independence, the Pakistan medal was created in 1948. The government also authorized the founding of a set of orders and decorations following the British style.

**The Republic of the Philippines** has created a series of decorations on U.S. lines with slightly different titles which speak for themselves—the medal for valour, distinguished-service star, distinguished-conduct star, legion of honour, gold cross, distinguished-aviation cross, silver wing medal, medal of military merit, etc. The Philippines had their own medal for Korea (ribbon, yellow with red-white-blue centre) and the United Nations medal they use has the reverse inscription in the native language Tagalog.

**Poland.**—The *ordo virtuti militari*, originally established at the end of the 18th century, was revived in 1919. It has five classes and is awarded for services in the field. Other decorations include the Grunwald cross for outstanding service during World War II, the Warsaw medal, (awarded to those who took part in the fighting round Warsaw in 1944), the cross of merit and the cross of merit for bravery.

**Portugal.**—Portugal's last war medal commemorated World War I. Many awards are, however, made for services of various kinds, especially in Portuguese African dependencies, among which may be named the distinguished service medal and the distinguished service overseas medal.

**South Africa.**—A silver medal was instituted in 1920 by the Union government for award to officers and men who served against Britain during the South African War. After issuing the Africa service medal for World War II, South Africa created in 1952 an entirely new set of decorations to replace in future all British decorations. They are named after people and places with South African associations and include the Castle of Good Hope decoration (the equivalent of the Victoria cross), the Van Riebeeck decoration, the star of South Africa, the Louw Wepener decoration, etc.

**Spain.**—During the 19th century Spain issued more than 150 medals, the majority commemorating actions in the Peninsular and Carlist wars. Medals were issued for the Spanish-American War and for campaigns in Morocco. For the civil war of 1936–39 decorations issued included a general service medal and medals for the defense of Oviedo, volunteers of Bilbao and Majorca, etc.

### UNITED NATIONS

The United Nations medal was instituted for award to those who took part in operations in Korea during 1950–53. It is of bronze with the UN device on the obverse side and an explanatory inscription on the reverse. The ribbon consists of 17 narrow stripes, nine blue and eight white, representing the 17 nations that participated in the Korean War.

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(L. F. GE.)

**MEDAN,** a town of Sumatera-Utara (North Sumatra) province, Indonesia, on the Deli river. Pop. (1961) 479,098 (municipality), largely Indonesian but including also nearly 80,000 Chinese. The town's chief historical building is the palace of the sultan of Deli, presented to the sultan by the Dutch government in the 19th century. Medan is the home of the University of North Sumatra, founded 1952, with seven faculties (medicine, law, agriculture, economics, technology, teaching and dentistry) and more than 6,000 students. The Indonesian Islam University of Medan, also founded in 1952, has about 2,500 students. The town has elementary, middle and high schools as well. Medan's museum was destroyed during the Indonesian revolution. There are two public parks, one for mass meetings, the other for youth recreation. Transportation is chiefly by bus, but a railway carries agricultural products—latex, palm oil, coffee, cinnamon, tobacco, rubber and sisal—from the interior to Medan's harbour, Belawan (*q.v.*), 16 mi. away. Polonia international airport provides transportation by air; after its enlargement is completed it will be able to handle and service jet planes. The town has only small industries, but plans are under way to set up larger industrial undertakings.

Medan originated as several Indonesian and Chinese villages situated around the tobacco plantations of Medan Puteri. In 1886 the Dutch government pronounced Medan a city and made it the capital of the east coast of Sumatra; at the same time it became the residence of the sultan of Deli. In 1909 it was given the status of municipality and since then has been governed by a mayor and city council.

**MEDAWAR, PETER BRIAN** (1915– ), British biologist, co-winner, with Sir Macfarlane Burnet (*q.v.*), of the 1960 Nobel prize for medicine for the discovery of acquired immunological tolerance. He was born in Brazil on Feb. 28, 1915, and was educated at Marlborough and at Magdalen college, Oxford. In 1947 he was appointed Mason professor of zoology in Birmingham university and in 1951 he became Jodrell professor of zoology and comparative anatomy at University college, London.

The concept behind the original and important immunological work was first formulated by Burnet in 1949. The theory put forward was that cells "learn" during embryonic life to distinguish between their own tissue substances and unwanted cells or materials introduced from without—bacteria, for example, or incompatible transfused blood or a skin graft. The idea was then suggested that if substances that would be antigenic to an adult were injected during embryonic life, they should inhibit the development of an antibody response. Medawar showed that this was correct and that the phenomenon of acquired immunological tolerance could be produced in the laboratory. He injected foreign living cells into mice embryos and found that mice so injected failed to react against skin grafts transplanted later in life. It was thought that this discovery might lead to the solution of the problem of grafting foreign tissues and that it would profoundly influence the study of immunity in general. Medawar was elected a fellow of the Royal society in 1949 and received its Royal medal in 1959. His publications include *The Uniqueness of the Individual* (1957) and *Reith Lectures on the Future of Man* (1960).

(W. J. BR.)

**MEDEA,** in Greek mythology, an enchantress who helped Jason (*q.v.*), the leader of the Argonauts (*q.v.*), to obtain the Golden Fleece from her father, King Aeetes of Colchis. She is not mentioned in Homer, but Hesiod knows her as Jason's wife. The earliest account of her is in Pindar's fourth Pythian ode; she marries Jason, who uses her magic powers and advice to perform the labours set him by Aeetes and to bear off the fleece. Pindar refers to Medea's "immortal mouth," thus implying that she is a goddess, and gives her the gift of prophecy. Euripides' tragedy *Medea* takes up the story at a later stage: Jason and Medea, after escaping from Colchis and being driven out of Iolcos because of the vengeance taken by Medea on Pelias (who had sent Jason to fetch

the fleece), are living in Corinth when Jason determines to desert her for the daughter of King Creon of Corinth; in revenge Medea murders Creon, his daughter and her own two sons by Jason and departs in a chariot sent by Helios, Aeetes' father, to take refuge with King Aegeus of Athens (*see* EURIPIDES: *The Extant Plays*).

Medea plays an important part in the second half of Apollonius Rhodius' *Argonautica*, which, however, tells nothing of her life after the voyage of the Argonauts is over. According to Apollonius, Medea falls in love with Jason and helps him to obtain the fleece in return for his promise to marry her. She then flees from Colchis with the Argonauts and on her advice Jason murders her brother Apsyrtus in order to throw off the Colchians who are pursuing them. After being purified by Circe, Jason and Medea get married in Phaeacia before the end of the voyage. Ovid in his *Metamorphoses* carries the story on: after their return to Iolcos Medea uses her magic arts to rejuvenate Jason's father, and then entices Pelias' daughters to carry out similar treatment on their father, who dies under it, while Medea escapes in a winged chariot to Corinth. After fleeing from Corinth (because of the events described in Euripides' play) she becomes the wife in Athens of King Aegeus, who later drives her away after her unsuccessful attempt to poison his son Theseus (*q.v.*). Herodotus says that from Athens Medea went to Media, whose inhabitants were at that time called Arioi but thereafter changed their name to Medes. Other authors provide numerous variants of her story, including the late tradition that she was united with Achilles on the islands of the blessed.

It has been suggested on the basis of an uncertain reading in Athenagoras' *Presbeia* that Medea was worshiped as a goddess in Corinth; according to Pausanias her children's tomb still existed there and Euripides' play refers to their cult. In the stories about her, Medea's wisdom and witchcraft are evidence of superhuman powers, whether she uses them to save and to heal or to destroy. She is the heroine of Seneca's *Medea*, a tragedy based on that of Euripides, and of plays by Corneille, Franz Grillparzer and Jean Anouilh, as well as of an opera by Cherubini.

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**MEDELLÍN,** second city of Colombia and capital of the department of Antioquia, lies 150 mi. N.W. of Bogotá in a steep-sided valley in the Central cordillera, 5,100 ft. above sea level. Pop. (1951) 328,294; (1961 est.) 651,240. Founded in 1675 on the banks of the Río Porce, a tributary of the Cauca river, Medellín is considered one of the most attractive cities of the country. It is renowned for its temperate climate and its flowers, especially orchids, which are shipped in quantity to foreign markets. It has two universities, an agricultural college, a school of mines, assaying and refining laboratories and a mint. The principal industry of the surrounding area was originally mining, and some gold is still exported. Since the introduction of coffee growing in the 1880s Medellín has been one of the principal coffee markets of Colombia. In the 20th century the city became a major manufacturing centre, a feat especially remarkable in view of its geographic isolation. The vigour and initiative of the Antioqueño people, who have invested past profits from gold and coffee in factories, together with the availability of low-cost hydroelectric power have been largely responsible for the city's progress. Food and beverages, glassware, ceramics, chemicals and clothing are among the major products of Medellín. Bello, Itagüí and Envigado are the principal satellite industrial communities. Their textile mills are among the largest and most modern in South America, and they also have important electric steel furnaces and rolling mills. Industrialization has greatly accelerated population growth, for the labour force is drawn from the countryside. The *municipio* of Medellín had a population of 168,000 in 1938. This had increased to an estimated 485,000 in 1956, which was 28% of the total population of the department of Antioquia.

Medellín has had through rail connections with the navigable Magdalena river at Puerto Berrío only since 1929, when a tunnel was constructed through the La Quiebra divide. A railway outlet southward to the Cauca valley, linking Medellín with Cali and Buenaventura, was completed in 1942. Two years earlier it became possible to drive by highway to Manizales and Bogotá. In 1955 a road was completed to the Caribbean coast. The Medellín airport is one of the busiest in the country, although the constricted shape of the valley excluded four-engine planes until 1947.

(Js. J. P.)

**MÉDENINE,** a town of southern Tunisia, centre of the governorate of the same name, lies in the semidesert plain of Jefara, 47 mi. S.S.E. of Gabès by road. Pop. (1956) 5,350. Under French protection it was the chief town of the Southern Territories. Médenine was originally a curious type of fortified *ksar* where shepherds kept their supplies. It was made up of several courtyards surrounded by family granaries (*ghorfa*), several stories high; these have been demolished. An encampment was erected nearby; later two quarters took shape, one of dwellings and the other of shops with a market square (*souk*). The place is a military post and has an airfield.

MÉDENINE GOVERNORATE, composing the *délégations* (administrative districts) of Médenine, Ben Gardane, Beni-Kheddache, Dehibat, Ghoumrassen, Tataouine and Zarzis, includes the Jefara plain, the Jabal cliff and the Dahar plateau. Pop. (1956) 236,220. The inhabitants of the Jefara (Ouderna and Touazin tribes) are seminomadic shepherds and breeders of sheep and dromedaries; they also grow cereals and recently also trees. The Jabalia (highlanders) live in cavelike old villages and grow olive, fig and palm trees; they also breed goats and sheep. The inhabitants of Zarzis (pop. [1956] 10,829), on the coast, are gardeners and fishermen.

(J.-J. Ds.)

**MEDFORD,** a city of Middlesex county, Mass., U.S., on the Mystic river 5 mi. N. of Boston (*q.v.*); primarily a middle-class, residential suburb of Boston and an important trading area for the surrounding communities. Medford's history dates back to 1630 when Mathew Cradock, first governor of the Massachusetts company, sent a group of men from the Massachusetts Bay colony to settle his plantation, a promising location on the banks of the river. Its early economy was based on farming and fishing. Shipbuilding began in 1631 with the "Blessing of the Bay," the first oceangoing ship to be built in America. Merchants grew prosperous from both foreign and domestic trade; Medford rum became world famous; and the city served as a supply depot for New Hampshire and Vermont. Medford-built ships continued to bring prosperity to the town until the last sailing ship was built in 1873.

Medford was incorporated as a city in 1892. It has a council-manager form of government, in effect since 1950, and is the home of Tufts university, a private university founded in 1852. Pop. (1960) 64,971; for comparative population figures *see* table in MASSACHUSETTS: *Population*.

(L. G. Ba.)

**MEDFORD,** a city and the seat of Jackson county in southwestern Oregon, U.S., is located on Bear creek 10 mi. from its confluence with the Rogue river. Medford was founded in Dec. 1883 as a depot on the Oregon and California railroad and was named for the city in Massachusetts. It was incorporated as a town in 1884 and grew rapidly as a freight centre. It was the centre of the Rogue river pear boom of 1900–10; incorporated as a city in 1905, it grew steadily, becoming the county seat in 1927. The period 1921–34 was marked by political turbulence and violence as the Ku Klux Klan and, later, the Good Government league attempted to control city and county government. After that the city was characterized by steady growth based on a sound, expanding economy.

Medford is the residence of many retired persons. The principal industries are agriculture, with pears as the chief crop; forest products, supported by 1,500,000 ac. of commercial timber; and tourist trade, attracted by Crater Lake National park, 80 mi. N.E. of Medford, and the historic mining camp of Jacksonville. The city has a council-manager form of government, in effect since 1954. For comparative population figures *see* table in OREGON: *Population*.

(F. D. H.)

**MEDHURST, WALTER HENRY** (1796–1857), English Congregationalist missionary to China, famous for his work on the Chinese language, was born in London on April 29, 1796, and educated at St. Paul's school. He went to China via India in 1816

and was a missionary for the London Missionary society at Shanghai (1842–56). In 1838 he published *China, Its State and Prospects* to stimulate interest in Chinese missions. He assisted in the revision of existing Chinese versions of the Bible. The result was a new version in High Wen-li. He also translated the New Testament into the Mandarin dialect of Nanking. Medhurst died in London on Jan. 24, 1857. His son, Sir Walter Henry Medhurst (1822–85), was British consul in China.

**MEDIA,** the homeland of the Medes and the ancient name of the northwestern part of Iran which, just prior to and during the Persian empire (550–333 B.C.) corresponded to the modern provinces of Azerbaijan, Kurdistan and parts of Kermanshah. Media was separated from Armenia and the lowlands on the Tigris (Assyria) by the valley of the Aras (Araxes) and by the northern ranges of the Zagros (mountains of Kurdistan). In the east, it extended toward the Caspian sea; but the high mountains which surround the Caspian and produce the Elburz chain separated it from the coast, and the narrow plains of the border of the sea (Gilan and Mazanderan) cannot be reckoned as part of Media proper. Toward the southeast Media merged with the great central desert of Iran which, eastward of the city Raga (Rhagae; modern Ray, near Teheran) in the region of the "Caspian Gates," reaches to the foot of the Elburz chain.

From the mountains in western Media spring some great tributaries of the Tigris (*e.g.*, the Diyala, ancient Gyndes, and the Karkheh, ancient Choaspes). In the northwest lies a large inland lake, Urmia (Reza'iyeh); ancient Matiane); otherwise, Media contains only one river, the Safid Rud, ancient Amardus, that reaches a sea (the Caspian). However a great many streams are exhausted in the interior after a short course. The greater part of Media is a mountainous plateau, about 3,000–5,000 ft. above sea level; but it contains some fertile plains. The climate is temperate, with cold winters, in contrast to the damp and unwholesome air of the shores of the Caspian, where the mountains are covered with a rich vegetation.

**History.**—Medes, Persians and several other Iranian-speaking groups first appear in history in the records of Shalmaneser III (859–824 B.C.). In those records peoples of the lands "Mada" and "Parsua" are referred to, usually in close connection with peoples of the land "Mannai" (Mannaeans (*q.v.*), who dwelt southeast of Lake Urmia). When, toward the end of the 9th century B.C. and during the first half of the 8th, Assyrian power declined, the kingdom of Urartu in the Armenian highlands moved to the attack and expanded in all directions, even into Iran, there bringing into subjection the Mannaeans as well as peoples of Parsua and, no doubt, of Mada. With the accession of Tiglath-pileser III to the Assyrian throne in 745 B.C., however, the position was again reversed. Assyrian arms repeatedly entered Urartu proper and exacted heavy tribute from tribal chieftains living in fortified towns of Mannai, Mada and Parsua. A new king of Urartu (Rusa I) apparently endeavoured to retaliate on Assyria by forming a federation of all the mountainous tribes along his frontier; he again won over a number of Mannaeans, among whom appears, as a city governor, one Dayukku whom Sargon of Assyria captured and deported to Hamath in Syria in 715 B.C. Perhaps the deeds of his descendants were all later attributed to Dayukku, for in name and probably in fact he is that "Deioces son of Phraortes" (*qq.v.*) whom Herodotus credits with the creation of the Median kingdom and with the erection of its capital city at Ecbatana (modern Hamadan). Although the account of Herodotus is thus clearly erroneous in details, it does contain real historical elements, whereas the story which Ctesias gave (a list of nine kings beginning with Arbaces, and copied from Diodorus Siculus by many later authors) has no historical value, even if many of the names are derived from local tradition.

According to Herodotus, Phraortes, son of Deioces, was the first to attack Nineveh, but was defeated and slain; and when his son Cyaxares (*q.v.*) renewed the attack, his progress was interrupted by an invasion of the Scythians who, after pursuing the Cimmerians across the Caucasus, founded an empire in western Asia which was brought to an end about 28 years later when Cyaxares, by a stratagem, killed the Scythian king Madyes, son of Protothyes. The history of Media is here on no firm ground whatsoever; for although a Median Phraortes (real name: Khshathrita) does appear in omen texts foretelling the issue of operations which Assyrian troops undertook toward the centre of Iran in order to procure horses for the army of Esarhaddon (681–669 B.C.); and although the same omens also refer to Scythians, their king Partatua (the Protothyes of Herodotus), and their confrères the Cimmerians; it is nevertheless clear that, late in the reign of Esarhaddon, Assyria was able to conclude vassal treaty stipulations with a number of Median (and other) rulers in such a way as to preclude the existence of a single "kingdom of Media" centred at Ecbatana throughout most of the 7th century.

Perhaps, therefore, it was not before 625 B.C. that Cyaxares, son of Khshathrita (Phraortes), succeeded in uniting into some semblance of a kingdom the many Iranian-speaking Median tribes, together with some Scythians as well as the indigenous non-Iranians like the Mannaeans. Being on favourable terms with Babylonia and perhaps with other Scythians, he captured Ashur (614 B.C.). In 612, in full alliance with Nabopolassar of Babylon, his forces stormed Nineveh, and the victors divided the Assyrian provinces among themselves: Syria with Palestine, parts of southern Assyria, and all of southern Mesopotamia fell to the Chaldean empire of Babylon; the Median king ruled over a large part of Iran, northern Assyria and parts of Armenia, where the kingdom of Urartu had long since disappeared. Subsequently, there ensued a bitter struggle between the Medes and a powerful Lydian state under Alyattes in Anatolia—a struggle ended in 585 B.C. when, following an eclipse of the sun, an armistice was concluded by which the Halys river was established as the boundary.

In many respects, the internal organization of the Median empire must have resembled that of Assyria, but it is known only that the Greeks derived a great part of the ceremonial of the later Persian court, the costume of the king, etc., from Media. In the absence of identifiable "Median" objects, little can be said of Median art, although it was surely eclectic. Like the Scythians and others (*e.g.*, the producers of objects known as "Luristan bronzes"), the Medes must have had a taste for richly ornamented weapons, vessels of precious metal and garments with elaborately coloured embroidery. No doubt also, as among the Mannaeans, the artistic influence of Assyria was strongly felt. Similarly, certain architectural features which the later Persian structures at Pasargadae and Persepolis have in common with the buildings of the people of Urartu may have been transmitted to the Persians by the Medes. Since no Median written documents of any kind have ever been discovered, the spiritual and economic life of the Medes is a matter of conjecture only.

By the rebellion of Cyrus II, king of Persia, against his suzerain Astyages, the son of Cyaxares, in 553, and his victory in 550, the Medes were made subject to the Persians. In the new empire they retained a prominent position; in honour and war they stood next to the Persians; the ceremonial of their court was adopted by the new sovereigns who in the summer months resided in Ecbatana, and many noble Medes were employed as officials, satraps and generals. After the assassination of the usurper Smerdis, a Mede, Fravartish (Phraortes), who doubtless legitimately claimed to be of the race of Cyaxares, tried to restore the Median kingdom, but was defeated by the Persian generals and executed in Ecbatana (Bisitun inscription of Darius I). Another rebellion, in 409, against Darius II was of short duration. But the non-Aryan tribes of the north, especially the Cadusians, were always troublesome; many abortive expeditions of the later kings against them are mentioned.

In the official annals of the Persian kings, Media is listed as but one of the provinces (satrapies) of the empire. For taxation purposes, however, as recorded in Herodotus, each of the satrapies seems to have been subdivided into a number of districts; thus the south, "Greater Media" as it was sometimes called, with Ecbatana and Rhagae, formed the 11th fiscal district and the northwest, the region of Matiane (Urmia) together with the Alarodians (Urarteans), formed the 18th.

Alexander the Great (*q.v.*) occupied Media in the summer of 330 and in 328 he appointed as satrap Atropates, a former general

of Darius III. Later, in the partition of his empire, southern Media was given to the Macedonian Peithon; but the north, which lay far off, was left to Atropates. While southern Media with Ecbatana passed to the rule of Antigonus I, and afterward (about 310) to Seleucus I, Atropates succeeded in founding an independent kingdom. Thus the partition of the country became lasting; the north was named Atropatene after the founder of the dynasty, a name which is preserved in the modern Azerbaijan. The capital was Gazaca in the central plain, near the strong castle Phraaspa or Vera, all probably identical with the great ruin Takht-i-Suleiman, with remains of Parthian, Sasanian and Islamic times. Polybius and Strabo relate that the kings had a strong and warlike army, especially cavalry. Nevertheless, King Artabazanes was forced by Antiochus III the Great in 220 to conclude a disadvantageous treaty, and in later times the rulers became in turn dependent on the Parthians, on Tigranes of Armenia and then on Rome.

In the 1st century B.C. Pompey received the ambassadors of their king Darius, but this is the last time an independent Atropatene is mentioned; the kingdom perhaps was absorbed into Parthia. In 36 B.C., Antony's invasion of Atropatene, including an attempted siege of Phraaspa, all a part of his attack on Parthia, ended in disaster. Augustus appointed the son of a former Atropatenian king to "rule" the kingdom, but Parthian influence was undoubtedly dominant thenceforth.

Southern Media remained a province of the Seleucid empire for a century and a half, and Hellenism was introduced everywhere. "Media is surrounded everywhere by Greek towns, in pursuance of the plan of Alexander, which protect it against the neighbouring barbarians," says Polybius (x, 27). Only Ecbatana retained much of its old character, although it was renamed Epiphaneia. But Rhagae became a Greek town, Europus; and with it Strabo names Laodicea, Apamea, Heraclea or Achais, most of them founded by Seleucus I and his son Antiochus I. In 221 B.C. the satrap Molon tried to make himself independent of the Seleucid empire, together with his brother Alexander, satrap of Persis, but they were defeated and killed by Antiochus III the Great. In the same way, in 161, the Median satrap Timarchus took the diadem and conquered Babylonia; on his coins he calls himself "the great King Timarchus"; but this time again the legitimate king, Demetrius I, succeeded in subduing the rebellion, and Timarchus was slain. But with Demetrius the dissolution of the Seleucid empire, brought on chiefly by the intrigues of the Romans, begins and about 152 the Parthian king, Mithradates I, conquered Media.

From this time Media remained subject to the Arsacids, who changed the name of Rhagae, or Europus, into Arsacia and divided the country into five small provinces. From the Arsacids or Parthians it passed *c.* A.D. 226 to the Sasanians, together with Atropatene. By this time the old tribes of Aryan Iran had lost their character and been amalgamated into the one nation of the Iranians. The revival of Zoroastrianism, which was enforced everywhere by the Sasanians, completed this development. It was only then that Atropatene became a principal seat of fire worship, with many fire altars. Rhagae became the most sacred city of the empire and the seat of the head of the Zoroastrian hierarchy; the Sasanian Avesta and the tradition of the Parsees therefore consider Rhagae as the home of the family of the Prophet. Thenceforth the name of Media was used only as a geographical term and began to disappear from the living language. *See* also PERSIAN HISTORY.

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**MEDIAN,** something that falls in the middle; a band of turf down the centre of a highway is a median strip; a median fissure traverses the human spinal cord. In a triangle (*q.v.*) the three medians (lines from each vertex to the midpoint of the opposite side) intersect in a median point (the centroid). In such fields as the behavioural sciences the median of an ordered set of measurements (*i.e.*, the middle value below which half the numbers fall) is used as an average (measure of central tendency). It is more typical of the values in a skew distribution (*see* STATISTICS) than is the popularly used average, the arithmetic mean. For example, in the skewed (asymmetrical) array 3, 4, 5, 6, 7, 8, 100, the median (middle number) is 6, while the arithmetic mean of 19 falls well above the typical measures. In perfectly symmetrical distributions both averages coincide. *See* MEAN.

**MEDIANT,** in music, the third degree of the ascending diatonic scale; *e.g.*, E in the key of C. *See* SCALE.

**MEDIAŞ,** a town of Braşov region, Rum., is situated on the left bank of the Tîrnava Mare, about 30 mi. N.N.E. of Sibiu. Pop. (1956) 32,855. It was founded by German colonists in the 12th century, and there are still a 14th-century fortress and town walls and a 17th-century Lutheran church. Mediaş lies in an area noted for its wines and also rich in methane gas deposits. Its light industries include the manufacture of glass, textiles, leather goods and hardware.

**MEDIATION,** the practice under which, in a conflict, the services of a third party are utilized as a means of reducing differences or of seeking a solution. Mediation differs from "good offices" in that the mediator usually takes more initiative in proposing forms of settlement. It differs from arbitration (*q.v.*) in that the opposing parties are not bound by prior agreement to accept the suggestions made.

**Mediation of Industrial Disputes.**—In labour disputes, if the conflict does not fall within a labour-management agreement, or if it exceeds the capacity of such machinery to settle, the government usually provides a mediator. The U.S. government and the majority of the governments of western Europe maintain labour mediation or conciliation services. In the United States several states and some cities have developed mediation services available to regional or local industry. In the great majority of situations in which labour mediation agencies have been created by a governmental unit, these agencies have the power to intervene in a dispute when in their judgment the public interest is threatened. Such public bodies do not have the power to compel an acceptance of the terms they propose, but their freedom to publicize their recommendations and their power to report to a superior body capable of recommending legislative action usually serve as an important stimulus to agreement. (*See* also INDUSTRIAL RELATIONS.)

**International Mediation.**—While mediation procedures are less fully developed in international conflicts, important moves forward were made in the Hague treaties of 1899 and 1907, in the League of Nations covenant, and in the United Nations charter.

There were several instances of successful mediation in the 19th century: of Great Britain in 1825 between Portugal and Brazil; of the great powers in 1868–69 between Greece and Turkey when relations were strained over Crete; and of Pope Leo XIII in 1885 between Germany and Spain in the matter of the Caroline Islands. In these cases mediation probably averted war. In the Austro-Prussian war of 1866, the war between Chile and Peru in 1882 and that between Greece and Turkey in 1897, the mediation of neutral powers was instrumental in bringing hostilities to a close. Despite the successful outcome of these efforts, however, the conviction persisted throughout much of the 19th century that the mediatory intervention of a third state constituted an unfriendly act. In the Hague treaties it was specified that an offer of mediation was not to be so considered.

While the Hague treaties provided certain procedures for mediation, it was not until the League of Nations was established that states assumed an obligation to submit disputes "likely to lead to a rupture" to the procedures of peaceful settlement (League covenant, article 12). The secretary-general of the League was authorized on request of a member of the League to summon a meeting of the council. (Article 11.) He was also authorized to take certain initiatives in arranging for a full investigation and consideration of disputes. (Article 15.) Once the dispute had been submitted to the council, or to the League assembly if it was so referred, the body could proceed on the basis of (1) good offices; (2) mediation; (3) seeking a judicial opinion on some aspect of the case; or (4) some general but less distinct form of

conciliation. (*See* also ARBITRATION, INTERNATIONAL.)

**United Nations.**—Under the United Nations system members assumed an even more precise obligation to settle their disputes in a peaceful manner. Article 2, paragraph 3, states *inter alia* that all members "shall settle their international disputes by peaceful means." Under article 33 the parties to any dispute likely to endanger the maintenance of international peace and security are enjoined first to "seek a solution by negotiation, inquiry, mediation, conciliation, arbitration, judicial settlement, resort to regional agencies or arrangements or other peaceful means of their own choice." Should they fail to settle it by these means they are obliged under article 37 to refer it to the security council. The council, or the general assembly if the dispute is referred to it, then undertakes the form of settlement which it believes suited to the particular case.

Following discussion in the council or in the assembly, the dispute is frequently submitted to mediation. In May 1948, for instance, the general assembly appointed Count Folke Bernadotte af Wisborg of Sweden as mediator in Palestine. After his assassination, Ralph Bunche of the United Nations secretariat was appointed acting mediator. In the winter and spring of 1949 he was able to conclude armistice agreements between Israel and the four neighbouring Arab states. Sir Owen Dixon of Australia was appointed by the security council to mediate the Kashmir dispute between India and Pakistan. He was succeeded in 1951 by Dr. Frank P. Graham of the United States.

Several commissions appointed by the security council and by the general assembly had mediatory functions, *e.g.*, the commission on Indonesia, the India-Pakistan commission, the Palestine Conciliation commission and the commission on Korea.

With the growth of international political organization such clear lines as formerly existed between fact finding, good offices, mediation, arbitration and judicial settlement tended to become somewhat blurred. Disputing states and the United Nations may use different procedures in sequence, or they may separate out certain parts of a dispute for a judicial opinion. The initial discussion in the security council or in the general assembly usually assists in clarifying the issues. In connection with these considerations conciliatory influences are brought to bear. This process has been referred to as parliamentary diplomacy. The term mediation has usually been reserved for the work of the subsidiary bodies set up by the security council or the general assembly to conduct the more intimate and detailed negotiations with the countries in dispute.

The secretary-general of the United Nations, in article 99 of the charter, was given power "to bring to the attention of the security council any matter which in his opinion may threaten the maintenance of international peace and security." This is considerably more power than the secretary-general of the League of Nations was given. The rules of procedure of the general assembly permit the secretary-general to place any item on the provisional agenda of the assembly. While Trygve Lie, the first secretary-general of the United Nations, and Dag Hammarskjöld, the second secretary-general, were cautious about exercising these powers, both men interpreted their role as a broad one.

*See* Elmore Jackson, *Meeting of Minds: a Way to Peace Through Mediation* (1952); Philip C. Jessup, *Parliamentary Diplomacy*, Académie de Droit International, 181 (1957). (EE. JN.)

**MEDIATIZATION** was the process whereby former sovereign houses of the Holy Roman empire were deprived of their sovereignty or "immediate" relationship to the emperor and to the *Reich* and were made "mediate" or subject to some other German sovereign, without, however, being dispossessed of their lands.

Napoleon's establishment of the Confederation of the Rhine (July 1806) was accompanied by the subjection of a great number of formerly immediate dynasties to the rulers of the confederate states; and it was followed by the dissolution of the old *Reich* when Francis II abdicated the imperial title (Aug. 1806). On Napoleon's downfall, the congress of Vienna (1814–15) had to consider whether or not to restore the mediatized dynasties to sovereignty. Schemes for reviving the *Reich* were discarded, and the German confederation or *Bund* was formed, with the nine chief member states absorbing the sovereignties of 48 princes of the Holy Roman empire and 44 counts of the empire. Members of these mediatized dynasties, however, were still recognized as of equal birth (fit to intermarry) with sovereign dynasties, and the heads of their houses had not only control over family affairs and property but also special status at law and some rights of local jurisdiction. Bavaria, moreover, in 1818 accorded the style of *Durchlaucht* (serene highness) to its mediatized princes, and that of *Erlaucht* (illustrious highness) to its mediatized counts; the federal diet voted the general use of the former styling in 1825 and of the latter in 1829 (the states followed suit partly or wholly as they saw fit). Some of the external privileges of the mediatized houses were formally revoked later in the 19th century; the rest were revoked by the republican regime after World War I.

**MEDICAL CARE, GOVERNMENT.** From earliest times the state has intervened in the care of the sick in times of public crisis. Its part in the general task of looking after the sick and ailing poor has, however, been small, and in Europe the church and private charity were the sponsors of such aid until the latter part of the 19th century. Then the state, which had already assumed major responsibility for public health, began, in one country, to assume it for health insurance and medical care also. (For medical insurance in the United States *see* HEALTH INSURANCE.)

Modern governmental medical care can be said to date from 1883 when, as part of Otto von Bismarck's massive social reform legislation, a German act introduced for the first time in any country compulsory sickness insurance for industrial and other workers, up to a given income limit. This included free treatment, free medicine and cash allowances.

Almost 30 years later the British National Insurance act of 1911 came into force. Under this act "insurance against loss of health and for the prevention and cure of sickness" was provided for persons employed on a contract of service: nonmanual workers up to a remuneration limit of £160 a year, and all manual workers without a remuneration limit. In addition to paying the cost of both treatment and drugs, the act provided for the payment of cash allowances during sickness and disability. The funds were provided by a weekly levy of 4*d.* from each male employee, 3*d.* from his employer and 2*d.* from the state. In other countries at that time health insurance was provided mainly by voluntary organizations, such as the Danish "sick clubs" that had been formed in 1857, though these were sometimes regulated by law (in Denmark in 1892).

In the U.S.S.R. the Labour code of 1922, which purported to introduce a comprehensive social insurance service for employees, including medical aid, was generous, at least on paper. Costs were to be met by charges on employers of up to 20% of wages paid. This code was reaffirmed by the 1936 constitution but did not take full practical effect until after World War II.

New Zealand achieved a comprehensive state service with the Social Security act of 1938, which inaugurated a system of state-supported hospital and medical benefits for the whole population partly financed by a charge of 1*s.* 6*d.* on the pound on all earnings, which also covered other security benefits.

In 1948, as a result of the National Health Service act of 1946, a comprehensive medical service for all was introduced into England and Wales and extended to Scotland by an act of 1947. Hospitals became state-owned and were administered by local voluntary committees; free consultation, drugs and hospital services were provided. All employees and their employers paid a flat-rate contribution toward the cost. Although state intervention inevitably aroused political passions (as it did at first in other countries), the principle of a comprehensive medical service was eventually accepted by all British political parties and a system was developed in which government practice and private practice continued side by side.

In the years following World War II, legislation was introduced in a large number of other countries and by 1965 every western European country had a compulsory prepayment program of medical insurance covering at least a section of the population. In the United States the federal and state governments continued to

provide care for special classes of patients, including seamen, war veterans, tuberculosis sufferers and the mentally ill. In 1965 congress enacted the so-called Medicare bill to provide limited hospital care for persons 65 and older, plus a voluntary health insurance plan to help pay doctor bills for such persons.

Though the concept of a national health service has become widespread, the practice shows infinite variety. This applies not only to the scope of the service but also to the means of financing it and the method of paying doctors. The most controversial issue has been the method of paying doctors.

**Payment of Doctors.**—Outside the Communist bloc, doctors have feared that they might become servants of the state and that thereby the traditional doctor-patient relationship might be disturbed. Doctors have also argued that, no matter how comprehensive the service, private practice should be allowed to exist for the maintenance of medical standards. Some independence for doctors has been accepted in principle by practically all the governments concerned, though inevitably there has been disagreement on financial aspects of a government service.

Three main methods of remuneration are in force: (1) full-time salary; (2) fee per item of service; (3) capitation fee. The first of these is largely confined to the Communist bloc (though some private practice may still exist there, *e.g.*, in Poland), but it is also used to a limited extent in some non-Communist countries. It applies particularly to hospital doctors and even in Great Britain a small proportion of consultants have chosen to serve on a full-time salaried basis. The full-time salary method is also used in certain countries, such as Switzerland, New Zealand and Italy, to remunerate general practitioners in remote areas where, because of the sparseness of the population and its scattered nature, it would be impossible for a doctor to earn a reasonable living on the basis of either a capitation fee or a fee per item of service.

Fee per item of service is the method most widely used, though the details vary considerably. The scale of fees is usually negotiated between the doctors and the sick fund. In some countries, particularly for the lower income group and those accepting public assistance, the doctors are directly reimbursed by the fund. The advantage of the fee-per-item-of-service system is that the doctor is paid according to the amount of work he does. Its disadvantages are the possibility of abuse by the doctor and the intricate system of accountancy that it involves. One method of overcoming the first of these is to make the patient pay part of the cost, so that he has a personal interest in keeping the cost as low as possible. In Denmark the higher income groups (which are not covered by compulsory insurance) and all patients in Belgium, Sweden and Australia pay their doctor's fees and recover the greater part of the sum from the sick fund. In France patients may be required to pay personally as much as 50% of consultation fees.

A capitation fee is the method used in Great Britain, Denmark and the Netherlands. Under this system the doctor receives an annual sum for each patient on his list. Its advantage is simplicity of administration (though in Great Britain this is complicated by the very complex "pool" system). From the administrator's point of view the system has the further advantage that it is possible to forecast with some accuracy how much money will be required annually, whereas under the fee-per-service plan the sum depends upon the amount of illness there may be in any one year. Its disadvantage is that it encourages a doctor to take on the maximum number of patients in order to achieve as large an income as possible, and to avoid chronically sick and elderly patients who need a disproportionately large amount of attention. In an attempt to counteract these tendencies in Great Britain a supplementary capitation fee is paid for each patient from the 501st up to the 1,700th on the doctor's list, while there is a fixed maximum number.

**Services Available.**—*Hospital Costs.*—Free hospital care is provided under Communist and most western European systems, and in Canada and New Zealand; in France, Australia and Ireland the patient invariably pays a proportion of his costs (excluding care for infectious diseases and mental treatment). Some countries and some funds, however, provide free care for only a limited period—in the Netherlands for ten weeks, in Austria for less than a year (under most funds) and in the Federal Republic of Germany (West Germany) for roughly 18 months. Patients requiring special facilities, such as a private room, may have to pay a part or the whole of the cost.

*Maternity Benefits.*—Nearly all countries offer free maternity care, including prenatal and postnatal care. This was often the starting point for countries trying to build up systems of national health insurance, *e.g.*, in South America and the middle east.

*Drugs and Other Costs.*—In a few countries drugs prescribed by a physician are free to all. In Italy the National Health institute reimburses the pharmacist directly for drugs administered to patients who are insured with the institute. In most countries certain listed drugs are free; for instance in Austria, Norway and Sweden "essential medicines" are free. In Austria the fund pays part of the cost of drugs on a second list; in Sweden it pays part of all other drug costs; in Norway the patient usually pays for all other drugs. In Poland the patient pays 10% of the cost of "essential medicines" and 30% of the cost of other drugs. In a few countries, such as Germany, Great Britain, Australia and Yugoslavia, there is a prescription charge. In others the pharmacist collects the patient's percentage of the drug cost at the time of sale and later recovers the rest of the cost from the sick fund. In other countries, such as France, the patient pays for the drugs and recovers the money from the fund. Prosthetic devices may also be supplied free, though usually the patient must pay part of the cost.

*Dental and Ophthalmic Treatment.*—Many national health plans envisaged covering dental and optical care but lack of funds and of trained personnel meant that such care was not universally available, even in western Europe in the mid-1960s. For example, in Denmark, France and Germany, free or partly free dental treatment was available; in Switzerland it was available under some funds but not under others; in New Zealand it was available only for primary-school children. Payment methods varied from country to country. In Britain a flat rate of £1 was paid for a course of treatment irrespective of its length and in France and Belgium 80% of the cost was refunded, on a fixed scale. In Germany treatment was free but a grant only was made toward the cost of dentures. Ophthalmic services were provided in only a few countries. In Denmark, for example, a grant toward the cost of spectacles was made. In Britain and Germany testing was in the main free but the patient was required to pay part of the cost of spectacles.

**Contributions Toward Health Services.**—Methods of payment for health services vary considerably. In Great Britain, the Republic of Ireland, Denmark (for the lowest income group) and four provinces of Canada there is a basic flat-rate contribution, independent of earnings or income. In the first three this contribution is required of everyone, whether he participates in the service or not. In many other countries, on the other hand, health insurance contributions are graduated in relation to income. Employees and employers pay a fixed percentage on each salary up to a certain limit; for example, in Austria, Belgium, West Germany and the Netherlands each pays on an average about 2%–3%, though in Italy, Spain and Portugal the employer pays the larger portion, while in France in some low-income groups employees may even pay as much as 20%. In Chile contributions are made by employers and employees, while in Communist countries the employing body alone usually pays.

**Cost and Administration of Services.**—In Great Britain most of the cost of the health service is met from general taxation, contributions covering only about 16% of expenditure on the social security services. In many other countries most of the cost is defrayed from contributions; for instance the sick fund of the Netherlands (which does not include other social security benefits) is entirely self-supporting, and those of France and West Germany are nearly so, the government meeting any deficit. The Belgian sick fund was intended at the outset (1945) to be self-supporting but by the late 1950s it regularly incurred a substantial deficit, which was met by the government. On the European continent a much higher proportion of the cost of government

medical care is met by direct payment by patients than in Great Britain.

The administration of the health plans also varies widely, and it often forms part of a comprehensive social security program. In Great Britain the administration is centralized in the ministry of health, but in most other countries the service works through sickness insurance funds to which the central government makes contribution to supplement payments by members. In West Germany, for instance, there are about 2,000 funds of different types participating in health insurance. They are linked in each *Land* in federations which in turn come under a federal federation covering the whole country. In Norway the health service is organized by local insurance funds attached to each municipality, the whole controlled by a National Insurance institution. In Switzerland there are many cantonal and communal societies and mutual aid funds. In the Netherlands the health system is organized by more than 100 private companies. Another variation is that of Australia where medical benefits are provided under a voluntary insurance plan with the help of additional cash payments by the government to insured patients. A similar arrangement exists in Japan where the government subsidizes part of the health benefits administered by nongovernmental societies.

In a number of countries certain groups of employees organize their own fund; *e.g.*, the Belgian "Mutuelle" organized for railway workers. In Spain mutualities are organized by various industries and in Austria, where insurance is compulsory in certain states for groups such as farmers, the fund for the group is run as an independent government corporation. Reciprocal arrangements, *e.g.*, between Britain, Australia and New Zealand and between certain European countries, may exist to provide benefits to people who may need medical care while abroad. (*See* also SOCIAL SECURITY.)

**Scope.**—In Communist countries comprehensive services are the aim and in Great Britain and Sweden such services are provided, though in Sweden the patient may have to bear part of the cost. In many countries, however, the health services are not operated directly by the central government and their scope is limited to part of the population. In all of the western European countries compulsory programs exist for those earning less than the average income; *e.g.*, the German Krankenkassen. In Portugal, however, those earning less than about £15 a month are exempted from contributing, on the understanding that free care will be available, and in some countries public assistance plays a substantial part in the provision of medical care.

In all countries voluntary programs exist for those for whom insurance is not compulsory (*e.g.*, the German Ersatzkassen), with the result that in western Europe, at least, up to nine-tenths of the population is covered. Where the health plan is limited in scope, the benefits are fewer; public health services, such as the control of infectious diseases and the care of the mentally ill may be available for all, but those outside the insurance plans have to pay their own medical expenses.

Government medical care has developed rapidly in the 20th century, especially since World War II. It has been found to be compatible with professional independence and with the maintenance of the traditional doctor-patient relationship, though inevitably there has been disagreement between government and doctors. The cost to the community of a government health service, run reasonably efficiently, would seem to be comparable to the cost of private medical care. *See* also PREVENTIVE MEDICINE; PUBLIC HEALTH; HEALTH AND SAFETY LAWS.

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**MEDICAL EDUCATION** is devoted to teaching the knowledge and skills used in the prevention and treatment of disease and to developing the methods and objectives appropriate to the study of the still unknown factors that produce disease or favour well-being.

**History.**—The Greeks' spirit of rational inquiry may be considered the starting point of medical education because it introduced the practice of observation and reasoning regarding disease. Rational interpretation and discussion lend themselves to teaching and thus to the formation of schools such as that at Cos where Hippocrates (*q.v.*) taught. Later the Christian religion greatly contributed to both the learning and the teaching of medicine because it favoured as acts of Christian piety not only the protection and care of the sick but the establishment of institutions where collections of sick people encouraged observation, analysis and discussion among physicians by furnishing excellent opportunities for comparison. With the rise of the universities in Italy and later in Cracow, Prague, Paris, Oxford and elsewhere in western Europe, the teachers of medicine were in some measure drawn away from the life of the hospitals and were offered the attractions and prestige of university professorships and lectureships. As a result, the study of medicine led more often to a familiarity with theories about disease than with actual sick persons. However, the establishment in 1551 of the Royal College of Physicians of London, largely through the energies of Thomas Linacre, who in 1518 had obtained from Henry VIII the original letters patent for a body of regular physicians, produced a system of examination of medical practitioners. William Harvey provided the necessary stimulus to the scientific study of the normal processes of the body so that gradually the emphasis upon theory and doctrine decreased, although it lasted well into the 18th century.

Little by little the value of hospital experience and the training of the students' sight, hearing and touch in studying disease were reasserted, though to rather indifferent contemporaries, in London by Thomas Sydenham and later in Leiden by Hermann Boerhaave (*qq.v.*) and more effectively in Vienna by Gerhard van Swieten. In the 18th century in Europe medical education began slowly to assume its modern character in the application of a gradually increasing knowledge of natural science to the actual care of patients. This return to the bedside aided the hospitals in their long evolution from dwelling places of the poor, the diseased and the infirm, maintained by charity and staffed usually by religious orders, to the well-equipped, efficient places of today used by every part of the community, maintained by charity or at public expense and staffed by trained nurses, physicians, surgeons and lay assistants.

The 19th-century discoveries of Louis Pasteur, which showed the relation of microorganisms to certain diseases, Joseph Lister's application of Pasteur's concepts to surgery and the studies of Rudolf Virchow and Robert Koch brought immense stimulus to the practice of medicine and surgery. The passage of the Medical act of 1838 has been described as the most important event in British medicine. This established the General Medical council, which thenceforth controlled admission to the medical register and thus had great powers over medical education and examinations.

In the U.S., medical education was greatly influenced by the example set in 1893 by the Johns Hopkins Medical school, Baltimore, Md. It admitted only college graduates with a year's training in the natural sciences. Its clinical work was superior because the school was supplemented by the Johns Hopkins hospital, created expressly for teaching and research carried on by members of the medical faculty. The number of inadequate medical schools in the United States was reduced after the Carnegie Foundation for the Advancement of Teaching published in 1910 a report by Abraham Flexner (*see* FLEXNER). The report attracted attention to the need of medical schools for better laboratory facilities, better access to patients in hospitals and larger, better-trained teaching staffs. Aided by the General Education board, the Rockefeller foundation and a large number of private donors, U.S. and Canadian medical education was characterized by substantial improvements from 1913 to 1929 in point of endowments, buildings, laboratories, clinical facilities, teaching staffs and methods of instruction.

**General Characteristics.**—The distinctive feature of medical education is the thoroughness with which theoretical and scien-

tific knowledge are fused with what experience teaches in the practical responsibility of taking care of human beings. It must be remembered that the clinical teacher has an immediate and absolute responsibility to his patients as well as to his students. This double burden of theory and practice is all the heavier when great advances are being made in medical science. The curriculum is already overcrowded, and no one now expects a specialist in any branch of medicine to complete a fully adequate training in less than one to five years after receiving the minimum four- or five-year medical education necessary in most countries to secure the licence to practise.

The premedical courses required in most countries emphasize the subjects of physics, chemistry and biology. Graduation from a recognized secondary school is required. The courses in physics, chemistry and biology are required in order to make it possible to present subsequently the subjects of anatomy, physiology, biochemistry and pharmacology with precision and economy of time to minds prepared in scientific method and content. Each of the courses required should include laboratory periods of from two hours to six hours a week for a full academic year. However, the extent of the student's familiarity with the use of instruments and laboratory procedures varies widely from country to country since premedical instruction is expensive and is often of inferior quality.

The medical schools begin their work with the study of the structure of the body and its formation: anatomy, histology and embryology. Concurrently, or soon thereafter, come the studies related to function; *i.e.*, physiology, biochemistry, pharmacology and, in most schools, biophysics. Usually after the microscopical study of normal tissues (histology) has begun, the student is introduced to pathological anatomy, bacteriology, immunology, parasitology—in short, to the agents of disease and the changes they cause in structure and function of the tissues. Courses in medical psychology, biostatistics and public health may be found in the first two or two and one-half years of the medical course, but this was not common before 1935. Wide differences are observed from country to country and from decade to decade in the sequence and emphasis given the courses in the above-named medical sciences, and in the balance between laboratory work, lectures and seminars. The essentials to be desired, however, remain: superior quality of the teaching staff, a high ratio of teaching staff to students, adequate funds for laboratory work and research and high-quality character, mind and training in the students.

The two or more clinical years of an effective curriculum are characterized by active student participation in small group conferences and discussions, a decrease in the number of formal lectures and an increase in the amount of contact with patients in teaching hospitals and clinics. Through work with patients under the supervision and guidance of experienced teachers, students learn methods of obtaining comprehensive, accurate and meaningful accounts of illness, how to conduct physical examinations and how to develop judgment in the selection and utilization of laboratory diagnostic aids. During this period they learn to apply the knowledge gained in their pursuit of the basic medical sciences to the study of general medicine and the medical and surgical specialties.

This first phase of clinical indoctrination can only develop a foundation through offering the opportunity to learn certain essentials; to this the student physician must add expertness and competence through special and advanced education and training. Such advanced education and training in medicine is of two general types. (1) On completion of medical school, the physician usually seeks graduate training and experience in a hospital under the supervision of competent clinicians and other teachers. In Britain after 1953 a year of resident hospital work was required after qualification and before admission to the medical register. In North America the first year of such training is known as an internship. Persons seeking further graduate education and training to qualify themselves as specialists, or to fulfill requirements for a higher academic degree, subsequently become hospital residents or fellows for periods of from one to four or five years. (2) The second type of advanced training is known as postgraduate education. It consists of courses and training opportunities of from a few days to several months in duration, designed to enable physicians to learn of new developments within their special areas of concern. Such courses, fostering the continuing education of physicians, are offered by medical schools, hospitals and medical societies in many parts of the world.

**Pedagogical Aspects.**—Abraham Flexner rightly insisted that medical education is a form of education and not a mysterious process of professional initiation or apprenticeship. In terms of educational methods the following points deserve mention:

In the United States, Great Britain and the commonwealth, medical schools are inclined to limit the number of students admitted so that each student may have a reasonably good opportunity. In western Europe, South America and most other countries, no exact limitation of numbers of students has been effected, though there is a trend toward such limitation in some of the western European schools. Some medical schools in North America are able to show ratios of teaching staff to students as high as 1 to 1 or 1 to 2, in contrast with 1 teacher to 20 or even 100 students in certain European universities.

Where the laboratory or the clinical facilities are inadequate for a large number of students, or where the teaching force is small, the relative importance of the examination increases. When the examination is the sole indication of the student's industry, knowledge and capacity, emphasis usually comes to be placed on memory rather than on powers of observation and reasoning.

As applied to clinical teachers the term "full time" originally implied an educational ideal: that a clinician's salary from the university should be large enough to relieve him of any reason for seeing private patients for the sake of supplementing his salary by professional fees. "Full time" has come to be applied, however, to a variety of modifications; it may mean that a clinical professor may supplement his salary as a teacher up to a defined maximum, or may see private patients only at his hospital office, or may see such patients only a certain number of hours per week. The intent of "full time" has always been to place the professor's capacities and strength entirely at the service of his students and the patients entrusted to his care as a teacher and investigator.

Courses in the medical sciences commonly follow the formula of three hours of lectures and six to nine hours of laboratory work per week for a three-, six- or nine-month course. Instruction in the clinical subjects, though retaining the formal lecture, tends to diminish the time and emphasis allowed to lectures in favour of experience with and attendance on patients. Nonetheless, the level of lecturing and formal presentation in continental Europe remains high. Formality and a considerable measure of emphasis on status also characterize the relationship between professor and student in European schools.

In the United States the fifth, or intern, year is of special importance and value, though it is not usually directly controlled by the medical school and ordinarily follows the award of the M.D. degree. The intern usually lives in an approved hospital and in any case devotes his entire time to the work of the hospital. Often the intern year leads to a second year called assistant residency or residency, a continuation of this extremely valuable practical experience. In the United States approximately three-fourths of graduate physicians enter residency training for a period of two to five years following the internship.

The clinicopathological conference is a distinctive feature of medical education in North America. As a public exercise, a clinician comments upon the record of a case of fatal illness in a patient he has not seen and discusses from this record the probable cause and nature of the illness. The pathological anatomist who examined the organs of the deceased then reports upon the actual findings. The lessons are vivid and the effect upon the fullness and accuracy of hospital records is excellent.

In Great Britain, Canada, Australia, New Zealand, South Africa and Ireland the academic degrees given at the end of five years of study are the M.B. and B.Ch. (bachelor of surgery). Only after considerable further study is the M.D. given, and only to a few persons; only these persons are entitled to be addressed

as "doctor." However, it is customary in Great Britain and the British Commonwealth to address all physicians as "doctor" whether or not they hold the M.D. degree; but surgeons, including holders of the M.D. degree, prefer to be called "mister," although in northern England and in Scotland they are called "doctor."

In some countries of western Europe, in South America, North America, China and the Philippines, the M.D. is given at the end of four to six years of study and is not, therefore, an advanced degree.

The quality of medical education is supervised in the English-speaking countries by councils appointed by the profession as a whole—*e.g.*, the Council on Medical Education and Hospitals of the American Medical association in the U.S.—or, in the case of Great Britain, by a statutory body, the General Medical council, most of whose members are from the profession, although only a minority of the members are appointed by it. In other countries this is a function of the ministry of public instruction with, in some cases, the help of special councils to represent professional knowledge and experience.

**Social Factors.**—In the United States, licensure to practise medicine is controlled by boards of licensure in each of the states. These boards set and conduct examinations of applicants to practise within the state and examine the credentials of applicants who wish licences obtained in other states to be accepted in lieu of examination. In 1915 the National Board of Examiners was created as a voluntary organization with two representatives each from the army, navy and public health service, three representatives from state licensing boards and seven other physicians to hold examinations leading to a diploma that would be acceptable to all the state boards.

National laws regulating professional practice cannot be enacted in the United States.

In Canada the Medical Council of Canada conducts examinations and enrolls successful candidates on the Canadian medical register. The provincial governments accept the certificate of this registration as the main requirement for licensure. In Great Britain, the medical register is kept by the General Medical council, which supervises the licensing bodies; unregistered practice, however, is not illegal. In most European countries, graduation, on conditions set by law, from the state-controlled university or medical school in effect serves as a licence to practise; and the same is true for the U.S.S.R., China and Japan.

After 1920 there was a steady growth and improvement of preventive medicine and public health in the U.S., both in terms of the number and qualifications of professional personnel employed by cities, counties, states and the U.S. public health service and in terms of its importance in the medical curriculum. A similar development characterized many other countries, especially the U.S.S.R.

It is becoming apparent that it is of special advantage to a patient to obtain care in a teaching hospital, since, if his case is to be used for discussion or teaching, there is every likelihood that the examination, diagnosis and treatment will receive particular care and repeated attention; hence, a hospital's affiliation with a medical school for research and teaching purposes is very desirable. This was realized by the U.S. Veterans administration in 1945 when the Deans' committee assured collaboration between the medical schools and the hospitals of the Veterans administration. Collaboration between school and hospital has given rise to the so-called medical centres.

**Economic Aspects.**—The income of a medical school is derived from four principal sources: (1) tuition and fees; (2) endowment income or appropriation from the government (taxation); (3) gifts from private sources; (4) donation of teachers' services. Tuition or student fees are large in the English-speaking countries, except in U.S. state universities, and small throughout the rest of the world. Only rarely does income from tuition exceed 50% of a school's total income. The total cost of maintaining a medical school, if prorated among the students, would give a figure from 3 to 50 times the tuition or other charges paid by the student.

The expenses of medical education fall into two groups: those of the instruction given in the medical sciences and those connected with hospital teaching. The cost of building maintenance, laboratory equipment and supplies, research expenses, salaries of teachers, wages of employees, etc., in the medical sciences, though heavy, are comparable to those in other departments of the university. In the clinical subjects all expenses in connection with the care of patients usually are considered as hospital expenses and not carried from the medical school budget, which should be reserved for expenses of teaching and research. Here the heavy expenses are salaries of clinical teachers, especially the full-time teachers, and the cost of studying cases of illness with a thoroughness appropriate to their use as teaching material.

To a considerable degree in all countries except the U.S.S.R., the cost of securing an adequate medical education has tended to exclude the student whose family cannot contribute a large share of his living expenses and tuition for a period of four to ten years. This difficulty is offset in some medical schools by loan funds and scholarships, but these aids are commonly offered only in the second or subsequent years. In Britain scholarships and maintenance grants are available, through both state and local educational authority funds, so that a clever boy or girl can have the opportunity of a medical education even though the parents may not be able to afford its cost.

**Scientific Aspects.**—Medical education has the double task of passing on to students what is known and of attacking what is still unknown. The cost of research is borne by a few; the benefits are shared by many. There are countries whose inhabitants are too poor to support physicians or use them; countries that can support a few physicians but are too poor to maintain a good medical school; countries that can maintain medical schools where what is known can be taught but no research can be carried out; and a few countries where teaching and research in medicine can be carried on to the great advantage of the world at large.

A medical school having close geographical as well as administrative relationships with the rest of the university of which it forms a part usually profits by this intimate and easy contact. From the biological sciences medicine cannot wisely be separated. From chemistry, physics, mathematics and psychology, medicine has already gained immensely and continues to profit. The social sciences have a contribution to make in helping physicians provide a better distribution of medical care. Contact with teachers and the advancing knowledge in other faculties of the university would extend and improve the chances of progress in medicine.

**International Aspects.**—With the development of the World Health organization and the World Medical organization following World War II there has been increasing international interest in medical education. World War II showed the advantages and economy derived from satisfactory systems of medical education. Defects and diseases were more widely and accurately detected among recruits than ever before, health and morale were effectively maintained among combatants, and disease and battle injuries were effectively treated in the armed forces of those nations whose medical schools had been of high quality, and only in those nations. However, as a result of the war, the medical schools of Norway, Finland, western U.S.S.R., Poland, Czechoslovakia, Germany, Austria, the Balkan states, Italy, France, Belgium, the Netherlands and England, as well as those of China, Japan, the Philippines, Java and Thailand, suffered either physical destruction of laboratories, hospitals and libraries or serious losses of teaching personnel and students.

In Aug. 1953 over 600 registrants from 59 nations attended the first World Conference on Medical Education in London. That conference was centred around undergraduate medical education and concerned itself with the requirements for entry into the medical schools, the aims and content of the medical curriculum, the techniques and methods of medical education and preventive and social medicine.

The second World Conference on Medical Education, dealing with the problems of education beyond the medical school, was held in Chicago, Ill., during 1959, with representatives of 63 countries in attendance.

*See* also references under "Medical Education" in the Index.

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**MEDICAL JURISPRUDENCE,** or forensic medicine, is strictly defined as the application of the science of medicine in courts of law. In practice the subject includes many other matters which are not necessarily concerned with court proceedings. These include the medical aspects of proceedings before administrative or quasi-judicial bodies such as pensions tribunals, industrial injuries boards, medical appeal tribunals, etc., and medicolegal aspects of administrative law such as the control of dangerous drugs and poisons, the disposal of dead bodies and stillbirths, the exercise of compulsory powers of admission to hospital over persons of unsound mind, etc. Legal and ethical aspects of medical practice itself are included, such as the functions of professional disciplinary bodies, medical registration and licensing of doctors, professional negligence, medical certification and the code of medical ethics. The European practice of referring to the subject as "legal medicine" (*médecine légale* in French, *gerichtliche Medizin* in German) is therefore a more correct description of its scope and is increasingly used in the United States.

The broad canvas which the subject now covers is a reflection of the increasing part played by medicine in the social life of the community. Inevitably there is overlap into subjects such as public health, industrial medicine, criminology, addiction and into the wider field of forensic science. In some European countries university chairs of legal medicine are combined with criminology, or with social or insurance medicine.

**Growth of Medical Jurisprudence.**—Although instances of medical evidence being given in courts of law can be cited back to classical antiquity, the basis of modern medical jurisprudence cannot be traced back before the 13th century when the laws of the north Italian states first provided for medical experts to be appointed to advise the courts and laid down the requirements necessary to qualify as an expert medical witness. About the same time the first appointments as police surgeons were made. Post-mortem examinations (autopsies) were carried out for medicolegal purposes, particularly in cases of suspected poisoning. It was this practice which revived the interest in anatomical dissection, itself to have a profound effect on the development of modern European medicine. By the 16th century the procedure for assembling medical evidence and presenting it in courts of law in criminal cases was well developed and found expression in the Brandenburg, Bamberg and Caroline penal codes. At the same time the procedure for investigating cases of violent or sudden deaths was also laid down. Centuries were to pass, however, before these principles were accepted in Britain, where the development of medical jurisprudence was apparently unaffected by the important events taking place on the European continent. Although Johannes Bohn's classical monograph *De Renunciatione Vulnerum*, published in Leipzig in 1689, had emphasized the need for all the cavities of the body to be opened at medicolegal autopsy, it was not until 1953 that this important principle of legal medicine received official, and then only indirect, recognition in England. Indeed, until 1836 the coroner in England had no power to pay for medical evidence at inquests and it was even doubted whether he could order a post-mortem examination.

Similarly the teaching of medical jurisprudence at British universities lagged behind the continent. Although Johann Michaelis was lecturing on legal medicine at Leipzig in 1642, no course was given in Britain until Andrew Duncan (Sen.) lectured at Edinburgh university in 1801. Meanwhile, chairs of legal medicine, often combined with public health and hygiene, had been set up in many universities on the continent. The first chair in the United Kingdom was established by crown commission in 1807 when Andrew Duncan's son (of the same name) was appointed professor of medical jurisprudence and medical police. About the same time, James Stringham delivered a course of lectures in New York at Columbia college (1804) and was appointed in 1813 to the first chair of medical jurisprudence in the United States instituted by the College of Physicians and Surgeons in New York city. Other courses were given by Charles Caldwell at Philadelphia Medical college in 1812–13 and by T. R. Beck at Western Medical college in 1815. Since that period the majority of medical schools in the United States have included the subject in their courses of instruction.

Postgraduate instruction in legal medicine has been available on the continent of Europe for a considerable time. From the beginning of the 19th century attendance at courses at the medicolegal institute in Vienna was a condition of appointment as police surgeon in many European countries. Recognition as an expert in the subject on the continent is dependent upon a long course of postgraduate instruction at a medicolegal institute or a university department of forensic medicine. In Czechoslovakia, for example, after qualification as a doctor, three years in pathology and a pass in a special examination is required. This is followed by a further three years in a medicolegal institute and another examination, which includes the performance of a medicolegal autopsy and the giving of an opinion on legal documents. This contrasts favourably with the position in British and American courts, where any medically qualified person may give evidence in court as an expert witness. In parts of England and of the United States coroners' post-mortem examinations may be carried out by any qualified doctor irrespective of his experience in medicolegal work; in other parts only experienced pathologists are employed for the purpose, *e.g.*, in London, and in particular in Los Angeles, where coroners' autopsies may be carried out only by official autopsy surgeons.

**Medical Evidence in Courts of Law.**—Both criminal and civil courts receive medical evidence. In criminal courts such evidence is concerned chiefly with the identification and interpretation of injuries in support of charges of crimes such as murder, manslaughter, infanticide, woundings, poisonings, assaults (both sexual and nonsexual), rape, abortion, etc., and with matters such as the state of mind of the accused person and whether he was intoxicated, etc. The identification of human remains, the distinction between injuries received before death and after death, the time elapsed since death, the distinction between live birth and stillbirth, the signs of drowning, traumatic asphyxia, hanging, strangulation, suffocation, throttling, electrocution, burning and wounds received from instruments or firearms are but a few of the wide range of matters upon which medical evidence may be required in criminal courts.

The sensational nature of this kind of evidence usually overshadows the importance of medical evidence in the civil courts, where it may be needed in common-law actions based on negligence which results in personal injuries; *e.g.*, traffic accidents, nervous shock cases, etc. In such cases medical evidence may be relevant both as to the cause and extent of the injuries, as well as their possible consequences in terms of assessing damages. Medical evidence may also be needed by the courts in connection with mental capacity to make a will disposing of property (testamentary capacity), with presumption of survivorship, inability to consummate a marriage, the state of mind of one or other spouse, duration of pregnancy, illegitimacy, etc. In England the president (senior judge) of the probate, divorce and admiralty division of the high court appoints special medical inspectors to examine the parties in nullity cases. Courts may also require medical evidence in the exercise of their jurisdiction over the property of persons of unsound mind (in England, court of protection orders). Other civil cases in which medical evidence may be required include paternity orders, maintenance orders, noncohabitation orders, etc., which are often dealt with by lower courts of summary jurisdiction. Jurisdiction in civil cases in the United States varies considerably from state to state.

Coroners (*q.v.*) have jurisdiction over violent, unnatural or sudden deaths of unexplained cause, and it is in these cases that

medical evidence is essential. In some areas coroners themselves are medically qualified, and in those parts of the United States where coroners have been replaced by medical examiners a medical qualification is a condition of appointment. The coroners in London are qualified both in medicine and in law. The main evidence received by the coroner is the report of the autopsy carried out on the body of the deceased person, and in many areas such examinations are carried out in nearly every case. Corresponding, though less comprehensive, investigations are carried out by the procurator fiscal in Scotland. There is no corresponding procedure for investigating sudden death on the continent of Europe. Deaths attract investigation in such cases only where there is manifest suspicion of crime or delict. They are often notified to the police or local public prosecutor (*e.g., procureur de la république*). Unlike the coroner, neither the police nor public prosecutors have power to order medicolegal autopsies, and the authorization of an investigating judge (*juge d'instruction*) has to be obtained. Exceptions include Denmark, Finland and Portugal, where the police are so authorized, and the Netherlands and U.S.S.R., where the local public prosecutor may authorize an autopsy. In some countries, *e.g.*, the Federal Republic of Germany, the judge has to be present at the autopsy. Finally the right, and in some cases duty, of the coroner to hold a public inquest at which persons can be examined under oath and a verdict of a jury on the cause of death obtained, is peculiar to the Anglo-American coroner system and does not exist under the medical examiner or continental systems of medicolegal investigation. The coroner system therefore secures a far more comprehensive check on sudden deaths.

**Medical Witnesses.**—Two kinds of medical evidence may be given in courts of law. Evidence can be given as to facts which have come within the doctor's knowledge in the course of his practice, and in respect of which he is in the same position, in principle, as other witnesses to fact; he can also be called to give expert evidence in which he gives his opinion on facts presented to him which have not come within his knowledge in the course of his practice, or where he had carried out a special examination or investigation for the specific purpose of providing the evidence.

The question whether information obtained in a professional capacity should be disclosed without prior consent of the patient may bring the doctor into conflict with the law. The international code of medical ethics which has been adopted in principle by all countries whose medical associations are affiliated to the World Medical association embodies the Declaration of Geneva (1949), which states: "I will respect the secrets which are confided in me." In circumstances where the court requires disclosure of information, the doctor may risk imprisonment for contempt of court if he declines to give the information. This is the position in Great Britain and about 15 states of the United States. In about 35 states, however, varying degrees of privilege, precluding disclosure of confidential information obtained in the course of treating a patient, are allowed, but the privilege can be waived in certain circumstances; *e.g.*, where the patient offers himself or his physician as a witness, although this is not the invariable rule. The tendency is to allow privilege to doctors.

As a general rule evidence as to opinion is excluded from the courts on the grounds that it is for the court to form its own opinion on the facts which are before it, and the admission of expert evidence based on opinion would therefore trespass on the function of the judge and jury. However, in cases where the matter before the court is complicated or technical in nature it has become customary for the courts to admit evidence of expert opinion in order to assist it to reach its conclusions on the facts before it. Accordingly specialists in various branches of medicine may be called to assist the courts. It is in the field of pathology that expert medical evidence is most frequently required. Expert psychiatric opinion is also sought increasingly in connection with the state of mind of persons who have been accused of committing criminal offenses or other matters which have been dealt with above. The frequent need for courts to obtain evidence in these two fields has led to the development of specialities in forensic pathology and forensic psychiatry.

Other specialities on which the courts frequently require expert opinion include forensic odontology, which is concerned with the identification of persons or their remains through examination of their teeth; forensic immunology and serology are concerned with the identification of persons from examination of blood stains or of other secretions of the body such as spermatozoa, and with related problems such as disputed paternity; forensic toxicology is concerned with the unlawful or accidental use of poisons or drugs and their identification by analysis of specimens. Specialists in these fields are not necessarily medically qualified. The interpretation of a bullet wound may depend on a knowledge of ballistics; the question whether a person is fit to have control of a motor vehicle may depend on the concentration of alcohol in the body tissues, etc. Expert medical evidence in courts of law has become associated increasingly with supporting evidence of investigations carried out in the field of forensic chemistry, such as spectrophotometry, chromatography, activation analysis for minute amounts of various elements, and the identification of fibres, soils or other substances (*see* INVESTIGATION, CRIMINAL).

The handling of expert medical evidence by continental courts (based on civil-law "inquisitorial" procedure) is very different from the procedure in English and U.S. courts (based on common-law "accusatorial" procedure), and the difference is most marked in criminal or quasi-criminal (delictual) cases. In England documentary evidence is admitted only subject to strict limitations whereas on the continent the expert medical evidence is almost entirely documentary and is included in the "dossier." Either side in an English trial may call expert medical witnesses, who may frequently disagree in their opinions, and who may be examined, cross-examined by the other side and re-examined. On the continent expert medical evidence is only given by the court's officially recognized expert, who will appear in person only when it is necessary to explain any doubtful points in his written evidence. Even then he may be examined only by the presiding judge and cannot be questioned by counsel for the parties to the action. The limitation of medical evidence to experts recognized by the courts means that the spectacle of medical witnesses giving directly contrary evidence on behalf of either side—the so-called "battle of the experts"—is never seen in continental countries. In most continental countries medicolegal institutes have been set up by the state to provide the courts with the best evidence, the more famous ones being in Vienna (founded 1803), Berlin and Leipzig. In Denmark the courts are advised by the State Medico-Legal council, which examines about 4,000 cases each year. Each case referred by the courts is examined by three members of the council. These institutes are equipped to carry out investigations covering the whole field of forensic sciences and may deal with matters such as the examination of individuals injured in industrial accidents in addition to court work. They may also arrange for operations such as castration or sterilization of certain offenders, *e.g.*, hypersexed sadistic psychopaths, where the laws of the country permit it. Their nearest equivalent in English-speaking countries is the forensic science laboratories which have been set up by the home office in England on a regional basis, but their scope is limited and restricted mainly to the field of chemical analysis.

**Medical Certification.**—A doctor in any country will be asked to give certificates required by law for various purposes. Medical certification, in terms of legal duty, forms an important part of a doctor's practice and the consequences of inaccurate certification are serious. In many cases international forms of medical certificate have been introduced; *e.g.*, death certificates and certificates of vaccination. Stillbirth certification by doctors or midwives is obligatory in most countries, and the detention of a person of unsound mind in a hospital or under guardianship must always be supported by a medical certificate. Methods of disposal of dead bodies other than earth burial, *e.g.*, cremation (which destroys all evidence of the cause of death), must generally be authorized by special medical certificates. An increasing number of countries now require a medical examination and report on the child as well as the prospective adoptive parents before legal adoption of a child is permitted. Certain infectious diseases, depending on the country concerned, must be notified by doctors to public health authorities. Certificates of incapacity for work on

account of illness or injury are universally required from doctors, while many medical certificates are required in the insurance field in support of prospective policy holders or of claims for sickness or injury benefits.

**Medical Discipline and Conduct.**—Most countries have introduced regulations to enable the public to distinguish between duly qualified doctors and unqualified practitioners, and this is achieved by licensing or registration procedure. In the United States licensing is administered by the various states and may be either general or limited. General licences are issued to duly qualified doctors after scrutiny of their qualifications, character and experience. Limited licences are issued to dentists, osteopaths, chiropractors, etc., and are restricted to certain practices within their specialities. No licence to practise medicine is required in Great Britain and many European countries, but it is an offense for a person to pretend to the public that he is a registered medical practitioner, as by willfully and falsely using certain titles calculated to deceive (*e.g.*, in Britain, M.D.). A similar rule applies in the United States. Persons who are not licensed or registered are prohibited from various functions for which licensed or registered doctors are empowered; *e.g.*, prescribing dangerous drugs (narcotics), treating venereal disease, giving medical certificates or attending maternity cases (other than certified midwives).

The various registration and licensing bodies have power to suspend registration or a licence upon proof of professional misconduct in certain circumstances. For example, in Great Britain conviction of certain offenses or the judgment of the disciplinary committee of the General Medical council that a doctor has been "guilty of infamous conduct in any professional respect" are grounds for removal from the register. Professional misconduct can include adultery or other improper conduct with patients, procuring illegal abortions, drunkenness or drug addiction, advertising, canvassing, etc. The standards of professional conduct, however, vary greatly in different countries. Adultery with patients is not generally a ground for prohibiting a doctor from practising in other European countries than Britain, and advertising is permitted freely. An increasing number of countries have introduced state health services, and disciplinary bodies have been set up to pronounce upon alleged breaches by doctors of their terms of service with the state. Finally, national medical associations may expel from membership doctors who are found guilty of infringing their association's own code of medical ethics, and many associations, *e.g.*, the British Medical association (B.M.A.), have set up means to deal with such cases.

Finally, medical jurisprudence is concerned with the relationship of medical practice itself to the laws of the country. The legality of certain practices such as termination of pregnancy, sterilization, castration, artificial insemination, tissue grafting, contraception, animal experiments, anatomical dissection, euthanasia, to mention only a few, are matters of very considerable importance to doctors, and their position in law in relation to many of these practices is often obscure; *e.g.*, it is an offense in parts of the United States to run a birth control clinic, but the supply of contraceptives for prophylaxis against venereal disease may be permitted at the same time. Sterilization is permitted in some states and not in others. The grounds on which pregnancy can be terminated in different countries vary from absolute prohibition to almost any medical, eugenic or social consideration.

The doctor is in exactly the same position as any other professional man in that failure to exercise reasonable care may result in an action being brought against him in negligence if the patient suffers damage as a consequence. The same rules as to presumptive and contributory negligence apply. Both in England and in the United States a mistaken diagnosis or treatment is not per se actionable in negligence; it must be shown that the doctor omitted or committed some procedure which a reasonable doctor in his position would have done or not done; *e.g.*, failure to X-ray head injuries or omission to give antitetanic serum in the appropriate cases. Doctors will also be liable in trespass (assault) for carrying out procedures without the express or implied consent of the patient. Finally, patients may sue their doctors in contract for inadequate or faulty provision of services. The instruction of medical students in medical jurisprudence will protect them against many of the legal pitfalls of medical practice.

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**MEDICAL LEGISLATION** usually is considered to be a segment of the laws dealing with public health and safety. The subject encompasses food and drug laws, safety laws, workmen's compensation and related subjects. *See* HEALTH AND SAFETY LAWS.

**MEDICAL OPTICS:** *see* EYEGLASSES; OPTICS.

**MEDICAL RESEARCH** is the fundamental investigation, medical, biological and behavioural, of problems encountered in medical and public health practice. Its content and organization are extremely broad and complex. Annually throughout the world, about 180,000 research reports appear in approximately 5,000 journals, and an estimated 10,000 books are published on medical subjects. Research workers are employed by a wide variety of institutions—academic, philanthropic, industrial and governmental. Such diversity of activity and structure precludes a detailed review in this article. The topic will be treated in general terms and with a historical and socioeconomic perspective.

**History.**—Medical research is as old as the practice of medicine. No two cases of a disease are exactly alike, and the physician may have to change the treatment and even the diagnosis as facts about the patient's illness come to light. In the course of practice, he observes disease processes and the effects of therapy, learning through experience and communicating his findings. The modern medical scientist may treat many subjects—patients or experimental animals—with identical procedures in order to take into account the variation in individual reactions. Such methods accelerate the process of observation and discovery, but the ancients, though less systematic, also amassed medical knowledge.

Prior to the 18th century, medical research was predominantly descriptive rather than experimental. Hippocrates, in the 5th–4th centuries B.C., wrote on epidemics, fevers, epilepsy, fractures, health in general and medical ethics. Avicenna, the most illustrious physician in Arabian medicine, in the 11th century A.D. codified the whole of medical knowledge up to his time, producing a medical text that proved to be the most influential in Europe and Asia for several centuries. Andreas Vesalius issued at Basel in 1543 his masterpiece of anatomy, *De humani corporis fabrica*, illustrated in Titian's workshop; together with its companion *Epitome*, this volume remains one of the paramount descriptive anatomies of all time.

Classic descriptions of diseases include the writings of Johann Lange on nutritional anemias (1554), William Harvey on the circulation (1628), Gaspar Casal on pellagra (1735) and Percivall Pott on soot-induced cancer (1775). A pioneer of this early descriptive period was the Dutch microscopist Anton van Leeuwenhoek, the first to see single-cell organisms such as bacteria.

Among early experimenters was Lazzaro Spallanzani, who studied digestion, circulation, fertilization in animals, the senses of bats and regeneration of the limbs in salamanders. Experimental pathology was introduced in the 18th century by John Hunter, who described inflammation, compensatory circulation and fetal development. In 1796 Edward Jenner vaccinated a small boy with cowpox and demonstrated protection against small-

pox, anticipating the development of other vaccines by more than 80 years.

During the 19th century, medical research was continued and broadened by many dedicated workers. Major events of this period include the introduction of the cell theory by Theodor Schwann, a German anatomist (1839); the use of ether as an anesthetic by a U.S. dentist, William Morton (1846); the recognition by Ignaz Semmelweis, a Viennese obstetrician, that deaths from puerperal fever among women hospitalized for childbirth were due to infection by the hands of attending physicians (1847); the explanation of the function of nerves by the French physiologist Claude Bernard (1851); and the publication of a text on cellular pathology by the German Rudolf Virchow (1858). The theory of evolution propounded by Charles Darwin in *The Origin of Species* (1859) has many implications in medical science since it casts light on variation, the forerunner of natural selection in the evolutionary process; it thus led to the science of genetics, which, after being founded by the Austrian monk Gregor Johann Mendel in 1865, went unrecognized for 35 years.

The late 19th century saw the development of the basic principles that led eventually to the control of many infectious diseases. Earlier progress in physiology, pathology, chemistry, physics and other disciplines provided the foundation for such new sciences as microbiology and radiology. Louis Pasteur, French chemist and bacteriologist, set out to learn why wines soured. In studying wine and beer, he discovered that living microorganisms caused fermentation and putrefaction. His answer to the question of how to prevent this was heat—pasteurization (*c.* 1860). The work led to the concept that germs can cause disease. Pasteur also discovered the technique of vaccination with attenuated microbes, developed a preventive treatment for rabies (1885) and made many other basic contributions.

Lord Lister, in England, applied Pasteur's ideas on germs to surgery, performing operations in a spray of carbolic acid to prevent infection (1865). Modern aseptic techniques evolved from these experiments.

Robert Koch, a German, made bacteriology an exact science. While practising as a physician in Silesia, he isolated the anthrax bacillus from the blood of animals that had died in an epidemic of anthrax; he then grew the bacillus in pure culture and found that it would infect other animals (1876). The discovery that specific microbes cause specific diseases, one of the most epoch-making in the history of medicine, soon led to identification of the causal agents of gonorrhea, diphtheria, typhoid fever and many other diseases. Koch himself isolated the microorganisms of tuberculosis and cholera.

The theory of immunity is attributable to the Russian Élie Metchnikoff, who, while studying the origin of the digestive organs, observed that certain cells not involved in digestion can nonetheless engulf foreign bodies. He showed that these agents—white blood cells—destroy bacteria, and he called them the body's first line of defense against disease. This observation and its relation to antibodies is the foundation of immunology.

Another pioneer of this era was Paul Ehrlich, a German, who applied stains to cells and tissues in order to reveal their function, founded the science of hematology and developed the side-chain theory of immunity (1897). This theory held that unstable side chains on protein molecules can combine with harmful materials to neutralize them. Variants of the theory serve modern chemotherapy, a field launched by Ehrlich with the introduction in 1910 of Salvarsan for the treatment of syphilis.

Although microbiology predominated during this period, other sciences also flourished. The foundations for the science of radiology were laid by two discoveries made almost simultaneously—those of X-rays and radium. Wilhelm Conrad Röntgen, a German, discovered X-rays in 1895; and radium was discovered in 1898 by Pierre Curie, Marie Curie and G. Bémont.

The turn of the century saw the beginnings of a precise understanding of biochemistry. Svante Arrhenius of Sweden developed the theory of electrolytic dissociation (1887), which underlies modern fluid- and salt-balance therapy. In 1900 the Viennese pathologist Karl Landsteiner discovered blood groups, thus making possible the accurate typing and safe transfusing of blood. Frederick Gowland Hopkins of England isolated growth-promoting substances and in 1906 predicted the isolation of vitamins.

Progress against infectious diseases, which began with the discoveries of the late 19th century, was rapidly accelerated by the introduction of sulfa drugs in 1935 and the antibiotics during World War II. The fundamental agents in these two groups and their discoverers were Prontosil, Gerhard Domagk (Germany); penicillin, Sir Alexander Fleming (England, 1928); and streptomycin, Selman A. Waksman (U.S., 1944).

**Organization of Medical Research.**—Biological science is traditionally organized along disciplinary lines. In attacking health problems, the individual research worker generally applies his particular discipline—*e.g.*, pathology, endocrinology, genetics—to a specific disease, retaining orientation to his field. Thus, in universities and medical schools, a given health problem such as cancer is studied in several departments. Disciplinary orientation generally prevails in scientific teaching, societies and journals.

Medical research institutions, on the other hand, are often organized to attack a single disease or a group of related health problems. Early examples of disease-oriented institutions are those founded by Henry Phipps for the study of tuberculosis (1903) and the U.S. National Cancer institute (1937).

*Cardiovascular Disease Research.*—Heart disease, a general term for disease of the heart and blood vessels, causes half the deaths in the United States. The problem of heart disease is greatest in those countries where the life span has been lengthened by control of infectious diseases and good economic conditions. Indeed, the trend toward longer life—and a higher incidence of diseases affecting older persons—accounts for most of the tremendous increase in cardiovascular (and cancer) deaths.

Early clinical discoveries (*c.* 1700) included Théophile Bonet's association of shortness of breath with cardiac enlargement; Raymond Vieussens' explanation of the coronary circulation, the blood system serving the heart; and G. M. Lancisi's correlation of sudden death with autopsy findings. In 1749 Jean Senac gave advice about diagnosis and treatment in the first clinical text on heart disease. A few years later, Jenner related angina pectoris and disease of the coronary artery.

The first great step in treatment of heart disease was the introduction of digitalis by William Withering in 1785. Early diagnostic advances included Stephen Hales' technique for measuring blood pressure in animals (1733); Leopold Auenbrugger's method for detecting cardiac enlargement and edema by percussion (1761); and R. T. H. Läennec's invention of the stethoscope (1819). Thus the physicians of the early 19th century were equipped to begin precise identification and treatment of diseases of the heart.

In 1827 Richard Bright, an Englishman whose name was given to the kidney disease now called glomerulonephritis, described a part of the kidney's role in circulation and related this to dropsy (edema) in impaired heart action. This mechanism, together with the fact that much kidney disease is vascular (arteriosclerotic), accounts for the modern disease grouping "cardiovascular-renal."

Two invaluable aids in the diagnosis of heart disease—X-rays and the electrocardiograph—were discovered around the turn of the century. In 1903 Willem Einthoven of the Netherlands introduced the principle of the electrocardiograph in adapting a galvanometer to record the heart's electrical impulses. Four years later A. Keith and M. Flack of England discovered the sino-atrial node (the pacemaker), a tiny mass of tissue in the right atrium that sends out impulses—normally about 70 a minute—to the heart muscle.

The 20th century saw three revolutionary advances in cardiovascular pharmacology. The first was the introduction by Paul Saxl (Austria, 1920) of mercurial diuretic injections in the treatment of cardiac edema and congestive heart failure. The second was Karl Link's discovery of Dicumarol (U.S., 1940), an anticoagulant, used in surgery and in coronary thrombosis. The third was the introduction of antihypertensive drugs, such as reserpine (1952), which lower blood pressure. These advances led to an impressive array of agents for treating the cardiovascular patient.

Even more dramatic than the pharmacologic advances were the 20th-century developments in heart surgery. Robert E. Gross (U.S., 1939) was the first to correct patent ductus arteriosus, a congenital heart defect. Alfred Blalock and Helen Taussig (U.S., 1945) devised the "blue baby" operation for alleviating pulmonary stenosis, one of a combination of defects (tetralogy of Fallot) that deprive the body of oxygen. Also in 1945, in Sweden, C. Crafoord corrected a coarctation of the aorta, an abnormal narrowing of the body's main artery. Surgery within the human heart (rather than on the blood vessels outside it) was developed by Charles Bailey (U.S., 1948), though such surgery was first performed by E. C. Cutler (U.S.) and P. W. Souttar (England) in the early 1920s. Bailey, by means of a finger knife, opened a valve scarred by rheumatic fever. After 1952 several surgeons attacked other defects, particularly intraseptal lesions, through open-heart surgery. This type of cardiac surgery utilizes complicated heart-lung apparatus for bypass circulation, anticoagulants, advanced anesthesiology, artificial valves, sometimes hypothermia (reduction of body temperature) or stop-heart techniques, electronic controls and other aids, as well as the ultimate skills of a clinical team. (*See* also HEART AND LUNG, SURGERY OF.)

Heart research in surgery, physiology, pharmacology and biochemistry is advancing rapidly. Emphasis is placed on studies of hypertension and of atherosclerosis. These problems are being attacked on a vast front, but firm conclusions as to cause, prevention or treatment cannot be drawn.

*Cancer Research.*—The most effective cancer treatment known today—surgery—was practised in India 4,000 years ago. The early Egyptians treated tumours with an ointment of arsenic and vinegar, and caustic salves have been used since ancient times. A distinction between benign and malignant tumours was made by Hippocrates in the 5th century B.C. Until modern times the attitude toward cancer causation tended to be fatalistic. For example, Galen (2nd century A.D.), whose influence prevailed for several centuries, attributed it to the individual's constitution, recognizing, however, the danger of secondary tumours and the importance of early diagnosis.

The nature of cancer became better understood with the gradual progress of pathology. In the 7th century A.D. Paul of Aegina stated correctly that cancer can arise in any external or internal part of the body. Eleven centuries were to pass, however, before M. F. X. Bichat deduced and Johannes Müller established (1838) the fact that tumours represent a proliferation of cells. Virchow, a pupil of Müller, showed the way to the accurate diagnosis of cancer by microscopic examination.

Modern cancer research may be said to date from 1775, when Pott related scrotal cancer in chimney sweeps to prolonged exposure to soot. Over the years a variety of environmental agents —ionizing radiations, coal-tar products, azo dyes and chromate dust, to name a few—have been recognized as carcinogenic. First to demonstrate chemical carcinogenesis experimentally were two Japanese scientists, K. Yamagiwa and K. Ichikawa, who in 1915 induced tumours on the ears of rabbits with coal tar. In 1926 E. L. Kennaway and others at the University of London extracted from coal tar the potent carcinogen 3,4-benzpyrene (*see* also CARCINOGENIC CHEMICALS).

Viruses were shown to be a cause of cancer in chickens by Peyton Rous (U.S., 1911), who succeeded in transmitting a sarcoma by means of a cell-free extract. Interest in viruses as a cause of cancer grew through recognition of three properties: the resemblance between viruses (nucleic acid) and genes; the viruses' capacity for long, inert survival; and their ability to induce a variety of tumours in animals. During the 1930s virus cancers were identified in rabbits (Richard E. Shope), mice (John J. Bittner) and frogs (Balduin Lucké). Virus transmission of leukemia in chickens was established by V. Ellerman (1918) and in mice by Ludwik Gross (1951). A characteristic of all these viruses is high specificity—ability to cause cancer only in animals of the same or closely related species. In 1957, however, Bernice Eddy and Sarah Stewart (U.S.) incubated filtrates of mouse leukemia in tissue culture and extracted the polyoma virus, which induces a variety of cancers in hamsters and other species as well as mice. These studies over half a century suggest strongly that methods may be found for discovering a cancer virus in human beings.

Discovery of the mammary tumour agent by Bittner in 1936 was a result of studies in genetics. Through inbreeding with selection over many years, geneticists had developed strains of mice with high, predictable rates of cancer and others in which tumours were uncommon. Bittner found that mice of a strain with a high rate of mammary cancer frequently develop few tumours if nursed by mice of a low-tumour strain, indicating that a tumour agent in mice is transmitted by the milk. Hereditary factors are undoubtedly involved in human cancer, but they are probably multiple, thus precluding eugenic control. Further genetic studies, however, may establish environmental and hereditary factors in man as they have in animals.

Genetically pure strains of mice, tumour-transplantation techniques and dependable means of inducing experimental cancers have made possible the achieving of productive biochemistry in cancer research. After the 1930s, biochemical analysis contributed greatly to an understanding of the properties of tumours and the tumour-bearing host. Whereas earlier investigation was concerned largely with describing tissues in terms of composition, modern biochemical studies are elucidating tissue function.

Emphasis is placed on those aspects of metabolism that are likely to be instrumental in the origin or maintenance of cancer; enzyme activity, which underlies and effects the metabolic processes; the role of nucleic acids, which are associated with cellular reproduction; protein synthesis, which in tumours is obviously excessive; and carbohydrate utilization, which suggests impaired respiration in the cancer cell.

As in other areas of medical research, many valuable tools are available in the study of cancer. One is the Warburg apparatus, which enables the scientist to measure the activity of enzymes, the natural accelerators of chemical reactions in the tissues. By means of chromatography, substances such as the components of protein may be separated. Tracer studies with radioisotopes constitute an invaluable approach to the mapping of body chemistry. Biophysical developments include the electron microscope; the ultracentrifuge, a high-speed separator; and electrophoresis apparatus for tissue analysis.

The research attack upon cancer has two major aims: the gaining of basic knowledge, with a long view to practical application; and the development of improved methods of prevention, diagnosis and treatment in the absence of an adequate explanation of the cancer process. Attempts to treat cancer with drugs were reported as early as 1865. Effective chemotherapy, however, began in 1941, when Charles Huggins in the United States succeeded in arresting prostatic cancer with female hormone. During World War II nitrogen mustards, closely related to mustard gas, were observed to damage cell nuclei and soon proved to be useful against cancers of the blood-forming organs. In 1948 Sidney Farber in the United States found that chemical antagonists to folic acid, a B vitamin, could alleviate acute leukemia in children.

Contemporary approaches to and techniques in this important area of medical research are discussed more fully in a separate article, CANCER RESEARCH.

**Medical Research in the United States.**—Until the late 19th century, medical research in the United States was sporadic, poorly financed and little recognized. Many physicians went abroad for their education, and most applied their knowledge to therapy and prevention. Historians attribute the delayed development to two factors—the struggle to settle a new country and the lack of a tradition of learning.

Early landmarks were the founding of the Medical society in Boston (1735), the American Philosophical society (1743), the Philadelphia hospital (1751) and the publication of a pharmacopoeia (1778). Individual contributions included Benjamin Rush's description of dengue (1780), William Beaumont's studies on digestion (1833) and several surgical advances.

Organized research efforts resulted from public clamour over the medical problems of the Civil War. With the reorganization of the army medical department, the Army Medical museum was founded in 1862, and eight years later a massive work, *The Medical*

*and Surgical History of the War of the Rebellion,* was completed. The museum acquired a laboratory for microscopy, anatomy and pathology, and contact was maintained with European scientists. Over the years, such famous researchers as John Shaw Billings, Walter Reed and James Carroll helped make the museum—now the Armed Forces Institute of Pathology—a centre of medical investigation.

The U.S. public health service (formerly the marine hospital service) has conducted medical research since 1887, when a laboratory of bacteriology was established on Staten Island, N.Y. Its director, Joseph J. Kinyoun, was the first to detect the cholera organism among immigrants to America. From this early laboratory, later transferred to Washington, D.C., evolved the National Institutes of Health, the world's largest centre for the conduct and support of medical science.

Research by pharmaceutical manufacturers probably had its start in the 1860s when A. C. Abbott of Chicago, finding plant extracts unreliable, studied Belgian techniques and isolated pure alkaloids. The drug industry, also stimulated by the Civil War, began to expand rapidly. Biologics against smallpox, tetanus and diphtheria were on the market by the end of the 19th century, and World War I gave a powerful impetus to applied research in biological products and chemotherapy.

Privately supported health research in the United States began with the founding in 1893 of the Johns Hopkins medical school, for which support was provided through private endowment, inaugurating an important trend. The turn of the century brought into being the Rockefeller Institute for Medical Research (1901) and the Carnegie Institution of Washington (1902). Generous annual contributions to medical research were made by the Milbank Memorial fund, Julius Rosenwald fund, Commonwealth fund, Rockefeller foundation (independent of the institute) and other organizations.

A peculiarly American approach to the support of health services and, to a substantial extent, of medical research is seen in the large voluntary health agencies, beginning with the National Tuberculosis association in 1904. Other outstanding examples are the National foundation (formerly the National Foundation for Infantile Paralysis), the American Cancer society and the American Heart association. Nearly every major health problem is represented by a private national agency that raises funds for services and research.

Total U.S. expenditure for medical research rose from $75,000,000 in 1945 to about seven times that amount by the mid-1960s. During that period each of the major contributors—philanthropy, endowment, industry and government—increased its support, the federal government most rapidly. In the mid-1960s, government supported about half the medical research in the United States and industry about a third. Most of industry's investment in medical research is spent in its own laboratories. Thus it has fallen largely to government and voluntary health agencies to support most of the research effort in medical schools, universities and other private institutions.

The principal government contributors are the public health service, department of defense, Atomic Energy commission, Veterans administration and National Science foundation. Among these the public health service represents by far the principal investor in the biological sciences related to medicine. The National Institutes of Health conducts its research and support programs at Bethesda, Md., where laboratories, offices and a research hospital are located on a 305-ac. tract. The nine institutes comprising the NIH are concerned primarily with major killing and crippling diseases. (Js. A. S.)

**Medical Research in the United Kingdom.**—The organization with the main governmental responsibility for medical research in the United Kingdom is the Medical Research council, the successor of the Medical Research committee, which was incorporated under its present title by royal charter in 1920. The council, which is financed largely by an annual parliamentary grant-in-aid, is responsible to the Committee of the Privy Council for Medical Research, of which the secretary of state for education and science is chairman. Of the 12 members of the council, who are appointed by the committee for four years, 9 are scientifically qualified; of the 3 lay members, 1 must be a member of the house of lords and 1 a member of the house of commons. The council's chief function is the promotion of research on all aspects of health and disease, and to this end it is advised by three major boards: a Chemical Research board, a Biological Research board and a Tropical Medicine Research board. The council is also assisted by special committees that are appointed to advise on particular subjects.

The council supports research in three main ways: by appointing its own staff for work in the National Institute for Medical Research and in research units, which in 1964 numbered 74; by awarding grants for research projects to the staffs of universities and hospitals; and through its schemes of fellowships and scholarships for training in research methods. In addition to its work in the United Kingdom the council undertakes research overseas, maintaining establishments in Gambia, Uganda and Jamaica. Through the Tropical Medicine Research board it acts jointly with the Department of Technical Co-operation in assisting work supported by funds provided by that department.

Medical research is also undertaken in the medical faculties of universities and in the medical schools. This is supported primarily out of the block grant made to the universities by the University Grants committee on a five-year basis in aid of their teaching and research programs.

Further support for medical research is provided by the ministry of health and the Scottish Home and Health department, which also initiate and maintain particular projects and services. A considerable amount of research is, of course, undertaken in the national health service in the normal course of hospital treatment of patients. Other government departments, such as the ministry of labour and the ministry of pensions, and bodies such as the Atomic Energy authority request and authorize special investigations and health surveys.

Private organizations also do important work; for example, the British Empire Cancer campaign, the Imperial Cancer Research fund, the National Fund for Research into Poliomyelitis and Other Crippling Diseases, the Nuffield foundation, the Wellcome trust and the British Heart foundation. Co-operation is maintained between these organizations and the Medical Research council to ensure the best allocation of resources. (H. P. Hh.)

**Medical Research in the British Commonwealth.**—In the Indian subcontinent research dates from the 1840s, when T. E. Dempster began to measure malarial endemicity by estimating the spleen rate (*i.e.*, the rate at which splenomegaly, or enlargement of the spleen, occurs in a population; splenomegaly, which can be detected by palpation, indicates possible malarial infection). Other independent workers studied trypanosomes, filaria, spirilla, mycetomas, cholera, snakes and snake venoms. Organized research began in the late 19th century; and until the 1940s much work on malaria, plague and nutrition in the tropics was done by English and Indian investigators at institutes in Kasauli, Madras, Bombay and Calcutta. The Calcutta School of Tropical Medicine commemorates L. Rogers' studies in cholera, kala azar and leprosy; much distinguished work on nutrition and the anemias also has been done there. The Indian Council for Medical Research distributes funds from the Indian government, gives grants to workers in the universities and supports the Institute for Mental Health, Bangalore, the All-India Institute of Hygiene and Public Health, Calcutta, and other bodies. In Pakistan the medical schools conduct research; for example, that on dysenteric infections at Karachi, Lahore and Multan.

In Australia the National Health and Medical Research council distributes annual grants to workers in universities and institutes. The Walter and Eliza Hall Institute for Medical Research, University of Melbourne, in the 1960s was doing a great deal of important work on influenza. The School of Public Health, Sydney, was responsible for work on the epidemiology of filariasis. The Queensland Institute of Medical Research works especially on zoonoses, including toxoplasmosis, rickettsial infections and leptospirosis. Internationally recognized work has been done at the University of Queensland on the nematodes responsible for visceral

larva migrans and at the University of Adelaide on the physiology of nematodes.

Medical schools conduct research in New Zealand; well known is the work on renal disease at Dunedin.

In Canada two main bodies draw government funds for research: the National Health Research Grant program and the National Research council. The former distributes funds mainly to provincial health departments and medical schools for public health programs; the latter supports basic and applied research on a broad front. The Best institute, founded by C. H. Best, codiscoverer of insulin, derives funds principally from manufacturing rights relating to insulin and works chiefly on diabetes. The Connaught laboratories, world-famous for their biological products, apply their revenue to research mainly on poliomyelitis and rabies vaccines and similar products. Much research revenue comes from abroad.

The East African Common Services commission administers a series of institutes of international reputation; they include the East African Institute of Malaria and Vector-borne Diseases, Amani, and the East African Institute for Medical Research, Mwanza, both in Tanganyika; the East African Virus Research institute, Entebbe; and the East African Trypanosomiasis Research organization, Tororo, both in Uganda. Grants are made to workers in both teaching and nonteaching hospitals and also to lone workers on outstations.

The West African Research office at Accra, Ghana, co-ordinates and administers research conducted and financed jointly by the governments of Ghana, Nigeria and Sierra Leone.

The ministry of health of the Federation of Rhodesia and Nyasaland sponsors internationally recognized researches into the eradication of schistosomiasis.

In Malaysia the Institute for Medical Research, Kuala Lumpur, with government support, works especially on rickettsial infections. (A. W. Wo.)

In colonial territories money and men for research used to be provided both by the territorial governments and by the colonial office. In 1945 the latter allocated funds provided by parliament for colonial medical research under the Colonial Development and Welfare act. These funds financed research units and staffs for the territorial organizations, provided grants for the colonial universities and aided colonial health research in British universities. The funds were formerly administered by the Colonial Medical Research committee, which, in 1960, was replaced by the Tropical Medicine Research board of the Medical Research council, members of which are appointed by the Medical Research council in consultation with the department of technical co-operation. The board's members are drawn from the department, from the council and from the universities and schools of tropical medicine in Great Britain. The board is assisted by specialist committees appointed by the Medical Research council and by two overseas regional medical research organizations, one in East Africa and one in the Caribbean; the overseas groups co-ordinate efforts in their respective regions. Additional help is given by organizations including the Medical Research council, the Nuffield foundation, the Wellcome trust, the Rockefeller foundation, the Walter Reed Army Research and Graduate school and the World Health organization. (Rd. L.)

Many notable advances were applied in colonial territories after World War II; *e.g.*, in malaria, the discriminative use of residual insecticides and chemoprophylactic and chemotherapeutic drugs; in yellow fever, the 17D vaccine and antimosquito measures; in leprosy, the sulfone drugs; in rickettsial and typhoid fevers, chloramphenicol; in plague, streptomycin; in the pyrexias of unknown origin, the identification of several causal viruses; in typhoid, the demonstration by field trials in British Guiana of a new and highly efficacious antityphoid vaccine.

**Medical Research in Europe.**—After World War II medical research in Europe was conducted chiefly in university laboratories and university hospitals. Special institutes for medical research exist but are usually small and closely affiliated to the universities. Exceptions to this are such large institutes as the Institut Pasteur in Paris, devoted to the study of microorganisms and their importance in disease; the Instituto Cajal de Investigaciones Biológicas in Madrid, devoted to the study of the microscopical structure of the human body and the brain; and the Istituto Superiore di Sanità in Rome, devoted to the study of parasitology, microbiology and biochemistry. Many of the European universities are state owned and supported, but some are governed by private foundations and in all cases require heavy support from public funds for large-scale research. The medical research councils also are sources of funds. They may be part of a larger organization, supporting all kinds of research; *e.g.*, the Deutsche Forschungsgemeinschaft in Germany, the Consiglio Nazionale delle Ricerche in Italy, the Consejo Superior de Investigaciones Científicas in Spain and the Norges Almenvitenskapelige Forskningsråd in Norway. Councils devoted to medical research exclusively include the French Institut National d'Hygiène, the Dutch Gezondheidsorganisatie T.N.O. and the Swedish Statens Medicinska Forskningsråd. Support from private foundations and U.S. funds, such as the Rockefeller foundation and various U.S. federal agencies, also plays an important part. Much medical research is promoted by the pharmaceutical and chemical industries in their own or in university laboratories, especially in Switzerland.

In the U.S.S.R. medical research is organized somewhat differently. The medical schools, which are directed by the ministries of health of the various republics, are devoted chiefly to the training of doctors. Medical research is directed largely by the Central Academy of Medical Sciences in Moscow, a government academy of medical scientists. About 40 research institutes devoted to all branches of medical science function under the academy. The personnel of these institutes spend all their time on research, though some members occasionally teach. The institutes present their research projects to the academy, which is thus ultimately responsible for the planning and direction of most medical research in the U.S.S.R. The same general organization also prevails in Poland, Czechoslovakia, Hungary, Rumania and Yugoslavia. (B. Rd.)

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**MEDICAL SERVICES, MILITARY.** The providing of medical services in the armed forces is a problem in almost every country. As wars increase in extent and magnitude, provision for the care of the sick and wounded has to be made on a larger scale. The nuclear age presents problems of unprecedented nature and extent, calling for close co-operation between the medical services of the armed forces and those of the civilian population.

Up to the middle of the 19th century the army or navy surgeon was mainly concerned with the care of the sick and wounded in battle; the organization of the medical departments was extremely deficient; and the status and conditions of service of the medical officers were deplorably low. By the middle of the 20th century a complete revolution had taken place in all these respects. The most striking change was seen in the way in which the functions of the medical officer were regarded. Emphasis had shifted to achieving the highest physical efficiency in all servicemen. The modern soldier is fed on a precisely balanced diet and is immunized against most of the communicable diseases which formerly decimated armies. His personal equipment is designed with the help of physiologists and psychologists and, when he is actually in battle, the whole organization—with everything that relates to first-

aid treatment, surgery and evacuation to hospital—follows him into the fighting line. In early wars at least three-quarters of those wounded died, but in World War II the recovery rate among the Allies for nearly all types of wounds was over 90%.

(W. J. Bp.)

## UNITED STATES

Except for certain joint activities such as the supply system, the medical services of the U.S. army, navy and air force are independent of one another. Because each service has its own peculiar medical support obligations to its operating forces, the organization, administration and techniques are separately adapted to the particular character of the forces served.

The three military departments are subordinate to the department of defense, which has an assistant secretary of defense (health and medical). He formulates broad medical policies applicable to all three military departments and co-ordinates their medical activities to avoid unnecessary duplication. He is aided by an advisory council composed of leading figures in the civilian medical field.

Medical co-ordination began before the establishment of the department of defense in 1947, after which time a number of joint agencies were created, usually with representation from the three military departments. Among them are the Armed Forces Institute of Pathology; Epidemiological board; Regulating office, which governs the flow of patients to military hospitals; Military Medical Supply agency, which is mainly concerned with procurement; Publishing agency for producing the *United States Armed Forces Medical Journal* and the *Medical Technicians Bulletin;* and an office for dependents' medical care. The last-named agency contracts with civilian medical agencies for the care of persons dependent on members of the army, navy, air force and certain other governmental services when medical treatment facilities of the services are not available for their care.

**Army.**—The army medical service is a partly centralized, partly decentralized organization. The surgeon general of the army, who bears the rank of major general in the medical corps (*see* below), is appointed by the president of the United States for a statutory four-year term, subject to approval by the senate. In the establishment of army policies concerning the health and medical care of troops and the utilization of professional medical personnel he is subordinate only to the secretary of the army and the army chief of staff, having direct access to both in these matters. For policy making in other fields, such as medical supply and finance, he operates under the direction of the army's deputy chief of staff for logistics. His office has "technical supervision" over all medical operations of the army—that is, it develops and promulgates the techniques for carrying out general policies. The surgeon general exercises the power of command over certain medical facilities, including the widely known Walter Reed army medical centre in Washington, D.C., and the Brooke army medical centre at Ft. Sam Houston, Tex.

Each subordinate command of the army normally has a medical officer known as the chief surgeon, or surgeon, who is responsible to the commander for the operation of all medical services within the latter's jurisdiction, and who has technical supervision of all medical troops of the command.

The army medical service is composed of officers, both male and female, and enlisted personnel, together with a large force of civilian employees most of whom assist with ordinary administrative work, although a considerable number occupy high posts as consultants or serve in other professional capacities. The officer group comprises a medical corps (physicians), a dental corps, a veterinary corps (mostly concerned with the sanitary inspection of meat and dairy products consumed by the armed forces), a nurse corps, a medical specialist corps (dietitians, physical and occupational therapists) and a medical service corps (trained in administration or in fields of science or technology allied to medicine).

The army medical service possesses reserves, both commissioned and enlisted, and large numbers of reserve officers are constantly on active duty.

The training of officers is accomplished partly before and partly after their appointment. A candidate for the medical corps in the regular army, for example, must be a graduate of an approved civilian medical school and must have served an internship or have had equivalent experience in the practice of medicine; after appointment he receives instruction in military subjects and may continue his medical education in army, other governmental or civilian institutions. The opportunities for advanced education open to officers are extensive; internships, residencies and fellowships in the various professional specialties and other types of postgraduate training are available in the field of medicine; in nursing, courses in special techniques have a prominent place in the program. For enlisted personnel the army, besides providing basic medical training, offers courses of study which produce technicians in various medical fields.

For the care of its sick and injured the army employs numerous types of units, ranging in capability from the regimental medical company—whose "aid men" individually accompany combat platoons into battle—to completely equipped hospitals. Thus means are at hand to establish series of treatment stations extending from the front line to the extreme rear in any military operation. The echelonment of medical units in this fashion, called the chain of evacuation, enables lightly equipped medical troops near the front to keep pace with the foremost combat elements, to care promptly for their casualties and quickly to restore to duty those suffering from minor ailments.

Patients needing lengthy or specialized treatment are passed farther along the chain to more fully equipped and therefore less mobile establishments. For the care of patients whose condition does not permit them to be transported any great distance, small mobile surgical hospitals are sent well forward to supplement the facilities of less completely equipped medical units and enable them to retain their mobility. In conditions of peace, the pattern of evacuation is apt to be less complex and more stabilized; when troops are concentrated on posts or camps they are served by static dispensaries and hospitals. In both war and peace certain hospital facilities are set aside for highly specialized care of various types of cases.

In the prevention of disease the army medical service employs a full range of measures, including physical examinations, control of communicable diseases and the establishment of standards for sanitation and proper nutrition. It also conducts an extensive occupational health program for all military and civilian personnel of the army.

As auxiliaries to its system of preventive and restorative medicine the army medical service possesses a complement of laboratories and supply depots. To improve the quality of army medicine it also carries on extensive programs of training and research, and keeps comprehensive statistics on the incidence of death, sickness and injury in the army. After World War II it became concerned with the medical aspects of nuclear warfare, including the medical use of radioisotopes, management of mass casualties and training in nuclear-weapons effects.

(S. B. Hs.; D. O. Wr.)

**Navy.**—The personnel and facilities devoted to maintaining the health of members of the navy and marine corps and to treating them when they are injured or ill are collectively termed the medical department. This comprises a central administrative and management agency, the bureau of medicine and surgery, and a multitude of activities ashore and afloat, at home and abroad. These activities vary greatly in character, and range in size from large, fully equipped general hospitals to small medical departments on ships or at advanced bases. Some are specialized for medical research or as epidemiology or sanitation units. All are concerned with various aspects of the mission to promote physical fitness, prevent disease and injury and provide the best possible professional care for the sick and injured.

The medical, dental, nursing and allied activities of the navy are supervised by a senior naval medical officer who is appointed by the president of the United States, subject to approval by the senate, for a statutory four-year term with the rank of rear admiral and the title of surgeon general of the navy. This officer

is directly responsible to the secretary of the navy, and acts as chief of the bureau of medicine and surgery, through which he directs and co-ordinates the activities of the medical department.

The bureau formulates policy; develops plans to meet service needs; procures, trains and assigns personnel; assembles and codes statistical data; procures and allocates funds and matériel; and assembles and reviews medical records. Medical and dental officers are detailed to the staffs of commandants of naval districts and commanders of certain fleet forces and supervise medical and dental care in the district or command and assist in the administration of medical and dental services through recommendations to their commanders and reports to the bureau. The bureau has both command and technical control of naval hospitals, schools, research units and similar activities that are commanded or supervised by medical department officers. Over medical and dental departments of other activities ashore and afloat, it has technical supervision only.

The military personnel are technically trained for their particular duties, and have prerogatives and responsibilities common to all naval officers or men of comparable rank or rating. There are five separate corps, of which the medical, dental, nurse and medical service corps are composed entirely of officer personnel. The hospital corps consists of medical service warrant officers and enlisted men, the latter constituting the largest group in the medical department.

To qualify for appointment, medical officers must be graduates of accredited civilian professional schools and have completed approved internships. Dental and nurse officers have corresponding qualifications. Candidates for appointment in the pharmacy, optometry, and medical allied sciences section of the medical service corps must hold degrees in their chosen fields, whereas officers of the administration and supply section are appointed from the enlisted ranks.

Throughout a career in the navy, medical department personnel have repeated opportunities for advanced training and specialization. Newly appointed medical officers are given indoctrination in the special features of military medicine. Subsequently they may choose one of many planned careers. In addition to the clinical subspecialties of medicine and surgery, possible career patterns include specialization in research, aviation medicine, submarine medicine, atomic medicine, preventive medicine, field medicine and amphibious medicine. The latter two concern medical care of marine corps troops in the field and medical support of units engaged in amphibious assault.

New members of the hospital corps are given elementary professional education in an extensive basic course. They later may enter an advanced course preparing them for duty independent of a medical officer, as on board a destroyer or mine sweeper, or they may take one of many specialized courses that train administrators and technicians for supporting the medical-dental service.

A large reservoir of trained officers and enlisted personnel on inactive duty is available in case of national emergency. Training and refresher courses at reserve training centres are supplemented by short tours of active duty for training purposes.

Each naval activity has its own medical unit for (1) sanitary inspections of crew, provisions and living quarters; (2) instruction of crew in hygiene and first aid; (3) immunization of crew against disease; and (4) treatment of the sick and injured. Ordinarily, patients requiring prolonged or specialized treatment are transferred to an adjacent hospital or hospital ship that has more equipment and a larger staff. The medical and dental departments on an aircraft carrier may include medical, dental, medical service corps and medical service warrant officers and perhaps 20 corpsmen. This unit would be prepared to treat bed patients and perform major surgery. At shore stations the medical department may be a small dispensary with one corpsman, a 20-bed station hospital or a general hospital with well over 1,000 beds that is equipped and staffed to provide every type of specialized medical care. (B. W. Hs.; B. F. Ay.)

**Air Force.**—The surgeon general, traditionally a major general, heads the air force medical service, which is composed of the several groups of health specialists in various fields: medicine, aviation medicine, dentistry, nursing, preventive, occupational and environmental medicine, public health, physical medicine, nutrition and medical administration.

As senior medical adviser, the surgeon general reports directly to the chief of staff and the secretary of the air force. Like other air staff offices, the office of the surgeon general is organized under the directorate system with responsibility and authority delegated to three directors—those of professional services, medical staffing and education, and plans and hospitalization—and to special assistants for dental and veterinary services. All report directly to the surgeon general.

The surgeon general's staff determines air force medical policies and offers technical guidance to the major commands into which the air force is organized.

In procuring and retaining career officers, the air force sponsors programs for active commissioning in the senior years of medicine and dentistry; internships; residency training; and the reserve officers training corps (ROTC). It offers direct commissions to trained professional men and women for both career service and reserve duty. Opportunities for advanced study in aviation medicine are offered at the school of aviation medicine, Randolph air force base, Tex.

Leaders in the principal medical specialties are retained as consultants, some being assigned to individual bases and a small group of nationally recognized professional men and women acting as advisers to the surgeon general. The consultants provide a source of training and supervision, ensuring adequate standardization of medical practices and rendering advice and assistance in determination of policies.

To provide the information, techniques and equipment required for protection, escape and survival of air crews, an extensive aeromedical research and development program is carried out at several air force research centres and at several leading universities throughout the United States. The results of this effort make it possible to bridge the gap between conditions and requirements imposed by rapid technological advances in aviation and man's limited capabilities. Aeromedical endeavour also is directed toward the solution of the physiological and psychological problems of space flight, involving sealed cabin existence and protection against the hazards of cosmic radiation, temperature extremes, meteorites and the gravity-free state.

The military air transport service provides rapid transportation for the army, navy and air force and also emergency evacuation of the sick and wounded in time of catastrophe among civilian communities. (D. C. O.; M. M. Lk.)

## GREAT BRITAIN

The medical services of the navy, army and air force in Great Britain are each headed by a director-general. A chain of medical liaison and control is maintained by the director-general and his staff right down to the medical officers of units. All newly qualified doctors liable for military service are required to serve for two years in the medical branch of one of the armed services.

The medical branches of the armed forces provide for their personnel a health service similar to that available to the civilian population; *i.e.*, a general practitioner service, a specialist service and a hospital service. The medical officer in charge of a unit corresponds to the general practitioner. The specialist service covers all branches of medicine and surgery, and military specialists carry out the same duties as those performed by civilian specialists and consultants. All three services maintain hospitals, medical reception stations, convalescent depots and rehabilitation centres. Medical care extends to the families of servicemen and includes antenatal and maternity services. A forces medical and dental services committee, the Waverley committee, was set up in 1953 and reported in 1956.

**British Army Medical Service.**—The only medical men engaged in early warfare were the personal attendants of the king and the nobility, but by the time of the Hundred Years' War they were also recruited to look after the rank and file. More than a score of medical men were attached to the English army at the

battle of Agincourt in 1415. The status of the army surgeons was generally very low; in the time of Elizabeth I they were ranked with drummers and received the same basic pay. Doctors were first offered a permanent career by the purchase of a commission when a standing army was founded by Charles II. Following the scandals of the Crimean War, some reforms were made but the royal army medical corps (R.A.M.C.) was not founded until June 23, 1898.

Two-thirds of medical officers in the R.A.M.C. are employed on general practitioner duties. After attending the junior officers' course at the R.A.M.C. college, Millbank, London, they start their career as regimental medical officers. They later serve overseas. On their return they attend a senior course at Millbank and at various London hospitals, and they may then choose to remain at general medical duties or take up field training or junior staff appointments.

Specialists are employed on specialist duties up to the rank of colonel. Thereafter they may serve in this rank up to the retiring age of 57 or may be selected for promotion to brigadier in either a specialist or nonspecialist capacity.

At the end of World War II the establishment of the R.A.M.C. was 11,421 officers and 78,171 other ranks. The designation "other ranks" comprises dispensers, clerks, radiographers, nursing orderlies, laboratory assistants, masseurs and sanitary assistants. All ranks are trained as stretcher bearers.

Though there were over 800 dental surgeons in the British army by the end of World War I, the army dental corps was not founded until 1921. During World War II the corps reached a maximum of 2,300 officers and 3,500 other ranks. The army dental corps was given the prefix "royal" in 1947.

**Royal Navy Medical Service.**—A graphic picture of the life of a surgeon's mate in an 18th-century man-of-war is given in Tobias Smollett's *Roderick Random*. It was not until 1855 that assistant surgeons won the right to be considered as wardroom officers. Naval medicine includes the physical aspects of service afloat and ashore, tropical diseases, industrial hygiene, aviation medicine, the physiology of diving and a variety of other subjects. Entry to the service is by short commission in the first instance. Short service consists of either three or four years, during which a medical officer becomes a surgeon lieutenant, R.N., and is eligible to apply for a transfer to the permanent list. Promotion to the full rank of surgeon lieutenant normally follows after one year's service and to surgeon lieutenant commander after a further seven years' service. Further promotion is by selection. Service on the active list is up to the age of 55 for all officers, 57 for surgeon captains and 60 for surgeon rear admirals. Officers on the permanent list are encouraged to specialize and are given full facilities for obtaining higher qualifications.

**Medical Branch of the R.A.F.**—On the formation of the Royal Air Force (R.A.F.) in April 1918 medical officers who had served with the Royal Naval Air service and the Royal Flying Corps were transferred or attached to the new air force. They were granted R.A.F. rank in November of the following year. Appointment is usually to short service commissions for three, four or five years, but permanent commissions can be applied for at any time during short service. The normal rank on appointment is flying officer, with promotion to flight lieutenant after one year's service, to squadron leader after eight years' service and to higher ranks by selection. Since the safety and efficiency of the air force depend to a large degree on its medical service, great importance is attached to recruitment of the right type of medical officer. The air force medical officer is concerned with problems of high-altitude flying, flying at supersonic speeds, parachuting, mountain rescue, air evacuation of sick and wounded and the special type of injuries associated with flying accidents, as well as with the clinical specialties and the treatment of service families. *See* also SANITATION, MILITARY. (W. J. BR.)

**MEDICAL TECHNOLOGY** is the branch of medicine concerned with laboratory and instrumental procedures that are of aid in the diagnosis and treatment of illness. The term is usually applied to the actual performance of these procedures, but in a broader sense it also includes their professional supervision and the medical interpretation of the results obtained by their use. The procedures constituting medical technology are derived chiefly from biochemistry, physiology, hematology, microbiology, immunology, histology, physics and radiology.

Mounting knowledge of disease processes and the introduction of new forms of therapy have increased greatly the use of laboratory techniques in following the course of illness, and the increase is paralleled by development of instrumentation that enables rapid and precise performance. For example, in the late 1940s the flame photometer, based on the measurement of intensity of the characteristic spectra of vaporized sodium or potassium, was introduced for the analysis of these elements in blood and urine; it replaced older methods and greatly increased the rate of performance of these determinations.

In the late 1950s the process of automation began to be reflected in the field of medical technology, and machines requiring little attention were devised for preparing tissues for microscopic study or for analyzing certain components directly from the blood. Such advances tend to increase the scope and sophistication of medical technology and to raise its importance to clinical medicine.

**Content of Medical Technology.**—The biochemical aspects consist in the quantitative and occasionally qualitative determination of the approximately 100 chemical components in body fluids, secretions and excretions that may show abnormal concentrations in disease. Among the analyses most commonly performed are those for protein and glucose in urine; urea, glucose, carbon dioxide, sodium, potassium, chloride, calcium, phosphate, cholesterol, bilirubin and various enzymes in blood; protein and glucose in spinal fluid.

Among the physiological procedures that are important in medical technology is the measurement of rate of oxygen consumption under resting and other basal conditions, which permits calculation of the basal metabolic rate, a value of particular use in the diagnosis of thyroid disease. The electrocardiogram is a pattern of the electrical potential differences and the resulting currents produced in the body by the mechanical action of various parts of the heart; many types of heart disease show characteristic deviations from the normal pattern. The electroencephalogram is a record of electrical waves of varying amplitudes and frequencies that appear to arise spontaneously in the central gray matter of the brain; it is of value in the diagnosis and treatment of various brain disorders.

Medical technology in hematology consists of a wide variety of methods for studying the blood, such as the determination of the number of red and white blood cells and the microscopic examination of the structure of the blood cells. Blood cells from bone marrow may be obtained by special puncture and examined in a similar fashion. Of considerable importance is the collection and classification of blood in blood banks for use in transfusions.

Microbiological techniques include the examination and study of the presence and nature of bacteria and other microorganisms in the blood, urine, cerebrospinal fluid, stools, sputum and infected areas of the body. The examination may be made by direct smear and stain of the material on a slide or by growing the organism in special media (*see* TISSUE CULTURE). Closely associated with microbiological techniques are immunological methods, for immunological reactions are the processes by which the living body protects itself against the attacks of microorganisms (*see* IMMUNITY AND IMMUNIZATION).

Technology in histology is concerned with the preparation of various body tissues for microscopic examination by the pathologist. Small blocks of fresh tissue are immersed in fixative solutions to stop natural decay. They are then washed and dehydrated, embedded in paraffin or similar material and cut into very thin sections, which are stained with dyes that bring out various details of the cellular and tissue structure.

The field of physics has contributed much to medical technology. X-ray technicians assist the radiologist in therapy and diagnosis. With the rapid advances in radiation and nuclear physics, persons with varying degrees of training in physics have been utilized in such activities as calculation of tissue dosage, personnel and area monitoring and maintenance of equipment.

**Training of Medical Technicians.**—This varies widely. The

physician in private practice often teaches his office assistant a few office procedures for which he has frequent use, such as urine analysis, red and white blood cell counts or the taking of electrocardiograms or X-rays. In this situation, the physician can supervise his assistant closely.

In the small or moderately sized hospital, a need exists for medical technologists who are capable of performing a greater variety and number of procedures. In 1936 the Board of Registry of Medical Technology of the American Society of Clinical Pathology, in association with the Council on Medical Education and Hospitals of the American Medical association, instituted standards of training for medical technologists, and such standards have been periodically revised. In addition to the prerequisite of three years of college, the duration of the training program in approved schools, which are located in hospitals and often affiliated with universities, was 12 months in most institutions and ranged up to 36 months in some. The usual fields of medical technology, exclusive of X-ray, were included in these programs. In Great Britain applicants who are at least 16 years of age and have a general school certificate or the equivalent, with completion of specified science courses, are accepted for training in laboratories approved by the Institute of Medical Laboratory Technology. At the end of three years' training, these student technicians are eligible to take the examination for the intermediate diploma of the Institute of Medical Laboratory Technology and, if they pass it successfully, attain the rank of junior technician. Further training and higher ranks also are available.

Because of the large load of work and the complexity of certain procedures, many large hospitals, particularly those affiliated with medical schools or research institutes, have special laboratories in biochemistry, bacteriology or hematology. In these the medical technologists are usually college graduates who, instead of performing a varied array of clinical pathological procedures, are trained in one special field.

**Professional Supervision.**—As the result of advances in medicine during the 20th century and because of the growing dependence of clinical medicine upon laboratory procedures and the increase in the number and size of hospitals and medical centres, the role of professional personnel in supervision of technological procedures and medical interpretation of results has been much expanded. In general, the function of supervision and interpretation is fulfilled by a physician who, in addition to some postdoctoral clinical experience, has had several years of training in a laboratory specialty. In the United States the American Board of Pathology designates competence by granting of certification in clinical pathology, clinical chemistry, clinical bacteriology, clinical microbiology or hematology. Similarly, the American Board of Radiology grants certification in such special fields as radiological physics and medical nuclear physics. In Great Britain similar professional competence is denoted by diplomas from various graduate schools of medicine or from the royal colleges. *See* also DIAGNOSIS; PATHOLOGY.

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**MEDICI,** the great Italian family whose name is linked for more than three centuries with the history of Florence and of Tuscany. When it is necessary to distinguish them from other bearers of the surname, which is common enough, its members are designated as Medici di Cafaggiolo, since Cafaggiolo, in the Mugello (that is, the upper valley of the Sieve, north of Florence), where the family had originated, was their property from the middle of the 14th century at the latest.

In this article the Italian patronymic system of identification will occasionally be used to distinguish bearers of the same Christian name from one another: thus for instance Salvestro di Alamanno di Lippo II, that is, Salvestro son of Alamanno son of Lippo II, is not to be confused with the Salvestro sometimes called Chiarissimo III (Salvestro or Chiarissimo di Averardo according to the traditional genealogy).

**The Early Medici.**—The Medici appear in Florence at the beginning of the 13th century, when Chiarissimo di Giambono de' Medici (Chiarissimo I), a member of the city's general council in 1201, was residing in the Mercato Vecchio. Ardingo de' Medici, *priore* and gonfalonier in 1296, and his brother, Guccio, gonfalonier in 1299, are supposed to be from Chiarissimo's paternal uncle Bonagiunta. Chiarissimo's son Lippo I had two sons, Chiarissimo II and Averardo I, ancestors of the major branches of the house. Up to the end of the 14th century, however, records of the family are confused, and the precise kinship of many historically notable members of it is obscure. Meanwhile the family as a whole accumulated an enormous fortune through trade and moneylending and played an ever-increasing part in politics, acting as a compact unit and ready to resort to violence in the interests of the *popolani* against the *grandi* and the Parte Guelfa (*see* FLORENCE: *History*).

In 1301 the "gang" (*masnada*) of the Medici of the Mercato Vecchio played an active role in the overthrow of the Bianchi or White Guelphs; and in 1343, by which time they were settling in the San Lorenzo quarter, they had a hand in the expulsion of Walter de Brienne, duke of Athens, from Florence. In the 1350s Giovanni di Conte de' Medici and one of Chiarissimo II's great-grandsons, Salvestro di Alamanno di Lippo II, made names for themselves in the war against the Visconti. Salvestro proceeded to become the first of the house to win political eminence beyond ordinary civic office in Florence. Elected gonfalonier for the first time in 1351, this rich man retained the favour of the *popolo minuto*, took no part in the rivalry between the oligarchs of Ricci and Albizzi families and long abstained from opposing the despotism of the Parte Guelfa. Eventually, however, he emerged as the champion of popular reaction against the Parte Guelfa and was re-elected gonfalonier in May 1378, despite the Parte. When his decrees were opposed, he threatened to resign, but was brought to almost absolute power by the revolt of the *ciompi* or artisans of the lowest class. Thereupon he began a reign of terror in which his former supporters were sacrificed to his personal ambition. Deposed by the new combination of the *popolo* with the Parte Guelfa in 1382, Salvestro was exiled to Lendinara but was later allowed to return to Florence, where he died in 1388.

In 1393, during another popular rising, Vieri di Cambio de' Medici, another of Chiarissimo II's descendants (d. 1395), was invited to take power in order to supplant the oligarchy, but declined to do so and tried to act as a mediator. After his mediation, however, the oligarchs banished or prosecuted other members of the Medici family, in particular the descendants of Salvestro di Alamanno. Thereafter the line of Chiarissimo II ceases to be significant historically, though one branch of it survived till 1742.

There is some uncertainty whether the Averardo de' Medici who was gonfalonier in 1314 was Averardo I or his son Averardo II. The latter had six sons, one of whom, Salvestro, otherwise called Chiarissimo III, was the father of Averardo III, called Bicci. With the latter's descendants this article will henceforth be concerned.

**Giovanni di Bicci.**—The family fortune of the Medici was much reduced after Salvestro di Alamanno's failure and the subsequent sentences of exile. Its restoration, which paved the way to political power, was the work of Giovanni di Averardo III, generally known as Giovanni di Bicci (1360–1429). Having made himself one of the richest bankers in Italy, Giovanni put his resources to the service of the family's political ambition; but he also spent much money on behalf of his friend Baldassare Cossa (the schismatic pope John XXIII), took him eventually into his house and finally erected the funeral monument to him in the baptistery of San Giovanni. Giovanni di Bicci protected the interests of the common people without risking his own career. As gonfalonier (1421) he introduced no new legislation; and his advice in favour of the lesser guilds was often sought by the oligarchs Maso degli Albizzi and Niccolò da Uzzano, to whom he showed no antagonism. Some historians claim that he helped to introduce the *catasto* or register of property for fiscal purposes (1427). Dying on Feb. 20, 1429, Giovanni was buried in the old sacristy of the church of San Lorenzo, the building of which, by

Filippo Brunelleschi, he had sponsored. From his sons, Cosimo and Lorenzo, the most illustrious branches of the Medici descended. (*See* Table.)

**Cosimo the Elder.**—On Giovanni's death his son Cosimo, born in 1389, who had hitherto concerned himself exclusively with business affairs, emerged into politics as a formidable adversary of Rinaldo degli Albizzi, Maso's son. Rinaldo was for a time dissuaded by the old Niccolò da Uzzano from having Cosimo banished, but after Niccolò's death he treacherously had him arrested (1433). Thanks to his shrewdness and to his money, Cosimo escaped death, but he was sentenced to a ten-year exile. In Venice, however, he received a princely welcome, while in Florence attempts to bankrupt him only added to his prestige. In 1434 a newly elected government showed itself favourable to the Medici, and Rinaldo's attempt to overthrow this government failed, so that Cosimo was recalled to Florence in triumph. Pope Eugenius IV sought in vain to reconcile him with Rinaldo, who was subsequently banished from Florence for life.

Cosimo, later to be called *pater patriae* ("the father of his country"), thus became the virtual lord of a republic keenly jealous of its liberty. Though he never assumed any extraordinary title, the *balia* or committee of magistrates (renewed every five years) was packed with citizens devoted to his interests and prompt to strike at every possible rival. Cosimo abolished the *catasto* and used the *decima scalata* (progressive taxation) to ruin all who stood in the way of his absolute power, while favouring the lower classes and his supporters. His attempts to undermine republican institutions were denounced in vain by the great archbishop of Florence, Saint Antoninus.

Cosimo's prestige was further enhanced by the Florentine victory at Anghiari (1440) over the forces of the Visconti of Milan, against whom Florence and Venice had been waging intermittent war since the 1420s. This was followed by the peace of Cavriana (1441). Subsequently, however, the traditional alignment of the Italian states was set aside, and when Francesco Sforza succeeded the Visconti as duke of Milan (1450), Florence was his ally against Venice and Naples. The foreign policy of the Medici was designed to achieve a balance of power in Italy.

Cosimo died on Aug. 1, 1464, at Careggi, leaving an immense fortune. Yet he had spent vast sums on the arts and on public works, encouraging architects, sculptors, painters and humanists: Brunelleschi, Michelozzo (Michelozzi), Lorenzo Ghiberti, Luca della Robbia, Leon Battista Alberti, Fra Angelico, Paolo Uccello, Poggio Bracciolini and Giannozzo Manetti all worked in Florence during his rule. Cosimo also sponsored the first public library in Florence, protected Marsilio Ficino's Platonic academy and promoted the teaching of Greek. It was he moreover who invited Pope Eugenius IV to transfer the council at which the reunion of the Greek Church with the Roman was being discussed from Ferrara to Florence in 1439 (*see* FERRARA-FLORENCE, COUNCIL OF).

**Piero the Gouty.**—Cosimo's position was inherited by his elder son Piero (1416–69), a generous, cultured and gentle-natured man who might have made energetic use of his political and diplomatic abilities had he not suffered extremely from gout (a hereditary ailment of the Medici) during his brief tenure of power. When a plot against him was detected (1466) he forgave the conspirators. On Venice's launching a new war against Florence, he made an alliance with Milan and Naples, defeated the *condottiere* Bartolomeo Colleoni at Imola and, under the peace of 1468, acquired Sarzana and Sarzanello. His wife, Lucrezia Tornabuoni, was highly intelligent, and his children received a careful literary and artistic education. Piero died on Dec. 2, 1469.

**Lorenzo the Magnificent.**—Piero's elder son Lorenzo, born in Florence on Jan. 1, 1449, was invited by the leading citizens of Florence to undertake the government of the republic in succession to his father. Formally respecting the republican system, he accepted no title other than that of *magnifico signore*, commonly given to all its heads. He had enlightened ambitions, high ideals and personal charm, and popular support enabled him to suppress obsolete republican institutions, to reform the councils, to dissolve the Parte Guelfa and to unify the administration both of the town and of the districts subject to Florence. Two military achievements of his first years of power were the reconquest of rebellious Prato (1470) and the subjection of Volterra (1472).

In 1478 a conspiracy against the Medici was formed by members of the Pazzi family, with the connivance of Francesco Salviati, archbishop of Pisa, and Girolamo Riario, a nephew of Pope Sixtus IV. On April 26, 1478, during Mass in the cathedral, Lorenzo was wounded and his brother Giuliano was stabbed to death. The people, scandalized at this sacrilege, once more proved loyal to the Medici, and the outrage was avenged with much bloodshed (Salviati was hanged) and with the exile of entire households. The pope thereupon excommunicated Lorenzo, put Florence under an interdict and induced Ferdinand of Naples to declare war. Lorenzo might then have been overthrown, but he took the bold step of going to Naples (late in 1479) and presenting himself alone before Ferdinand, whom he persuaded to make peace (March 1480) despite the pope, lest the French should intervene. On his return to Florence, he was triumphantly welcomed, and the pope finally absolved him and removed the interdict. Exploiting his success, meanwhile, Lorenzo had tightened his control over the republic by creating a new council of 70, whose function was to appoint nominees of his to government posts. In 1490 all authority in the republic was vested in a *balia* of only 17 members.

In his diplomacy Lorenzo was able to maintain a balance of power among the rival Italian states and to avert the danger of foreign intervention. When Innocent VIII, a friend of the Medici, succeeded Sixtus IV as pope, Florentine politics became more closely bound up with those of the papacy, and in 1489 Lorenzo's 13-year-old son Giovanni, the future pope Leo X (*q.v.*), was created cardinal. In his last years Lorenzo was contemplating a league of all the Italian states against the threat of French invasion.

Though the Medici themselves and Florence were less prosperous than in Cosimo's time, Florence enjoyed under Lorenzo the most splendid period of its Renaissance. Himself a poet (*see* ITALIAN LITERATURE), he was the friend and patron of writers, artists and scientists. Politian, Luigi Pulci, Pico della Mirandola, Botticelli, Antonio and Piero del Pollaiuolo, Mino da Fiesole, Benedetto da Maiano, Verrocchio, Giuliano da Sangallo and Paolo Toscanelli were among those who adorned the city or gravitated round Lorenzo's palaces and villas.

The pleasures and the pagan atmosphere of Lorenzo's Florence were denounced by the austere Dominican preacher Girolamo Savonarola (*q.v.*), who arrived in 1489. He also more or less directly criticized the absolute political power which had encouraged this licence and had suppressed the former republican freedom. Even so, Lorenzo himself admired Savonarola, whose blessing he received before dying, at Careggi, on April 9, 1492.

**The Medici Twice Exiled and Restored, 1494–1531.**—Piero di Lorenzo, born in Feb. 1472, succeeded his father in 1492. Called the Fatuous (*il Fatuo*), he proved incapable of mastering the problems that arose when the French king Charles VIII invaded Italy in 1494. Though he had originally declared himself against Charles, Piero went to meet him at Sarzana and agreed to surrender several important strongholds to him. This humiliation exacerbated the discontent which was being fomented in Florence not only by Savonarola's preaching but also by the intrigues of Piero's Medici cousins, Lorenzo and Giovanni, the self-styled Popolani (grandchildren of Cosimo the Elder's brother). Accused of having betrayed the republic, Piero was forced to flee from Florence, as also were his brothers Cardinal Giovanni and Giuliano (later duc de Nemours). The people sacked the Medici palace, and after a brief French occupation (Nov. 1494), during which Florence came to terms with Charles, the ancient forms of republican government were restored. The Palleschi, as the remaining partisans of the Medici were called (from the *palle*, or balls, in the arms of the house), encouraged Piero to try to restore himself (1496, 1497 and 1498), but his attempts failed. He was still an exile, serving with the French king Louis XII's forces in southern Italy, when he was drowned in the rout after the Spanish victory on the Garigliano river (Dec. 28, 1503).

In Florence, meanwhile, the republicans had been split into two factions: the Piagnoni, who continued the Savonarolan tradition; and the Arrabbiati, who had reacted against puritan theocracy.

The French alliance, moreover, to which the republic remained faithful, led to the political isolation of Florence when Pope Julius II organized his Holy League against Louis XII. Prompted by Cardinal Giovanni, the pope in 1512 demanded that Florence should enter the league, dismiss Piero Soderini (who had been elected gonfalonier for life in 1502) and allow the exiled Medici to return. Florence was forced to submit by a Spanish army, which sacked Prato. The Medici returned in Sept. 1512, and Lorenzo the Magnificent's constitution was restored.

Giuliano de' Medici used harsh measures to suppress a conspiracy, but generally showed moderation during his short rule. In 1513, however, his brother Giovanni became pope as Leo X, and Giuliano, appointed gonfalonier of the Holy Roman Church, went to join him in Rome. Having been granted the French title of duc de Nemours in 1515, Giuliano died on March 17, 1516.

In Aug. 1513 Giuliano's place in Florence was taken by Lorenzo (1492–1519), son of Piero the Fatuous. This Lorenzo was invested by the pope as duke of Urbino in Oct. 1516, having helped to expel Francesco Maria della Rovere from that duchy. Francesco Maria, however, returned to contest his possession of Urbino early in 1517, and Lorenzo died on May 4, 1519. His daughter Caterina later became queen of France as the consort of Henry II (*see* CATHERINE DE MÉDICIS).

With the exception of Pope Leo X, the line of Cosimo the Elder was now represented only by three bastards: Cardinal Giulio (1478–1534), son of Lorenzo the Magnificent's brother Giuliano; Ippolito (1511–35), son of Giuliano duc de Nemours; and Alessandro (1511–37), whose paternity is ascribed either to Lorenzo, duke of Urbino, or, with more likelihood, to Cardinal Giulio. Cardinal Giulio was entrusted with the lordship of Florence in 1519, but was elected to the papacy as Clement VII in Nov. 1523 (his Medici predecessor Leo X had died in Dec. 1521, and the intervening pontificate of Adrian VI had lasted only 21 months). Thereupon Silvio, Cardinal Passerini, became regent in Florence for Ippolito and Alessandro de' Medici. Alessandro had meanwhile been created duke of Penna by the emperor Charles V (1522).

It was during this period that Giovanni de' Medici (1498–1526), known as Giovanni delle Bande Nere, son of Giovanni il Popolano, was making his name as a military leader. Having fought for Leo X against Francesco Maria della Rovere (1516–17) and against the French (1521), he took service with the French in 1522, went over to the emperor's side in 1523, but returned to the French service in 1525 (before the battle of Pavia). In 1526 he entered the army of the League of Cognac against the emperor, but was mortally wounded in battle near Mantua on Nov. 25 and died five days later. His *bande nere* or "black bands" were named from the black banners that they began to carry in mourning for Leo X.

Republican sentiments and Savonarolan ideas were still strong in Florence, and Cardinal Passerini's regency was unpopular. When imperial forces sacked Rome (May 1527), revolution broke out in Florence, and Passerini and the bastards fled. The Piagnoni then came to power and restored the old regime of the republic. Clement VII's indignation counted for little so long as he was at variance with Charles V; but in June 1529 pope and emperor came to terms. Charles agreed to restore the Medici in Florence and sent an army against the city, which capitulated after a siege of 11 months (Oct. 1529–Aug. 1530). Reprisals were taken against the opponents of the Medici; and Alessandro, whom Charles had nominated head of state for Florence in Oct. 1530, returned in June 1531. Ippolito had been created cardinal (Jan. 1529).

Michelangelo's greatest work for the Medici in Florence belongs to the 12 years from 1522.

**Alessandro as Duke, 1532–37.**—The new Florentine constitution of April 1532 declared Alessandro to be hereditary duke and perpetual gonfalonier of the republic. Though his common sense and his feeling for justice won his subjects' affection, Alessandro was rough and uncultured, a lover of sensual pleasures who enriched himself personally through taxes and duties and was determined to make his authority absolute beyond all question. After Clement VII's death (1534) the exiled opposition sought to oust the duke from Florence and persuaded Cardinal Ippolito to submit its case to Charles V. Ippolito, however, died suddenly at Itri (Aug. 10, 1535), on his way from Rome to Tunis, where Charles then was; and Charles, returning from Tunis, received Alessandro at Naples and decided to uphold him. Married in 1536 to the emperor's natural daughter Margaret of Austria, the duke now felt altogether secure; but in the night of Jan. 5–6, 1537, his distant cousin Lorenzino or Lorenzaccio (1514–48), the companion and procurer of his licentious amusements, took advantage of his confidence in order to murder him. Disappointed at the Florentines' failure to rise against tyrannical government, Lorenzino fled first to Bologna, to await the result of the exiles' attack on Florence (*see* below). When this was defeated, he went to Turkey, to France and finally to Venice, where he was murdered in 1548.

**Cosimo I.**—Innocenzo, Cardinal Cybo, governor of the city of Florence and a son of Maddalena de' Medici (daughter of Lorenzo the Magnificent), might have assumed a regency for Alessandro's three-year-old bastard Giulio; but the murdered duke's old advisers, Francesco Guicciardini, Baccio Valori and Niccolò Acciaiuoli prevailed on him to disregard this infant, to consider the line of Cosimo the Elder as extinct, and to transfer the leadership in Florence to a descendant of Lorenzo di Giovanni di Bicci, namely to the son of Giovanni delle Bande Nere, the 17-year-old Cosimo (born June 12, 1519).

In Jan. 1537, therefore, Cosimo was elected head of the republic, in the government of which he was to be assisted by the senate, the assembly and the council. This election was approved by Charles V, and on Aug. 2 the emperor's general Alessandro Vitelli, at Montemurlo, defeated an army which the exiles, led by Filippo Strozzi and Bernardo Salviati, had raised against Cosimo. Cosimo then had Vitelli's principal captives beheaded (Strozzi, kept in prison, either killed himself or was killed later) and began, with Charles V's approval (Sept. 1537), to style himself duke. Senate, assembly and council were soon powerless.

Married in 1539 to Leonor de Toledo (daughter of Pedro de Toledo, Charles V's viceroy of Naples), Cosimo as the emperor's protégé could withstand the hostility of Pope Paul III and Francis I of France. Shrewd and unscrupulous, with Florence under his control, he could turn his ambition to territorial aggrandizement. His plans for annexing Lucca and Piombino in the 1540s were frustrated, but his enterprise against the republic of Siena, which sheltered exiles from Florence and pursued a pro-French policy, was successful. Cosimo launched an attack on Siena in 1554; a French army under Piero Strozzi was defeated at Scannagallo, near Marciano; and in 1555, after a long siege, the city capitulated. Philip II of Spain, as the successor of Charles V in Italy, had to agree to enfief Cosimo with the lordship of Siena in July 1557. The accession of Pius IV to the papacy in 1559 strengthened Cosimo still further, since Pius was a Medici of Milan and was well-disposed toward the Florentine Medici. He gave a cardinal's hat to Cosimo's son Giovanni in 1560 and, after Giovanni's death, one to Ferdinando (*see* below) in 1563.

Having brought nearly all Tuscany under his control, Cosimo used his despotic power to promote the country's well-being. Since commerce and industry were in decay, he set himself to develop agriculture, encouraging the growth of a landed nobility, draining the marshes and introducing new systems of cultivation. He also built up an effective navy, with Portoferraio (finally acquired in 1557), on the island of Elba, as a major base and with the institution of the knightly Order of St. Stephen (1561) for the protection of shipping against the Barbary pirates. Among writers and artists who contributed to the glory of Florence under his patronage were Agnolo Firenzuola, Benedetto Varchi, Bronzino, Bartolomeo Ammanati, Benvenuto Cellini and Vasari.

Cosimo was deeply afflicted when his wife, two of his daughters and two of his sons all died within six years (1557–62); his enemies exploited these misfortunes to spread calumnies against the dynasty. On March 1, 1564, he resigned the actual government of his dominions to his eldest son Francesco (1541–87), though he retained his ducal title and certain prerogatives; and in Dec. 1565 Francesco was married to the Austrian archduchess Joanna (Joan), a diplomatic achievement celebrated with great festivity.

Finally, on Aug. 27, 1569, Pope Pius V conferred the title of

grand duke of Tuscany on Cosimo. This title, however, was not recognized by the Habsburg powers or by the other Italian duchies. To gratify Pius, Cosimo in 1570 married Camilla Martelli, who had long been his mistress. He died at Castello on April 21, 1574.

**Francesco.**—Francesco, born on March 25, 1541, and head of the government from 1564, succeeded his father in 1574. He obtained the grand ducal title (without reference to the papal collation of 1569) from the emperor Maximilian II in Nov. 1575. By subservience to the Habsburgs he won recognition of his dynasty's hereditary right to all his possessions in Tuscany; and he twice refused invitations to stand as a candidate for the Polish crown (1575 and 1587). He sponsored Bernardo Buontalenti's plan for developing Leghorn (Livorno) (1577), which was to make it the greatest Tuscan port; he strengthened the fleet; and he opened several trading posts in the eastern Mediterranean.

A scholar and a keen student of chemistry, mechanics and ballistics, Francesco also continued his family's patronage of artists (notably Giovanni da Bologna) and was the first to house the Medici collection of paintings in the Uffizi palace in Florence. His reign was tarnished, however, by domestic scandals: his brother Pietro murdered his own wife, the younger Leonor de Toledo (night of July 9–10, 1576); his sister Isabella was murdered by her husband Paolo Giordano Orsini, duca di Bracciano (July 10, 1576); and Francesco himself grossly offended opinion by his relations with Bianca Capello (*q.v.*), whom he married on his first wife's death (1578). His death, at his villa of Poggio a Caiano, in Oct. 1587, followed shortly by Bianca's, was maliciously attributed to poison.

**Ferdinando I.**—Francesco's brother, Cardinal Ferdinando, born on July 30, 1549, succeeded to the grand duchy in 1587. He did not renounce his cardinalate till 1589, when he married Christine of Lorraine, daughter of Charles III of Lorraine, and a granddaughter of Catherine de Médicis through her mother Claude de France. This marriage, moreover, symbolized his policy of rapprochement with France in order to counteract Spanish influence in Italy, where Tuscany's independence and prosperity was assured by his skill at playing one great power off against another. For all his ecclesiastical background, he was a far more capable exponent of Cosimo's policy than Francesco had been.

Secret loans from Ferdinando helped Henry of Navarre, even before his conversion to Catholicism, in his war to make himself king of France as Henry IV; and the occupation of the Château d'If by Tuscan forces (1591) obstructed Spanish designs on Marseilles during the same war. There was some dispute between Ferdinando and Henry before Ferdinando withdrew his garrison from the Château d'If (1598), but their friendship was sealed by Henry's marriage, in 1600, to Ferdinando's niece Maria. To preserve good relations with the Austrian Habsburgs, on the other hand, Ferdinando's son Cosimo was married in 1608 to the archduchess Maria Magdalena, a first cousin of the emperor Rudolf II; and Tuscan forces helped the Austrians in their war against the Turks. The Knights of St. Stephen won notable victories over the Turks in the Ionian and Aegean seas (1605–09) and on the African coast (Bône, 1607).

Ferdinando's wise administration, an increase of commercial activity and the continuance of his predecessors' plans for draining the marshes and for developing Livorno and its port (where political exiles from abroad were encouraged to settle) raised the grand duchy to a new zenith of prosperity. In Rome, as a cardinal before becoming grand duke, Ferdinando had distinguished himself as a lover of the arts and as the builder of Villa Medici; and in Tuscany under his rule Giovanni da Bologna and Buontalenti remained active among artists and architects. Ferdinando also patronized Giulio Caccini, Jacopo Corsi and other musicians of the Camerata de' Bardi, whose work marked the birth of opera in Florence. Ferdinando I died on Feb. 7, 1609.

**Cosimo II.**—Cosimo II, born on May 12, 1590, succeeded his father in 1609. Guided by his mother, Christine of Lorraine, and by Belisario Vinta, he followed his father's example and sought to establish a balance between France and Spain. He used his influence to promote the Franco-Spanish negotiations of 1611–12, which led to the marriages of 1615 (between Louis XIII of France and Anne of Austria and between the future Philip IV of Spain and Elizabeth of France). His fleet, under the admirals Jacopo Inghirami and Giulio di Montauto, checked the Turks in the Mediterranean; and his friendly relations with the Druze amir Fakhr al-Din secured commercial advantages in the Levant for Tuscans.

It was Cosimo who appointed Galileo "first professor of philosophy and mathematics" at Pisa (1610). Under Cosimo also the architect Matteo Nigetti worked on the funeral chapel of the Medici (according to designs by Cosimo I's brilliant natural son, the younger Giovanni, who also won fame as a soldier and as a diplomat); and the sculptor Pietro Tacca began his bronzes for the monument to Ferdinando I. Cosimo, however, died on Feb. 28, 1621.

**Ferdinando II.**—Ferdinando II, born on July 14, 1610, was a child when he succeeded to the grand duchy in 1621. For six years, therefore, his grandmother, Christine of Lorraine, and his mother, Maria Magdalena of Austria, governed as regents for him. Assuming power in 1627, he showed generous solicitude for his people when famine and plague ravaged Tuscany. He contrived with difficulty to remain neutral, despite pressure from Spain, in the War of the Mantuan Succession (1628–31; *see* GONZAGA) and in the later Franco-Spanish hostilities of the Thirty Years' War. On the other hand his relations with the papacy were unhappy. Pope Urban VIII's annexation of Urbino to the papal states (1626) precluded Ferdinando from acquiring anything more than the freehold property of the former dukes of Urbino when he married their heiress, Vittoria della Rovere, in 1634 (this patrimony, however, included important art treasures); and though he allied himself with Venice and Modena to support his brother-in-law, Odoardo Farnese, duke of Parma, against Urban during the War of Castro (1642–44; *see* FARNESE) and won a victory at Mongiovino, near Perugia, in 1643, he received no advantage under the treaty of peace.

Deeply religious and austere, Ferdinando II was blamed for his acquiescence to the Holy Office's treatment of his teacher and protégé Galileo (1633); but he continued to take an interest in science, encouraging his brother Leopoldo, the future cardinal, in the foundation of the Accademia del Cimento in Florence (1657) and offering hospitality to scientists of all nations.

When France was emerging as the foremost power in Europe, Ferdinando negotiated the unfortunate marriage (1661) of his eldest son Cosimo to Marguerite Louise d'Orléans, daughter of Louis XIV's uncle Gaston, duc d'Orléans. The grand duke died on May 24, 1670.

**Cosimo III.**—Cosimo III, born on Aug. 14, 1642, became grand duke in 1670. He had a long and depressing reign. Though he traveled widely and spent money generously (in particular for the benefit of the church), he had a reserved manner aggravated by conjugal, political and dynastic disillusionments and took refuge more and more in devout practices. After continually trying to represent her marriage as invalid, his frivolous consort, Marguerite Louise, finally abandoned him in 1675 and went back to France. The humiliations that he had to endure in order to keep Tuscany neutral in the European conflicts of the age of Louis XIV were barely compensated by his navy's share in Francesco Morosini's victories over the Turks (1684). When his brother and his two sons proved childless, Cosimo and his brilliant minister Carlo Rinuccini had to envisage the extinction of his dynasty and even proposed, at one point, that a republican form of government should be restored in Tuscany. The European powers, however, coveted his succession and ignored his remonstrances; and by the Treaty of London (1718) the Quadruple alliance, namely Great Britain, France, the United Provinces of the Netherlands and the emperor Charles VI, decided that on the extinction of the male line of the Medici the grand duchy, together with Parma and Piacenza, should pass to Don Carlos de Borbón (*see* CHARLES III, king of Spain). Cosimo III died on Oct. 31, 1723.

**Gian Gastone.**—Cosimo's only surviving son, Gian Gastone (Giovanni Gastone; born in May 1671), became grand duke in 1723. Embittered by marriage (1697) to a contumacious wife, Anna Maria Francesca of Saxe-Lauenburg, who refused to leave

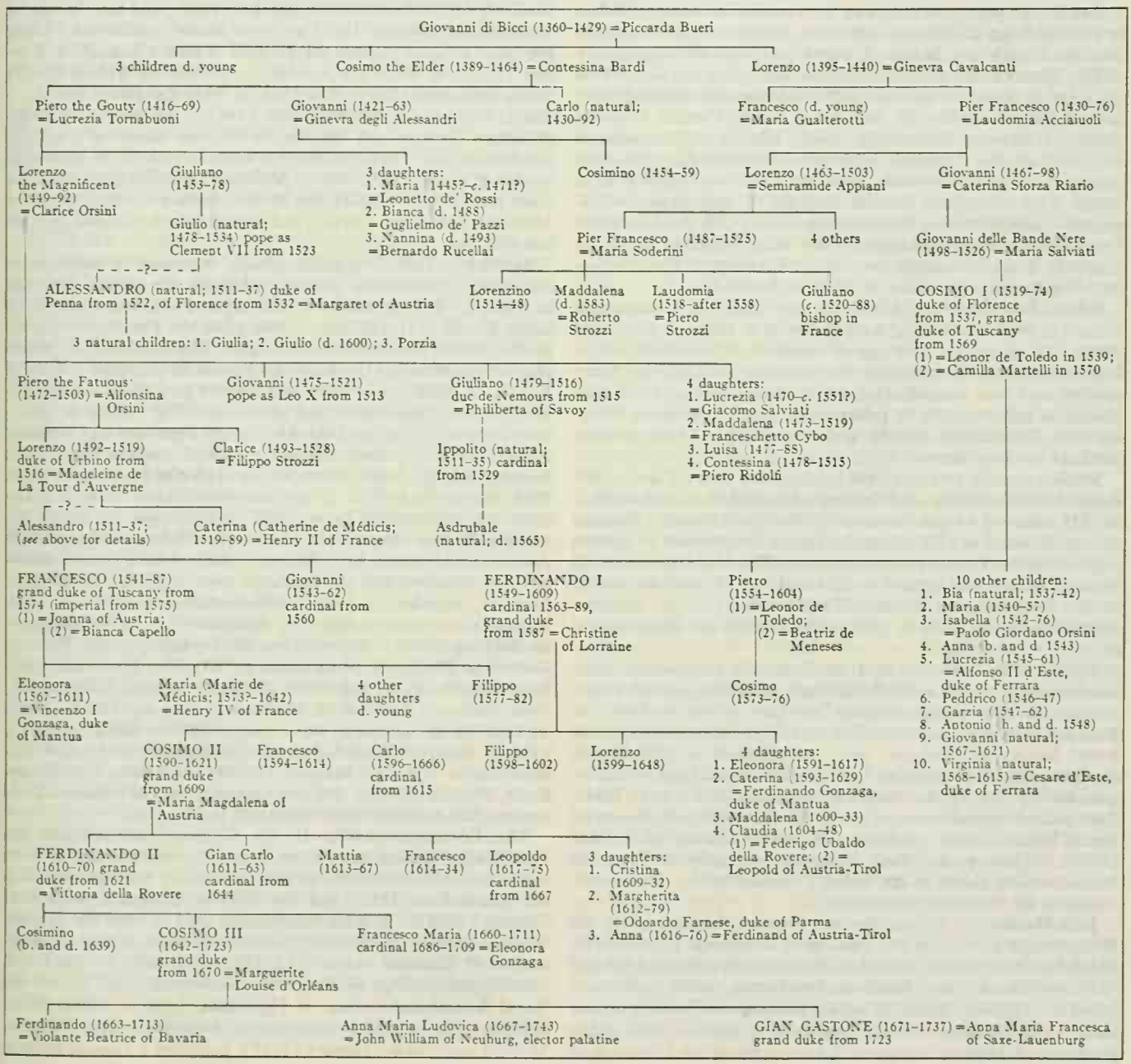
her family estates in Bohemia, he had led a life of dissipation, and he no longer had the energy to carry out the economic and financial rehabilitation of the grand duchy, though he embarked on it with an intelligence characteristic of his greater predecessors.

By the treaty of Seville (Nov. 1729), Great Britain, France and Spain agreed that Spanish troops should occupy Livorno and Portoferraio to ensure the Tuscan succession for Don Carlos on Gian Gastone's death, lest the emperor Charles VI should revoke his consent to the arrangement of 1718. Gian Gastone was induced to accept this decision, but when the Spaniards arrived, late in 1731, the grand duke drew up a secret protest stating that he had accepted the decision under constraint and that, for his part, he gave freedom to all his subjects. His views were again ignored by the powers in 1735 when, during the War of the Polish Succession, it was decided, in the preliminaries of the peace of Vienna, that Don Carlos, having conquered Naples, should renounce Tuscany and the other duchies and that the Medici succession should pass instead to Francis Stephen of Lorraine (the future emperor Francis I). Gian Gastone died on July 9, 1737, and the peace of Vienna was signed in 1738. The last survivor of the grand ducal line of the Medici, Gian Gastone's sister Anna Maria Ludovica (1667–1743), widow of the elector palatine John William of Neuburg, bequeathed all the art treasures of the Medici to the grand duchy and to Florence.

*See* also references under "Medici" in the Index.

BIBLIOGRAPHY.—Apart from histories of Florence and Tuscany, general works on the Medici include G. Pieraccini, *La stirpe de' Medici di Cafaggiolo*, 3 vol. (1924–25), particularly interesting from a genetic and medical point of view; G. F. Young, *The Medici* (1930); U. Dorini, *I Medici e i loro tempi* (1947); F. Schevill, *The Medici* (1949). For the earlier period in general *see* J. Ross, *Lives of the Early Medici as Told in their Correspondence* (1910); S. Brinton, *The Golden Age of the Medici . . . 1434–1494* (1926). For the 17th-18th centuries *see* E. Robiony, *Gli ultimi dei Medici* (1905); H. Acton, *The Last Medici* (1949). For Giovanni di Bicci *see* B. Dami, *Giovanni di Bicci 'de' Medici* (1899). For Cosimo the Elder *see* C. S. Gutkind, *Cosimo de' Medici, pater patriae, 1389–1464* (1938). For Lorenzo the Magnificent, W. Roscoe's classic *Life of Lorenzo de' Medici*, 2 vol. (1795; new ed. 1883), can be supplemented by B. Buser, *Lorenzo de' Medici als italienischer Staatsmann* (1879); R. Palmarocchi, *La Politica italiana di Lorenzo de' Medici* (1933); F. G. Fiori, *Lorenzo de' Medici* (1937); U. Dorini, *Lorenzo il Magnifico* (1949); B. Cicognani, *Le Poesie di Lorenzo de' Medici* (1950); C. M. Ady, *Lorenzo dei Medici and Ren-*

*The Ducal and Grand Ducal Descent of the Medici*



*aissance Italy* (1955). For Cosimo I *see* C. Booth, *Cosimo I, Duke of Florence* (1921); G. Spini, *Cosimo I . . . e la indipendenza del principato mediceo* (1945). (PI. B.)

**MEDICINE, SOCIETIES OF.** The early medical societies were formed by the meeting for discussion of persons interested in kindred subjects. These groups were sometimes designated as schools, lyceums, museums, societies, universities, academies and congresses, coming into existence in this order. Some scientific societies included medical subjects within their scope; medicine is still incorporated as a subdivision in certain more general societies. Medical societies also began as book societies whose main function was the dissemination of knowledge by means of discussion, by the provision of libraries and by the publication of journals and monographs.

Italy was the home of the earliest scientific societies, the short-lived Academia Secretorum Naturae having been established at Naples in 1560, followed in 1603 by the Accademia dei Lincei, founded in Rome by Prince Frederigo Cesi. The Lincei group had a checkered career and lapsed in 1647, the name being revived by the foundation of the Reale Accademia dei Lincei in 1870. The third of the early societies in Italy was the Accademia del Cimento, established in 1657 at Florence, where nine scientists worked together for ten years, the results of their researches being published in 1667 as *Saggi di Naturali esperienze*, which was translated into English, French and Latin. A physician, Joachim Jung (1587–1657), founded the German Societas Ereunitica at Rostock in 1622 but it ceased to exist in 1625. Another physician, Johann Lorenz Bausch (1605–55), founded in Schweinfurt in 1652 the Academia Naturae Curiosorum, which, after several changes of title, became the Academia Caesarea Leopoldina-Carolina Germanica Naturae Curiosorum (Academia Caesarea Leopoldina) in 1859. Two other early German societies of note were the Collegium Curiosorum sive Sperimentale (1672) and the Königliche Preussische Societät (Akademie) der Wissenschaften zu Berlin (Societas Regia Scientiarum, or "Berlin Academy," 1700), the latter being founded by Gottfried Wilhelm Leibniz.

**Great Britain.**—The Royal Society (*q.v.*) of London was formed in 1660 and received a royal charter in 1662. It originated about 1645 in weekly meetings of scientists at Gresham college, London; in 1648 the meetings were continued at Oxford. Many medical men were numbered among its original members and were elected as fellows, while its publications, which include the *Philosophical Transactions* (1665) and *Proceedings* (1856), contain much of medical interest.

Student medical societies have existed since an early date. The Royal Medical Society of Edinburgh, founded as a student body in 1737, received a royal charter in 1779. Guy's Hospital Physical society, founded in 1771, formed a branch for students in 1830 as Guy's Hospital Pupils' Physical society. The Middlesex Hospital Medical society was formed in 1774 and the Abernethian society at St. Bartholomew's hospital, London, was founded by John Abernethy (1764–1831) in 1795 as the Medical and Philosophical society.

John Coakley Lettsom (1744–1815) in 1773 founded the Medical Society of London, which continues to publish annual *Transactions;* in 1805 many members left this society to form the Medico-Chirurgical society. This was later incorporated in the Royal Society of Medicine, which was formed in 1907 by the amalgamation of 18 societies, including the Royal Medico-Chirurgical society (1805), the Pathological society of London (1846), the Epidemiological society (1850), the Odontological Society of Great Britain (1856) and the Obstetrical Society of London (1858). These pooled their resources eventually to form the largest medical library in the British Commonwealth. The society publishes its *Proceedings* monthly.

John Hunter and George Fordyce founded the Society for the Improvement of Medical and Chirurgical Knowledge (1783–1818), which met monthly and published *Transactions* between 1793 and 1812, and the Lyceum Medicum Londinense, which was established in 1785 and conducted weekly meetings in Hunter's lecture room. The Hunterian society originated in 1819 as the London Medical and Physical society and has published its *Transactions* since 1885; it also awards the Hunterian Society medal annually for an essay. The Harveian society of London was established in 1831 as the West London Medical society and institutes the Harveian lectures. At the instigation of the Yorkshire Philosophical society, the British Association for the Advancement of Science held its first meeting at York in 1831; its meetings, mainly concerned with general science but with sections covering medical subjects, are held annually and its *Proceedings* were published annually until 1938.

The oldest society in Great Britain devoted to pathology is the Reading Pathological society, formed in 1841. The trend in the 19th century toward specialization was evidenced by the foundation of the Edinburgh Obstetrical society, the Royal Microscopical society (both 1846), the Physiological society (1876), the Glasgow Obstetrical and Gynaecological society (1885), the Anatomical Society of Great Britain and Ireland (1887) and many others. The Provincial Medical and Surgical society, which was founded by Charles Hastings in 1832 and which became the British Medical association in 1856, has over 100 branches in various parts of the world and publishes the *British Medical Journal* and several specialist periodicals.

The Royal College of Obstetricians and Gynaecologists (1929), the Irish Medical association, Dublin (1936), and the College of General Practitioners (1952) are more recent foundations. Other specialist societies include the Medical Women's federation, London (1916), of which the Association of Medical Women (1879) was a forerunner; the British Medical Students' association, London (1941); the Nutrition society (1941); the Society of Endocrinology (1946); and the Society for the Study of Fertility, London (1950). Historical medical societies include the Historical section of the Royal Society of Medicine (organized in 1913), the Osler club, London (1928), the Scottish Society for the History of Medicine, Edinburgh (1948), and several others attached to medical schools.

**Europe.**—Medical societies greatly increased in numbers in the course of the 20th century and there are several thousand in Europe. The Académie de Chirurgie, Paris, was founded by Louis XV in 1731 and was revived after the French Revolution as the Société Nationale de Chirurgie. The Académie de Médecine, which succeeded the Académie Royale de Chirurgie et Société Royale de Médecine in 1820, was divided into three sections devoted to medicine, surgery and pharmacy. The Société de Médecine de Paris (1796) and the Association Française de Chirurgie, Paris (1884), represent the more general medical societies in France, while the Société Française de Médecine Psychosomatique, Paris (1956), is typical of modern specialization. In Germany there are the Deutsche Gesellschaft für Chirurgie, Berlin (1872), which publishes *Langenbeck's Archiv für klinische Chirurgie;* the Anatomische Gesellschaft, Mainz (1886), which issues *Anatomischer Anzeiger;* and the Deutsche physiologische Gesellschaft, Münster, founded in 1904. Representative societies in other European countries include the Académie Royale de Médecine de Belgique (1841); Genootschap tot bevordering van Natuur-, Genees- en Heelkunde, Amsterdam (1790); Det Medicinske Selskap i Bergen (1831) and Norsk Medicinsk Selskab, Oslo (1833); Real Academia Nacional de Medicina (1732) and the Academia de Ciencias de Madrid (1931); the Ordem dos Médicos, Lisbon (1938), which publishes a *Boletin;* the Academy of Medical Sciences in the U.S.S.R., Moscow (1944); the Finska Läkaresallskapet, Helsinki (1935), and the Suomalainen Lääkariseura Duodecim (1881), which issues numerous publications.

**The Commonwealth.**—In the British Commonwealth the Port Phillip Medical association, Australia, was founded in 1846 but lasted only five years. It was followed by the Victoria Medical association (1852) and the Medico-Chirurgical Society of Victoria (1854), which amalgamated in 1855 to form the Victoria Medical society, this title being changed in 1869 to Medical Association of Victoria. Australia is also represented by the Royal Australasian College of Surgeons, Melbourne (1927), and the Royal Australasian College of Physicians, Sydney (1938), which publishes the *Australasian Annals of Medicine.* The Canadian Medical association, Toronto (1867), publishes a *Journal* and the

*Canadian Journal of Surgery*. The Academy of Medicine, Toronto (1907), which publishes a *Bulletin*, was formed by the amalgamation of several Toronto medical societies, and houses an extensive library. The Indian Medical association, Delhi (1926), is affiliated to the British Medical association and issues several publications.

**The United States.**—The United States of America contains innumerable medical societies, the largest, the American Medical association (*q.v.*), being based on state associations representing almost 2,000 county societies. There are also about 200 national or interstate societies and many local ones. The American Medical association (founded 1847) publishes a *Journal* and specialist periodicals.

Several early attempts at founding medical societies were made, notably at Boston (1736), New Haven (1739), Charleston (1755) and Weymouth, Mass. (1765), but the oldest existing medical society in the United States is the Medical Society of New Jersey, founded in 1766 as the New Jersey Medical society. Other early foundations include the American Medical society, Philadelphia (1773), the Massachusetts Medical society (1781), the Medical Society of New Haven county, Conn. (1784), the College of Physicians of Philadelphia (1787), the Medical and Chirurgical Faculty of Maryland (1789 and 1798), the Medical Societies of Delaware and of South Carolina (1789), the New Hampshire Medical society (1791), the Connecticut Medical society (1792) and the Maryland Medical society (1798).

A Medical Society of New York state existed from 1794 to 1806, but membership was devoted almost exclusively to physicians in New York city and the current society of the same name was organized in Feb. 1807 as the result of legislation enacted the previous year. The state medical societies were largely organized to promote and enforce legislation regulating the practice of medicine.

In the first two-thirds of the 19th century, many new state and local societies were formed as the nation grew and expanded westward. The new organizations included the Société Médicale de la Nouvelle Orléans (1812), Medical Society of the District of Columbia (1819), Medical Society of Virginia (1820), Michigan State Medical society (1820), Ohio State Medical society (1846) and the Chicago Medical society (1850). On the west coast, the California Medical association was organized in 1856.

As specialties developed in medicine, specialized societies appeared. Among them were the American Psychiatric association (1844), American Ophthalmological society (1864), American Gynecological society (1876), Society of Medical Jurisprudence (1883), American Physiological society (1887), American Association of Anatomists (1888), American Pediatric society (1888), American Roentgen Ray society (1900), American Urological association (1902), American Association of Pathologists and Bacteriologists (1910), American College of Surgeons (*q.v.;* 1913) and the American College of Physicians (*q.v.;* 1915).

The founding of societies continues to keep pace with the expansion of medical knowledge, as is indicated by the founding of the Aerospace Medical association (1929), the Society of Nuclear Medicine (1954) and the American Society for Artificial Internal Organs (1955).

Student medical organizations were created early in the U.S. The first is believed to have been the Anatomical society, founded in 1771 and composed chiefly of Harvard students. The Student American Medical association, founded in 1950, consists of 75 local chapters with 50,000 medical students, interns and resident physicians as members.

Major national societies include the Association of American Medical Colleges (1876); the National Medical association (1895), with 50 state and about 75 local groups; American Medical Women's association (1915); and the American Academy of General Practice (1947), with about 26,000 members in 50 state chapters. The American Association of the History of Medicine was organized in 1924 as a section of the International Society of the History of Medicine (1920).

Many medical societies issue journals and some house excellent libraries.

**Latin America.**—Most of the Latin-American countries have medical societies. Brazil possessing the Academia Nacional de Medicina, Rio de Janeiro (1829); the Medical Society of Pernambuco (1843); the Sociedade de Medicina e Cirurgia de Rio de Janeiro (1880); the Sociedade de Medicina e Cirurgia de São Paulo (1895), which publishes the *Revista;* and the Associação Paulista de Medicina, São Paulo (1930), which issues a *Revista* and *Boletin*. The Asociación Médica Argentina, Buenos Aires, was founded in 1918; the Asociación Médica Dominicana, founded in 1941, publishes a *Revista*. Chile is represented by the Sociedad Médica de Santiago (1869), publishing the monthly *Revista Médica de Chile;* Sociedad Médica de Valparaíso (1913); and Sociedad de Cirurgia de Chile, Santiago (1922); the latter two also publish journals. The Academia Nacional de Medicina de México (1864) is divided into 38 sections and publishes the *Gaceta Médica de México*, while the Sociedad Mexicana de Pediatría (1894) issues a *Revista*. The Peruvian Asociación Médica Peruana "Daniel A. Carrión" (1930) publishes the *Revista médica peruana*, and the Círculo Médico del Perú (1883) issues *La Crónica médica*. Uruguay is represented by the Sociedad de Cirugía del Uruguay (1920) and the Ateneo de Clínica Quirúrgica (1934), both publishing journals.

**The East and Africa.**—Far Eastern medical societies are comparatively recent in origin. In China the All-China Federation of Scientific Societies, Peking (1950), has numerous affiliated organizations, including the Chinese Medical association (1914), which publishes the *Chinese Medical Journal* and several specialist periodicals. The Chinese Society of Physiological Sciences was founded in 1926 and the Chinese Anatomical society (1952) publishes *Acta Anatomica Sinica*. Many societies exist in Japan, including Nippon Kaibo Gakkai (anatomy; 1843), which issues *Kaibogaku Zasshi;* Nihon Geka Gakkai (surgery; 1901); Nihon Naika Gakkai (internal medicine; 1903); and Nippon Saikingakkai (bacteriology; 1927), which publishes the *Japanese Journal of Bacteriology and Parasitology* and the *Japanese Journal of Microbiology*. The Indonesian Medical association (Ikatan Dokter Indonesia) was founded in 1950 and the Medical Association of Thailand, Bangkok (1920), publishes a *Medical Journal*.

The Medical Association of South Africa, Cape Town (1927), publishes the *South African Medical Journal* and the *South African Journal of Laboratory and Clinical Medicine*.

The Egyptian Medical association (1919) publishes a *Journal;* the Persian Gulf Medical society was founded in 1948. In the Philippines there are the Manila Medical society (1902) and the Philippine Medical association (1903).

**International.**—International societies are intended to initiate co-operation between national associations, to promote the exchange of information and to inaugurate international congresses. Such organizations include the Pan American Medical association, New York (1925); the International College of Surgeons, Chicago, founded in 1935 and incorporated at Washington in 1940; the International Society of Haematology, Boston (1946); the International Society of Internal Medicine, Basel (1948); and the World Federation for Mental Health, London, founded in 1948. The International Union for Child Welfare, Geneva, was formed in 1946 by the amalgamation of the Save the Children International Union, Geneva (1920), and the International Association for Child Welfare (1921).

The World Health organization (*q.v.*) was formed in 1946 as a result of an international health conference for the establishment of an international health organization, convened by the Economic and Social Council of the United Nations, New York. The constitution was originally signed by 64 states, and WHO became functionary on April 7, 1948, when the necessary 26 states completed ratification of its constitution. It took over the functions of the League of Nations Health organization, certain activities of UNRRA and the duties of the Office International d'Hygiène Publique, Paris. The work of WHO is carried out by the World Health assembly, the executive board and the secretariat, and its functions include acting as a directing and co-ordinating body on international health problems, collaborating with appropriate organizations and governments in strengthening health services, promoting

and conducting research and providing information and assistance.

The first meeting of the general assembly of the World Medical association was held in Paris in Sept. 1947; among its objectives are the promotion of closer ties among the national medical organizations and the establishment of relations with WHO and UNESCO. The association holds annual meetings in various countries, investigates professional education and has issued an Approved International Code of Medical Ethics. It publishes a *Bulletin*.

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**MEDICINE AND SURGERY (ARTICLES ON).** The article MEDICINE AND SURGERY, HISTORY OF discusses the evolution of knowledge of the nature of diseases and of methods for combating them; the relationship of medicine and surgery to other sciences and to society in various eras and regions; and the contemporary status of the medical profession. Developments that exemplify recent progress in many fields are cited in MEDICAL RESEARCH. Special aspects of the medical profession are surveyed in MEDICAL EDUCATION; MEDICAL JURISPRUDENCE; and HEALTH AND SAFETY LAWS.

PATHOLOGY deals with the major causes of disease; the mechanisms of the human body for combating these; and the techniques employed for reinforcing resistance to injuries and bacterial invasions. Among the articles dealing with broad fields of pathology are ALLERGY AND ANAPHYLAXIS; ARTERIES, DISEASES OF; BLOOD, DISORDERS OF; CONNECTIVE TISSUE, DISEASES OF; EYE, HUMAN: *Diseases of the Eye;* GASTROINTESTINAL TRACT, DISEASES OF; GALL BLADDER, BILIARY TRACT AND LIVER, DISEASES OF; LUNG, DISEASES OF; PARASITOLOGY; PLEURA, DISEASES OF; RESPIRATORY SYSTEM, DISEASES OF; SKIN, DISEASES OF; SPINE, DISEASES AND DISABILITIES OF; URINARY SYSTEM: *Diseases and Their Medical Treatment*.

Pediatrics is discussed in CHILDREN, DISEASES OF. Articles on fields of specialization include ENDOCRINOLOGY; GYNECOLOGY; OBSTETRICS; OPHTHALMOLOGY; PHARMACOLOGY; PSYCHIATRY; SKIN, DISEASES OF. Fields of medicine linked to environmental and occupational conditions are discussed in the articles AVIATION MEDICINE; DANGEROUS OCCUPATIONS; INDUSTRIAL MEDICINE; MEDICAL SERVICES, MILITARY, and TROPICAL MEDICINE.

Specific ailments are dealt with in such articles as ANEMIA; ARTHRITIS; ASTHMA; CANCER; CEREBRAL PALSY; COLD, COMMON; DIPHTHERIA; ENCEPHALITIS; EPILEPSY; GOUT; HAY FEVER; INFLUENZA; MENINGITIS; NEURITIS; PNEUMONIA; POLIOMYELITIS; TUBERCULOSIS; ULCER; YELLOW FEVER; etc. The guiding principles employed in the identification of disease are described in DIAGNOSIS. Additional articles are devoted to individual factors of major importance—for example, CHOLESTEROL, dealing with one of the indications of disease of the arteries. Articles on major handicaps include BLINDNESS, DEAFNESS AND IMPAIRED HEARING; SPEECH DISORDERS; and REHABILITATION, MEDICAL AND VOCATIONAL.

THERAPEUTICS discusses the basic concepts of treatment and the various fields in which they find application. Among the articles on specialized branches of therapeutics are PHYSICAL THERAPY; RADIOLOGY; SERUM THERAPY; ULTRASONICS; and VACCINE THERAPY. The history of the use of drugs in the treatment of disease and the general principles accepted today in the study of the biological properties of drugs are outlined in PHARMACOLOGY. CHEMOTHERAPY discusses the theoretical basis of the selection of specific drugs to combat invading microorganisms.

Articles devoted to various groups of drugs include ANTIHISTAMINES; ANTIBIOTICS; BARBITURATES; SULFONAMIDES; TRANQUILIZING DRUGS; etc. Also, many articles are devoted to individual drugs—for example, AMPHETAMINE; ASPIRIN; ATROPINE; DIGITALIS; INSULIN; PENICILLIN; SCOPOLAMINE; TETRACYCLINE; etc. The establishment of standards of quality and strength for drugs is described in PHARMACOPOEIA.

Articles dealing in whole or in part with bacteriology, in addition to the article under that heading, include ANTISEPTICS; BACTERIAL AND INFECTIOUS DISEASES; EPIDEMIOLOGY; FOOD POISONING, BACTERIOLOGICAL; IMMUNITY; PARASITOLOGY; PHAGOCYTOSIS; RICKETTSIAE; VACCINATION; and VIRUSES. The problem of transmittal of infectious disease by persons who have themselves become immune is discussed in CARRIER.

DIET AND DIETETICS discusses the physiological needs that must be taken into account in a well-planned diet for the typical man and woman and for members of special population groups such as the aged. The functions of enzymes, carbohydrates, fats, proteins, salts, water and vitamins are discussed in NUTRITION and in MALNUTRITION. VITAMINS reviews the history of their role in counteracting deficiency diseases, and the chemical constituents and special functions of the various vitamins. VEGETARIANISM summarizes the hygienic and sociological benefits claimed by its advocates.

Articles on surgery include ABDOMEN, SURGERY OF; ANESTHESIA AND ANESTHETICS; BLOOD VESSELS, SURGERY OF; CAESAREAN SECTION; EYE, HUMAN: *Surgery of the Eye;* HEART AND LUNG, SURGERY OF; HERNIA; ORTHOPEDIC SURGERY; PLASTIC SURGERY; TRANSPLANTS, TISSUE AND ORGAN; etc. Among many articles in which surgical information is combined with discussions of medical problems in general are APPENDICITIS; BONE, DISEASES AND INJURIES OF; INTESTINAL OBSTRUCTIONS; VARICOSE VEINS; etc. Dental surgery is discussed in DENTISTRY and ORTHODONTICS.

CHILDREN, DISEASES OF is supplemented by ADOLESCENCE and INFANTS, CARE OF. Articles dealing with medical problems of women include CHILDBIRTH; MATERNAL AND CHILD HEALTH; MENOPAUSE; PREGNANCY; PUERPERAL FEVER; etc. Medical problems of old age are discussed in GERONTOLOGY AND GERIATRICS, and articles on related topics include DEATH (BIOLOGICAL) and LIFE SPAN, HUMAN.

The interconnection of physiological and psychological factors in all forms of life is exemplified by SEXUAL BEHAVIOUR. Articles discussing maladjustment of these two sets of factors include ALCOHOLISM; DEMENTIA; DRUG ADDICTION; HYPOCHONDRIASIS; NEUROPHARMACOLOGY AND PSYCHOPHARMACOLOGY; NEUROSES; PARANOID REACTIONS; PSYCHOANALYSIS; PSYCHOSES; PSYCHIATRY; etc. Additional listings will be found under PSYCHOLOGY (ARTICLES ON).

MEDICAL TECHNOLOGY summarizes the activities of technicians in bacteriology, clinical chemistry, hematology, serology, parasitology, etc., and the educational disciplines that are a prerequisite for these. Additional articles on occupations associated with medicine are APOTHECARY; NURSING; OPTOMETRY; PHARMACY; etc. CLINIC and HOSPITAL deal with the history and administrative procedures of these institutions. Articles on hygiene, in addition to the article under that title, include PREVENTIVE MEDICINE; PUBLIC HEALTH; WATER SUPPLY AND PURIFICATION.

Accidents and industrial diseases and measures to control their effects are discussed in ANTIDOTES; ARTIFICIAL RESPIRATION; BLOOD TRANSFUSION; BURNS; DANGEROUS OCCUPATIONS; DROWNING AND LIFESAVING; DUST; *The Dust Problem in Industry;* FIRST AID; FRACTURES AND DISLOCATIONS; HEATSTROKE; POISON; SHOCK; SILICOSIS; WOUND.

ANIMAL EXPERIMENTATION discusses advances in medicine and surgery that have accrued from this form of research, and the procedures by which it is legally regulated. Articles on medical topics of general interest include BLOOD PRESSURE; CANCER RESEARCH; EUGENICS; HEMORRHAGE; INFLAMMATION; NIGHT BLINDNESS; OBESITY; PAIN; SLEEP; etc.

Much of the science of medicine is inseparable from the related fields of anatomy, physiology, biochemistry and biophysics. The articles under these headings should be consulted, as well as ANATOMY (ARTICLES ON); BIOLOGY (ARTICLES ON); and PHYSIOLOGY (ARTICLES ON).

Many biographical articles describe the work of great physicians, surgeons and exponents of medical research, from such classical figures as Hippocrates and Galen to recent Nobel prize recipients.

Since medical subjects are widely interrelated, any given topic may be discussed from several points of view, in more than one article. The reader, therefore, will find it advisable always to consult the Index first.

**MEDICINE AND SURGERY, HISTORY OF.** Before outlining the history of medicine from earliest times, it may be of interest to consider the need for a study of medical history. Some explanation is essential in light of the increased specialization in medicine. No longer is medicine divided, as it once was in the 19th century, into three parts, namely medicine, surgery and obstetrics, but instead it is subdivided into very many smaller branches, each of them a lifework for the specialist.

What position does history occupy in this modern rearrangement? Emphatically, it is not just another of the numerous specialities. The history of medicine is not a branch of medicine; it is medicine itself. Here is no mere antiquarian pursuit or hobby for elderly or retired doctors. Medical history stems from a time when it was possible to survey medicine in all its branches as a whole, and its study enables one to recapture in some degree the broad outlook of the early days, when a physician was also a philosopher. When the modern patient, a significant onlooker upon the medical scene, tends sometimes to be pushed into the background by overspecialization, a glance at history will reaffirm the humanism of medicine and will reinstate the patient to the position he ought to hold; *i.e.*, that of the central figure. Thus, properly viewed, the history of medicine becomes the very basis of medical education. It is the antithesis of specialism and it serves to integrate and unite the various departments. Fortunately it is a fascinating and easy study, still using a language intelligible to the average reader.

An article on so vast a subject can trace only an outline of the rise and development of medical thought and practice from the earliest times. No rigid classification can be applied to the history of medicine and the story cannot be unfolded as a steadily progressive series of events. It has had many developments and setbacks and is best understood as a simple narrative, rather than as a chapter of epochs. It is often stated that medicine, like so many other arts and sciences, had its origin in ancient Greece, but that is only a partial truth. There were many great men before Agamemnon and even before the tale could be written down, the healing art was taught and practised.

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Extensive supplementary material on the history of medicine and surgery appears in other articles, including those on the major subdivisions of medicine and surgery, the major concepts of illness and treatment, the chief therapeutic agents and most of the persons mentioned in this article. To find these related entries, consult the article MEDICINE AND SURGERY (ARTICLES ON).

## I. MEDICINE AND SURGERY BEFORE 1700

### A. Primitive and Prehistoric Medicine

Unwritten history is not easy to interpret and, although much may be learned from a study of the drawings, bony remains and surgical tools of early man, it is difficult to reconstruct his mental attitude toward the problems of disease and death. It seems probable that man, as soon as he had reached the stage of reasoning, discovered, by the process of trial and error, which plants might be used as foods, which of them were poisonous and which of them had some medicinal value. Folk medicine or domestic medicine, consisting largely in the use of vegetable products, or herbs, originated in this fashion and still persists.

But that is not the whole story. Man did not at first regard death and disease as natural phenomena. Common maladies, such as colds or constipation, he accepted as part of his existence and administered such herbal remedies as were available; *e.g.*, certain household or domestic treatments that continued down to the 20th century. Serious and disabling diseases, however, he placed in a very different category. These were of supernatural origin, the work of a malevolent demon or of an offended god who had either projected some object—a dart, a stone, a worm—into the body of the victim or had abstracted something, usually the soul of the patient. The treatment then applied was to lure the errant soul back to its proper habitat within the body or to extract the evil intruder, be it dart or demon, by suction, incantations or other means. One very curious method of providing the disease with a means of escape from the body was by making a hole in the skull of the victim; *i.e.*, the practice of trepanning or trephining. Trepanned skulls of prehistoric date have been found in Britain, France and other parts of Europe and in Peru. The practice still exists among primitive people in parts of Algeria, in Melanesia and perhaps elsewhere, though it is fast becoming extinct.

Since such curious methods were used in treating disease, it is not surprising that magic and religion played a large part in the medicine of prehistoric or primitive man. The vegetable drug or remedy administered by mouth was accompanied by incantations, dancing, grimaces and all the tricks of the magician. Thus, the first doctors or "medicine men" were witch doctors or sorcerers. The use of charms and talismans, still prevalent in modern times, is of ancient origin. Apart from the treatment of wounds and broken bones, the folklore of medicine is probably the most ancient aspect of the art of healing, for primitive physicians showed their wisdom by treating the whole man, soul as well as body.

### B. Babylonian and Egyptian Medicine

The establishment of the calendar and the invention of writing marked the dawn of recorded history. The clues to early knowledge are scanty, consisting of clay tablets bearing cuneiform signs and seals that were used by Babylonian physicians about 3000 B.C. In the Louvre museum, Paris, there is preserved a stone pillar on which is inscribed the Code of Hammurabi (*see* BABYLONIA AND ASSYRIA: *History: Old Babylonian Period*), an early king of Baby-

lon. This code includes laws relating to medical practice; the penalties for defaulters were severe. For example, "If the doctor, in opening an abscess, shall kill the patient, his hands shall be cut off", if, however, the patient was a slave, the doctor was simply obliged to supply another slave. Herodotus in his *History* states that every Babylonian was an amateur physician, since it was the custom to lay the sick in the street so that anyone passing by might offer advice. Divination, from the inspection of the liver of a sacrificed animal, was widely practised and applied to foretell the course of a disease. Little else is known regarding Babylonian medicine and the name of not a single physician has survived.

It is only with the study of the medicine of ancient Egypt that the picture becomes clearer. The first physician to emerge was Imhotep, grand vizier to King Zoser of Egypt (2980–2900 B.C.), who designed one of the earliest of the pyramids, the Step pyramid at Saqqarah, and who, as the Egyptian god of medicine, rivals the Greek god Asclepius (*q.v.*), or Aesculapius, with whom he is sometimes confused. Knowledge becomes surer with the study of the Egyptian papyri, especially the Ebers papyrus and the Edwin Smith papyrus discovered in the 19th century. The former is a list of remedies, with appropriate spells or incantations, while the latter is a surgical treatise on the treatment of wounds and other injuries. One might imagine that the widespread practice of embalming the dead body would have stimulated the study of human anatomy, but that was not so.

The search for information regarding ancient medicine leads naturally from the papyri of Egypt to Hebrew literature. Strangely enough, the Bible contains little on the subject of the medical practices of Old Testament times. It is, however, a mine of information on social and personal hygiene. The Jews were indeed pioneers in matters of public health. (D. Gu.)

### C. Traditional Medicine and Surgery in the Orient

**1. India.**—Indian medicine is very ancient. Its earliest concepts are set out in the Vedas, especially in the metrical passages of the Atharvaveda, which may possibly date as far back as the 2nd millennium B.C. According to a later writer, the Ayurveda was received by Dhanvantari from Brahma, and Dhanvantari was deified as the god of medicine. In later times his status was gradually reduced until he was credited with having been an earthly king who died of snakebite. Legend tells of Dhanvantari's relations with snakes and illustrates the skill with which early Indian practitioners treated snakebite.

The period of Vedic medicine lasted until about 800 B.C. The Vedas are rich in magical practices for the treatment of diseases and in charms for the expulsion of the demons traditionally supposed to cause diseases. The chief conditions mentioned are fever (*takman*), cough, consumption, diarrhea, dropsy, abscesses, seizures, tumours and skin diseases (including leprosy). The herbs recommended for treatment are numerous.

The golden age of Indian medicine, from 800 B.C. until about A.D. 1000, may be termed the Brahmanistic period. It is marked especially by the works of Charaka and Susruta, known respectively as the *Charakasamhita* and the *Susrutasamhita*. Both these works were formerly regarded as being of great antiquity, and hence claims arose for the priority of Indian scientific medicine over its Greek counterpart. Another school asserted that these works were written many centuries after the beginning of the Christian era. The most recent estimates place the *Charaka* in its present form as dating from the 1st century A.D., and there were earlier versions. The *Susruta* probably originated in the last centuries of the pre-Christian era, and became fixed in its present form in the 7th century A.D. at the latest. Other medical treatises of lesser importance are those attributed to Vagbhata (*c.* 8th century). All later treatises were based on these works.

As the Hindus were prohibited by their religion from cutting the dead body, their knowledge of anatomy was limited. Susruta recommended that a body should be placed in a basket and sunk in a river for seven days. On its removal the parts could be easily separated without cutting. As a result of these crude methods the emphasis in Hindu anatomy was given to the bones, and then to the muscles, ligaments and joints. The nerves, blood vessels and internal organs were very imperfectly known. The texts state that the body has 360 bones, 210 joints and 500 muscles.

The Hindus believed that the body contained three elementary substances, microcosmic representatives of the three divine universal forces, which they called spirit (air), phlegm and bile. These were comparable with the humours of the Greeks. Health depends on the normal balance of these three elementary substances. The spirit has its seat below the navel, the phlegm above the heart, and the bile between the heart and the navel. The seven primary constituents of the body—blood, flesh, fat, bone, marrow, chyle and semen—are produced by the action of the elementary substances. Semen was supposed to be produced from all parts of the body and not from any individual part or organ.

Both Charaka and Susruta state the existence of a very large number of diseases (Susruta says 1,120). Rough classifications of diseases are given. In all texts "fever," of which numerous types are described, is regarded as very important. Phthisis (wasting disease, especially pulmonary tuberculosis) was apparently common and the Hindu physicians knew the symptoms of cases likely to terminate fatally. Smallpox was also common, and it is probable that smallpox inoculation was practised.

In diagnosis the Hindu physicians used all five senses. Hearing was used to distinguish the nature of the breathing, alteration in voice and the grinding sound produced by the rubbing together of broken ends of bones. They appear to have had a good clinical sense, and their sections on prognosis contain acute references to symptoms that are of grave import. However, even until late in the classical period magical beliefs still persisted; the prognosis could be affected by such fortuitous factors as the cleanliness of the messenger sent to fetch the physician, the nature of his conveyance, or the types of persons whom the physician met on his journey to the patient.

Indian therapeutics was largely dietetic and medicinal. Dietetic treatment was very important and it preceded any medicinal treatment. Fats were much used, internally and externally. The most important methods of active treatment were referred to as the "five procedures": emetics, purgatives, water enemas, oil enemas and sneezing powders. Inhalations were frequently employed, as were leeching, cupping and bleeding.

The Indian materia medica was extensive and consisted mainly of vegetable drugs, all of which were from indigenous plants. Charaka knew 500 medicinal plants and Susruta 760. However, animal remedies (such as the milk of various animals, bones, gallstones) and minerals (sulfur, arsenic, lead, copper sulfate, gold) were also employed. The physicians collected and prepared their own vegetable drugs. Among those that eventually appeared in Western pharmacopoeias are cardamom and cinnamon.

As a result of the strict religious beliefs of the Hindus, hygienic measures were very important in treatment. Two meals a day were prescribed, with indications of the nature of the diet, the amount of water to be drunk before and after the meal, and the use of condiments. Bathing and care of the skin were carefully prescribed, as also were the cleansing of the teeth with twigs from named trees, the anointing of the body with oil, and the use of eyewashes.

In surgery, ancient Hindu medicine reached its zenith. Detailed instructions about the choice of instruments and the different operations are given in the classical texts. It has been said that the Hindus knew all ancient operations except the arrest of hemorrhage by the ligature. Their operations were grouped broadly as follows: excision of tumours; incision of abscesses; punctures of collections of fluid in the abdomen; extraction of foreign bodies; expression of the contents of abscesses; probing of fistulas; and stitching of wounds.

The surgical instruments used by the Hindus have received special attention in modern times. According to Susruta the surgeon's armamentarium should contain 20 sharp and 101 blunt instruments. The sharp instruments included knives of various patterns, scissors, trocars, saws and needles. The blunt instruments included forceps, specula, tubes, levers, hooks and probes. The *Susrutasamhita* does not mention the catheter, but it is referred to

in later writings. The instruments were largely of steel. Alcohol seems to have been used as a narcotic during operations.

In two types of operations especially, the ancient Hindus were outstanding. Stone in the bladder (vesical calculus) was very common in ancient India, and the surgeons frequently carried out the operation of lateral lithotomy for removal of the stones. They also introduced plastic surgery. Amputation of the nose was one of the prescribed punishments for adultery, and repair was carried out by cutting from the patient's cheek a piece of tissue of the required size and shape and applying it to the stump of the nose. The results appear to have been tolerably satisfactory, and the modern operation is certainly derived indirectly from this ancient source. The Hindu surgeons also performed an operation for the cure of anal fistula, and in this they were definitely in advance of the Greeks.

In the past there has been much speculation as to whether the Greeks derived any of their medical knowledge from the Hindus. Mid-20th-century opinion held that there was certainly intercommunication between Greece and India before the time of Alexander the Great.

**2. China.**—The Chinese system of medicine is of great antiquity and is independent of any recorded external influences. According to legend it commenced with Fu Hsi (*c.* 2953 B.C.) and was continued by the emperors Shen Nung (*c.* 2838–2698 B.C.) and Huang Ti (*c.* 2698–2598 B.C.). The latter, the Yellow Emperor, was always regarded as the author of the canon of internal medicine called the *Nei Ching*, but there is some evidence that in its present form it does not date from earlier than the 3rd century B.C. Most of the Chinese medical literature is founded on the *Nei Ching* and it is still regarded as a great authority. Other famous works are the *Mo Ching* (known in the West as the "Pulse Classic") composed *c.* A.D. 300; and the *Golden Mirror*, as a compilation, made about A.D. 1700, of medical writings of the Han dynasty (202 B.C.–A.D. 221). Chinese medicine continued to progress to its zenith about A.D. 170, and until about A.D. 960 some progress was made, after which it was static and then degenerated because progress was considered simply as the detailed elaboration of the ancient themes. European medicine began to obtain a footing in China early in the 19th century, but the native system is still very widely practised.

The basis of traditional Chinese medicine is the dualistic cosmic theory of the *yang* and the *yin*. The *yang*, the male principle, is active and light, and is represented by the heavens; the *yin*, the female principle, is passive and dark, and is represented by the earth. The human body, like matter in general, is made up of five elements: wood, fire, earth, metal and water. With these are associated the five planets, the five conditions of the atmosphere, the five colours, the five tones, etc. Health, character and the success of all political and private ventures are determined by the preponderance, at the time, of the *yang* or the *yin*. In the body their proportions can be controlled, and this is the great aim of ancient Chinese medicine.

The teachings of the religious sects forbade the mutilation of the dead human body; hence traditional anatomy rests on no sure scientific foundation. One of the most important writers on anatomy, Wang Ch'in Jen, gained his knowledge in A.D. 1798 from the casual inspection of dog-torn bodies of children who had died in a plague epidemic in that year. Chinese anatomy is based on the cosmic system, which postulates the presence of such hypothetical structures as the 12 channels. Anatomical knowledge is therefore simply a corroboration of the system and, when there is a contradiction, the system is assumed to be right. The body contains five organs (heart, lungs, liver, spleen and kidneys), which store up but do not eliminate; and five viscera (such as the stomach, intestines, gallbladder and bladder), which eliminate but do not store up. Each organ is associated with one of the planets, colours, tones, smells and tastes. There are 365 bones and 365 articulations in the body. There are also three so-called burning spaces, but there is little agreement concerning the form and position of these hypothetical structures.

According to the physiology of traditional Chinese medicine, the blood vessels are supposed to contain blood and air, in proportions varying with those of the *yang* and the *yin*. These two cosmic principles circulate in the 12 channels and control the blood vessels and hence the pulse. The *Nei Ching* says that "the blood current flows continuously in a circle and never stops. It may be compared to a circle without beginning or end." On this flimsy evidence it has been claimed that the Chinese anticipated Harvey's discovery of the circulation of the blood. Tears are supposed to be secreted by the liver, and there are two kinds of salivary secretion, one arising from the heart and the other from the kidneys.

Traditional Chinese pathology is also dependent on the theory of the *yang* and the *yin*, and this had led to a very detailed classification of diseases in which most of the detailed types are without any scientific foundation.

In diagnosis, detailed questions are asked about the history of the illness and the patient's taste, smell, dreams, etc. Attention is paid to the quality of the voice and far-reaching conclusions are drawn from it. Note is made of the colour of the face and of the tongue. The most important part of the investigation, however, is the examination of the pulse.

The doctrine of the pulse is very ancient. Some say that it was introduced about 255 B.C., and Wang She-ho, who wrote the "Pulse Classic," lived about A.D. 280. This work (with innumerable commentaries) asserts that health depends on the harmonious balance of the *yang* and the *yin*. If the flow of one of these principles is obstructed, disharmony and disease result. The state of the pulse indicates the point at which obstruction in the hypothetical channels has occurred. Feeling the pulse is the most important aspect of diagnosis. Three fingers are used to feel the radial artery (serving the forearm, wrist and hand); and, as there are six pulses, each of which must be felt three times with strong, medium and weak pressure successively, the number of possible variations is very large. Several other qualities of the pulse at any point are also noted, and the pulses on the two sides differ. The pulse also varies according to the time of day and season of the year. These comments refer only to the radial pulse at the wrist; but there are ten other places at which the pulse can be, and often is, felt. The minimum time necessary to feel the pulse is ten minutes, and the operation may take three hours. It is often the only examination made, and it is used not only for diagnosis but also for prognosis. Some say that from it the organs that are diseased can be ascertained and the time of death or recovery foretold.

From the point of view of the Western observer, Chinese medical treatment has three points of interest: the materia medica; moxibustion; and acupuncture.

The materia medica has always been very extensive, and consists of vegetable, animal (including human) and mineral remedies. There were famous herbals from ancient times; but all these, to the number of about 1,000, were collated, correlated, corrected and used by Li Shih-chen in the compilation of the *Pen-Ts'ao Kang Mu* (the "Great Herbal," A.D. 1552–78). This work, in 52 volumes, has been frequently revised and reprinted, and is still very authoritative. The use of drugs is mainly to restore the harmony of the *yang* and the *yin*. The drugs are also related to the five organs, the five planets, the five colours, etc. The art of prescribing is therefore complex. Almost every conceivable natural substance has at one time or another been used therapeutically. In addition, in prescribing there are often the elements of sympathetic magic, and the doctrine of signatures, long since abandoned by Western medicine. Various plasters are often applied, sometimes far from the seat of the pain.

Among the drugs taken over by Western medicine from the Chinese are rhubarb, iron (for anemia), castor oil, kaolin, aconite, camphor and *Cannabis sativa* (Indian hemp). Chaulmoogra oil was used by the Chinese for leprosy from at least the 14th century, and about a century ago it began to be used for this purpose by Western physicians. The herb *ma huang* has been used in China for at least 4,000 years. Botanically it is *Ephedra vulgaris* (or *E. sinica*) and the isolation of the alkaloid ephedrine from it has greatly improved the Western treatment of asthma

and similar conditions. The most famous and expensive of Chinese remedies is ginseng (*q.v.*). Western methods have shown that it has diuretic and other properties but is of doubtful value.

Hydrotherapy is probably of Chinese origin, since cold baths were used for fevers as early as 150 B.C. The inoculation of smallpox matter, in order to produce a mild but immunizing attack of the disease, was practised in China from ancient times and came to Europe about 1720.

Moxibustion consists in making a small, moistened cone of powdered leaves of mugwort, or wormwood (*Artemisia* sp.), applying it to the skin, igniting it and then crushing it into the blister so formed. Other substances are also used for the moxa. Dozens of these are sometimes applied at one sitting. The practice is often associated with acupuncture.

Acupuncture consists of the insertion into the skin and underlying tissues of a metal needle, either hot or cold. The theory is that the needle will affect the distribution of the *yang* and the *yin* in the so-called burning spaces and in the hypothetical channels of the body. The site of the insertion is chosen to affect a particular organ or organs. The practice of acupuncture dates from before 2500 B.C. and is peculiarly Chinese. Little of practical importance has been added since that date, although there have been many well-known treatises on the subject.

A bronze model, *c.* A.D. 860, shows the hundreds of specified points for the insertion of the needle; this was the forerunner of the innumerable models and diagrams that were later produced. The needles used are 3 to 24 cm. (about 1 to 10 in.) in length. They are often inserted with considerable force and after insertion may be screwed to the left or right. One Western observer saw unsterilized needles driven up to 15 cm. (6 in.) into solid organs such as the liver. The practice of acupuncture, often combined with moxibustion, is still widely used for many diseases, including fractures. (*See* ACUPUNCTURE.)

**3. Japan.**—In ancient times Japan had its own system of medicine, but about the 3rd century A.D. the country learned of the Chinese principles of healing, which remained in favour until about the 16th century. Of the native physicians, Nagata Tokuhon is probably the best known. Western medicine was introduced into Japan by Portuguese missionaries and was fully established by 1870.

(E. A. U.)

### D. Early Greek and Roman Medicine

**1. Before Hippocrates.**—The first rational and scientific system of medicine is of Greek origin and is usually associated with the name of Hippocrates. It must be remembered, however, that the transition from magic to science was a gradual process that lasted for centuries and there can be little doubt that ancient Greece inherited much from Babylonia and Egypt, and even India and China. The reader of the Homeric tales, the *Iliad* and the *Odyssey*, may well be bewildered by the narrow distinction between gods and men in the characters and between historical fact and poetic fancy in the story. Two military surgeons, Podalarius and Machaon, are said to have been sons of Asclepius, who may have had a human existence about 1200 B.C. and who performed many miracles of healing. He was worshiped in hundreds of temples throughout Greece; remains of these temples may be seen at Epidaurus, Cos, Athens and elsewhere. To these resorts or hospitals came many sick persons for the healing ritual known as incubation, or temple sleep; they lay down to sleep in the dormitory or abaton and were visited by Asclepius or one of his priests, who gave advice, and in the morning the patient departed cured. There are at Epidaurus many inscriptions recording the cures, but there seem to have been no failures and no deaths. Diet, baths and exercises played their part in the treatment and it would appear that these temples were the prototype of modern health resorts. Each had its theatre for amusements and its stadium for athletic contests. The cult of incubation continued far into the Christian era and in Greece and some of the Aegean islands, as well as in the south of Italy, Sardinia and Sicily, sick persons are still brought to spend a night in certain churches in the hope of a cure.

It was, however, the work of the early Greek philosophers, rather than that of the priests of Asclepius, that provided the impetus that led men to refuse to be guided solely by supernatural influence and to seek out for themselves the causes and reasons for the strange ways of nature. Pythagoras (fl. *c.* 530 B.C.) was the philosopher whose chief discovery was the importance of numbers and who may be said to have founded arithmetic. Empedocles (*c.* 490–430 B.C.) regarded the universe as composed of four elements—fire, air, earth and water—and this conception led to the doctrine of the "humours." The maintenance of health was held to depend upon the harmony of the humours: the hot and the cold, the moist and the dry.

**2. Hippocrates.**—Medical thought had reached this stage and had partly discarded the conceptions based upon magic and religion when, in 460 B.C., there was born in the island of Cos one who was to become known as "the father of medicine" and who was well worthy of the title. It would serve no useful purpose to discuss whether Hippocrates was a man or a god, whether several physicians bore his name and whether he was the author of some, or of none, of the books that make up what is known as the *Hippocratic Collection*, or the *Corpus Hippocraticum*. Little is known of the life of Hippocrates, save that he taught and practised medicine in Cos and in other parts of Greece, including Athens, and died at a great age. With such scanty information on which opinions can be based, it seems only fair to accept such facts as are found in the writings of "the Hippocratic school," if not of Hippocrates, and to accept the man himself as the founder of modern scientific medicine. Some of the works, notably the *Aphorismi* (*Aphorisms*), were used as textbooks until the 19th century. Admittedly they contain much that is obsolete, but they embody a code of teaching and principles that are surprisingly modern and they deserve to be read and studied by every practitioner of medicine and surgery. The first aphorism is "Life is short, and the Art long; opportunity fleeting; experiment dangerous, and judgment difficult." This is followed by a large number of brief comments on diseases and symptoms, many of which remain true. Hippocrates used neither thermometer nor stethoscope, since they were not then known, nor indeed did he employ any aid to diagnosis beyond his own powers of observation and of logical reasoning, and he had an almost uncanny ability to foretell the course of the malady, laying more stress upon prognosis than upon diagnosis. On the mainland, close to Cos, was the rival school of Cnidus, where the physicians were apt to confuse symptoms and diagnosis; they insisted upon naming the disease and treating it and were not concerned with prognosis, nor with causes. Hippocrates had no patience with the idea that disease was a punishment sent by the gods. Writing of epilepsy, then called "the sacred disease," he said, "It is not any more sacred than other diseases, but has a natural cause, and its supposed divine origin is due to man's inexperience." "Every disease," he continued, "has its own nature, and arises from external causes." He noted the effect of food, of occupation and especially of climate in causing disease, and one of his most interesting books, entitled *De aere, aquis et locis* (*Airs, Waters and Places*), would today be classed as a treatise on human ecology. Pursuing this line of thought, Hippocrates stated that "Our natures are the physicians of our diseases" and that this tendency to natural cure should be fostered, laying much stress on diet and using few drugs. He knew well how to describe illness clearly and concisely and recorded failures as well as successes; he viewed disease with the eye of the naturalist and studied the entire patient in his environment.

Perhaps the greatest legacy of Hippocrates to the medical profession was the following charter of conduct known as the oath of Hippocrates, which has been adopted as a pattern by medical men throughout the ages and is still used during the ceremony of graduation at many universities and schools of medicine:

I will look upon him who shall have taught me this Art even as one of my parents. I will share my substance with him, and I will supply his necessities, if he be in need. I will regard his offspring even as my own brethren, and I will teach them this Art, if they would learn it, without fee or covenant. I will impart this Art by precept, by lecture and by every mode of teaching, not only to my own sons but to the sons of him who has taught me, and to disciples bound by covenant and oath, according to the Law of Medicine.

The regimen I adopt shall be for the benefit of my patients according to my ability and judgment, and not for their hurt or for any

wrong. I will give no deadly drug to any, though it be asked of me, nor will I counsel such, and especially I will not aid a woman to procure abortion. Whatsoever house I enter, there will I go for the benefit of the sick, refraining from all wrongdoing or corruption, and especially from any act of seduction, of male or female, of bond or free. Whatsoever things I see or hear concerning the life of men, in my attendance on the sick or even apart therefrom, which ought not to be noised abroad, I will keep silence thereon, counting such things to be as sacred secrets.

The term "oath" should not be interpreted too narrowly. It was, rather, an ethical code or ideal and in no sense a law. It is an appeal for correct conduct but contains no threat of punishment. In one or other of its many versions, it has guided the practice of medicine for more than 2,000 years.

**3. Between Hippocrates and Galen.**—Closely following Hippocrates in point of time was Aristotle (384–322 B.C.), the first great biologist, whose work was of inestimable value to medicine. A pupil of Plato at Athens and tutor to Alexander the Great, Aristotle studied the entire world of living things, laying the foundations of comparative anatomy and of embryology.

After the time of Aristotle, Greek culture began to fade in the land of its birth. The scene shifted to Alexandria, where a famous medical school was established *c.* 300 B.C. There, the two best medical teachers were Herophilus, whose treatise on anatomy may have been the first of its kind, and Erasistratus, regarded by some as the founder of physiology, who noted the difference between sensory and motor nerves but thought the nerves were hollow tubes containing fluid. He also believed that air entered the lungs and heart and was carried through the body in the arteries. Alexandria continued as a centre of medical teaching even after the Roman empire had attained supremacy over that of Greece for, although Rome became mistress of the world, medical knowledge remained predominantly Greek. Aulus Cornelius Celsus, the Roman nobleman who wrote his *De medicina* about A.D. 30, based his knowledge on Greek medicine. His book, overlooked in his day, attained a long-delayed fame when printed at Florence in 1478, thereby becoming one of the first medical books to appear in print. Celsus followed the teaching of Asclepiades of Bithynia (b. 124 B.C.), who differed from Hippocrates in that he denied the healing power of nature and insisted that disease should be treated safely, speedily and agreeably (*tuto, cito et jucunde*).

An opponent of the humoral theory, Asclepiades drew upon the atomic theory of the 5th-century Greek philosopher Democritus in advocating a doctrine of *strictum et laxum*—the attribution of disease to the constricted or relaxed condition of solid particles supposedly making up the body. To restore harmony among the particles and thus effect cures, Asclepiades used typically Greek remedies: massage, poultices, occasional tonics, fresh air and corrective diet. He gave particular attention to mental disease, clearly distinguishing hallucinatory conditions from those marked by delusions. He released the insane from confinement in dark cellars and prescribed a regimen of occupational therapy, soothing music, soporifics (especially wine) and exercises to improve the attention and memory. Asclepiades did a great deal to win acceptance for Greek medicine in Rome. His teachings were strongly dogmatized in the period following his death—a period of much disputation as to the nature of disease. This period was brought to a close by the career of Galen (*c.* A.D. 130–*c.* 200), a Greek who began practising in Rome in A.D. 164.

**4. Galen.**—During the early centuries of the Christian era, many Greek doctors sought fame and fortune in Rome. The most illustrious of them was Galen, who acknowledged his debt to Hippocrates and followed the Hippocratic method, accepting the doctrine of the humours. He laid stress on the value of anatomy and he virtually founded experimental physiology. Galen recognized that the arteries contain blood and not merely air and showed how the heart set the blood in motion in an "ebb and flow" fashion, but he had no idea that the blood circulated. Dissection of the human body was at that time illegal, so that he was forced to base his knowledge upon the examination of apes and pigs. A voluminous writer who stated his views forcibly and with confidence, he not surprisingly remained for centuries the undisputed authority from whom no one dared to differ.

Although the contribution of Rome to the practice of medicine was negligible when compared with that of Greece, it must be admitted that in matters of public health Rome set the world a great example. The city of Rome had an unrivaled water supply. Gymnasiums and public baths were provided and there was even domestic sanitation and adequate disposal of sewage. The Roman army had its medical officers, public physicians were appointed to attend the poor and hospitals were built; a Roman hospital excavated near Düsseldorf, Ger., was strangely modern in design.

### E. Arabian Teaching and the School of Salerno

After the fall of Rome, learning was no longer held in high esteem, experiment was discouraged and originality became even a dangerous asset. During the dark ages medicine passed into the widely contrasting hands of the Christian church and the Arab scholars.

**1. The Christian Reservoir of Learning.**—It is sometimes stated that the early Christian church had an adverse effect upon medical progress: disease was regarded as a punishment for sin and such chastening demanded only prayer and repentance. Furthermore, the human body was held sacred and dissection was forbidden. It seems probable, however, that the infinite care and nursing bestowed upon the sick by the Christian church far outweighs any intolerance shown toward medicine in the early days. Perhaps the greatest service rendered to medicine by the church was the preservation and transcription of the classic Greek medical manuscripts. This work was carried on in many medieval monasteries and was also pursued by the Nestorian Christians, who established a school of translators for the purpose of translating the Greek medical texts into Arabic. This famous school and also a great hospital were located at Shahpur in southwest Persia, where the chief physician was Jurgis Bukht-Yishu, the first of a dynasty of translators and physicians that lasted for six generations. A later translator of great renown was Hunayn ibn Ishaq, or Johannitus (b. A.D. 809), whose translations were said to be worth their weight in gold.

About this time there appeared a number of saints whose names were associated with miraculous cures. Among the earliest of them were the twin brothers Cosmas and Damian, who suffered martyrdom (*c.* 303) and who became the patron saints of medicine; and they are so commemorated in many paintings and stained-glass windows. The Christian church sought to replace the signs of the zodiac, to which parts of the human body were referred, by various patron saints: St. Blaisius dominated the throat and lung, St. Apollonia the teeth, St. Erasmus the abdomen, SS. Lucia and Triduana the eyes. Other saints were powerful healers of certain diseases: St. Vitus, for example, was invoked for chorea or St. Vitus' dance and St. Anthony for erysipelas or St. Anthony's fire. The cult of these saints was widespread in medieval times and a later cult, that of St. Roch for plague, was widespread in the 15th century when that disease was prevalent.

**2. The Arabian Medical Reservoir.**—The second reservoir of medical learning during those early times was the great Muslim empire, which extended from Persia to Spain. Although it is customary to speak of Arabian medicine in describing this period, it must be remembered that the physicians were not all Arabs or natives of Arabia. Nor, indeed, were they all Muslims; some were Jews, some Christians, and they were drawn from all parts of the great empire, extending along the entire northern coast of Africa and invading Spain. Only a few of the leading figures need be mentioned. One of the earliest was Rhazes (*c.* 865–923 or 932), a Persian born near the modern Teheran who wrote a voluminous treatise on medicine, *Al-Hawi* ("Comprehensive Book"), but whose most famous work *De variolis et morbillis* (*A Treatise on the Smallpox and Measles*) deals with the distinction between these two diseases and gives a clear description of both.

Of later date was Avicenna (980–1037), who has been called, and not without good reason, "the prince of physicians." Like Rhazes, Avicenna was a Persian. Born near Bukhara, he could repeat the Koran before he was 10 years old and at the age of 18 became court physician. It is not surprising that his principal work, *Al-Qanun fi'l-Tibb* ("The Canon of Medicine"), became

a classic and was used at many medical schools—at Montpellier, France, as late as 1650—and is still said to be used in the east. Avicenna died at Hamadan, where his tomb is a place of pilgrimage.

The greatest contribution of Arabian medicine was in materia medica and chemistry; many drugs now in use are of Arab origin, as also are such processes as distillation and sublimation. Too often the chemistry of that time was mainly a search for the philosopher's stone, which supposedly would turn all common metals to gold. Astronomers were astrologers and chemists were alchemists and it is therefore surprising that, despite all this, the physicians of the Muslim empire did make a noteworthy contribution to medical progress. At that period and, indeed, throughout most historical times, surgery was regarded as inferior to medicine. One Arab surgeon, however, Abul Kasim (Albucasis) of Córdoba (*c.* 936–*c.* 1013), wrote the first illustrated book on surgery, which was widely used. He was a careful and conservative surgeon who did much to raise the status of surgery in Córdoba, an important centre of commerce and culture with a fine hospital and medical school equal to those of Cairo and Baghdad.

Another great doctor of Córdoba, born just as the sun of Arabian culture was setting, was the Jew named Maimonides (1135–1204). Banished from the city because he would not become a Muslim, he eventually went to Cairo where the law was more lenient and where he acquired a reputation so high that he became physician to Saladin, the Saracen leader. He was the original of El Hakim in Sir Walter Scott's *Talisman*. A few of his works, written in Arabic, were eventually translated into Latin and printed; perhaps the best known is *Yad-Hachazakah* (*The Code of Maimonides*), an ethical code still adopted in Jewish medical circles.

**3. Salerno.**—About this time there was established at the city of Salerno, in southern Italy, the first organized medical school in Europe. After centuries of comparative stagnation, medical learning was at last to be established on a sound basis and, although the school of Salerno produced no brilliant genius and no startling discovery, it was the parent of the great medieval schools soon to be founded at Montpellier, Bologna, Padua and Paris. The Salerno school reached the zenith of its fame in the 10th or 11th century. It owed much to the enlightened Holy Roman emperor Frederick II, who decreed in 1221 that no one should practise medicine until he had been publicly approved by the masters of Salerno.

Salerno drew scholars from near and far. One of the earliest was Constantine the African (*c.* 1020–87), who, after years of wandering in the east, sought refuge in Salerno and then retired to Monte Cassino, the monastery founded by St. Benedict in the 6th century, there to translate from Arabic into Latin many of the Greek classic writings. The Salernitan school also produced a literature of its own and the best-known work, of uncertain date and of composite authorship, was the *Regimen Sanitatis Salernitanum*. Written in verse, it has appeared in numerous editions and has been translated into many languages. The *Regimen* is said to have been written as a handbook of domestic medicine for Robert, duke of Normandy, a crusader who visited Salerno for the treatment of a wound, but the most authentic contemporary manuscript is that of Arnold of Villanova (1235–1312). The best English translations are by Sir John Harington (1608) and Sir A. Croke (1830). Among the oft-quoted couplets is the following:

> Use three physicians still, first Doctor Quiet,
> Next Doctor Merryman, and Doctor Diet.

### F. Reform and Revival in Medicine

**1. The Spread of New Learning.**—Salerno yielded its place as the premier medical school of Europe to Montpellier about A.D. 1200. John of Gaddesden (1280–1361), the pattern of the "doctour of physick" in Chaucer's *Canterbury Tales*, was one of the English students there and that he relied upon astrology and upon the humours is evident from Chaucer's description.

> Well could he guess the ascending of the star
> Wherein his patient's fortunes settled were.
> He knew the course of every malady,
> Were it of cold or heat or moist or dry . . .

Among the teachers of medicine in the medieval universities there were many who clung to the past, but there were not a few bold spirits who determined to explore new lines of thought. The new learning, or Renaissance, born in Italy, grew and expanded slowly. Two great scholars who influenced medicine were Roger Bacon (*c.* 1220–*c.* 1292), an active observer and tireless experimenter, and Albertus Magnus (*c.* 1192–1280). About this time, also, Mondino de'Luzzi (1270?–1326) taught at Bologna, Italy, performing his own dissections rather than entrusting the task to a menial; he wrote the first practical manual of anatomy in 1316, although he perpetuated the errors of Galen. Foremost among the surgeons of his day was Guy de Chauliac (*c.* 1300–68), a good physician as well as a surgeon and one who based his writing on observation and experience. His *Chirurgia magna* ("Great Surgery") had a profound influence upon the progress of surgery.

The full force of the Renaissance was not felt until the 14th century. The Renaissance was much more than merely a reviving of interest in Greek culture; it was rather a change of outlook, an eagerness for discovery, a desire to escape from the limitations of tradition and to explore new fields of thought and action. In medicine, it was perhaps natural that anatomy and physiology, the knowledge of the human body and its workings, should be the first aspects of medical learning to receive attention from those who realized the need for reform.

It is not surprising, therefore, that Andreas Vesalius (1514–64), the young professor of anatomy at the University of Padua, should entitle his magnificent work *De humani corporis fabrica* ("On the Fabric of the Human Body") when he published it in 1543. It was the fruit of his own observations, showing that Galen could no longer be regarded as the final authority from whom none dared to differ; he corrected many of Galen's errors and depicted the body not as dead anatomy but as a living and active study. Some of the great artists, among them Leonardo da Vinci (1452–1519), did not hesitate to dissect the human frame and in doing so made noteworthy discoveries. The good work of Vesalius at Padua was continued by Gabriel Fallopius (1523–62) and later by Hieronymus Fabricius ab Aquapendente (1537–1619), whose work on the valves in the veins, *De venarum ostiolis* (1603), suggested to his pupil William Harvey the idea of the circulation of the blood. It was natural that surgery should profit from the new outlook in anatomy and the time was ripe for the appearance of a great surgical reformer. He was Ambroise Paré (1510–90), surgeon to four kings of France in succession, who well earned for himself the title of "the father of modern surgery." Of course surgery still had a long way to go: pain was unconquered and sepsis was rife. Paré served for 30 years as an army surgeon and, after he retired from the army and settled in Paris, he wrote his fascinating autobiography, giving a clear picture of the life of his times. He describes how he abolished the painful cautery for gunshot wounds and used soothing dressings instead; his favourite expression, "I dressed him; God healed him," is characteristic of this humane and careful surgeon.

**2. Medical Colleges in Britain.**—About this time surgery, which was ahead of medicine in the establishment of controlling bodies, underwent a reorganization in Britain. As early as 1505 a decree or "seal of cause" was granted to the Incorporation of Barber-Surgeons of Edinburgh and confirmed by King James IV of Scotland a year later. In 1540, King Henry VIII of England granted a royal charter to Thomas Vicary, the first master of the Barber-Surgeons company, which became the Company of Surgeons of London in 1745, the Royal College of Surgeons in 1800 and still later the Royal College of Surgeons of England. Thus were founded the bodies that became the Royal Colleges of Surgeons in Scotland and in England. At the end of the century, in 1599, Peter Lowe obtained from King James VI of Scotland a charter for the Faculty (now Royal College) of Physicians and Surgeons of Glasgow to control practice in and around the city. Lowe had the foresight to include all who practised medicine or surgery and thus sought to unite the two aspects of the healing art that had long been separated. Another event of great importance during the 16th century was the foundation of the College of Physicians in London, which received its charter from Henry VIII in

1518 and which had the sole privilege of permitting persons to practise as physicians in London and the surrounding district. The first president was Thomas Linacre (*c.* 1460–1524), the leading Oxford scholar of his day, who was succeeded by John Caius (1510–73), the second founder of the modern Gonville and Caius college, Cambridge, and author of an excellent account of the curious disease called sweating sickness, which ravaged the country in a series of epidemics attended by a high mortality. The Royal College of Physicians of Edinburgh was founded in 1681 and Edinburgh university was the first British university to found (1726) a medical faculty and to provide a complete training in medicine.

**3. Paracelsus.**—No account of Renaissance medicine can afford to omit some mention of that strange man known as Paracelsus (*c.* 1490–1541). Theophrastus Bombastus von Hohenheim, who called himself Phillipus Aureolus Paracelsus, was the son of the country doctor of Einsiedeln, near Zürich. He traveled far and wide in Europe, practising and teaching as he went, but he was ahead of his time and in his eagerness for reform he allowed his intolerance to outweigh his discretion. When he prefaced his lectures at Basel by publicly burning the works of Avicenna and Galen, it is not surprising that the authorities were annoyed and, to this day, Paracelsus is highly regarded by some and as strongly decried by others. He remains a mystic and an enigma. There is no doubt, however, that he simplified prescribing and introduced chemical drugs in place of vegetable remedies.

**4. Fracastoro.**—A contemporary scholar physician of very different mold was Girolamo Fracastoro (1478–1553) of Verona. His account of the disease syphilis was written in verse and entitled *Syphilis sive Morbus Gallicus* (1530; "Syphilis or the Gallic Disease"). Fracastoro called it the French disease but others called it the Neapolitan disease as it was said to have been brought to Naples from America by the sailors of Columbus, and its origin is still questioned. Fracastoro was also interested in epidemic infection, his ideas on which were surprisingly modern, and in 1546 he published his great work *De Contagione*, in which he presumed that the seeds of certain diseases were imperceptible particles carried by air or by contact.

### G. William Harvey and the Experimental Method

The medical progress of the 17th century can now be considered, together with the leading part played by William Harvey (1578–1657), whose classic little book *Exercitatio anatomica de motu cordis et sanguinis in animalibus* ("An Anatomical Experiment Concerning the Movement of the Heart and Blood in Animals"), often called for short *De motu cordis*, was printed at Frankfurt am Main in 1628.

Born at Folkestone, Kent, the eldest of the seven sons of the mayor, Harvey studied at Caius college, Cambridge, and then spent several years at Padua, where he came under the influence of Fabricius. By the time Harvey began to lecture in London, in 1616, he had already reached his conclusion regarding the circulation of the blood, although he waited for 12 years before printing his views. That the book aroused much controversy is not surprising. There were still many who adhered to the ancient teaching of Galen and affirmed that the blood followed an "ebb and flow" movement in the blood vessels. Harvey's work was the result of many careful experiments; few of his critics took the trouble to repeat the experiments but instead simply argued in favour of the older view, in their bookish and scholastic fashion. His second great book, published in 1651 and entitled *Exercitationes de generatione animalium* ("Experiments Concerning Animal Generation"), laid the foundation of modern embryology. Harvey's discovery of the circulation of the blood was a most important landmark of medical progress; the new experimental method by which the results were secured was as noteworthy as the work itself. He drew the truth from experience and not from authority, following the method described by the philosopher Francis Bacon.

There was one gap in Harvey's argument—he was obliged to assume the existence of the capillary vessels that conveyed the blood from the arteries to the veins at the periphery. This link in the chain of evidence was supplied by Marcello Malpighi of Bologna, who, born in 1628, the year of publication of *De motu cordis*, with a primitive microscope saw a network of tiny blood vessels in the lung of a frog. Harvey also failed to show why the blood circulated and, after Robert Boyle (1627–91) had shown that air was essential to animal life, it was Richard Lower (1631–91) who traced the interaction between air and the blood. Eventually the importance of oxygen, which masqueraded for a time as phlogiston (*see* CHEMISTRY: *History of Chemistry: Understanding of Combustion*), was revealed, but it was not until 1775 that Antoine Laurent Lavoisier (1743–94) discovered the nature of oxygen and solved a problem that had puzzled many.

The invention of the compound microscope is usually attributed to a spectacle maker named Zacharias Janssen, in Holland, but its development, like that of the telescope, was the work of the great scientist Galileo (1564–1642), who was the first to lay stress upon the value of measurement in science and in medicine, thus replacing theory and guesswork with accuracy. One of the greatest of the early microscopists was Anton van Leeuwenhoek (1632–1723) of Delft, who devoted his long life to microscopical studies and who was probably the first to see and describe bacteria, reporting his results to the Royal Society of London. In England, Robert Hooke (1635–1703), who was Boyle's assistant and curator to the Royal society, published his classic book *Micrographia* in 1665.

### H. The Futile Search for an Easy System

It was during the 17th century, which produced so many brilliant investigators, that several attempts were made to discover an easy "system" as a clue to the problems of medical practice. A substratum of superstition still remained at this time; *e.g.*, Richard Wiseman, surgeon to Charles II, affirmed his belief in the "royal touch" as a cure for king's evil, or scrofula, while even the learned Sir Thomas Browne stated that witches really existed. There was, however, a general desire to discard the past and to adopt new ideas.

The philosopher Descartes had already regarded the human body as a machine and this view had its repercussions in medical thought. One school adopting this explanation called themselves the iatrophysicists; another school, preferring to view life as a series of chemical processes, were called iatrochemists. Sanctorius (1561–1636) at Padua was an early exponent of the iatrophysical view and he did much pioneer work in what is now called metabolism, being especially concerned with the measurement of what he called "insensible perspiration," described in his book *De statica medicina* (1614). Another Italian who developed the idea still further was Giovanni A. Borelli (1608–79), a professor of mathematics at Pisa university, who busied himself with the mechanics and statics of the body and with the physical laws that govern its movements. The iatrochemical school was founded at Brussels by Jan Baptista van Helmont (1577–1644), although his writings are tinged with the mysticism of the alchemist. A more logical and intelligible view of iatrochemistry was advanced by Franciscus Sylvius (1614–72) at Leiden, while in England a leading exponent of the same school was Thomas Willis (1621–75), who is better known for his description of the brain in his *Cerebri anatome nervorumque descriptio et usus* (1664), illustrated by Sir Christopher Wren.

It soon became apparent that no easy road to medical knowledge was to be found along these channels and that the best method was the age-old "system" of straightforward clinical observation originally initiated by Hippocrates. The need for a return to Hippocratic views was strongly urged by Thomas Sydenham (1624–89), well-named "the English Hippocrates." Sydenham was not a voluminous writer and, indeed, he had little patience with book learning in medicine, but nevertheless he gave excellent descriptions of the phenomena of disease. His greatest service, so much needed at the time, was to divert men's minds from speculation and to lead them back to the bedside, for there only could the art of medicine be studied.

## II. MEDICINE IN THE 18TH CENTURY

**1. Brown and Hahnemann.**—Sydenham's praiseworthy appeal for a return to Hippocratic methods was not accepted by everyone. Even in the 18th century the search for a simple way

of healing the sick continued and in Edinburgh a writer and lecturer named John Brown (1735–88) expounded, at the Royal Medical society (of which he was president twice), his "Brunonian system." In his view, there were only two diseases, sthenic and asthenic, and two treatments, stimulant and sedative. Lively and heated debates took place between Brunonians and the more orthodox Cullenians (followers of William Cullen) and the disturbance spread to Europe. Meantime the unfortunate Brown, at war with all his colleagues, became a victim of his own system and died in debt and poverty, his end hastened by his two chief remedies, opium and alcohol. At the opposite end of the scale, at least in regard to dosage, was Samuel Hahnemann (1755–1843) at Leipzig, the originator of homeopathy. His ideas had a salutary effect upon medical thought at a time when prescriptions were lengthy and doses were large; his system has had many followers.

**2. Medical Teaching in Britain.**—Before the 18th century, there was little organized medical teaching in Britain. Those who wished to become doctors first became apprentices; they could then also attend classes in anatomy, botany and chemistry, the tripod of learning upon which medicine was then founded. Those who could afford it studied and even graduated at one of the European universities, as William Harvey did at Padua in 1602. When the centre of medical learning shifted from Padua to Leiden, many students were attracted thither from abroad. Among them was John Monro, an army surgeon who resolved that his native city of Edinburgh should have a similar medical school. He specially educated his son Alexander (1697–1767) with a view to having him appointed professor of anatomy and the bold plan was most successful. Alexander Monro studied at Leiden under Hermann Boerhaave (1668–1738), the central figure of European medicine and the greatest clinical teacher of his time, and on returning to Edinburgh was appointed professor of anatomy. Monro was followed in the chair by his son Alexander Monro *secundus* (1733–1817) and he, in turn, by the grandson Alexander Monro *tertius* (1773–1859); although in the third generation the high standard was not maintained, the three Alexander Monros taught anatomy in Edinburgh university over a continuous period of 126 years. Robert Sibbald (1641–1722) and Archibald Pitcairne (1652–1713), who had helped to found the Royal College of Physicians of Edinburgh in 1681, were now gone, but medicine was brilliantly taught by Robert Whytt (1714–66), then by the Gregorys, John (1724–73) and James (1753–1821), and still later by William Cullen (1710–90), who, in 1747, founded the faculty of medicine in Glasgow.

**3. Surgery and Obstetrics.**—In the early years of the 18th century the leading surgeons of London were William Cheselden (1688–1752) and Percivall Pott (1714–88), although their work tends to be overshadowed by their more famous pupil, John Hunter (1728–93). John left his home in Lanarkshire in 1748 to assist his elder brother, William (1718–83), who was already well established in London as an obstetrician and anatomist. Although he made no great single discovery, John, by his vast researches in comparative anatomy and physiology, raised surgery to the level of a definite branch of science and was actually the founder of surgical pathology. After his death the museum that he had collected so laboriously eventually became the property of the Royal College of Surgeons, which honours his memory with the Hunterian oration, although the museum was mostly destroyed by German action in World War II. Just as John Hunter raised the status and prestige of surgery, so his contemporary William Smellie (1697–1763) performed a similar service for midwifery. Like the Hunters, Smellie was a Lanarkshire lad who, after practising medicine in the town of Lanark for 16 years, settled in London in 1739 and soon became the leading obstetrician, or man midwife, as specialists of this kind were then called. He placed midwifery on a sound scientific footing, his well-known *Treatise on the Theory and Practice of Midwifery* being published in three volumes in 1752–64.

**4. Pathology.**—In the 18th century, too, the science of modern pathology was created by Giovanni Morgagni (1682–1771) of Padua when, in 1761, he published his great work *De sedibus et causis morborum* ("On the Seats and Causes of Diseases"), a description of the appearances found by post-mortem examination of almost 700 cases, revealing many new facts. Flowing from work begun in the 18th century, René Laënnec (1781–1826), a native of Quimper who became a physician in Paris, invented the stethoscope, or *cylindre*, as it was originally called, and wrote a treatise, *De l'auscultation médiate* (1819), describing many of the curious sounds in the heart and lungs revealed by the stethoscope. Meanwhile a Viennese physician, Leopold Auenbrugger (1722–1809), discovered another method of investigating diseases of the chest, that of percussion. The son of an innkeeper, he is said to have conceived the idea of tapping with the fingers when he recalled he had used this method to gauge the level of the fluid contents of his father's casks.

**5. Public Health.**—Public health and hygiene began to attract attention in the 18th century, although a more lively awakening was later to accompany the Industrial Revolution. Toward the end of his life, Bernardino Ramazzini (1633–1714) wrote the first work on occupational diseases, *De morbis artificum diatriba* (*On the Diseases of Artificers*), a most interesting book of the period. At this time, too, Johann Peter Frank (1745–1821) evolved his scheme of health legislation and attempted to awaken a health consciousness not only in the people but also in their rulers. In his *System einer Vollständigen medicinischen Polizey* (1779), he was one of the first to suggest that the government of a country should be responsible for the health of its inhabitants.

**6. Smallpox and Digitalis.**—One important discovery of the 18th century was vaccination. Smallpox was then very prevalent, disfiguring and often fatal, but inoculation, which had been practised in the east, was brought to England by Lady Mary Montagu, wife of the British ambassador in Turkey in 1717 (*see* VACCINE THERAPY). A mild form of the disease was produced and thus immunity was secured, although not without its dangers. A country practitioner named Edward Jenner (1749–1823), of Berkeley, Gloucestershire, who had been a pupil of John Hunter, observed that those who became infected with cowpox did not become infected with smallpox. He performed the first vaccination on James Phipps and then found, on inoculating him with smallpox eight weeks later, that no disease appeared. That was in 1796 and the advantage of the method became apparent everywhere. William Withering's discovery of the value of foxglove, or digitalis, as a remedy for dropsy and for cardiac disease is another example of the good work of a general practitioner. Withering (1741–99) practised in Shropshire and noted that the country folk often used a decoction of foxglove leaves. After many experiments, he wrote *An Account of the Foxglove* (1785), a classic that has become very rare.

**7. Phrenology and Mesmerism.**—Phrenology and mesmerism are two quasi sciences that first appeared in the 18th century. The first owed its birth to F. J. Gall (1758–1828) and his pupil J. K. Spurzheim (1776–1832) and it became a subject of lively controversy. Mesmerism, another product of Vienna, was sponsored by F. A. Mesmer (1734–1815), who, it must be admitted, did attempt to place treatment by "touching," or the use of "animal magnetism," upon a scientific basis. There were others, however, who used the method simply as charlatans. This was easy in the 18th century, when quacks flourished as never before or since, for it was not until 1858 that medical registration in Britain was required by act of parliament.

**8. Scurvy and Military Hospitals.**—No account of 18th century medicine would be complete without a passing reference to two important advances affecting the health of the navy and of the army. James Lind (1716–94) was an Edinburgh graduate who entered the navy. At that time scurvy was very prevalent: G. Anson lost three-fourths of his ship's company during his voyage round the world in 1740–44 and Lind often had 300–400 cases in his wards at Haslar. He recommended the use of lemon juice, as a result of which scurvy disappeared as if by magic, but nevertheless several years passed before his advice was officially accepted. Lind's account of his researches, *A Treatise on the Scurvy*, is dated 1753.

In 1752 there had been published another medical classic entitled *Observations on the Diseases of the Army*. The author was Sir John Pringle (1707–82), who had been professor of moral phi-

losophy at Edinburgh before embarking upon his military career and who rendered valuable service by his recommendations for the health and comfort of the troops. He had suggested, at the battle of Dettingen in 1743, that military hospitals on both sides should be regarded as sanctuaries, and this plan eventually led to the establishment of the Red Cross organization, although the first Geneva convention was not assembled until 1863, at the instigation of the Swiss banker Jean Henri Dunant.

### III. THE RISE OF SCIENTIFIC MEDICINE IN THE 19TH CENTURY

The portrayal of medical history becomes more difficult as modern times are approached. Discoveries seem to multiply and the number of eminent doctors is so great that the story is apt to become a mere string of biographies. This synopsis selects some of the leading trends in medical thought in order to provide a scaffolding upon which the reader may build more detailed knowledge by wider investigation on his own.

By the beginning of the 19th century, the structure of the human body was almost fully known, thanks to new methods of microscopy and of injections. Even the minute structure of the body was understood. Much more important than anatomical knowledge was the knowledge of physiological processes that was becoming rapidly elucidated, especially in Germany. There, physiology became established as a distinct science under the guidance of Johannes Müller (1801–58), who was professor at Bonn and then Berlin universities. An energetic worker and an inspiring teacher, he described his discoveries in a famous textbook, *Handbuch der Physiologie des Menschen* (1833–40). Among his pupils were Hermann von Helmholtz (1821–94), who made great discoveries relating to sight and hearing and who invented the ophthalmoscope, and Rudolf Virchow (1821–1902), also of Berlin, whose greatest achievement was his conception of the cell as the centre of all pathological changes. Virchow's work on *Cellular-pathologie* (1858) gave the final deathblow to the outmoded "humoral" pathology. In France, the leading physiologist of the time was Claude Bernard (1813–78). All his work was the outcome of carefully planned experiments. His first researches were directed to digestion. Next, he explained the presence of glycogen in the liver, while his third discovery was that of the vasomotor mechanism. Toward the end of his life he expounded his methods and principles in his *Introduction à la médecine expérimentale* (1865), a classic still worthy of study by all who undertake research. Meantime, physiology had made progress in Britain under the leadership of Marshall Hall (1790–1857), whose greatest discovery was that of reflex action; William Sharpey (1802–80), the first in Great Britain to devote his exclusive attention to physiology, separating it from anatomy and physics and placing it among the sciences; and, the greatest of all, Sir Charles Bell (1774–1842), whose researches on the nervous system yielded notable advances in that field. His *New Idea of the Anatomy of the Brain*, first expounded in 1811, has been called the magna carta of neurology, although it is true that François Magendie (1783–1855) gave a more complete demonstration of the functions of motor and sensory nerves.

**1. Verification of the Germ Theory.**—Perhaps the greatest medical advance of the 19th century, certainly the most spectacular, was the conclusive demonstration that certain diseases, as well as the infection of surgical wounds, were directly caused by minute living organisms. This discovery changed the whole face of pathology and effected a complete revolution in the practice of surgery.

The idea that disease was caused by the entry into the body of tiny imperceptible particles was of ancient date. It had been expressed by Varro as early as 100 B.C., by Fracastoro in A.D. 1546, by Athanasius Kircher and Pierre Borel about a century later and by Francesco Redi (*c.* 1626–97), who in 1684 wrote his *Osservazioni intorno agli animali viventi*, in which he sought to disprove the idea of "spontaneous generation." Everything must have a parent, he wrote; only life produces life. Another worker in this field, regarded by some as founder of the parasitic theory of infection, was Agostino Bassi (1773–1856), who showed that a disease of silkworms was caused by a fungus that could be destroyed by chemical agents.

Nevertheless the main credit for the establishment of the science of bacteriology must be accorded to Louis Pasteur (1822–95). It was Pasteur who, by a brilliant series of experiments, proved that fermentation, or putrefaction, was not a chemical process but was caused by the living organisms known as bacteria. He solved one problem after another during his strenuous life, problems concerning the fermentation of wine and the prevention of anthrax in sheep and cattle, of chicken cholera and, finally, of rabies in man and dogs, a bold experiment that resulted in the widespread founding of Pasteur institutes.

From Pasteur, Joseph Lister (1827–1912) borrowed, with full acknowledgment, the idea that led to his introduction of the antiseptic system in surgery. Lister, who was born close to London, at Upton, Essex, made known in 1865, while professor of surgery at Glasgow university, his great discovery, the placing of an "antiseptic" barrier between the wound and the germ-containing atmosphere. Though Lister did not at first realize that infection was not only air-borne but also could be carried by the hands, skin, instruments, etc., he left a noble example and a priceless heritage. Besides creating a complete revolution in the surgical outlook, he is to be remembered as one of the founders of bacteriology.

Obstetrics had already been robbed of some of its terrors by Alexander Gordon at Aberdeen, Oliver Wendell Holmes (1809–94) at Boston, Mass., and Ignaz Semmelweiss (1818–65) at Vienna and Pest (mod. Budapest), who, not knowing exactly why, advised disinfection of the hands and clothing of midwives and students who attended confinements.

Another pioneer of bacteriology was Robert Koch (1843–1910), who showed how bacteria could be cultivated and stained and how their specificity could be proved. Koch discovered the tubercle bacillus in 1882 and the vibrio of cholera in 1883, and before the turn of the century many other disease-producing organisms had been identified.

**2. Medicine and Anesthesia.**—There was a danger at this time that in the feverish search for bacteria other causes of disease would escape detection. Physicians of slightly earlier date, who worked along other lines, deserve to be remembered. Among them were the physicians to Guy's hospital, London: Richard Bright (1789–1858), Thomas Addison (1793–1860) and William Gull. Bright made important advances in the knowledge of diseases of the kidneys, including so-called Bright's disease, while Addison also gave his name to a disease. Gull (1816–90), a great clinical teacher, left a legacy of pithy and helpful aphorisms that might well rank alongside those of Hippocrates.

In Dublin, two eminent physicians were Robert Graves (1796–1853) and William Stokes (1804–78), while in Paris, Pierre C. A. Louis (1787–1872) was attracting many students from the United States by the excellence of his teaching. By this time the U.S., having drawn from Leiden, Edinburgh and London the learning that went to found in the 18th century the first medical schools at Philadelphia and elsewhere, under the guidance of such pioneers as John Morgan (1735–89), William Shippen and Benjamin Rush (1745–1813), was now ready to send back the results of its own researches. Daniel Drake (1785–1852) founded medical schools at Cincinnati and described the diseases of the Ohio valley (1850–54), Ephraim McDowell (1771–1830) performed a bold ovariotomy in a small Kentucky village (1809) and William Beaumont (1785–1853), in treating a gunshot wound of the stomach, was led to make many original observations, published in 1833 as *Experiments and Observations on the Gastric Juice and the Physiology of Digestion.*

The most famous contribution by the U.S. to medical progress at this period was undoubtedly the introduction of general anesthesia, a discovery that was marred by controversy. Crawford Long (1815–78), Gardner Colton (1814–98), Horace Wells (1815–48) and Charles Jackson (1805–80) are all claimants for priority; some used nitrous oxide gas, others employed ether, which was less capricious. There is little doubt, however, that it was William Thomas Morton (1819–68) who, on Oct. 16, 1846, at Massachusetts General hospital, first demonstrated before a gathering of

medical men the use of ether as a general anesthetic. News of the discovery soon reached Europe. In Edinburgh, the professor of midwifery, James Young Simpson (1811–70), had been experimenting upon himself and his assistants, inhaling various vapours with the object of discovering a general anesthetic. In Nov. 1847 chloroform was tried with complete success. Within a few days it was tested in an operation and soon it was preferred to ether and became the anesthetic of choice. Although Simpson is remembered mainly as the discoverer of chloroform, he did a great deal more to enhance the reputation of Edinburgh and was created a baronet in 1866.

**3. Later Advances.**—While antisepsis and anesthesia placed surgery on an entirely new footing, similarly important work was carried out in other branches of medicine. Sir Patrick Manson (1844–1922) showed in Amoy, China, in 1877 how insects may carry disease and how the embryos of the little worm *Filaria*, causing elephantiasis, were transmitted by the mosquito. Manson explained his views to the young doctor who became Sir Ronald Ross (1857–1932), then working on the problem of malaria, and Ross discovered the malarial parasite in the stomach of the *Anopheles* mosquito in 1897. Carlos Finlay (1833–1915) in Cuba expressed the view, in 1881, that yellow fever was carried by the *Stegomyia* mosquito and, following him, Walter Reed (1851–1902), William Gorgas (1854–1920) and others conquered the scourge of yellow fever and made possible the completion of the Panama canal by reducing the death rate there from 176 per 1,000 to 6 per 1,000. An event of equally startling significance was the control of typhoid fever by the method of inoculation devised by Almroth Wright (1861–1947). There were other victories in preventive medicine because the maintenance of health had now become as important a duty as the cure of disease; and the 20th century was to witness the evolution and progress of national health services in a number of countries. In addition, spectacular advances in diagnosis and treatment followed the discovery of X-rays by Wilhelm Conrad Röntgen (1845–1923) in 1895 and of radium by Pierre (1859–1906) and Marie (1867–1934) Curie in 1898; and the new field of psychiatry was opened up by Sigmund Freud (1856–1939). The development of chemotherapy, immunology, endocrinology and the science of nutrition, which were later advances, are described below. (D. Gv.)

## IV. MEDICINE IN THE 20TH CENTURY

The first six decades of the 20th century witnessed such a plethora of discoveries and advances that in some ways the face of medicine was changed out of all recognition. In 1901, for instance, the standardized mortality ratio (S.M.R.; *i.e.*, the ratio of observed deaths to expected deaths for the whole population, expressed as a percentage) in England and Wales was 266; in 1962 it was 92. For tuberculosis the S.M.R. in the decade 1901–10 was 649; in 1962 it was 22. Even more striking was the position with regard to diphtheria in children. In the decade 1901–10 the death rate per 1,000,000 population at ages under 15 years was 571; in 1961 it was 1. Indeed, the outlook was so altered that, with the notable exception of cancer, attention became focused on morbidity rather than mortality and the emphasis changed from keeping people alive to keeping them fit.

In the medical kaleidoscope of this era four main trends may be distinguished: the first, and most important, was the development of chemotherapy; the second, and closely associated, was the development of immunology; the third was the progress in endocrinology; and the fourth was the progress in nutrition.

**1. Chemotherapy.**—At the turn of the century Germany was well to the forefront in medical progress. The scientific approach to medicine had been developed there long before it spread to other countries and postgraduates flocked to German medical schools from all over the world. The opening decade of the 20th century has been well described as the "golden age of German medicine" and outstanding among its leaders was Paul Ehrlich (1854–1915). While still a student at Strasbourg he carried out some work on lead poisoning from which he evolved the theory that was to guide all his subsequent work—that certain tissues had a selective affinity for certain chemicals. A quarter of a century was to pass before success crowned his efforts. By his discovery of arsphenamine, once sold under the commercial names of Salvarsan and 606, he inaugurated the chemotherapeutic era, which revolutionized the treatment and control of infectious diseases. Salvarsan is a synthetic arsenical preparation that is lethal to the microorganism responsible for syphilis. Until the introduction of penicillin it, or one of its modifications, remained the standard treatment of syphilis and went far toward bringing this social and medical scourge under control.

Another quarter of a century was to pass before the next great step forward was taken in chemotherapy. Again it came from Germany when, in 1932, Gerhard Domagk (1895–1964) announced that the dye Prontosil red was active against streptococcal infections in mice and in man. Soon afterward French workers showed that the colourless moiety of Prontosil—sulfanilamide—was the active antibacterial agent. In 1936, Leonard Colebrook (1883– ) and his colleagues provided overwhelming evidence of the efficacy of both Prontosil and sulfanilamide in streptococcal septicemia thereby ushering in the sulfonamide era. New sulfonamides appeared with almost embarrassing rapidity—with either greater potency, a wider antibacterial spectrum or lower toxicity. Some stood the test of time; others, like the original sulfanilamide and its immediate successor, sulfapyridine, were replaced by safer and more potent successors.

Finally came the era of the antibiotics—in some ways the most dramatic episode in modern medicine. It was in 1928 that Alexander Fleming (1881–1955) noticed the inhibitory action of a stray mold on a plate culture of staphylococci in his laboratory at St. Mary's hospital, Paddington, London. Many another bacteriologist must have made the same observation but none had had the shrewdness to realize the possible implications. The mold was a strain of *Penicillium—Penicillium notatum*—and so was born the term penicillin which became known throughout the whole world. In spite of his conviction that penicillin was a potent antibacterial agent, Fleming was unable to carry his work to fruition, mainly because biochemists at the time were unable to isolate it in sufficient quantities or in a sufficiently pure form to allow its use on patients. Ten years were to pass before Howard Florey (1898– ), Ernst Chain (1906– ) and their colleagues at Oxford were to take up the problem again and solve it. By the time Florey and his team had isolated penicillin in a form that was relatively pure by standards then current, though hopelessly crude by modern ones, and demonstrated its potency and relative lack of toxicity, World War II had begun. In some ways this was an advantage because if it had not been for the top priority given to commercial production, penicillin would never have become available in adequate amounts in such an amazingly short time.

While penicillin is the most useful and the safest antibiotic, it suffers from certain disadvantages. The most important of these is that it is not active against *Mycobacterium tuberculosis*, the bacillus of tuberculosis. In view of the importance of tuberculosis as a public health hazard, this is a serious defect, but the position was rapidly rectified when, in 1944, Selman A. Waksman (1888– ) and his colleagues announced the discovery of streptomycin from cultures of a soil organism, *Streptomyces griseus*, and stated that it was active against *Mycobacterium tuberculosis*. Subsequent clinical trials amply confirmed this claim. Unfortunately, the one great disadvantage of streptomycin was that the *Mycobacterium tuberculosis* tended to become resistant to it. Fortunately, other drugs became available that compensated for this, the two most important being para-aminosalicylic acid (or PAS, as it is usually referred to) and isoniazid. With a combination of two or more of these preparations, the outlook in tuberculosis was revolutionized. Tuberculosis was not conquered but—provided reasonable precautions were taken—it was well under control.

Apart from its inadequacy as an antituberculosis drug, the other main disadvantage of penicillin was that its antibacterial spectrum did not cover the entire field of microorganisms pathogenic to man. In an attempt to rectify this position the pharmaceutical companies of the world—and particularly those of the United States—devoted a large part of their energies during the 1950s to a search for antibiotics to fill this gap. On the whole the search

was successful, but only one discovery need be specifically mentioned here; *i.e.*, chloramphenicol which, like streptomycin, was isolated from a streptomyces—*Streptomyces venezuelae*. Chloramphenicol has two claims to special mention. It was the first antibiotic discovered (1947) that was active against rickettsiae, the group of microorganisms intermediate between bacteria and the viruses. The most notorious disease caused by the rickettsiae is epidemic typhus fever, one of the great killing diseases of the past. Chloramphenicol's second useful attribute is that it is active against *Salmonella typhosa*, the causative organism of typhoid fever.

**2. Immunology.**—Dramatic though they undoubtedly were, the advances in chemotherapy still left one point vulnerable, that of the viruses, and it was in bringing them under control that advances in immunology, *i.e.*, the study of immunity, played such a striking part. It is one of the paradoxes of medicine that the first large-scale immunization against a virus disease was instituted and established long before viruses were discovered. When Edward Jenner introduced smallpox vaccination as it is now known, the identification of viruses was still 100 years ahead and almost another half century had to pass before an effective method was discovered of producing antiviral vaccines that were both safe and effective. In the meantime immunization against bacterial diseases made rapid progress.

It was in 1897 that Almroth Wright (1861–1947) introduced a vaccine prepared from killed typhoid bacilli as a preventive of typhoid fever. Preliminary trials in the Indian army produced excellent results and it was adopted for the use of the troops serving in the South African War but, unfortunately, its method of administration was inadequately controlled and all the war office would sanction was that only such men would be inoculated as "voluntarily presented themselves for this purpose prior to their embarkation for the seat of war." The result was that, according to the official records, only 14,626 men volunteered out of a total strength of 328,244 who served during the three years of war. Although later analysis showed that inoculation had had a beneficial effect, there were 57,684 cases of typhoid fever—approximately one in six of the British troops engaged—with 9,022 deaths. In the subsequent embittered discussions Karl Pearson, a statistician, challenged the validity of the claims put forward by Wright. To settle the matter an antityphoid commission was set up. Its report was published in 1913 and on the strength of this the British army officially adopted immunization against typhoid, Lord Kitchener decreeing that no man would be sent abroad who had not been inoculated. The result was that almost 100% of the British Expeditionary force was immunized by the end of 1915. If figures mean anything, those for the South African War and World War I provide striking confirmation of the value of antityphoid (T.A.B.) inoculation, even when all due allowance is made for better sanitary arrangements in World War I. In the South African War the annual incidence of enteric infections (typhoid and paratyphoid fever) was 105 per 1,000 strength and the annual death rate was 14.6 per 1,000 strength. The comparable figures for World War I were 2.35 and 0.139 respectively.

The other great hazard of war that was brought under control in World War I was tetanus. This was achieved by the prophylactic injection of tetanus antitoxin into all wounded men. The World War I use of this serum, which was originally prepared by Emil von Behring (1854–1917) and Shibasaburo Kitasato (1853–1931) in 1890–92, was the first large-scale trial of tetanus antitoxin and the results amply confirmed its efficacy. It was not until the 1930s that an efficient vaccine, or toxoid, as it is known in the cases of tetanus and diphtheria, was produced against tetanus. Again, a war was to provide the opportunity for testing its efficacy on a large scale and experience with it in World War II indicated that it gave a high degree of protection.

The story of diphtheria is comparable to that of tetanus, though even more dramatic. First came the preparation of diphtheria antitoxin, as in the case of tetanus antitoxin, by Behring and Kitasato in 1892. As diphtheria antitoxin came into general use for the treatment of cases, the death rate began to decline. There was no significant fall in the number of cases, however, until a toxin-antitoxin mixture introduced by Behring in 1913 was used to immunize children. A more effective toxoid was introduced by G. Ramon in 1923 and with subsequent improvements this became one of the most effective vaccines available in medicine. Where mass immunization of children with the toxoid has been practised, as in the U.S. and Canada beginning in the late 1930s and in England and Wales in the early 1940s, diphtheria cases and deaths from the disease became almost nonexistent. In England and Wales, for instance, the number of deaths fell from an annual average of 1,830 in 1940–44 to 2 in 1962.

If, as is universally accepted, prevention is better than cure, immunization is the ideal way of dealing with diseases due to microorganisms. An effective, safe vaccine protects the individual from disease, whereas chemotherapy merely copes with the infection once the individual has been affected. In spite of its undoubted value, however, immunization was a recurring cause of controversy. Reference has already been made to the controversy surrounding the introduction of typhoid immunization and the later controversy over poliomyelitis immunization was another example. Yet another form of immunization, or vaccination, that evoked widespread controversy was that for tuberculosis. It was in 1908 that Albert Calmette (1863–1933), a pupil of Pasteur, and Camille Guérin (1872–1961) produced an avirulent strain of the bovine *Mycobacterium tuberculosis*. About 15 years later vaccination of children against tuberculosis was introduced, using a vaccine made from this avirulent strain and known as BCG (Bacillus Calmette-Guérin) vaccine. Although widely adopted in France, Scandinavia and elsewhere, British and U.S. authorities frowned upon its use on the grounds that it was not safe and that the statistical evidence in its favour was not convincing. One of the stumbling blocks in its widespread adoption was what came to be known as the Lübeck disaster. In the spring of 1930, 249 infants were vaccinated with BCG vaccine; by autumn 73 of the 249 were dead. Criminal proceedings were instituted against those responsible for giving the vaccine; the final verdict was that contamination of the vaccine had occurred and BCG vaccine was exonerated from any responsibility for the deaths. A bitter controversy followed, but in the end the protagonists of the vaccine won when a trial sponsored by the Medical Research council showed that the vaccine was safe and that it protected four out of five of those vaccinated.

As far as viruses were concerned, with the exception of smallpox, it was not until well into the century that efficient vaccines became available. This is scarcely surprising when it is realized that it was not until the 1930s that much began to be known about viruses. The two advances that contributed most to the rapid advance in knowledge since then were the introduction of tissue culture as a means of growing viruses in the laboratory and of the electron microscope. Once the virus could be cultivated with comparative ease in the laboratory, the research worker could study it with care and evolve methods for producing one of the two desiderata for a safe and effective vaccine: either a virus that was so attenuated that it could not produce the disease for which it was responsible in its normally virulent form, or a dead virus that retained the faculty of inducing a protective antibody response in the vaccinated individual.

The first of the viral vaccines to result from these advances was for yellow fever, developed by Max Theiler (1899– ) in the late 1930s. About 1945 the first relatively effective vaccine was produced for influenza; in 1954 Jonas E. Salk (1914– ) introduced his vaccine for poliomyelitis; and in 1960 an oral poliomyelitis vaccine developed by Albert B. Sabin (1906– ) came into wide use. These vaccines went far toward bringing under control three of the major diseases of the time, although in the case of influenza a major complication was the disturbing proclivity of the virus to change its character from one epidemic to another. Even so, sufficient progress was made to ensure that a pandemic of the order of the one that swept the world in 1918–19, killing more than 15,000,000 people, is unlikely to occur again. In guarding against such a tragic eventuality, one of the most potent safeguards was the World Influenza centre, which was established in London by the World Health organization. Thither

information about outbreaks of influenza anywhere in the world was immediately sent, together with samples of the causative virus. This meant that the identity of the virus could quickly be established and, if necessary, steps taken to produce an effective vaccine. If the virus was a new one, a vaccine would not be ready for the early stages of the epidemic, should one occur, but it would be available for the later stages.

In 1963 two vaccines for measles were licensed for use in the U.S. Work was progressing in the early 1960s on a vaccine for German measles. Of great importance was the isolation of the virus of trachoma by Chinese and British workers. The significance of this discovery was that it raised high hopes for the possibility of evolving a vaccine that would be effective in curbing the ravages of the greatest blinding disease in the world.

**3. Endocrinology.**—At the beginning of the 20th century endocrinology was in its infancy. Indeed, it was not until 1905 that Ernest H. Starling (1866–1927), one of the many brilliant pupils of Sir Edward Sharpey-Schäfer (1850–1935), the *doyen* of British physiology during the early decades of the century, introduced the term "hormone" for the internal secretions of the endocrine glands. In 1891, G. R. Murray (1865–1939) was the first to treat myxedema (the common form of hypothyroidism) successfully with an extract of the thyroid gland. Three years later Sharpey-Schäfer and George Oliver demonstrated in extracts of the adrenal (suprarenal) glands a substance that raised the blood pressure and in 1901 Jokichi Takamine (1854–1922), a Japanese chemist working in the U.S., isolated this active principle: epinephrine (as it is known in the *United States Pharmacopeia*) or adrenaline (as it is known in the *British Pharmacopœia*).

During the first two decades of the century steady progress was made in the isolation, identification and study of the active principles of the various endocrine glands, but the outstanding event was the discovery of insulin by Sir Frederick Banting (1891–1941), Charles H. Best (1899– ) and J. J. R. Macleod (1876–1935) in 1921. Almost overnight the lot of the diabetic patient was changed from a sentence of almost certain death to a prospect not only of survival but of being able to lead a long and healthy life. As so often happens with the great discoveries in medicine, this one came from a most unexpected source. For more than 30 years some of the greatest minds in physiology had been seeking the cause of diabetes mellitus. In 1889, J. von Mering (1849–1908) and Oskar Minkowski (1858–1931) had shown that removal of the pancreas in dogs produced diabetes. In 1901, Eugene L. Opie (1873– ) described degenerative changes in the clumps of cells in the pancreas known as the islets of Langerhans, thus confirming the association between failure in the function of these cells and diabetes. Sharpey-Schäfer concluded that the islets of Langerhans secreted a substance that controlled the metabolism of carbohydrate and in 1916 he gave this then-undiscovered hormone the name of insuline. Five years were to pass before Banting, then a young Canadian orthopedic surgeon interested in physiology, working with Best, a medical student, in the laboratory of Macleod at the University of Toronto, succeeded in isolating the elusive hormone and gave it the name of insulin. Insulin was available in a variety of forms, but synthesis on a commercial scale was not achieved and the only source of the hormone was the pancreas of animals. One of its practical disadvantages was that it had to be given by injection and during the subsequent years an intense search was conducted for some alternative preparation that would be active when taken by mouth. Various preparations—oral hypoglycemic agents, as they are known—appeared that were effective to a certain extent in controlling diabetes, but all the available evidence indicated that these were only of value in relatively mild cases of diabetes. For the well-established diabetic patient, a normal healthy life remained dependent upon the continuing use of insulin injections.

The other major advance in endocrinology came with the announcement from the Mayo clinic, Rochester, Minn., in 1949 by Philip S. Hench (1896– ) and his colleagues that a substance isolated from the cortex of the adrenal gland had a dramatic effect upon rheumatoid arthritis. This was compound E, or cortisone as it came to be known, which had been isolated by E. C. Kendall (1886– ) and his colleagues at the Mayo clinic in 1935. The subsequent course of events showed that cortisone was not the answer to the problem of rheumatoid arthritis, but ample evidence was forthcoming to show the potent influence of cortisone and its many derivatives as anti-inflammatory agents. It was not a cure for rheumatoid arthritis but as a temporary measure it could often control the acute exacerbation of the disease, just as it could in such other diseases as acute rheumatic fever, certain kidney diseases, certain serious diseases of the skin and certain allergic diseases, including acute exacerbations of asthma. Of even more importance from the long-term point of view was the valuable role it served as a research tool.

**4. Nutrition.**—In the field of nutrition the outstanding advance of the 20th century was the discovery, and the appreciation of the importance, of the "accessory food factors," or vitamins. Although various workers had shown that animals did not thrive on a synthetic diet containing all the correct amounts of protein, fat and carbohydrate, and even suggested that there must be some then-unknown ingredients in natural food that were essential for growth and the maintenance of health, little progress was made in this field until the classical experiments of F. Gowland Hopkins (1861–1947) were published in 1912. So conclusive were these that there could be no doubt that what he termed "accessory substances" were essential for health and growth. The name "vitamine" was suggested for these substances by Casimir Funk (1884– ) in the belief that they were amines. In due course, when it was realized that they were not amines, the term was altered to vitamin—largely on the suggestion of Jack Drummond (1891–1952).

Once this concept of vitamins was established on a firm scientific basis it was not long before their identity began to be revealed; soon there was a long series of them, each best known by the letter of the alphabet after which they were originally named when their chemical identity was still unknown. Deficiency diseases such as rickets (due to deficiency of vitamin D) and scurvy (due to lack of vitamin C, or ascorbic acid) practically disappeared from civilized communities, while deficiency diseases such as beriberi (due to lack of vitamin $B_1$, also called thiamine or aneurine), which were endemic in eastern countries, either disappeared or could be remedied with the greatest of ease.

The last of this group of essential factors to be isolated—vitamin $B_{12}$, or cyanocobalamin—was of particular interest as it rounded off—or almost rounded off—the fascinating story of how pernicious anemia was brought under control. Throughout the first two decades of the century the diagnosis of pernicious anemia, like that of diabetes mellitus, was almost equivalent to a death sentence. Unlike the more common form of so-called secondary anemia, it did not respond to the administration of suitable iron salts and no other form of treatment touched it. Hence the grimly appropriate title of pernicious anemia. In the early 1920s George R. Minot (1885–1950), one of the many brilliant investigators whom Harvard university contributed to medical research, became interested in work being carried out by George H. Whipple (1878– ) into the beneficial effects of raw beef liver in severe experimental anemia. With William P. Murphy (1892– ) he decided to investigate the effect of raw liver in patients with pernicious anemia and in 1926 they were able to announce that this form of therapy was successful. The validity of their findings was amply confirmed and all fears of pernicious anemia were ended. As so often happens in medicine, many years were to pass before the rationale of liver therapy in pernicious anemia was fully understood. In 1948, however, almost simultaneously in the U.S. and in Britain, the active principle was isolated from liver. It was originally known as vitamin $B_{12}$ but came to be known as cyanocobalamin and became the standard treatment for pernicious anemia.

**5. Malignant Disease.**—While progress was the hallmark of medicine after the beginning of the 20th century, there was one field in which a gloomier picture must be painted, that of malignant disease, or cancer. It was the second most common cause of death in most western countries early in the second half of the 20th century, being exceeded only by deaths from heart disease.

However, some progress was achieved. The cause of cancer was not known but many more methods were available for attacking the problem; surgery remained the great therapeutic standby, but radiotherapy and chemotherapy played increasingly important parts.

Soon after the Curies announced the discovery of radium in 1898 its potentialities in treating cancer were realized and in due course it assumed an important role in therapy. Simultaneously, deep X-ray therapy was developed and, finally, with the atomic age came the use of radioactive isotopes. High-voltage X-ray therapy and radioisotopes largely replaced radium. Whereas irradiation had long depended upon X-rays generated at 250 kv., machines that were capable of producing X-rays generated at 8,000 kv. and betatrons of up to 22 Mev were in clinical use. In the application of radioactive isotopes to the treatment of malignant disease the most important development was the use of radioactive cobalt ($Co^{60}$). Telecobalt machines (*i.e.*, those that hold the cobalt at a distance from the body) were available containing 2,000 curies or more of the isotope, an amount equivalent to 3,000 g. of radium (an unheard-of amount), and giving a beam equivalent to that from a 3,000-kv. X-ray machine.

Of even more significance were the developments in the chemotherapy of malignant disease. Nothing remotely resembling a chemotherapeutic cure for malignant disease was achieved but in certain forms of malignant disease, such as leukemia, which cannot be treated by surgery, palliative effects were achieved that not only prolonged life but also allowed the patient in many instances to lead a comparatively normal existence. (*See* also CANCER RESEARCH.)

**6. Tropical Medicine.**—In the field of tropical medicine, the first six decades of the 20th century witnessed the virtual conquest of three of the major diseases of the tropics: malaria, yellow fever and leprosy. At the turn of the century, as for the preceding two centuries, quinine was the only known drug to have any appreciable effect on malaria. With the increasing development of tropical countries and rising standards of public health, it became obvious that quinine was not completely satisfactory. Intensive research between World Wars I and II indicated that several synthetic derivatives in the acridine and quinoline groups of organic compounds, as well as other synthetic aromatic compounds, were more effective than quinine. The first of these to become available, in 1934, was quinacrine (Mepacrine, Atabrine or Atebrin), an acridine derivative. In World War II it amply fulfilled the highest expectations, and helped the Allied troops achieve victory in Africa, southeast Asia and the far east. Other effective antimalarial drugs that subsequently became available included chloroquine (Aralen), a 4-aminoquinoline, 1939; chloroguanide (Paludrine, or Proguanil), 1946; primaquine, an 8-aminoquinoline, 1946; amodiaquin (Camoquin), 1948; hydroxychloroquine (Plaquenil), 1950; and pyrimethamine (Daraprim), 1951.

An even brighter prospect—the virtual eradication of malaria—was opened up by the introduction, during World War II, of DDT (chlorophenothane in the *U.S. Pharmacopeia*, dicophane in the *British Pharmacopœia*). It had long been realized that the only effective way of controlling malaria was to eradicate the anopheline mosquitoes, which transmit the disease. The older methods of mosquito control, however, were cumbersome and expensive. The lethal effect of DDT on the mosquito, its relative cheapness and its ease of use on a widespread scale provided the answer. An intensive world-wide campaign, sponsored by the World Health organization, was planned and went far toward bringing malaria under control. The major problem encountered was that of the developing resistance of the mosquito to DDT, but the introduction of other insecticides, such as dieldrin and lindane (BHC), helped to overcome this difficulty.

Reference has already been made to the important part that the introduction of an effective vaccine played in bringing yellow fever under control. As this is another mosquito-transmitted disease, the prophylactic value of the introduction of modern insecticides was almost as great as in the case of malaria. The forest reservoirs of the virus present a more difficult problem than in the case of malaria, but the combined use of immunization and insecticides did much to bring this disease under control.

Until the 1940s, the only drugs available for treating leprosy were the chaulmoogra oils and their derivatives. These, though helpful, were far from satisfactory. In the 1940s the group of drugs known as the sulfones appeared and it soon became apparent that they were infinitely better than any other group of drugs in the treatment of leprosy. Several other drugs that later became available proved of promise. Although it was clear that there was as yet no known cure—in the strict sense of the term—for leprosy, the outlook so changed that there were good grounds for believing that this age-old scourge could be brought under control and the victims of the disease saved from those dread mutilations that gave the disease such a fearsome reputation. (W. A. R. TH.)

## V. SURGERY IN THE 20TH CENTURY

**1. From 1900 to 1914.**—The transition of surgery from a humble craft, despised alike by priests and learned doctors, to one of the most esteemed branches of the healing art was a dramatic one. The discoveries of anesthesia and of antisepsis paved the way for the new era, but it did not come suddenly: the year 1900 can only be an arbitrary date as marking the change from the old methods of the 19th century to the birth of modern surgery in the 20th century. At that time the leading surgeons were men who had known "hospital gangrene" and who had accepted the antiseptic methods of Lister with the belief of converts rather than as self-evident truths.

Hospitals in 1900 were large buildings in the chief cities, supported by charity in the United States and Great Britain, by the state in continental Europe. Surgeons were bluff, hearty, forceful men with the courage and the skill that alone could succeed at that time. Having seen their art transformed by the miracle of antisepsis, having tied every artery, having opened every cavity of the body, they were pleased with the progress that had been made.

Antisepsis had been accepted as the complete and ultimate answer to wound infection. Putrefaction—to use the term current at the time—was due to the entry of germs and could be prevented by using antiseptic solutions before and during the operation and by covering the wound afterward with a dressing impregnated with antiseptic. Carbolic acid (phenol) was still the most frequently used antiseptic but salicylic acid, mercury salts, iodoform and boric acid were also used.

Operations were performed in the "theatre," a place designed to favour the spectators rather than the surgeon or the patient. In a high room lit by a skylight, tiers of benches surrounded a small floor space on which stood a narrow wooden operating table, a stool for the anesthetist and glass cupboards for the instruments. The instruments were of forged steel, unplated, many of them with handles of wood or ivory. Instruments and dressings were sterilized by soaking them in dilute carbolic acid or similar antiseptics though heat sterilization was being introduced in a few centres. The anesthetic, usually ether or chloroform in the U.S. and a mixture in England, was given by a junior, often a student, and in Europe sometimes by a porter. The surgeon did not change into operating clothes but worked in his shirtsleeves, over which he wore a mackintosh which eventually became caked with the blood from successive operations. Although he believed in avoiding germs, he had not developed an instinctive routine and was quite capable of adjusting his spectacles or picking an instrument off the floor and then continuing the operation. At the turn of the century most surgeons worked bareheaded and with bare hands, but improvements were imminent: the wearing of rubber gloves by all members of the surgical team, introduced by W. S. Halsted (1852–1922) in 1890, came into wide use in the first decade of the 20th century; the wearing of surgical caps and masks, introduced by William Hunter (1861–1937) in 1900, also was adopted widely. These pioneers of modern surgery were ready to tackle anything, the bigger and more spectacular the better. Sustained by a feeling of omniscience as the heralds of a new age, they were prepared to accept any failure as an "act of God," or as being caused by the constitution of the patient or the atmosphere of the hospital. They therefore preferred to do private operations in the patient's home, where the atmosphere could be controlled.

The surgery of 1900 was influenced to some extent by the prevalence of two diseases, tuberculosis and syphilis. Amputation to correct some conditions brought on by these two diseases was one of the most commonly performed operations, closely followed by more conservative operations on tuberculous joints, such as drainage and excision. The treatment of aneurysms loomed large in surgical teaching but cancer, apart from that of the tongue and the breast, was rarely operated upon. Fractures were treated by traditional splints; and union, rather than restored function, was the criterion of success. Abdominal surgery was largely limited to the repair of hernias, the removal of large ovarian or uterine swellings and the relief of intestinal obstruction due to strangulation or to cancer. Stones in the kidney were seldom treated surgically, except for the removal of a destroyed kidney, but stones in the bladder remained as common as in Samuel Pepys' day. The old bladder operation of lateral lithotomy persisted, but it was rivaled by crushing with the lithotrite and a few surgeons were opening the bladder through the abdominal wall.

The beginning of the 20th century was a period of transition. On the heels of the great masters, who had accepted their godlike role with Olympian complacency, came a fresh generation trained in the belief that infection had been overcome and that henceforth the whole body, with its organs and systems, was theirs to explore and the whole gamut of disease theirs to investigate and to treat. Discovery proceeded apace. X-rays, discovered in 1895, were coming into general use; at first a curiosity used only for the demonstration of fractures, they were applied by W. B. Cannon (1871–1945) and A. F. Hurst to the investigation of the form, position and movements of the alimentary tract. Blood groups were discovered in 1900, but the technique of blood transfusion had yet to be learned.

Specialized branches of surgery began to appear. Vascular surgery was developed by R. Matas and Alexis Carrel, neurosurgery by W. MacEwen, Victor Horsley and Harvey Cushing, and MacEwen, Arbuthnot Lane and Robert Jones laid the foundations of orthopedics. Otology, laryngology and ophthalmic surgery, which until that time had been practised by general surgeons following their particular interest, were segregated as special surgical branches. Urology, with the new aids to investigation of cystoscopy and X-rays, soon progressed from its early concern with the treatment of stones to a highly skilled branch of surgery. Prostatectomy, known as the perineal operation in the U.S. and Germany and as the transvesical operation in Britain, abolished the misery of bladder stones and hypertrophy of the prostate that, until then, had dominated the surgery of middle-aged men. Goitre surgery, later to be superseded by treatment with medicines, was established in Germany, Switzerland and the U.S.

The advances in abdominal surgery during the first two decades of the 20th century form a chapter to themselves. Appendicitis, concealed previously in the portmanteau diagnosis of perityphlitis, was brought to the forefront of attention by the sudden illness of King Edward VII in the year of his coronation and, for a time, it became the chief interest of abdominal surgeons. Earlier operation was advocated and the mortality dropped from 30% to near the vanishing point. Gastric surgery, under the influence of X-ray investigation and the increased safety of better operative methods, instruments and materials, developed apace. The problem of peptic ulcer started to appear but in an aspect different from the one it assumed later; gastric ulcers were common and usually multiple, while duodenal ulcers were so rare that they barely received mention in the textbooks. Short-circuiting operations and local resections were favoured. The technique of intestinal resection and anastomosis, first rendered safe by the device invented (1892) by J. B. Murphy (1857–1916) and known as the Murphy button, was so improved that operations for the removal of cancers of the colon and rectum and of diseased portions of the small intestine were performed in increasing numbers. A less happy aspect of this period of exploration was the discovery by X-rays of supposed misplacements of abdominal organs that were said to be due to ptosis and were treated by ingenious "pexy" operations (*i.e.*, operations intended to fix the part in question in the position that was believed to be anatomically correct). The surgery of the gall bladder and biliary passages, however, took part in the general advance.

**2. World War I.**—At the outbreak of World War I, general surgery in North America and western Europe had very much assumed the pattern that it later maintained. From a modern point of view, the operating theatre was poorly lit and was cluttered with furnishings, the surgeons were pompous and too conscious of their own merits, the operating was rough and bloody and the anesthesia dreadful; but it worked, most patients recovered and the sum of human misery was reduced immeasurably. The era that ended in Aug. 1914 was dominated by surgical giants such as William MacEwen, William Lane, B. G. A. Moynihan, A. C. T. Billroth, J. von Mikulicz-Radecki, A. von Eiselberg, J. B. Murphy, G. W. Crile, W. S. Halsted and C. H. and W. J. Mayo.

The years of war made a break with the past that was unequaled in completeness by anything that came before or after. First, the war broke the surgical hierarchy and the rule of tradition; till then, in Europe at any rate, a surgeon had been able to secure a place only by long and servile apprenticeship, by years of waiting that took him into middle age before he could exercise his initiative or use his hands. Suddenly a group of young surgeons at the peak of their skills were presented with decisions of the utmost importance and operations requiring the highest skill and courage to perform in large numbers. Henceforth there might be idols, often self-appointed, but no real giants. Secondly, the problems brought before these young men, the fundamental problems of inflammation and repair, were presented in numbers and of a uniformity that reproduced the conditions of a scientific experiment. Lacerated and stinking wounds were brought before a generation that had been taught to look on sepsis as a thing of the past. The cry of the older surgeons who were in authority was "back to Lister," but stronger and stronger antiseptics proved unable to check or even ameliorate the putrefaction and gangrene. Slowly the lesson was learned by young surgeons working in the war theatres that the answer to wound infection is the early removal of all foreign matter, together with all dead and damaged tissue in the track of the wound. Newer and less toxic antiseptics were made, notably the hypochlorites and the acridine dyes, and methods to promote the flow of lymph and wash out wound discharge, such as the hypertonic saline solution of Almroth Wright and the Carrel-Dakin irrigation, were introduced; but it became clear that the best antiseptic was the action of the healthy tissues of a healthy patient. Advances that were inevitable were hastened; transfusion was developed and used to combat shock; wound shock, one of the major problems of surgery, was studied intensively by the scientists of all the combatant nations, although the simple volumetric explanation remained undiscovered; anesthesia was improved by the use of intratracheal intubation and rectal administration, and by the increasing use of nitrous oxide and oxygen.

Special centres were set up for the long-term treatment of some of the more disabling later results of wounds, particularly fractures, injuries of the peripheral nerves and facial injuries. These centres continued after the war to treat the aftermath of military and civilian injuries and from them developed the orthopedic and plastic surgery institutions that became a feature of civilian surgery. Chest surgery, though not segregated, began to develop toward the close of the war; it came into being because of the special experience and teamwork of many surgeons, physicians and anesthetists.

To sum up, World War I brought a fundamental change in the whole aspect of surgery. At its commencement surgery was in the hands of men who were good pathologists and excellent clinicians and teachers; *i.e.*, safe but not brilliant operators. At its close a number of young men trained to make decisions while their brains were active and to operate while their hands were nimble were ready to undertake, indeed to lead, the surgery of the next decade. They had learned to think in terms of function rather than of anatomy and they had learned that the secret of good surgery is gentleness rather than speed. In purely military surgery, the most important lesson was the change from the expectant (*i.e.*, relieving only the symptoms) to the active (*i.e.*, seeking an immediate cure) treatment of gunshot wounds of the abdomen.

**3. Between Wars.**—The 20 years between World Wars I and II were marked by steady and progressive development due, in the main, not to technical improvements but to parasurgical advances in anesthesia, in methods of investigation, in instruments and materials and in physiological and biochemical knowledge. The combined advance continued at a steadily increasing tempo and, although World War II marked a definite stage and must be considered as such, from 1920 onward one forward step so led to another that a survey from that time must be sectional rather than chronological.

The major surgical advances from 1920 to 1940 and thereafter depended chiefly on new anesthetic techniques. As operations became more severe and more prolonged and as greater safety and better results were demanded, the search for safer and more pleasant anesthetic drugs and methods was intensified while, as asepsis replaced antisepsis, the need to remove the anesthetist from the immediate neighbourhood of the operation became dominant. The use of intratracheal and rectal anesthesia made it possible for the neurosurgeon or the plastic surgeon to isolate the head with sterile towels. Neither basal (*i.e.*, preliminary) nor intratracheal anesthesia made any notable progress during World War I but later a number of gases including ethylene, cyclopropane and trichloroethylene were introduced; they were used mostly in lengthy operations to continue anesthesia induced by ether or tribromoethanol (Avertin). Intravenous anesthesia came into use in 1932 with hexobarbital (Evipan), followed in 1934 by thiopental sodium (Pentothal Sodium); these methods avoided both the unpleasantness of induction by inhalation and the danger of rectal anesthesia. A further step forward was the use of muscle relaxants, starting with curare in 1942. But the step that paved the way for modern surgery was the small modification in intratracheal anesthesia that appeared almost unnoticed toward the end of World War I; *i.e.*, by using an inflatable cuff to make a gastight fit with the trachea, or by packing the pharynx with gauze, the anesthetist became able to breathe for the patient. This change meant that surgeons could now operate without time restrictions on the thorax, diaphragm, esophagus, lungs or heart.

Until World War I, the fear of pneumothorax had limited thoracic surgery to the drainage of empyemata. Although toward the close of the war several surgeons had operated upon the lungs for war wounds, such ventures were brief and during the 1920s pulmonary surgery remained extra-pleural and became intrathoracic only after obliteration of the pleural space. Operations were performed for infective conditions—tuberculosis, bronchiectasis and chronic empyema—but they were confined to (1) collapse therapy by various forms of thoracoplasty (surgery of the chest), by apicolysis (collapse of apex of the lung) or by phrenic avulsion (removing a piece of the phrenic nerve); or to (2) partial destruction of an affected lobe after its isolation by adhesions. About 1930, however, open-thorax surgery developed rapidly: E. A. Graham removed a lobe for cancer of the bronchus in 1933 and thereafter operations for cancer of the lung tended to overtake and soon to exceed those for tuberculosis. This tendency, which continued throughout and after World War II, was influenced by the virtual disappearance of tuberculosis as a major problem after the discovery of streptomycin (1944), para-aminosalicylic acid and isoniazid and the simultaneous increase in bronchial cancer. Limited resections for tuberculous foci tended to replace collapse operations. Lobectomy (excision of a lobe) or total pneumonectomy (excision of an entire lung) for cancer, according to the site and extent of the disease, was performed with increasing success and diminishing mortality. Cancer of the esophagus, despite about a half dozen operations between 1913 and 1930, was considered beyond surgical approach till the development of controlled-respiration anesthesia, but from 1930 onward resections of the esophagus were performed in increasing numbers with a mortality that, in the hands of many surgeons, descended below 10%.

The surgery of the heart followed similar lines. Till World War I and the development of controlled-respiration anesthesia, it was limited to suture of heart wounds, drainage of the pericardium and partial excisions for constricting pericarditis and, although H. S. Souttar had dilated the mitral valve in 1925, the surgical correction of cardiac abnormalities only truly started with the ligature by R. E. Gross of a patent ductus arteriosus in 1939. The bypassing of pulmonary stenosis was successfully effected in Baltimore, Md., followed, in Stockholm in 1945, by the resection of aortic coarctation. Direct attack on the heart followed two years later with operations on the mitral and pulmonary valves. The ultimate goal of cardiac surgery, *i.e.*, operation on the open heart for the closure of defects in the septum between the two sides, was attained in the 1950s by three developments: (1) the use of hypothermia to reduce the need of the tissues for oxygen; (2) the design of heart-lung machines that can carry on an artificial circulation through the great vessels while the heart is bypassed; and (3) the discovery that the cooled and bypassed heart can be stopped for as long as an hour and started again without suffering permanent damage. (*See* also ARTIFICIAL ORGANS.)

X-ray investigation was extended progressively by the use of contrast media to visualize hollow structures. Retrograde pyelography, introduced in 1906, was succeeded in 1923 by intravenous pyelography. Cholecystography was introduced in 1923. In each case an iodine salt, which ultimately was excreted by the liver or the kidneys, allowed X-ray demonstration of the biliary and upper urinary tracts. Ventriculography, the introduction of air into the ventricles of the brain, was discovered in 1918 and cerebral angiography in 1931. The visualization of tubes, cavities or spaces by the introduction of air or opaque fluids into them was increasingly applied, and by the 1950s angiography (the examination of blood vessels rendered opaque by the injection of iodine salts) was used increasingly in the investigation of the brain, the kidneys, the heart and great vessels and the peripheral arterial tree.

With the diagnostic help afforded by ventriculography, cerebral angiography and myelography (X-ray examination of the spinal cord), neurosurgery progressed steadily. It also was benefited by pathological research into the nature of tumours, by basal anesthesia, by special instruments and techniques and by the increasing technical dexterity of this specialty, which was separated earlier than any other from general surgery. Urology also was benefited by improved radiology and by new electro-optical instruments that brought a steady development of transurethral surgery. The surgery of the prostate progressively improved, while that of urogenital tuberculosis was virtually eliminated by the advent of chemotherapy.

Of the parasurgical methods that revolutionized surgery between the wars, two of the most important—at any rate as regards abdominal surgery—were intravenous alimentation and gastrointestinal decompression. The introduction of continuous intravenous infusion in 1926 enabled surgeons to do something that had never been done before; *i.e.*, to keep the body supplied with all its needs of fluid and nutriment while leaving the alimentary canal at rest. Continuous gastrointestinal suction through an indwelling tube enabled them to relieve distension when present, to remove pathological accumulations and to keep the alimentary canal rested and empty. These methods brought the most dramatic improvement in the treatment of intestinal obstruction, peritonitis and the acute abdominal emergencies generally, but every branch of abdominal surgery was made safer and more successful. Operations for peptic ulcer, yearly becoming more frequent, were increasingly undertaken with growing success. Operations for cancer of the stomach, colon and rectum became more radical and, at the same time, safer and more curative.

**4. World War II and After.**—World War II was an epoch as important to surgery as World War I but was less clearly marked because on this occasion civilians were involved equally with soldiers, so that the war merely guided and accelerated advances that were inevitable. Once again trauma and infection were in the forefront of study: in trauma the main advances were a better understanding of shock, the use of stored blood and the employment of blood in quantities never before contemplated; in infection the use of chemotherapy was extended. At the start of the war, only one or two sulfonamides were known; at its conclusion, in addition to many new sulfonamides, penicillin and other antibiotics were available. The surgical services of the nations at war trained special units to deal with head, chest and face injuries, with

ophthalmic casualties and with wounds of the limbs and, from these special teams of neurosurgeons, plastic surgeons and orthopedic surgeons developed when the war ended.

Postwar surgery was characterized by increasing elaboration and an increasing tendency to specialization and the division of labour. The main specialties became more distinct, requiring a longer and more elaborate training, and further subspecialties appeared, combining the special skills of more than one group. Thus hand surgery, to which plastic surgery is also linked, and accident surgery developed from orthopedics, while burns became of equal interest to plastic surgery and accident surgery. The treatment of prolapsed intervertebral discs was shared or quarreled over by neurosurgeons and orthopedic surgeons. The surgery of the heart and that of the great vessels tended to be practised by different experts. With the emergence of these highly skilled groups, one-man surgery was gradually replaced by team surgery. Some of the tools of modern surgery, such as the heart-lung machine and the artificial kidney, require a special team whose sole job is to see that they will work perfectly when they are needed; these groups of machine-minding experts require a large theatre to accommodate them. Apart from the teams that work these elaborate instruments, some of the larger operations, especially rectal and gynecological operations that are done partly from the abdomen and partly from the pelvis, were redesigned to be performed by two surgeons working simultaneously.

Two other postwar developments must be mentioned. One was the increasing use of indwelling foreign materials, which may be (1) inactive metals, such as Vitalium, used largely in orthopedics, or tantalum wire or mesh, used in neurosurgery or for the repair of large defects; or (2) plastics such as nylon used as thread or net, Orlon tubing to replace large arteries, or plastic sponge to patch septal defects in the heart. Specially molded pieces of solid plastic were used to replace the head of the femur, gaps in the skull, or the lens of the eye following extraction for cataract. The second postwar development was the use of radiation as an addition, as distinguished from alternative, to surgery in the treatment of cancer, as described in *Malignant Disease* above. The use of radium and of deep X-rays began shortly after World War I but, till just before World War II, the use of both was haphazard, the dosage uncertain and unfortunate sequelae all too common. From 1940 onward the work of the physicist standardized dosage, clarified the methods of application and introduced many new techniques.

*See* also references under "Medicine and Surgery, History of" in the Index. (W. H. Og.)

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**MEDICINE BOW MOUNTAINS,** a northwest-southeast oriented Rocky mountain range that extends for about 40 mi. on either side of the Wyoming-Colorado border. The southern terminus of the range merges with the Front range of Colorado near Longs peak. To the north in Wyoming the Medicine Bow range becomes wider and higher; there the dissected upland is 10,000 ft. above sea level and 2,500 ft. above the adjacent Laramie basin. Surmounting the upland is a glaciated alpinelike chain with ridges 12,000 ft. above sea level. Locally this chain is called the "Snowy range." (H. B. Ha.)

**MEDICINE HAT,** a city and electoral division in southeastern Alberta, Can. Pop. (1961) 24,484. On the South Saskatchewan river, it is a divisional point for the main line of the Canadian Pacific railway. Reputed to have been called "the city with all hell for a basement" by Rudyard Kipling, the city owns vast natural gas deposits that have attracted many industries including flour mills, brick and ceramics, greenhouses, tire, meat packing, fertilizer, and electrical fixtures plants. Medicine Hat still relies on agriculture for approximately 50% of its economy, being the centre for the shortgrass ranching area and for a specialty crops industry producing sugar beets, vegetables and garden produce.

Founded in 1883 as a camp for railway construction workers, Medicine Hat derived its colourful name from the Cree Indian word *Saamis* or "medicine man's hat" which, according to legend, marks the spot in the river where a Cree medicine man lost his headdress while fleeing Blackfoot warriors who massacred his tribe. (H. G. Ho.)

**MEDICINE MAN:** *see* SHAMANISM.

**MEDILL, JOSEPH** (1823–1899), U.S. newspaper editor and publisher, an outspoken editor of the personal journalism era who built the *Chicago Tribune* into a prosperous, powerful paper. He was born on April 6, 1823, in New Brunswick, Can. His Scotch-Irish father, who had emigrated from Belfast in 1819, moved to Ohio in 1832. Young Medill attended an academy in Massillon, O., and was admitted to the bar in 1846. His journalistic career began three years later when he purchased an Ohio village weekly, the *Coshocton Republican*. In 1851 he founded the *Daily Forest City* in Cleveland, which was soon renamed the *Leader*. Medill was originally a Whig in politics but when that party declined after 1850 he helped to organize the Republican party.

In 1855 Medill was one of four principal partners who purchased the *Chicago Tribune*, which had been founded in 1847. He was influential in setting editorial policy, personally reported Abraham Lincoln's speeches, wrote antislavery editorials and helped to bring about Lincoln's nomination and election as president. His paper substantially supported Lincoln's administration.

Medill was elected mayor of Chicago in Nov. 1871, a month after the great Chicago fire, and was given emergency powers to reorganize the city's finances. While the city was being rebuilt and its government reorganized, Medill managed to put through a plan to establish the Chicago Public library.

In 1874, after he had resigned his post as mayor and made a tour of Europe, Medill purchased a controlling interest in the *Tribune* and became its editor in chief, a position he held until his death in San Antonio, Tex., on March 16, 1899. Under his direction the paper won national recognition for its reportorial enterprise. Editorially, it became increasingly conservative in outlook as Medill advocated a free hand for business and fought liberal reformers and labour unions. Strongly nationalistic in foreign policy, the *Tribune* was in the forefront of interventionist papers during the Cuban crisis preceding the Spanish-American War.

Medill married Katharine Patrick in Ohio on Sept. 2, 1852, and had two daughters, Elinor Medill Patterson and Katharine Medill McCormick. His four grandchildren were Robert R. McCormick, who won control of the *Tribune* after 1914; Medill McCormick, U.S. senator; Joseph M. Patterson, publisher of the *New York Daily News;* and Eleanor M. Patterson, publisher of the *Washington Times-Herald*. The family endowed the Medill School of Journalism at Northwestern university, Evanston, Ill.

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(E. Em.)

**MEDINA, JOSÉ TORIBIO** (1852–1930), Chilean scholar, author and bibliographer, was born in Santiago de Chile on Oct. 21, 1852. After an excellent education, he received his degree of advocate at the university in Santiago in 1873, but such time as he could spare from the practice of his profession he consistently gave to literature and the study of American history. In 1875 he was appointed first secretary of legation in Lima, Peru. He went to the United States in the following year and spent the next

two years traveling in the United States and Europe, where he made a careful study of documents relating to the history of Chile. During the War of the Pacific Medina served as judge advocate of the reserve army and was then made judge of several new provinces, chiefly Tarapacá.

Medina left this post to make a dangerous journey into Araucania at the end of 1880 to gather materials for a work on *Los Aborígenes de Chile*, to be the first volume of a complete history of Chile which he had projected. In 1884 he went to Spain as first secretary of the newly established legation in Madrid, where he was able to make extensive researches into the archives of the Indies in Seville and Simancas. When he returned to Chile in 1886, he set up his own printing press; from this and its successors he sent out a great number of books. In addition to his own works, Medina edited numerous others relating to the whole range of discovery, exploration, history and geography in all the Americas, particularly Chile.

His labours in the entire field of Hispanic-American bibliography were stupendous; a list of his works would exceed 300 titles, among them: *Historia de la literatura colonial de Chile* (1878); *Biblioteca americana* (1888); *Colección de documentos*, 30 vol. (1888–1902); *Historiadores de Chile*, 33 vol.; *Biblioteca hispano-americana* (1898–1907); *Los Tribunales del santo oficio en América; La Imprenta en Río de la Plata* (1892), . . . *en Santiago de Chile* (1891), . . . *en Lima* (1904–07), . . . *en México* (1907–12); *La Araucana* (1910–18), a monumental edition in 5 folio vol.; *El descubrimiento del océano pacífico* (1913–20); *Cervantes en las letras chilenas* (1923). (W. B. P.; X.)

**MEDINA** (Al Madinah), a sacred city of Islam, was known as Yathrib before Mohammed's residence there. The name was thereafter changed to Madinat al Nabi, the Prophet's city. The town is situated in the Hejaz province of Saudi Arabia, about 250 mi. N. of Mecca and 650 mi. S.S.E. of Damascus, Syria. Medina is second only to Mecca as the holiest place of Muslim pilgrimage and the tomb of Mohammed in the Prophet's mosque is among the most sacred shrines in the Islamic world. The population is estimated at 60,000, but this increases greatly at times of pilgrimage. Medina is linked with Mecca by a metaled road via As Safra', Rabigh and Jidda. From 1908 to 1916 it was connected with Damascus by the metre-gauge Hejaz railway, destroyed during World War I. A project to reactivate this railway was initiated in 1963, and was to be a co-operative venture by the governments of Saudi Arabia, Syria and Jordan. Communication with the port of Yanbu' on the Red sea, 132 mi. W., is maintained by a metaled road branching off from the Jidda road at Badr Hunayn, famous for its "singing sands" and for the Prophet's victory over the Meccan tribe of Quraish in A.D. 624. Another metaled road, begun in 1959, was designed to link Medina with the northern towns of Khaybar, Tayma' and Tabuk.

The city, 2,050 ft. above sea level, is a noted pottery centre, situated in a prosperous oasis at the western edge of an extensive lava field, part of which dates from a volcanic eruption in A.D. 1207. This expanse of lava lies on the eastern slope of the main Hejaz mountain range. The date palms of Medina are world famous and a packing industry has been organized to facilitate the export of dates. Fruit, particularly grapes, vegetables and cereal crops are also cultivated and are irrigated from wells. Mechanical pumps, in use since Turkish times early in the 20th century, have virtually replaced the old draw wells. Drinking water is supplied by an aqueduct from a spring known as 'Ayn al Zarqa, the blue spring, near Quba (Qaba'), at the southern end of the oasis. In addition to the plentiful supply of subsoil water at no great depth, a number of important wadies (watercourses) meet in the vicinity of Medina and bring down torrents of water during the winter rains. Of these the most notable are the Wadi al 'Aqiq from the western mountains and a great wadi coming from the At Ta'if area to the south.

The Medina oasis is bounded on the east by the lava field. On the other three sides it is enclosed by a semicircle of arid hills. Of these the highest, rising more than 1,200 ft. above the oasis, is Uhud, with a reputed tomb of Aaron on its highest point. The whole of this area is sacred and forbidden to non-Muslims. But the airport lies just outside the sacred limits and a good view of the city can be obtained by foreigners from aircraft landing at the airport.

In Turkish times, there was a small military landing ground at Sultanah, to the south near the garrison's barracks, but the area is now occupied by the king's new palace and its extensive satellites. There too are the ruins of the tomb of Amr ibn al-As, the celebrated conqueror of Palestine and Egypt for early Islam.

Other features of the oasis are: the mosque of Quba, the first in Islamic history, whence the Prophet was vouchsafed a view of Mecca; the Mosque of the Two Qiblahs, commemorating the change of the prayer direction from Jerusalem to Mecca, at Ruma (Ar Rimah); the tomb of Hamza, uncle of the Prophet, and his companions who fell in the battle of Uhud (A.D. 625) in which the Prophet was wounded; the cave in the flank of Uhud in which the Prophet took refuge on that occasion; the mosque of Al Dir'a where he donned his armour for the battle; Al Mustarah where he rested on the way thither; the mosque of Al Raya, where he unfurled his standard for the battle of the ditch (*khandaq*); and the ditch itself (dug around Medina by Mohammed), in which the rubble of the great fire of Sultan Abdul-Mejid I's reign (1839–61) was dumped. All these spots are the object of pious visitation by all persons visiting Medina.

But the cynosure of all pilgrims is the Prophet's mosque, which Mohammed himself helped to build. Additions and improvements were undertaken by a succession of khalifas (caliphs) and the chamber of the Prophet's wives was merged in the extension during the time of the Omayyad caliph al-Walid ibn Abd-al-Malik. Fire twice damaged the mosque, first in 1256 and again in 1481, and its rebuilding was variously undertaken by devout rulers of several Islamic countries. Sultan Selim II (1566–74) decorated the interior of the mosque with mosaics overlaid with gold. Sultan Mohammed built the dome in 1817 and in 1839 painted it green, this being the accepted colour of Islam. Sultan Abdul-Mejid I initiated a project for the virtual reconstruction of the mosque in 1848 and completed it in 1860. This was the last renovation before the modern expansion planned by King 'Abdul-'Aziz in 1948 and executed by King Sa'ud in 1953–55. The mosque now includes a new northern court with its surrounding colonnades, all in the same style as the 19th-century building but of concrete instead of stone from the neighbouring hills. The *Qafas* (cage), to which female worshipers were formerly restricted, has been dismantled, while, apart from minor repairs, the southern (main) part of the mosque has remained intact. It comprises the three ornamental iron structures representing the houses of the Prophet and containing respectively (according to general consensus) the tomb of the Prophet himself under the great green dome, those of the first two caliphs, Abu Bakr and Omar, and that of the Prophet's daughter Fatima, and also a section of the pillared southern colonnade, specially adorned to represent the palm grove (Al Rawdha) in which the first simple mosque was constructed.

The modernization of Medina has not been so rapid as that of Jidda, Riyadh and other Saudi towns. There is a radio station that emphasizes religious features and the Islamic university was founded in 1960. Building development has involved the complete dismantlement of the old city wall and the merging of that historic area with the now built-up pilgrim camping ground (Al Manakh) and the Anbariya quarter, beyond the Abu-Jida' torrent bed, which was formerly the commercial quarter and in which the Turks established the railway station and terminal yards. The foundations of the old city wall were found to be about 20 ft. lower than the surface of accumulated silt and rubble; but unfortunately no attempt has been made to examine the excavations from the archaeological point of view. Nor has any archaeological work been done on the ruined sites of the old Jewish settlements, the largest of which was Yathrib (the Lathrippa or Iathrippa of Ptolemy and Stephanus Byzantius), which gave its name to the whole oasis until Islamic times. There are also several interesting mounds (*'itm*), besides the village of Al Quraidha, which would certainly produce historical data of interest. The famous (Islamic) cemetery of Al Baqiya (Baki al Gharkad) was shorn of all the domes

and ornamentation of the tombs of the saints at the time of the Wahhabi conquest of 1925; but the ruins so created have been tidied up, with simple concrete graves in place of the old monuments, and with a new circuit wall.

**History.**—The early history of Medina (Yathrib) is obscure, though it is possible that there may have been Jewish settlers there in pre-Christian times. But the main influx of Jews would seem to have taken place as the result of their expulsion from Palestine by the Roman emperor Hadrian in A.D. 135. It is probable that the Arab tribes of Aws and Khazraj were then in occupation of the oasis; but the Jews were the dominant factor in the population and development of the area by A.D. 400. In that year Abi-kariba As'ad, the Sabaean king of Yemen, visited the colony and imbibed the lore and teaching of the Jewish rabbis with the result that he adopted the religion of the Jews and made it the state religion of Yemen on his return, in supersession of the local paganism. The Yemeni Jews, who in 1949 emigrated to Israel, are mostly descendants of the Arabs then converted. In 622 the arrival of the Prophet Mohammed at Medina, in flight from Mecca, introduced a new chapter into the history of the oasis, and before very long the Jews, at first treated with indulgence, were driven out of all their settlements in Hejaz. Medina became the administrative capital of the steadily expanding Islamic state, a position it maintained till 661 when it was superseded in that role by Damascus, the capital of the Omayyad caliphs.

After the fall of the caliphs, who maintained a governor in Medina, the native amirs enjoyed a fluctuating measure of independence, interrupted by the aggressions of the sharifs of Mecca or controlled by an intermittent Egyptian protectorate. The Turks, after the conquest of Egypt, held Medina for a time with a firmer hand; but their rule grew weak, and was almost nominal long before the Wahhabis first took the city in 1804. A Turko-Egyptian force retook it in 1812, and the Turks remained in effective control until the revival of the Wahhabi movement under Ibn Sa'ud, from 1912 onward, increased their difficulties. Turkish rule ceased during World War I, and Husain ibn 'Ali, the Sharifian ruler of Hejaz, revolted against them. He later came into conflict with Ibn Sa'ud. Medina was in the hands of the Sharifian government up to 1924, when it was besieged for 15 months and ultimately fell to Ibn Sa'ud.

*See* also ARABIA; MECCA; ISLAM; HEJAZ; MOHAMMED.

(X.; J. B. GL.)

**MEDINA SIDONIA, ALONSO PÉREZ DE GUZMÁN,** DUQUE DE (d. 1619), commander in chief of the Spanish Armada of 1588, belonged to a branch of the noble and illustrious house of Guzmán, to which the duchy of Medina Sidonia had been granted in 1445. Since his father had died in 1555, he became the seventh bearer of the ducal title and the master of one of the greatest fortunes in Europe on the death of his grandfather, Juan Alonso de Guzmán, in 1559. Philip II of Spain regarded him with confidence (as can be seen from his letters of 1578–80 to him on the Portuguese succession and on the projected occupation of Portugal) and appointed him captain general of the coast of Andalusia in Jan. 1588.

In Feb. 1588, however, the marqués de Santa Cruz (Alvaro de Bazán) died; and Medina Sidonia was nominated in his place to command the Armada (*q.v.*) against England. He protested forcefully but in vain at being chosen for this post; and in the event his inexperience and lack of seamanship were among the causes of the failure of the enterprise. Even so, royal favour was not withdrawn from him: he was appointed captain general of the Ocean sea in 1595 and remained in practical control of the Spanish navy under Philip III also, notwithstanding further disasters (the sacking of Cádiz by the English in 1596 and the destruction of a squadron by the Dutch off Gibraltar in 1606). The duque died at Sanlúcar in 1619.

*See* Duque de Maura, *El Designio de Felipe II . . .* (1957) and other works cited under ARMADA.

**MEDIOLANUM;** *see* MILAN.

**MEDITERRANEAN SEA.** The Mediterranean is an intercontinental sea situated between Europe to the north, Africa on the south and Asia in the east. The maximum east-west extent, from the Strait of Gibraltar to the shores of the Gulf of Iskenderun, is more than 2,300 mi., and the maximum longitudinal extent, between the coasts of Yugoslavia and Libya, is nearly 850 mi. Its area, including the Sea of Marmara but excluding the Black sea, is close to 970,000 sq.mi.

The Mediterranean is the main existing fragment of the Tethys sea, which before the Alpine mountain-building period girdled the eastern hemisphere. The structure and present form of the basin and its bordering mountain system have been determined by the convergence and recession of the relatively stable continental blocks of Eurasia and Africa. The main movement of early Tertiary times was one of convergence and led to the uplift of the ranges of the Alpine system, largely composed of sediments originally deposited on the floor of the Tethys. The corresponding troughs of the fold system and the later foundering of areas encircled by the folds created the major basins within the sea. Still more recently the Mediterranean was widened and changed in form by a drawing apart of the continental blocks. This last movement created the Adriatic sea between Italy and the Balkan mass, shattered the southern ranges between Greece and Asia Minor, thus forming the Aegean, and opened the connection between the Mediterranean and the Black sea. The existence of an earthquake and volcanic belt along the whole length of the area shows that these great crustal adjustments are still proceeding. Moreover, marine terraces appearing below and above the present sea level and encircling the Mediterranean indicate the fluctuations in sea level during glacial advances and interglacial periods of the Pleistocene.

**Configuration.**—A submarine ridge extending across the narrows between western Sicily and Cap Bon has a maximum depth of less than 1,148 ft. and divides the Mediterranean into an eastern and western basin, oriented along a northwest-southeast axis. The major subdivisions of the western Mediterranean are the Alboran basin east of Gibraltar, between the coasts of Spain and Morocco, the Algero-Ligurian basin in which the Balearic Islands are located, and the Tyrrhenian basin north of the Sicilian straits. The structure of the eastern Mediterranean is more complicated, and more fracturing has occurred. A submarine ridge from western Crete to Cyrenaica separates the Ionian basin in the west from the Levantian basin in the east. Several other smaller basins have been mapped, such as the Cypro-Syrian basin and sections of the Aegean sea. The Adriatic sea between Italy and Yugoslavia consists of a basin up to 3,937 ft. deep in the south, a middle basin with a depth of only 656 ft., and a shallow northern section.

TABLE I.—*Per Cent of Area*

| Depth ft. | W. Medit. | E. Medit. | Adriatic | Aegean | Total to Dardanelles |
|---|---|---|---|---|---|
| 0.0–656 | 15.3 | 16.3 | 78.2 | 25.2 | 19.9 |
| 656–3,280.8 | 21.2 | 21.2 | 14.8 | 59.7 | 23.6 |
| 3,280.8–6,561.6 | 15.1 | 19.4 | 7.0 | 11.6 | 16.8 |
| 6,561.6–9,842.4 | 43.6 | 27.0 | — | 3.5 | 20.3 |
| 9,842.4–13,123.2 | 4.8 | 15.4 | — | — | 10.1 |
| more than 13,123.2 | — | 0.7 | — | — | 0.3 |

Except for the Adriatic and a shallow ramp extending some 200 mi. eastward from the Tunisian coast, the basins reach great depths and have steep continental slopes. Depths for various sections of the Mediterranean sea were calculated in relation to area by E. Kossinna in 1921 (Table I). While the western Mediterranean has more of its area at depths greater than 6,562 ft. the deepest soundings have been obtained in the Ionian basin south of Cape Matapan (Greece), where the basin floor is 15,900 ft. below sea level.

The bottoms of the basins are filled with brownish sediments varying in thickness from 328 to 8,858 ft. They are of sandy-clayey consistency with clay much in excess of sand, and they contain about 50% of carbonate of lime. The coarser calcareous constituents are chiefly pteropoda, while among the smaller shells foraminifera and coccoliths predominate. Fine riverine muds are deposited near the mouths of rivers emptying into the sea and are also carried considerable distances by offshore and submarine currents.

In general, coastal features are the direct result of the flooding

MAJOR BASINS OF THE MEDITERRANEAN SEA

of structural depressions and not of erosion. The shores are steep, and erosional cliffs and wave-cut platforms rare. In the northeastern Mediterranean deeply penetrating channels separated by high headlands recur along great stretches of coast, irrespective of the character of the rock of which they are composed. Coastal plains are small and scattered. Streams are heavily charged with sediments, but most of them have a small watershed because their headwaters are in highlands not far from the shore. The major exceptions are the large deltas of the Nile, Po and Rhône rivers, all of which drain large land areas. The formation of deltaic lowlands is aided by the low tidal range nearly everywhere in the Mediterranean. Only at Gibraltar and on the east coast of Tunisia does the tidal range exceed three feet. Thus, the Po delta in the last two centuries has advanced 230 ft. per year, and the Rhône delta 187 ft. per year since 1737. Deposits would be even more rapid, were it not for currents which carry them away and scatter them over a wide area.

**Temperature and Salinity.**—Temperatures of the surface water layers vary with the seasons. In February the lowest surface water temperature is 12° C. (54° F.) on the Provence coast in the western Mediterranean, and 10° C. (50° F.) in the northern Aegean in the east. In August the highest water temperatures occur along the coasts of Malaga and Israel, where they are 25° C. (77° F.) and 29° C. (84° F.) respectively. The average annual range in surface temperature for the Mediterranean as a whole is 12° C.; this range decreases with depth, and between 3,281 and 6,562 ft., temperature is remarkably uniform at all seasons—about 13° C. (55.4° F.) in the western basin and 13.7° C. (56.7° F.) in the eastern basin. Below 6,562 ft. there is a slight increase in temperature to the bottom, probably because of increased pressure.

Salinity is considerably higher than that of either the Atlantic ocean or the Black sea because of the heavy losses of water by evaporation. In general, it increases from west to east, from about 37 mills near Gibraltar and the Balearics to 39 mills in the Levant. However, salinity is lower everywhere toward the end of the rainy season, and it is considerably lower where fresh water is emptied into the sea. As a result of the Nile river floods, salinity as far north as the latitude of Mount Carmel decreases from 38.1 to 35.9 mills between August and September, and the discharge of the Vardar river into the Gulf of Salonika reduces salinity to 18 mills there. In depth there is a slight decrease from the surface to about 164 ft., then salinity increases to a depth of about 1,640 ft., and below that there is another slow decrease to 38.4 mills at the bottom in the west, and to 38.7 mills in the east.

**Water Balance.**—The basic factors in the water balance of the Mediterranean sea are evaporation, precipitation, runoff, and flow through the Strait of Gibraltar and the Bosporus. Calculations made by Douglas B. Carter in 1956 established the balance of the Mediterranean sea and the Sea of Marmara (Table II). The contribution of water through the Suez canal is insignificant. It should be added that the total inflow of water exceeds considerably loss by evaporation, so that there is a great outflow into the Atlantic and some into the Black sea beneath the surface currents. There is a seasonal change in depth and velocity of the two flows, and although surface currents are always into the Mediterranean, the outflow underneath is greater in volume when water gains in the Mediterranean exceed evaporation (December to April).

TABLE II.—*Water Balance*
(in 000,000 ac.ft.)

| | |
|---|---|
| Addition of water through: | |
| Net flow, Gibraltar | 972.0 |
| Direct precipitation | 838.4 |
| Runoff | 365.2 |
| Net flow, Bosporus | 164.4 |
| Total | 2,340.0 |
| Loss through evaporation | 2,340.0 |

The general pattern of surface currents is counterclockwise for the Mediterranean as a whole, as well as for individual sections. Locally, however, currents are complicated and modified by tides and winds.

**Climates.**—The basic factors which influence types and distribution of climates in the Mediterranean are the latitudinal and longitudinal position and extent, the orientation of the axis of the sea from northwest to southeast, and the great variety of land areas in shape, size and mountain systems, which break up the continuity of the water surface. As a result of the interaction of these factors, the Mediterranean region has not one type of climate, as is commonly stated, but several, ranging from deserts to mountains with the highest precipitation in Europe, and from marine to continental.

The latitudinal position of the Mediterranean sea is such that in winter, when the relatively warm waters of the Mediterranean form a vast area of low pressure with several centres, colder air is drawn in from adjacent land masses and the Mediterranean is a part of the westerly wind system with its passage of cyclones and their associated frontal precipitation. In summer, however, the waters remain relatively cooler than the land, so that the regional high pressure coincides with and strengthens the subtropical high which has expanded over the sea. Moreover, the eastern Mediterranean extends further south in latitude than the

western, bringing the entire shore from Tunisia to Egypt into the great Sahara-Arabian dry belt.

Total annual precipitation generally decreases from north to south and from west to east. Annual amounts range from more than 181 in. near the Dalmatian coast to less than 0.8 in. in the Sahara, and they are considerably higher on windward (west-facing) slopes than on leeward slopes. Precipitation maxima occur in winter in the southern portion of the Mediterranean, including southern Spain, southern Italy, and Greece, and the fringes of Turkey, at a time when the southern cyclonic tracks between Gibraltar and the Levant are significantly active. The northernmost section of Italy and the northern interior of Yugoslavia have distinct summer maxima indicating continentality and convectional precipitation. Between these two extremes is the transitional zone with two maxima, one in spring and the other in autumn, when storm tracks through the northern basins of the Mediterranean are most active.

Average winter temperatures in the Mediterranean do not fall below freezing except in the interior of Yugoslavia and Turkey, which are exposed to cold waves from eastern Europe. On the European coast there is a general decrease from west to east with the increasing influence of the Eurasiatic high; interiors are colder than coasts, and east coasts are colder than west coasts. Along the north African shores, on the other hand, there is little change in average winter temperatures, so that isotherms follow parallels of latitude fairly closely. In summer, average temperatures are hot everywhere; they increase eastward on the African shore and they are higher in the interior of land masses than on the coasts.

The great diversity of land and water and the peculiarity of pressure conditions give rise to many special wind systems. Among them the best known are the etesian winds which, belonging to the summer monsoon system of Asia, are steady, dry northwesterlies and northerlies blowing in the eastern Mediterranean; the sirocco, a dry and often hot wind originating in the dry lands south and east of the Mediterranean and blowing toward northern shores; the bora of the Yugoslav coast, the mistral of southern France, and others resulting from cold, dry air moving down slope from the mountains toward the sea.

**History.**—The Mediterranean has been described as "a melting pot for the peoples and civilizations which have seeped into it from its continental hinterlands." (Ellen Churchill Semple, *The Geography of the Mediterranean Region*, Henry Holt and Co., New York, 1931.) The revolutionary development of higher civilizations based on agriculture evidently originated in the lands beyond the eastern Mediterranean, but, having "seeped" into the basin, the sea facilitated further diffusion westward. Thus, the Mediterranean sea has served throughout history principally as a vital medium for communication from shore to shore, although at certain periods in its history man has made the sea a barrier, slowing down or paralyzing the interchange of people, goods and ideas.

The history of the Mediterranean sea can be divided into several major epochs. The first one encompassed the pre-Roman period during which a succession of maritime commercial states, such as Carthage, ancient Greece and Phoenicia, evolved on and near its coasts. Trading centres sprang up on all its shores and even in the Atlantic, many in competition with one another. Then, in the 3rd century B.C. the second major epoch began with the expansion of Rome, culminating in the political and economic unification of all lands bordering the Mediterranean sea as part of the empire.

The third epoch, extending roughly from A.D. 400 to the 11th century, saw the shattering of Roman unity by invasions of Germans and Slavs in the north, and by Moslem Arab conquests in the middle east, north Africa, Spain and Sicily. Saracen pirates endangered shipping and became a menace to coastal settlements. Commerce was greatly reduced and at times halted completely, and the centre of gravity shifted northward away from the Mediterranean toward the Atlantic, where by A.D. 800 Charlemagne had united much of continental Europe under one empire.

In the 11th century the next great age began with a return to the sea. The Arab empire was lapsing into disorder and the crusades aided in the reopening of seaports in the Levant. Constantinople, Barcelona and Italian commercial states regained their positions in world trade; until the 15th century these and other cities assumed the role of intermediaries between the orient and northwestern Europe. In the 15th century, however, the rise of the Ottoman Turks brought a second period of eclipse as well as an era of severe rivalries. Turkish conquest of the Levant, the Balkans and north Africa, was followed by a rule of oppression and exploitation, and piracy once again made traffic on the sea hazardous. Moreover, the discovery of the route to Asia around the Cape of Good Hope at the end of the 15th century created a safer and easier sea route connecting northwestern Europe directly with the orient. Mediterranean lands lost their commercial function as intermediaries between Europe and Asia, and for more than two and a half centuries the Mediterranean sea remained a backwater of world ocean trade and traffic.

The opening of the Suez canal in 1869, together with the advent of the steamship, continued industrialization in northwestern and central Europe, and French colonization in north Africa made the Mediterranean again one of the busiest sea lanes of the world. Much of the traffic, however, passed through the sea en route between Asia and northwestern Europe. Countries in the Mediterranean basin had not been able to industrialize and had retained their agricultural and artisan economies, which limited their purchasing power and reduced their ability to trade. Nevertheless, a fierce competition ensued among ports in northwestern Europe and Mediterranean Europe for the capture of transit trade to and from the industrialized areas of western and central Europe, a rivalry which has continued to this day.

From the 18th century until World War II, the Mediterranean was dominated by Great Britain, which had gradually acquired control over several strategic points along the sea route so vital to its empire trade, among them Gibraltar (1704), Malta (1800), Aden (1839), Cyprus (1878), and finally Egypt (1882). The most recent stage in the development of the Mediterranean sea began with United States entry into north Africa during World War II in 1942. After that war it became apparent that only the United States was strong enough to oppose the Soviet Union which made repeated attempts to expand into the Mediterranean sphere economically and politically. Thus, with the view of keeping the Mediterranean under noncommunist control and to protect western interests in the middle east and its oil fields, the United States took a leading role in the security of the Mediterranean and its borderlands, by initiation of the Marshall plan, the Truman doctrine, by participation in the North Atlantic Treaty organization which it helped create and the enactment of the Eisenhower doctrine for the middle east.

*See* also references under "Mediterranean Sea" in the Index.

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**MEDIUM:** *see* PSYCHICAL RESEARCH; SPIRITUALISM.

**MEDLAR** (*Mespilus germanica*), a tree of the tribe Pomeae of the family Rosaceae, closely allied to the genus *Pyrus*, in which it is sometimes included; it is a native of Europe from Holland southward, and of western Asia. It occurs in hedges, etc., in middle and south England, as a small, much-branched, deciduous, spinous tree, but is not indigenous. The medlar was well known to the ancients. The fruit is globular but depressed above, with leafy persistent sepals, and contains stones of a hemispherical shape. It is not fit to eat until it begins to decay and becomes "bletted," when it has an agreeable acid and somewhat astringent flavour. Several varieties are known in cultivation. The fruit should be gathered in November, on a dry day, and laid out upon

shelves. It becomes "bletted" and fit for use in two or three weeks. The Japanese medlar is *Eriobotrya japonica* (*see* LOQUAT), a genus of the same tribe of Rosaceae.

**MÉDOC,** a wine-producing district of southwestern France, situated on the left bank of the Gironde estuary north of Bordeaux. It stretches northward from Blanquefort for about 50 mi. to Pointe de Grave. The district is especially renowned for its vineyards, which for centuries have produced claret for export through Bordeaux. Behind the alluvium that flanks the estuary are terraces of rather coarse gravel, separated from the coast of the Bay of Biscay by the northernmost extension of the Landes forest. The grapes are grown especially along this strip of gravelly soils, and the finest red and white wines are produced on estates (derived from ancient feudal domains) which have been acquired by wine merchants and banking interests behind the Bordeaux wine trade. Some of the most famous *crus* (vineyards) are thus associated with châteaux (Lafite, Latour, Margaux), but wine is also produced from small holdings and sold under the name of Médoc or of the subdistrict of Margaux, where they are especially numerous. On the shore of the Gironde estuary, Pauillac serves as an outport for Bordeaux and has an oil refinery. (AR. E. S.)

**MEDRANO, FRANCISCO DE** (1570–1607), most notable of Spanish Horatian poets, was born at Seville and educated in Jesuit colleges at Salamanca and elsewhere. After the death of José de Acosta (*q.v.*), with whose abortive "rebellion" he had sympathized, he left the order, retiring at the age of 32 to his estate adjoining the ruins of Italica; his sudden death five years later aroused superstitious comment. His poems, dating almost entirely from the intervening period (posthumous edition, Palermo, 1617), include Italianate sonnets—religious, philosophical and amorous—as well as Horatian odes, and show an extraordinary grasp of their models' subtlest stylistic effects, together with a consistently heightened emotional tension expressed in the violent contortion of syntax by hyperbaton and anaphora; the *callida junctura* of Andalusian passion with Horatian nostalgia for fleeting youth and beauty is remarkable.

*See* Dámaso Alonso and Stephen Reckert, *Vida y obra de Medrano* (1948–58), with critical edition of the extant poems. (F. S. R.)

**MEDTNER, NIKOLAI KARLOVICH** (1880–1951), Russian composer of piano music and songs, was born at Moscow on Jan. 5, 1880 (new style; old style, Dec. 24, 1879). He studied the piano with his uncle, A. F. Goedicke, and later at the Moscow conservatory (1892–1900). In 1900 he won a "first honourable mention" in the Rubinstein competition at Vienna and then embarked on a career as pianist and composer, teaching at the Moscow conservatory for a short time in 1909 and again from 1914 to 1921. He settled in 1921 in Germany, in 1925 in France and in 1936 in England, making extensive concert tours of the United States in 1924–25 and 1930. He died in London on Nov. 13, 1951.

Medtner's work, consisting almost entirely of piano music and solo songs, stands apart from the main tradition of Russian music but in close relationship to that of late 19th-century Germany. He was a master of rich and complicated pianistic textures, which, however, sometimes overload his song accompaniments. Thoughtful and introspective, his music makes no concessions to either popular or fashionable taste. His lyrical feeling and admiration of technical accomplishment are also seen in the choice of poets for his best songs: Goethe, Pushkin, A. A. Fet and F. I. Tyutchev.

*See* R. Holt (ed.), *Nicolas Medtner* (1945). (G. AB.)

**MEDUSA,** in mythology: *see* GORGON.

**MEDUSA,** a technical name for a jellyfish (*q.v.*); *see* also COELENTERATA.

**MEDWALL, HENRY** (fl. 1490), the earliest known writer of an English secular play, is said on good authority to have been wellborn. The date of his birth and the circumstances of his youth and education are unknown. The earliest reference to him is in Cardinal Morton's register at Lambeth in the year 1490. On Aug. 27, 1492, he was admitted to the rectory of Balynghem in the English marches of Calais. It was not till Feb. 27, 1501 that he appears to have been granted letters of protection enabling him to go overseas, and a few months later he resigned. No later reference to him is known and probably he did not long survive.

Morton had appointed him his chaplain and it was for the entertainment of the cardinal and his guests that Medwall exercised his remarkable dramatic gifts. His reputation as a playwright has suffered from a story apparently invented by J. P. Collier, who stated that at Richmond in 1513 a moral interlude by Medwall, *The Fynding of Truth,* was performed but was not liked and that the king departed before the end to his chamber. There is no trace of the document on which the story is supposed to rest. Medwall did, however, write a morality play called *Nature,* in two parts and containing 22 characters. It is preserved in a single copy (printed by William Rastell, *q.v.*) in the British museum, and is a favourable example of the allegorical play. In it Medwall displays his talent for realistic dialogue and his skill as a versifier.

It is, however, as the author of *Fulgens and Lucres,* the first known secular play in English, that Medwall has a distinctive place in the history of the drama. The play was supposed to have been lost, except for a fragment, but a copy printed by John Rastell (*q.v.*) was found in 1919 in Lord Mostyn's library and passed, at the sale of his books, to Henry E. Huntington of California. Its ultimate source is a neo-Latin *declamatio* by Bonaccorso of Pistoia, *de Vera Nobilitate,* telling how Fulgentius, a Roman senator, had a daughter Lucretia who had two suitors, Publius Cornelius, well-born, rich and idle, and Gaius Flaminius, of humble birth but virtuous. Each pleads his case, but there is no decision. In the play, Lucres decides in favour of Flaminius, as the more truly "noble" of the two. Medwall also adds a comic underplot, in which the servants of the suitors are rivals for the favours of her handmaid. By virtue of this play Medwall stands at the head of the long line of English playwrights.

*See* also DRAMA: *Modern Drama.*

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**MEDWAY,** a river in the southeast of England, is 70 mi. long and drains 680 sq.mi. of the Weald and North Downs. It rises in the forest ridges of Sussex and part of its upper course forms the boundary between Sussex and Kent. Its source, like those of its Wealden tributaries, the Eden, Teise and Beult, is fairly active in erosion, gradually capturing the fringes of neighbouring catchment basins: the Ouse, Darent and Great Stour. The Medway makes a minor gap through the low ragstone ridge south of Maidstone, and a larger one of fine scenic quality through the North Downs between Maidstone and Rochester, where strong meanders abut against large paper mills and cement works. The Medway bridge, with a 500-ft. central span of prestressed concrete, carries the M2 motorway across this reach. Below Rochester the valley has been drowned. It forms a broad tidal estuary with many creeks and traverses low islands and mudbanks for 12 mi. until it discharges into the mouth of the Thames at Sheerness between the Isle of Sheppey and the Hundred of Hoo. The estuary is navigable by seagoing vessels drawing 24 ft. up to Rochester bridge. The river is tidal from Allington lock, 4 mi. below Maidstone. (A. M. Co.)

**MEERANE,** a town of Germany in the *Bezirk* (district) of Karl-Marx-Stadt, which after partition of the nation following World War II became part of the German Democratic Republic. It lies 40 km. (25 mi.) W. of Karl-Marx-Stadt (city) and about 61 km. (38 mi.) S. of Leipzig on the Leipzig-Zwickau-Plauen railway. Pop. (1950) 25,519; (1962 est.) 24,254. The town has a medieval church. It is in the centre of one of the largest industrial regions of eastern Germany, mainly devoted to the engineering and clothmaking industries. In addition there are factories making steam boilers and vehicle bodies. Meerane also has a textile training school.

**MEERSCH, JEAN ANDRÉ VAN DER** (1734–1792), Belgian general of the revolution of 1789, was born at Menin, in Austrian Flanders, on Feb. 10, 1734. He joined the French army in 1757, during the Seven Years' War, was present at the battles of Rossbach (Nov. 1757) and of Hochkirch (Oct. 1758) and rose to be lieutenant colonel in 1761. After the war he asked to be allowed

to serve in America, but was refused. Having retired in 1772 to Dadizeele, near Menin, he entered the Austrian service in 1778 and was made a colonel, but retired again to Dadizeele when he was refused admission to the Order of Maria Theresa (1779).

In Aug. 1789 the Belgian rebel Jean François Vonck offered to Van der Meersch the command of the forces that he was assembling in the principality of Liège for the invasion of the Austrian Netherlands (*see* BELGIUM: *History*). Van der Meersch received the rank of lieutenant general and, after the transfer of his forces to Dutch territory, led the invasion. He defeated an Austrian detachment at Turnhout on Oct. 24, won further successes and concluded an armistice with the Austrian general, Richard d'Alton, in December. He then occupied Louvain and Namur. Exposed to the hostility of Vonck's rival Henri van der Noot, he soon found his position difficult, and in April 1790 was arrested. On the restoration of Austrian authority in Dec. 1790, he withdrew to France, but was amnestied and welcomed back to Brussels in Feb. 1791. Retiring again to Dadizeele, he died there on Sept. 14, 1792.

(C. VE.)

**MEERSCHAUM,** the soft white mineral, sepiolite, sometimes found floating on the Black sea and rather suggestive of sea foam (Ger. *Meerschaum*). It was named sepiolite by E. F. Glocker in allusion to its resemblance to the "bone" of the cuttlefish *Sepia*. Meerschaum is an opaque white, gray or cream colour, breaking with a conchoidal or fine earthy fracture and occasionally fibrous in texture. Its chief use is for tobacco pipes and cigar and cigarette holders.

Meerschaum can be readily scratched with the nail, its hardness being about 2 on Mohs' scale. The specific gravity varies from 0.988 to 1.279, but the porosity of the mineral may lead to error. Meerschaum is a hydrous magnesium silicate with the formula $H_4Mg_2Si_3O_{10}$, or $Mg_2Si_3O_8 \cdot 2H_2O$.

Most of the meerschaum of commerce is obtained from Turkey, chiefly from the plain of Eskisehir where it occurs in irregular nodular masses in alluvial deposits. The mineral is associated with magnesite (magnesium carbonate), the primitive source of both minerals being serpentine. When first extracted the meerschaum is soft, but it hardens on exposure to the sun or when dried in a warm room.

Meerschaum is found also, though less abundantly, in France and in Tanganyika; in Greece, as at Thebes, and in the islands of Euboea and Samos; it occurs in serpentine in Moravia, in Czechoslovakia, and it is found to a limited extent at certain localities in South Africa, Spain and Morocco. In the United States, although not produced commercially after about 1914, it occurs in serpentine in Pennsylvania (as at Nottingham, Chester county) and in New Mexico, Utah and California.

**MEERUT,** a city, district and division located in Uttar Pradesh, India. The city (pop. [1961] 200,470), headquarters of the district and division, lies 36 mi. N.E. of Delhi and occupies the municipal area and cantonment (75,334) to the north. An important military station, Meerut was established in 1806 by the British. The first uprising of the Mutiny (called by Indians the freedom struggle) of 1857 took place there. (*See* INDIAN MUTINY.) It is now the subarea army headquarters of the northern region. There are three colleges affiliated to Agra university and numerous small temples. The city is a fast-growing industrial centre, and has cotton mills, chemical works, paint and varnish factories, and a sugar mill besides the well-developed small-scale industries of cloth weaving, hosiery, harness and saddle making and agricultural implements. It is particularly known for the manufacture of scissors, razors, musical instruments and sports goods, all established after the partition (1947) of the subcontinent. It is an important rail and road junction.

MEERUT DISTRICT (area 2,322 sq.mi.) forms part of the Upper Ganges–Jumna doab, with the Ganges (Ganga) forming its eastern and the Jumna (Yamuna) its western boundary. The Hindan river, a tributary of the Jumna, and the Kali Nadi, a tributary of the Ganges, drain the district, which is agriculturally rich, largely because of irrigation from canals and tube wells. The Eastern Jumna canal irrigates the tract between the Jumna and the Hindan; the main branch of the Ganges canal waters the middle tract between the Hindan and the Kali Nadi; and the Anupshahr branch irrigates the area between the Kali Nadi and the Ganges. The legendary Pandava capital, Hastinapur (celebrated in the Mahabharata), stood on the bank of the Burhi Ganga, the ancient channel of the Ganges, which lies at some distance from the present stream. The district was constituted in 1818. It had a population (1961) of 2,712,960 with less than half depending on agriculture. Wheat, sugar cane, pulses, millets and cotton are the chief crops. There are vegetable oil mills, and glass and ceramic works at Ghaziabad (63,190). The industrial township of Modinagar (24,266) has sugar, vegetable oil and textile mills, and a college affiliated to Agra university. Hapur is the chief wheat market. Other towns are Baraut, Mawana, Khekra, Sardhana and Pilkhuwa.

MEERUT DIVISION, the northern part of the *doab*, consists of the districts of Dehra Dun, Saharanpur, Muzaffarnagar, Meerut and Bulandshahr. Area 9,225 sq.mi. Pop. (1961) 7,939,770.

(S. S. BH.)

**MEGALOPOLIS** ("big city"), an ancient city of Arcadia, Greece, in a plain about 20 mi. S.W. of Tegea, on both banks of the Helisson (Elisson) river about 2½ mi. above its junction with the Alpheus (Alfios), just north of the modern town of Megalopolis. It was founded by the Theban general Epaminondas, probably in 369 B.C., as a bulwark for the southern Arcadians against Sparta, and as the seat of the Arcadian federal assembly, the "ten thousand." Forty townships are mentioned by Pausanias (viii, 27, 3–5) as having been incorporated in it. It was 50 *stades* (about 5½ mi.) in circumference, and was surrounded with strong walls. Its territory was the largest in Arcadia, extending northward 24 mi. The city was adorned with many handsome buildings. Its temples contained ancient statues brought from the incorporated towns. The Arcadian federation soon disintegrated; after the battle of Mantinea (362) many inhabitants of Megalopolis sought to return to their former homes, and it was only by the intervention of 3,000 Thebans under Pammenes that they were prevented. The continuing hostility of the Spartans led to an unsuccessful appeal to Athens (supported by Demosthenes in his speech *For the Megalopolitans* [352]) and eventually to friendship with Philip II of Macedonia. When the Spartans and their allies rebelled against the Macedonian regent Antipater (331), Megalopolis, loyal to its allegiance, stood a long siege. After the death of Alexander the Great, it was governed by native tyrants. In the war between Cassander and Polyperchon it supported the former and was besieged unsuccessfully in 318 by the latter. In 235 Lydiades, the last tyrant of Megalopolis, resigned, and the city joined the Achaean league, earning again the hatred of Sparta. In 223 Cleomenes III of Sparta plundered it, but in the next year its inhabitants were reinstated by Philopoemen, a native of the city. After this it sank into insignificance and in the time of Pausanias it was in ruins. Its only great men were Philopoemen and Polybius the historian.

The site was excavated by the British School at Athens in 1890–91. The description of Pausanias tallies closely with the reality. The town was divided into two approximately equal parts by the Helisson, which flows through it from east to west. The line of the walls may be traced, and confirms the estimate of Polybius that they had a circuit of 50 *stades*. The buildings north of the river were municipal, grouped round the square agora. The portico of Philip, on the north, was 500 ft. long, with three rows of columns running its whole length, and a projecting wing at either end. East of it stood the municipal offices (Archeia). At the southeast corner is the precinct of Zeus Soter, surrounded by a double colonnade, with a small temple on the west and an entrance on the east. In the midst was a substructure either for an altar or for the great group of Zeus and Megalopolis mentioned by Pausanias. North of this the Stoa Myropolis formed the east boundary. These buildings were of various dates but harmonious plan. On the south bank of the river were the chief federal buildings, the theatre (noted by Pausanias as the largest in Greece), the Thersilion or assembly hall and the great portico of the Thersilion facing the orchestra of the theatre. The theatre was probably used, as at Athens, for political assemblies; but the adjoining Thersilion provided cover for the "ten thousand" in wet weather. It is unique in plan, its

floor sloping up toward all sides like a theatre, with roof-columns set radially so as to obscure as little as possible the view from the centre.

*See* E. A. Gardner *et al., Excavations at Megalopolis 1890–1891* (1892).

**MEGAPODE,** the name given to the large-footed birds comprising a small gallinaceous family (Megapodiidae) confined to the Australian region. They are notable for burying their 6 to 24 buffy white eggs in sand, warm volcanic ash or mounds of decaying vegetation, which serve as natural incubators. Mound building is sometimes communal. The period of incubation, as much as 63 days, is the longest known in birds. The chicks are precocial, independent of their parents and capable of flight immediately after hatching.

The several species are known variously as brush turkey, scrub fowl, Mallee fowl and mound builders. They range from 10 to 25 in. in length and are either mainly brown or slate, or gray and brown, streaked and barred with chestnut. Some species have the head and chest bare; others have long wattles or a casque. The legs, feet and claws, especially in the wide-ranging *Megapodius,* are extraordinarily large. The sexes are similar in appearance. Essentially terrestrial, megapodes inhabit forested areas and dry scrub, subsisting on insects, worms, seeds and berries. The voice is loud and harsh, sometimes with cackling notes. (E. R. Be.)

**MEGARA** ("the halls"), an ancient Greek town on the Saronic gulf between Attica and Corinth. Its district, the Megarid (Gr. *Megaris* or *Megarike*) was bounded in ancient times by Attica, Boeotia and Corinthia and the gulf of Corinth and the Saronic gulf: it is at present divided between the *nomoi* or prefectures of Attica and Corinth. Mt. Geraneia (Yerania) extends across the country from east to west and forms a barrier between continental Greece and the Peloponnese. The shortest passage of this range is along the eastern side of the mountains, through the celebrated Scironian rocks, where Theseus destroyed the robber Sciron. The only lowland was the White plain, in which was the city, Megara. The modern town occupies two low hills within the ancient site. Its Easter dances attract visitors. There are remains of the aqueduct made by the architect Eupalinus for the tyrant Theagenes.

**History.**—In prehistoric days Megara had intercourse with the southern Aegean. The early inhabitants were extirpated in the Dorian migration, for in historic times the city had a homogeneous Dorian population. Favoured by its proximity to two great waterways and by its two ports, Nisaea on the Saronic and Pegae on the Corinthian gulf, Megara took a prominent part in commerce from the 8th century B.C. Its trade was with Sicily, where Megarian colonies were established at Megara Hyblaea (*c.* 728) and Selinus (*c.* 628), and with the Black sea, in which region the Megarians were pioneers of Greek commerce. In the Propontis (Sea of Marmara) they had to face the competition of the Samians and of Miletus; but on the Bosporus they established themselves by means of settlements at Chalcedon (675) and Byzantium (658). In the Black sea they exploited the shores of Pontus and Scythia. Their chief colonies were Astacus and Heraclea in Bithynia, and another Heraclea in the Crimea. Later this trade dwindled in face of the commercial activity of Miletus, and that of Athens on the Hellespont. Megarian commerce in Sicily was supplanted by Corinth and Corcyra.

Megara's economic development entailed a change in political power. The land-holding aristocracy began to lose its grip upon the community of artisans. The brief tyranny of Theagenes (*c.* 640–630) followed. The power of the nobles was broken in a war with Athens, in which Megara lost the island of Salamis (about 600 B.C.; *see* Solon); after a period of democracy the constitution was fixed as an oligarchy of a moderate type. During the Persian wars the state, which joined the Peloponnesian league, could muster 3,000 hoplites. But the expansion of Athens ruined the commerce of Megara. In 460 an attack by Corinth induced the people to summon the aid of the Athenians, who secured Megara in battle and by the construction of long walls between the capital and its port Nisaea. In 446 the Megarians massacred their Athenian garrison. The Athenians retaliated by placing an embargo upon Megarian trade throughout their empire (432), and in the Peloponnesian War, reduced their neighbours to misery by blockade and annual invasions. In 424 they nearly captured Megara, in collusion with a democratic party within the town, and secured Nisaea, which they held until 410. In the 4th century Megara recovered some measure of prosperity, but played an insignificant part in politics, and finally (243) was incorporated in the Achaean league (*q.v.*). It maintained itself as a place of some size in subsequent centuries, but was depopulated by the Venetians in A.D. 1500.

*See* E. L. Highbarger, *The History and Civilization of Ancient Megara* (1927); A. Philippson, *Die griechische Landschaften,* vol. i, part 3, pp. 940 ff. (1952).

**MEGARA HYBLAEA,** an ancient city on the east coast of Sicily, 12 mi. N.N.W. of Syracuse, founded about 728 B.C. by Megarian colonists. A hundred years later it founded Selinus. It was destroyed by Gelon about 483. In the Athenian expedition against Syracuse (415) Lamachus proposed (it being then deserted) to make it the Athenian base of operations; but this was not done, and in the next spring the Syracusans fortified it. It had a brief independent existence in the 4th century, when it coined (perhaps after Timoleon's expedition); but it is heard of mainly as a fortified place in 309 and in 214 (when Marcellus captured it). Fortifications discovered in modern excavations belong to the war against Sextus Pompeius (36 B.C.). Excavations begun in 1891 revealed part of the town wall, an extensive cemetery, many tombs of which have been explored, and a deposit of votive objects from a temple built over the ditch enclosing a Late Neolithic village of the Stentinello period. Excavations were resumed in 1949, after World War II; these uncovered part of the inhabited area and threw much light on the earliest years of the city. *See* also Hybla.

(T. J. Dn.)

**MEGARIAN SCHOOL OF PHILOSOPHY.** This school was founded at the beginning of the 4th century B.C. by Euclid (Eukleides) (*q.v.*) of Megara in Greece, a pupil of Socrates and the author of dialogues in the Socratic manner. The evidence for Euclid's teaching is fragmentary, but he is said to have held that "the good is one, though it is called by many names, sometimes wisdom, sometimes God and sometimes reason"; and that "the contrary to the good has no reality." These statements suggest that, besides the paramount influence of Socrates, a secondary influence operated from the first in the Megarian school, namely that of the Eleatics Parmenides and Zeno.

The Eleatics, however, started with the intention of proclaiming a view of reality and used their dialectic to shatter the objections of opponents. The Megarians, at least so long as Euclid himself was at the helm, had an ethical and educational purpose, and it was in this spirit that the unity of goodness was defended by them. They were, nevertheless, men of theory by comparison with other self-styled followers of Socrates, such as the Cyrenaics and Cynics. They consciously cultivated dialectical skill and could rightly claim that this was part of the master's procedure. It was the Socratic method of question and answer, rather than any positive doctrine, which linked them together. After Euclid's death (probably *c.* 365 B.C.), the practical and dialectical interests began to fall apart, and one wing of the school studied and propounded paradoxes in the manner of Zeno and otherwise advanced toward an independent treatment of logic.

Among Euclid's successors we know the names of Polyxenus and Bryson, the former of whom propounded the well-known "third man" objection to Plato's doctrine of ideas (*see* Universal). Eubulides (*q.v.*) took the lead in Megarian criticism of Aristotle. The objection was to Aristotle's doctrine of categories, to his definition of, and belief in, movement and to his concept of potentiality (according to the Megarians only that which is now actual is possible). Some passages in Aristotle's writings are probably retorts to Megarian criticism. Though the chronology is obscure, it is certainly Aristotle who should have the credit for making the first theoretical study of the forms of inference; but whereas Aristotelian logic was applicable to predicates or classes, the Megarians specialized in a complementary branch of logic, that of propositions. It was Chrysippus, a Stoic, who completed this work, but his debt to Megarian predecessors was evidently considerable. (*See* Logic, History of.)

Other Megarians were Diodorus Cronus (*q.v.*) and Stilpo, a representative of the older tradition inasmuch as he subordinated dialectic to a moral purpose. Stilpo was one of the teachers of the Stoic Zeno and of Menedemus (*q.v.*), leader of the Eretrian school. The Megarian school disappears from history at the beginning of the 3rd century B.C. and is notable more for its criticism of Aristotle and for its influence upon the Stoic logic than for any positive assertions.

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**MEGATHERIUM,** the largest of the ground sloths, an extinct group of edentate mammals related to the modern tree sloths. *See* GROUND SLOTH.

**MEGHNA,** a river of East Pakistan, which becomes the great estuary of the Bengal delta, carrying to the sea the main volume of the waters of the Ganges (Ganga) and the Jamuna (the main channel of the lower Brahmaputra river). These unite at Goalundo Ghat to form the Padma which farther down joins the Meghna at Chandpur, about 80 mi. from the sea. Total course is about 125 mi. The name Meghna is properly applied only to the channel of the old Brahmaputra from Bhairab Bazar downward after it has received the Surma or Barak from Sylhet, but some maps mark its headwaters as a small stream meandering through the Mymensingh district and joining the Brahmaputra near Bhairab Bazar. The Meghna is a mighty rolling flood of great depth and velocity, sometimes split up into half a dozen branches, at others a wide expanse of water, entering the Bay of Bengal by four principal mouths: the Tetulia, the Shahbazpur, the Meghna proper and the Bamni with Sandwip channel—enclosing 14 islands. The Meghna is navigable by large river boats and steamers all the year; but the navigation is difficult and sometimes dangerous because of shifting sandbanks and snags, or boisterous weather when the monsoon is blowing. The most favourable season is between November and February. Deposition of silt and its erosion are constantly taking place, especially along the seaboard. The regular rise of the tide is from 10 to 18 ft., and at spring tides the sea rushes up with a noise like thunder in a dangerous bore. It is greatest at the time of the equinoxes, when navigation is sometimes impeded for days. A still greater danger is the "storm wave" which occasionally sweeps up the Meghna under a cyclone. (K. S. AD.)

**MEGIDDO,** an important town of ancient Palestine, overlooking the plain of Esdraelon (valley of Jezreel); now called Tell al Mutesellim, it lies about 18 mi. S.S.E. of Haifa in northern Israel. Its strategic location gave the city an importance far beyond its size, which was about 13 ac. within the Solomonic walls, somewhat larger in the Bronze Age. Excavation of the site has proceeded through the 70 ft. of remains, including 20 strata, with a time span from the early 4th millennium B.C. to about 450 B.C. Harmagedon (Armageddon; *q.v.*) means the "hill of Megiddo."

**Strategic Position.**—Megiddo stands at the crossing of two important military and trade routes. For traffic between Egypt and Mesopotamia, it controls the most commonly used pass south of the Carmel ridge, leading also to the best route across the Esdraelon plain, much of which is marshy in the wet season. In addition, the natural northwest-southeast route along the edge of the plain goes by Megiddo, connecting the Phoenician cities with the Jordan depression and Jerusalem. Although the remark of Thutmose III of Egypt (1504–1450 B.C.), "The capture of Megiddo is the capture of 1,000 towns," referred primarily to the many princes whom he besieged there, he also illustrated the importance of the location itself.

**History.**—The first town on the site was built in the early 4th millennium B.C. It was captured by Thutmose III (*c.* 1468) when he surprised his opponents by making a swift approach through the pass south of the Carmel ridge. Nearly 400 Phoenician ivories (1350–1150 B.C.) were found at Megiddo, deriving their designs from various culture areas of the near east. Israel did not take Megiddo at the time of the conquest, but with other cities of the area it was taken later "when the people of Israel grew strong" (Josh. xvii, 11–13). Solomon rebuilt Megiddo as an important chariot city. Many of the stables excavated there probably go back to Solomon. They were well-built, with paved floors, stone mangers and stone pillars serving both as tie posts and as supports for the roof. Perhaps 500 horses could be stabled in this one city, illustrating both Solomon's chariotry and his horse trading. The city was guarded by impressive fortifications. A mutilated inscribed stela shows the occupation of Megiddo by Sheshonk (Shishak) I, who came to the throne of Egypt *c.* 945 B.C. King Ahaziah died at Megiddo (*c.* 842), and there King Josiah died (609), opposing the advance of Pharaoh Necho toward Assyria.

**Archaeology.**—The work of G. Schumacher (1903–05) for the Deutsche Orientgesellschaft was handicapped by lack of modern scientific method. The excavation by the Oriental institute of The University of Chicago, directed by C. S. Fisher (1925–27), P. L. O. Guy (1927–35) and Gordon Loud (1935–39), took advantage of large financial resources to proceed as scientifically as possible for that time. Several strata of the city were removed entirely (an unfortunate procedure, since nothing of these strata remains for more modern methods of investigation), and soundings were made down to the earliest occupation. (E. D. GR.)

**MEGIDDO, BATTLES OF.** For the principal battles fought in antiquity at Megiddo *see* MEGIDDO. It is considered probable that the word "Armageddon" (*q.v.*) is derived from Megiddo (the prefix *har* meaning in Hebrew "hill"). In modern times the battles of Megiddo are associated with the name of Gen. Edmund Allenby (later Field Marshal Viscount Allenby of Megiddo and Felixstowe), who commanded the British and imperial forces in Palestine during the latter part of World War I. It was on Sept. 19, 1918, and during the following days, at a number of points near Megiddo, that Allenby's cavalry, comprising British, Australian and Indian units, cut off the retreat of the Turkish 7th and 8th armies (which included German troops) after the victory of his infantry in the coastal plain. These brilliantly conceived operations led to the final defeat of the Turks and are regarded as classic examples of the use of cavalry in war and of the value of mobile forces.

**MEHEMET ALI:** *see* MOHAMMED ALI.

**MEHSANA,** a town and district located in Gujarat, India. The town, headquarters of the district, lies 40 mi. N.N.W. of Ahmedabad. Pop. (1961) 32,577. It was founded by the Chavada Rajputs (12th–14th centuries); the old town is believed to have had four gates of which only the Visnagari gate remains. Rajmahal, built by Sayajirao III in 1920–22, is an imposing structure. Mehsana is a junction on the metre-gauge section of the Western railway. It has an airfield but no regular service. Oil crushing and cotton ginning are the main industries.

MEHSANA DISTRICT (pop. [1961] 1,689,963; area 4,324 sq.mi.) was created out of the Kadi *prant* (district) of the former Baroda state and small jagirs (feudal estates). Patan to the northwest, capital of the Chavada and Solanki dynasties (720–1242), is the largest town. The Modhera sun temple built by Bhima I (1022–63) in the Chanasma subdivision, the Rani *wav* (step well) by his wife, Udyamati, and the Sahasralinga *talao* (pond), by Sidharaj (1093–1143), both in the Patan subdivision, are some of the historic monuments. Maneklal Nanchand college at Visnagar, established in 1946, is affiliated to Gujarat university. The main crops are millets, pulses, cotton, tobacco, wheat, castor and fodder. Kalol and Sidhpur are the cotton-ginning centres, and Patan is famous for *patolas* (handwoven cloth). Cotton, oilseeds and cereals are exported. (V. A. M. J.)

**MÉHUL, ÉTIENNE NICOLAS** (1763–1817), one of the principal French composers whose style reflected the ideals of the French Revolution. Born at Givet in the Ardennes on June 22, 1763, he studied in Paris from 1778 under Jean Frédéric Edelmann and in 1782 produced a cantata at the Concert Spirituel on a text by Jean Jacques Rousseau. Under the influence of Gluck he turned to dramatic music and between 1787 and 1822 wrote more than 40 operas, produced at the Opéra Comique, of which the most successful were *Le Jeune Henri* (1797), *Les Deux Aveugles de Tolède* (1806), *Uthal* (1806) and *Joseph* (1807). He also wrote patriotic works demanding great choral and orchestral resources to mark festive occasions of the Revolution, such as the *Hymne à la Raison*

(1793) and *Chant du Départ* (1794). In this sphere he was, with Cherubini and Lesueur, a predecessor of Berlioz. Though he had a bold sense of harmony and original gifts as a dramatist and orchestrator, he was poorly served by his librettists and only some of his overtures survived. Besides his dramatic works he wrote piano sonatas, chamber works and symphonic works. In the new musical spirit that broke through as a result of the Revolution his influence was, however, considerable, and his innovations were admired not only by Berlioz but also by Schubert, Weber and Beethoven. He died in Paris on Oct. 18, 1817.

*See* P. M. Masson, "L'Oeuvre dramatique de Méhul" in *Annales de l'Université de Paris* (1937); A. L. Ringer, "A French Symphonist at the Time of Beethoven" in *The Musical Quarterly* (Oct. 1951).

**MEIGHEN, ARTHUR** (1874–1960), Canadian statesman, Conservative leader and twice prime minister, was born on a farm near Anderson, Ont., on June 16, 1874. He was educated at St. Mary's collegiate institute and the University of Toronto. After teaching high school briefly he moved to Winnipeg and subsequently practised law at Portage la Prairie, Man. His political career began in 1908 when he was elected to parliament as Conservative member for Portage la Prairie. In 1913 he became solicitor general in Robert (later Sir Robert) Borden's ministry and in 1917 secretary of state and minister of mines. When the Conservatives and certain Liberals formed a coalition in Oct. 1917 he was appointed minister of the interior. He was a member of the Canadian delegation at the Imperial conference of 1918.

A brilliant debater and tireless worker, Meighen was prominent in formulating, expounding and defending the many controversial policies sponsored by the Borden government. He framed the closure rule, which for the first time permitted the limiting of debate in the house of commons. The statute imposing conscription in 1917 and the drastic alteration of the wartime franchise in the same year were largely his handiwork. He was chief author of the numerous enactments by which all major Canadian railways, except the Canadian Pacific railway, were nationalized. He also played an important part in working out the policy of soldier settlement on the land after World War I.

On July 10, 1920, when Meighen succeeded Borden as prime minister he was the youngest in Canadian history to hold that office. In June 1921 he attended the conference of prime ministers in London, where he waged a successful campaign against renewal of the Anglo-Japanese alliance. His government was defeated in the general election of Dec. 1921 and he became leader of the opposition. In the election of 1925 he led the Conservatives in a remarkable recovery but failed to win a majority of the seats, largely because of his unpopularity in Quebec where many of the policies he had supported in the past, especially conscription, had gained him the bitter enmity of the voters. In June 1926, however, he became prime minister again when Mackenzie King resigned. But Meighen's government was shortly defeated in the house of commons, as well as in the subsequent general election, and he retired from public life.

In 1932 he returned as government leader in the senate, serving until the defeat in 1935 of the Conservative ministry of Richard B. Bennett. In 1941 Meighen again became Conservative leader but, failing to win a seat in parliament in a by-election, he resigned the leadership once more.

Firmly believing in the maintenance of the ties between Great Britain and Canada, Meighen was convinced that the chief threat to Canada's national existence stemmed from the proximity and economic power of the United States. He was thus a stanch defender of the protective tariff system and of other measures which he believed would safeguard Canada from the industrial and financial might of her neighbour. Meighen died at Toronto on Aug. 5, 1960. (W. R. Gr.)

**MEIJI** (Mutsuhito) (1852–1912), emperor of Japan from 1867 to 1912 whose reign began with the transfer of rule from the hierarchy of feudal barons headed by the Tokugawa shogun to the throne; thereafter the social, economic, educational and political orders were reorganized along western lines as Japan rose from isolation to become one of the world's great powers. (*See* Japan: *History.*)

Meiji was born Nov. 3, 1852, and succeeded to the throne upon the death of his father, the emperor Kōmei, in 1867. He was officially crowned the following year. His name was Mutsuhito but he is known by the "year name," Meiji, which he adopted in 1868. During his youth Japan was dominated by the struggle over the treaties that the shogunate had been forced to sign with the western powers. National Shintō scholars had won much support for their doctrine that Japan was a superior nation by virtue of having a ruling house which, according to Shintō mythology, had been founded by the sun-goddess. The humiliating treaties signed by the shogunate were decidedly at variance with these teachings and they were seized upon by discontented and ambitious leaders in the great fiefs of southwestern Japan who sought to weaken the shogunate. These men had numerous allies among the prestigious but powerless nobles at the Kyōto court and Meiji's accession simplified their task.

When Tokugawa Keiki, the last shogun, resigned his powers to escape from the untenable position in which the alliance of court and feudal conspirators had placed him, the anti-Tokugawa forces around the young Meiji emperor maneuvered the shogun into a show of resistance against demands that he surrender all his feudal holdings. The result was a short war in which the "imperial army" from the southwestern fiefs subdued the Tokugawa centres of power in northern Japan.

Thereafter the young emperor was guided by a group of statesmen from the southwestern fiefs and a group of court nobles who immediately took steps to demonstrate that their antiforeign agitation had been chiefly a device to discomfit the Tokugawa. The young emperor's so-called charter oath of April 6, 1868, promised that public councils would be convened, "base customs" of former times would be abolished and knowledge would be sought throughout the world. With the abolition of the shogunate, ultimate power was declared to reside in the throne, preparing the way for sweeping reforms in education, military administration and constitutional organization. The emperor was now, in the language of the constitution of 1889, "sacred and inviolable"; the armed forces were responsible only to him; and the educational system instilled future subjects with obedience and loyalty to the emperor. The Meiji emperor was the first of his line to emerge from seclusion to spur his people on by inspection trips and public statements.

The emperor's part in these decisions is not fully clear. There is no reason to question his enthusiasm for the path that Japan took; he attended the meetings of the privy council in which the final language of the constitution was worked out and he showed much interest in the working of the parliamentary institutions thereafter. The respect and reverence his statesmen had for him were symbolized by the suicide with which General Nogi followed him in death in 1912. The correspondence and reminiscences of the Meiji leaders combine to give a picture of the emperor as earnest, devoted and able. Nevertheless, there is little doubt that while his personal wishes may have counted for a good deal toward the end of his reign when his personal relations with his principal advisers had a long history behind them, they did not count for very much in the tumultuous early years.

On the other hand, the emperor's role was central to the success of the reforms of his time. Sweeping changes were justified in terms of the return to personal rule by a sacred emperor and the revolution was described as a "return to antiquity." A department of religion made Shintō a proper function of the government of a divine emperor and every statement from the throne made clear that its prerogatives derived from ages past. Loyalties long focused upon local and regional lords were thus transferred to the emperor as the symbol of the nation; from this derived much of the patriotic fervour and single-minded enthusiasm that made modern Japan a united and disciplined nation. The Meiji emperor, in his inspection tours from his new residence in Tokyo (Eastern Capital, the former shogun's city of Edo), was in many respects the essential link whereby the ancient teachings were shown to point the way toward a greater, modernized Japan. The emperor died July 30, 1912, and was succeeded by his son Yoshihito, Taishō. (M. B. J.)

**MEIKTILA,** a district in the Mandalay division of Burma, lies in the Dry Zone, but it also includes a strip of the wetter, forested Shan plateau on the east. Area 2,232 sq.mi.; population, mostly Burmese Buddhists (1962 est.) 428,130. Except for this strip it is a slightly undulating plain with stretches of dark "cotton" soil. It has a low, uncertain rainfall and the climate is healthful except in eastern tracts, though, as in Mandalay, the temperature rises in the afternoons to over 38° C. (100° F.) from March to June. The chief agricultural products are rice (grown on land irrigated by streams from the Shan plateau), sesame, cotton, peanuts, peas, maize (corn), millet and gram. In the heart of the district is the interesting Meiktila lake, an ancient irrigation reservoir which according to Burmese legend was begun about 400 B.C. by the grandfather of Gautama Buddha. It is 7 mi. long, averages half a mile broad and covers an area of 3½ sq.mi. With the Minhla and other connected lakes it irrigates a large extent of country and supplies good drinking water.

MEIKTILA town (pop. [1953] 25,180), on the banks of the lake, is the district headquarters. A branch railway continues northwestward to its terminus on the Irrawaddy at Myingyan from Thazi station and connects it with the Rangoon-Mandalay line. Eastward from Thazi the Shan state railway ascends the plateau to the hill station of Kalaw, picturesquely situated in an open woodland of pine (*Pinus khasya*), and 35 mi. beyond. (L. D. S.)

**MEILLET, ANTOINE** (1866–1936), French linguist, specialist in the Indo-European languages, was born at Moulins, Nov. 11, 1866. A professor at the École des Hautes Études and the Collège de France, he was the originator of the peripheral theory of linguistic differentiation, a refinement of the so-called wave theory, which itself had supplanted the view that languages diverge from a parent stock sharply and finally, as do branches from a tree. According to the wave theory, genetically related languages spread out in successive and overlapping waves from a common centre, being influenced constantly by all phenomena which they encounter; thus geographically contiguous dialects and languages are likely to be more similar one to the other than those at widely separated points on the periphery of the linguistic area. The peripheral theory accounts for exceptions to this view (such as certain similarities in the Italo-Celtic and Indo-Iranian languages) by the proposal that languages on the periphery, being less disturbed by successive waves from the centre, may retain some archaic characteristics in common.

Meillet's *Introduction à l'étude comparative des langues indo-européennes* (1903) is thus written from a theoretical viewpoint different from that of the otherwise similar work of Karl Brugmann (*q.v.*) and Hermann Hirt (*q.v.*); it has gone through several editions and remains one of the authoritative books on the subject. His *Aperçu d'une histoire de la langue grecque* (1913, 1935) and his *Esquisse d'une histoire de la langue latine* (1928, 1933) are models of their kind. Meillet died at Châteaumeillant, Sept. 21, 1936.

A complete bibliography is published in the *Bulletin de la Société de Linguistique de Paris*, no. 38 (1937). (My. F.)

**MEINECKE, FRIEDRICH** (1862–1954), German historian, a leading exponent of the history of ideas, was born in Salzwedel, Prussia, on Oct. 30, 1862. He was professor in Strasbourg (1901), Freiburg im Breisgau (1906) and Berlin (1914–28), editor of the *Historische Zeitschrift* (1893–1935) and head of the Historische Reichskommission (1930–35). He died in Berlin on Feb. 6, 1954.

The trilogy of his main works (which were accompanied by numerous smaller historical and political publications) shows how his scholarly thinking developed in accordance with contemporary events. In *Weltbürgertum und Nationalstaat* (1908) he is the optimistic advocate of a national state which is to be based on justice and civilization. The inner dualism of the *Idee der Staatsräson* (1924; Eng. trans., *Machiavellism; the Doctrine of Raison d'état*, 1957) reflects the tragic antinomy of ethics and power politics, of value and causality, in which Meinecke found himself involved as a result of World War I. The insoluble problem of freedom and necessity is finally treated in *Die Entstehung des Historismus* (1936) in the form of a history of the development of historical consciousness. In this the German concept of individuality, which is founded on metaphysics and culminates in Goethe and Ranke, appears as the peak of modern western thought. As a political critic, Meinecke developed from an admirer of Bismarck into a liberal democrat. He rejected the hubris of the National Socialist totalitarian state, and after 1945 appealed for a renewed consciousness of the humanist values of German history.

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**MEINONG, ALEXIUS** (1853–1920), Austrian philosopher and psychologist, celebrated for his *Gegenstandstheorie*, was born in Lemberg on July 17, 1853. A pupil of Franz Brentano (*q.v.*) in Vienna from 1875 to 1878, he became in 1882 extraordinary professor and in 1889 ordinary professor of philosophy at Graz, where he remained until his death on Nov. 27, 1920. Among his more important writings are *Über Annahmen* (1902; 2nd ed., 1910), a study of supposals; *Über Möglichkeit und Wahrscheinlichkeit* (1915); *Über emotionale Präsentation* (1917); and the articles collected as *Gesammelte Abhandlungen*, 2 vol. (1913–14; 2nd ed., 1929).

Meinong's theory is rooted in the philosophical psychology of Brentano. He assumes throughout that "intentionality" or directedness-to-objects is the basic feature of mental states, but draws a distinction between two aspects of every experience: (1) a content (*Inhalt*), which gives it a direction to one particular object rather than another; and (2) an act, which represents the manner in which the experience approaches its object. Mental states are classified into (1) presentations (*Vorstellungen*); (2) thought experiences, which include judgments and certain judgmentlike experiences, of which the most interesting are supposals (*Annahmen*); (3) emotions; and (4) desires.

Meinong's most original contribution to philosophy lies in his object theory (*Gegenstandstheorie*), in which he postulates many classes of mind-independent objects corresponding to various kinds of mental approach.

Among the objects of presentation are particular things and their qualities, whose being (if they have any) is existence (*Existenz*), and relations and relational complexes, whose being (if they have any) is subsistence (*Bestand*). The objects of the thought experiences are called "objectives": these correspond to the objective propositions of Moore and Russell, they may be facts or nonfacts, and, if they are facts, they subsist. To emotions there correspond "dignitatives" (the agreeable, the beautiful, the true and the good); and to desires "desideratives" (various types of "ought"). Meinong holds, further, that objects remain objects and have a definite character and definite properties (*Sosein*) even if they have no being (*Sein*): thus a golden mountain is golden and is a mountain, even though no such object exists. Meinong did not teach that nonexistent objects enjoyed subsistence, though Russell imputed this doctrine to him and was led by it to his own theory of descriptions.

*See* G. Dawes Hick's "The Philosophical Researches of Meinong," in *Mind*, "New Series," 31 (1922), reprinted in *Critical Realism* (1938); J. N. Findlay, *Meinong's Theory of Objects* (1933). (J. N. F.)

**MEÏR,** Jewish rabbi of the 2nd century A.D., was born in Asia Minor. He was the most notable of the disciples of Akiba ben Joseph, and after the Hadrianic repressions of A.D. 135 was instrumental in refounding the Palestinian schools at Usha. Among his teachers was also Elisha ben Abuyah (*q.v.*), and Meïr continued to be devoted to Elisha after the latter's apostasy. Meïr's wife, Beruriah, a daughter of the martyr Hananiah ben Teradion, is often cited in the Talmud as an exemplar of generosity and faith. Meir himself was the author of many famous sayings. His wisdom was proverbial, and to him in particular was assigned an intimate acquaintance with fables. "With the death of Rabbi Meir," says the Mishnah, "fabulists ceased to be." Meïr contributed largely to the material from which finally emerged the Mishnah (*see* TALMUD). Of his great dialectic skill it was said jestingly that he could give 150 reasons to prove a thing clean and 150 to prove it unclean. His balanced judgment fitted him to

carry on Akiba's work, sifting and arranging the oral traditions, and thus preparing the ground for the Mishnaic code. Meïr left Palestine some time before his death, owing to disagreements between him and the patriarch. He died in Asia Minor.

**MEIR** OF ROTHENBURG (*c.* 1215–1293), the greatest rabbinical authority of German Jewry of the 13th century, was born in Worms. He studied under the French glossators (*tosaphists*) in Paris, where he witnessed, in 1242 or 1244, the public burning of the Talmud.

On settling in Rothenburg and opening a Talmudic school there, he soon became famous as an authority on rabbinic law. His *responsa* (answers to questions regarding law and ritual) contain elaborate discussions of the democratic principles underlying community government of his day. For nearly half a century he acted as the supreme court of appeals for Germany and surrounding countries. When in 1286 Emperor Rudolf I attempted to abrogate the political freedom of the Jews, and to force upon them the status of *servi camerae* ("serfs of the treasury"), Meir became the central figure in the tremendous struggle for freedom that ensued. Eventually he led a mass exodus out of Germany. After crossing the Alps, however, he was apprehended, brought back and imprisoned. Since the struggle of the Jews for freedom continued unabated, he was kept in prison as a pawn in the political game until his death in 1293; and his body was not delivered for burial until 1307.

Meir wrote glosses to the Talmud (*tosaphoth*) and numerous *responsa* of the utmost value for historical research. His main teachings, however, were included in numerous literary compositions by his disciples, compositions that became classical textbooks of law and ritual for Ashkenazic Jews of all subsequent generations.

*See* L. Ginzberg, in *Jewish Encyclopedia*, vol. viii; Irving A. Agus, *Rabbi Meir of Rothenburg* (1947). (I. A. A.)

**MEISSEN,** a mark or margraviate of eastern Germany in the middle ages, sometimes known in English under its latinized name MISNIA. It had as its nucleus the castle and town of Meissen, founded in 929 by the German king Henry I to hold the line of the middle Elbe river against the Slavs. Having been included in the great Saxon East mark under the margrave Gero, the Meissen area constituted one of the five districts into which the Holy Roman emperor Otto I split the East mark on Gero's death (965). In 985 the empress Theophano granted the office of margrave of Meissen to Ekkard or Ekkehard I, margrave of Merseburg, in recognition of his services in ensuring the succession to the throne for her son, the young Otto III. Ekkard enjoyed a high military reputation and was a candidate for election to the German throne after Otto III's death in 1002, but was assassinated near Pöhlde on April 30 of that year, possibly by agents of the successful candidate, Henry II. The margraviate passed in succession to Ekkard's eldest son, Hermann, who died in 1032, and to the latter's brother, Ekkard II, who died without male issue in 1046. It was next granted in turn to William and Otto, counts of Weimar, then, in 1067, to Ekbert I, count of Brunswick, who died in 1068. Ekbert's son and successor, Ekbert II, violent and unscrupulous, aspired to the German throne in opposition to King Henry IV but was condemned in 1089 and slain in 1090. Henry IV bestowed Meissen on Henry I of Eilenburg, count of Wettin, whose son Henry II succeeded him in 1103 and died childless in 1123. Then, in opposition to Conrad of Wettin, who was the nominee of Lothair of Saxony (later emperor as Lothair II), the emperor Henry V appointed Hermann of Winzenburg to the margraviate of Meissen. Hermann, however, was charged by Lothair with high treason in 1130, and the house of Wettin was then confirmed in the hereditary possession of Meissen. (*See* WETTIN.)

Conrad of Wettin abdicated in 1156 in favour of his son Otto the Rich (d. 1190), who profited from the exploitation of the silver, lead and copper deposits of the Erzgebirge, where he founded Freiberg. On the death of Otto's elder son, Albert the Proud, without issue in 1195, the emperor Henry VI seized Meissen as a vacant fief of the empire; but Albert's brother Dietrich the Oppressed obtained possession after the emperor's death in 1197. Dietrich's marriage to Jutta, daughter of Hermann I, landgrave of Thuringia, gave to his son Henry the Illustrious, who succeeded to Meissen in 1221, a claim to Thuringia, which he finally vindicated in 1263. At Henry's death in 1288 Meissen passed to his grandson Frederick Tuta and, after the death of Frederick Tuta in 1291, to the surviving grandsons, Frederick the Peaceful and Dietrich. The German kings Adolf of Nassau and Albert I intervened to claim Meissen as a vacant fief, but Frederick the Peaceful, left sole heir by the death of his brother Dietrich in 1307, was invested with Meissen and Thuringia by the German king Henry VII in 1310 and thus reunited all Wettin possessions.

Frederick the Peaceful was succeeded in 1324 by Frederick II the Grave (der Ernsthafte). A strenuous warrior, Frederick II combined with the emperor Louis IV the Bavarian to combat the rising power of Bohemia, which was then spreading over Lusatia on his eastern border. He declined, however, to become a candidate for the German throne on Louis IV's death in 1347. After Frederick II's death in 1349 his territories were governed jointly by his three sons. The eldest of these, Frederick III the Stern, died in 1381; and by the agreement of Chemnitz (1382) Meissen was assigned to the younger of the surviving brothers, William I. William died in 1407 without direct heirs. His successor, Frederick III's son Frederick IV the Warlike, was in 1423 granted the electoral duchy of Saxony (*q.v.*) by the emperor Sigismund, who required his continuous aid against the rebellious Hussites of Bohemia. The mark of Meissen was thus merged in the duchy of Saxony.

*See* R. Kötzschke, *Sächsische Geschichte,* vol. i (1935); S. Lüpke, *Die Markgrafen der sächsischen Ostmarken* (1937). (C. C. BA.)

**MEISSEN,** a town of Germany in the *Bezirk* (district) of Dresden, which after partition of the nation following World War II became part of the German Democratic Republic. It is situated on the Elbe about 23 km. (14 mi.) N.W. of Dresden city by road. Pop. (1961 est.) 47,874. The town is dominated by the group of Gothic cathedral buildings erected in the 13th and 14th centuries and the Albrechtsburg castle built in the 15th century. There are various educational establishments. Railways run to Dresden and Leipzig.

Extensive deposits of china clay and potter's earth southwest of the town are the basis for the predominant porcelain and ceramic industry. The Meissen state porcelain manufacture, founded in 1710, is the oldest of its type in Europe. The alchemist J. F. Böttger, seeking a formula for producing gold, discovered the process of producing reddish brown and, shortly afterward, white porcelain (white gold) in 1709. Meissen porcelain (commonly known as Dresden china) is marked with the crossed blue swords, the coat of arms of the elector of Saxony. There is also a plant for producing Russian leather, and engineering and metal goods plants. Wine is produced in the surrounding vineyards. The town grew out of the early Slavic settlement Misni and was founded in 929 by King Henry I as Meissen. It became a diocese in 968 which, in 1123, came into the possession of the house of Wettin. In 1559 the diocese accepted the Reformation and in 1921 the seat of the bishop was moved to Bautzen. Meissen, which received its municipal charter in the 13th century, was the seat of the margraves of Meissen until 1423 and after that date it was the residence of the electors of Saxony.

*See* also references under "Meissen" in the Index.

**MEISSONIER, JEAN LOUIS ERNEST** (1815–1891), French painter and illustrator of military and historical subjects, was born at Lyons on Feb. 21, 1815. He studied first under Jules Potier, then in the studio of Léon Cogniet and first exhibited at the Salon in 1834 the picture "Les Bourgeois Flamands," which is possibly the one afterward in the Wallace collection, London, entitled "Dutch Burghers." In his early years Meissonier spent much time making illustrations for the publishers Curmer and Hetzel, but he exhibited regularly at the Salon and received the highest official honours from the middle of the 1840s onward. He died in Paris on Jan. 31, 1891.

The greater part of Meissonier's painting is on a small scale and is concerned with military subjects or with genre in a historical setting. "Solferino" (1863) and "La Rixe" (1855) are examples in these two categories, though both pictures are some-

what larger than usual. Meissonier's minute and scrupulous technique was largely derived from the study of Dutch painters of the 17th century, but the documentary approach of his preparatory study of costume and armour and of his detailed observation of nature (such as his systematic analysis of the movements of horses) links him with the scientific spirit of the 19th century.

The largest collection of Meissonier's pictures is in the Louvre, Paris, and includes "Self-portrait" (1889), "L'homme a l'épée" (1851), "Les amateurs de peinture" (1860), "Napoleon III at Solferino" (1863) and "Campagne de France, 1814" (1864). The 16 pictures in the Wallace collection include "The Hired Assassins" (1852) and "The Roadside Inn" (1865).

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**MEISSONIER, JUSTE AURÈLE** (1675 or 1693–1750), French goldsmith, architect and interior decorator, also sculptor and painter, was born at Turin, Italy, in 1675 or 1693. He early migrated to Paris, where he worked until his death, July 31, 1750.

Meissonier's powerful and fertile imagination, his animated, unsymmetrical compositions uniting the most contrasting, original motifs, raised him to leadership among the insurgent creators of the rococo, a style of considerable though short-lived influence. He received his warrant as master goldsmith from Louis XV in 1724 and was appointed designer for the king's bedchamber and cabinet in 1726. Meissonier's fine sketches for interior decoration, furniture and goldsmith's work can be seen in his well-known collections: *Livre d'ornements en trente pièces*, *Livre d'orfèvrerie d'église en six pièces* and *Ornements de la carte chronologique du roi*. He ranged with equal facility from snuffboxes to watch cases or to sword hilts. As a goldsmith, moreover, he was especially remarkable for the boldness of his conceptions; *e.g.*, the two tureens and the centrepiece for a table supplied to the duke of Kingston in 1735.

As an architect Meissonier distinguished himself with a plan for the façade of the church of St. Sulpice in Paris; and Count Bielinski, grand marshal of the court of Poland, commissioned him for the decoration of his drawing room. Meissonier also planned the details of the firework display in honour of the birth of Louis XV's son, the dauphin.

*See* H. Nocq, *Le Poinçon de Paris*, vol. iii, p. 225 (1928). (S. GR.)

**MEISTERSINGER,** the name used by certain German musicians and poets, chiefly of the artisan and trading classes, in the 14th, 15th and 16th centuries. They claimed to be heirs of 12 old "masters," accomplished poets skilled in the medieval *artes* and in musical theory (Heinrich von Meissen, called "Frauenlob" [*q.v.*] was said to be their founder); their true predecessors, however, were probably fraternities of laymen, trained to sing in church and elsewhere. Later—since music and poetry were "crafts" to be taught and learned—these fraternities became *Singschulen* ("song schools"), organized like craft guilds; and their principal activity became the holding—still in church—of singing competitions. Composition was restricted to fitting new words to tunes ascribed to the old masters; subject matter, metre, language and performance were governed by an increasingly strict code of rules (*Tabulatur*). These deadening restrictions led Hans Folz, a barber-surgeon from Worms (died *c.* 1515), to persuade the Nürnberg *Singschule* to permit a wider range of subjects and the composition of new tunes. These reforms, adopted elsewhere, restored some life to the *Singschulen;* henceforth a member, having passed through the grades of *Schüler*, *Schulfreund*, *Singer* and *Dichter*, became a "master" by having a tune of his own approved by the *Merker* ("adjudicators"). In this freer atmosphere Hans Sachs (*q.v.*) flourished—though some regard the 16th century as a period of decline rather than of flourishing.

Nevertheless, music, form and subject matter remained remarkably constant through the centuries. The music, derived from Gregorian chant, determined the metre (*Ton* meant both "metre" and "melody"). Each strophe (*Gesätz*) consisted of two identical *Stollen*, forming the *Aufgesang*, and an *Abgesang* with its separate metrical scheme—a form derived from *Minnesang*. Verses were based on syllable counting regardless of stress or quantity; rhyme schemes were often elaborate. Three strophes, or a multiple of three, constituted a song (*Bar*); for large subjects several *Töne* were used. Songs were unaccompanied solos. For the *Singschulen* in church a wide range of religious subjects (*e.g.*, the nature of the Trinity, episodes from the Bible and from Jewish history, praise of the Virgin Mary) were versified, learnedly but without much original thought; after the Reformation the text of Luther's Bible was rigidly adhered to. From the 15th century serious secular subjects are also found. At the *Zechsingen*, held afterward in a tavern (perhaps not an official part of the *Singschule*), subjects were humorous, sometimes obscene.

From the earliest centres, Mainz, Worms and Strasbourg, the movement spread all over south Germany and to Silesia and Bohemia; north Germany had individual *Meistersinger*, but no *Singschulen*. The best documented centre is Nürnberg. The *Meistersinger* were not popular figures, as Wagner's opera *Die Meistersinger* suggests; they were largely ignored by professional men, humanists and the general populace, their craft was esoteric and their songs were not published. They produced few outstanding artists or songs. Their importance lies rather in their devotion to their art in a troubled age and in their constant efforts to inculcate religious and moral principles. After 1600, attempts—mostly unsuccessful—at modernization were made; but the *Singschulen* slowly declined and disappeared, though the last one, at Memmingen, was not disbanded until 1875.

BIBLIOGRAPHY.—Collections are *Meisterlieder der Kolmarer Handschrift*, ed. by K. Bartsch (1862); *Die Meisterlieder des Hans Folz*, ed. by A. L. Mayer (1908). Full discussion and bibliography in A. Taylor, *The Literary History of Meistergesang* (1937); W. Stammler, *Von der Mystik zum Barock*, 2nd ed. (1950); B. Nagel, *Der Deutsche Meistersang* (1952). (J. R. WE.)

**MEITHEI,** also known as MANIPURI, the dominant population of the valley of Manipur (*q.v.*) in the Republic of India, which at one time was inhabited entirely by peoples resembling such hill tribes as the Naga (*q.v.*) and Kuki. Intermarriage and the political dominance of the strongest tribes led to a gradual merging of ethnic groups and the formation finally of the Meithei people, numbering about 300,000 in the 1960s. They are divided into exogamous clans, the most prominent of which provided the maharaja, while another clan traditionally furnished a bride for the ruler.

They are genetically Mongoloid and speak a Tibeto-Burman language allied to the Kuki dialect, but differ culturally from the surrounding hill tribes by following Hindu customs. Vishnuism was proclaimed the state religion in the first half of the 18th century and the Meithei now claim Kshatriya (*q.v.*) status and wear the sacred thread (*see* HINDUISM). Their Brahman priests have immigrated from Bengal and it is probably largely due to them that the Meithei have adopted many of the customs and restrictions of high-caste Hindus. They abstain from meat (though they eat fish), do not drink alcohol, observe rigid rules against ritual pollution and revere the cow. Before their conversion to Hinduism, they were meat eaters, sacrificed cattle and practised headhunting. The worship of Hindu gods, with especial devotion to Krishna, has not precluded the cult of many pre-Hindu indigenous deities and spirits and this even receives official patronage.

Rice cultivation on irrigated fields is the basis of their economy; men plow but women do most of the other agricultural work and in addition engage in marketing and small-scale business. Meithei are keen horse breeders, and polo is a national game. Hockey, boat races, theatrical performances and dancing (famous throughout India as Manipuri style) are other pastimes (*see* DANCE: *The Orient*).

With the end of princely rule in India, the maharaja, previously the divine head of the state, lost his secular power but retains some ritual functions. Christian missions, though otherwise strong in Manipur, have made no impact on the Meithei. *See* also TIBETO-BURMAN LANGUAGES.

BIBLIOGRAPHY.—T. C. Hodson, *The Meitheis* (1908); J. Roy, *History of Manipur* (1958); D. N. Majumdar, *Races and Cultures of India*, 4th ed. (1961). (C. V. F.-H.)

**MEITNER, LISE** (1878– ), a distinguished Austrian physicist, whose main personal achievement (among many others)

was the elucidation of the relation between beta and gamma rays, was born in Vienna on Nov. 7, 1878, the third of eight children of a Viennese lawyer. In 1901 she entered the University of Vienna, where Ludwig Boltzmann's lectures confirmed her desire to do research in physics. After her doctorate (1906) she went to Berlin in 1907 and joined the chemist Otto Hahn in research on radioactivity; she also studied under Max Planck and for a time was his assistant. In 1913 she became a member of the Kaiser Wilhelm Institute for Chemistry and in 1917 was made head of its physics section and joint director with Otto Hahn (*q.v.*). During their three decades of joint work she and Hahn discovered protactinium and several other radioactive substances. She was made a professor of physics at the University of Berlin in 1926.

When in 1938 Nazi Germany occupied Austria, she went to Sweden where she continued her scientific work until her retirement to England in 1960. Hahn and F. Strassmann continued their work on the effect of neutrons on uranium and soon reported the discovery of the production of much lighter elements. Lise Meitner, with her nephew Otto R. Frisch, after elucidating the physical characteristics of this division of a heavy atomic nucleus, proposed, early in 1939, the name fission for the process.

Lise Meitner was elected a member of many scientific academies and was the recipient of numerous academic and other honours. *See* also RADIOACTIVITY; ATOMIC ENERGY: *Uranium Fission.*

*See* E. Yost, "Lise Meitner: Physicist," *Science Digest*, vol. 51 (1962). (O. R. F.)

**MEKHITARISTS,** a congregation of Roman Catholic Armenian monks, were founded in Constantinople in 1701 by the Armenian priest Mekhitar of Sebaste (1676–1749). Mekhitarists, whose rule is based on that of St. Benedict, have two branches founded after they were driven from Constantinople in 1703: one (1717) on the Island of San Lazzaro, Venice, Italy (Ordo Mechitaristarum Venetiarum), which was given to the community by the Venetian senate; the other, first in Trieste (1773), then after 1811, in Vienna (Ordo Mechitaristarum Vindobonensis). Both monasteries are noted for scholarly publications and sponsor several educational institutions for Armenians. *See* also ARMENIAN LITERATURE.

BIBLIOGRAPHY.—Minas Nurikhan, *The Life and Times of the Servant of God Abbot Mechitar* (1915); P. Vahan Inglisian, *Der Diener Gottes Mechithar Von Sebaste* (1929); *San Lazzaro: the Armenian Monastery Near Venice* (1938); Luke Arakelian, *The New Bishop and His 250 Year Old Monastery* (1951). (L. G. A.)

**MEKNÈS** (MEQUINEZ), a city of central Morocco, capital of Meknès province, about 70 mi. from the Atlantic and 36 mi. W.S.W. of Fès. Pop. (1960) 175,943. Meknès lies on a long spur in a vast, fertile plain on the road to Rabat. It is connected by rail with Fès, Tangier and Casablanca. The airport is east of the city. The town wall, with its four-cornered towers, is pierced by nine gates. A lower wall of wider circuit protects the luxuriant gardens in the outskirts. Meknès, at a distance, appears to be a city of palaces, but it possesses few buildings of any note except the palace and the mosque of Mulay Ismail, which serves as the royal burying place. The palace, founded in 1634, was described by John Windus in his *Journey to Mequinez* (1725) as "about four miles in circumference, the whole building exceeding massy, and the walls in every part very thick; the outward one is about a mile long and 25 ft. thick." The interior is composed of oblong courtyards surrounded by buildings and arcades. The new town, established under the French protectorate, is separated from the old by the Oued bou Fekrane. The carpets for which Meknès is noted are woven chiefly by Berber women of the Middle Atlas. Industries include woolen mills, cement and metalwork manufactures, distillation of essential oils, and fruit and vegetable processing and canning.

Meknès was founded in the 10th century by the Zenata tribe of the Miknassa, as a group of villages among the olive orchards. Then, in the 11th century, the Almoravids built a citadel there, Takarart, which became the nucleus of the present Muslim town. In the 17th century Mulay Ismail, of the Moroccan Filali dynasty, established his capital at Meknès, where he erected the buildings that have earned for it the name of the "Versailles of Morocco." After his death the town ceased to be the capital, and declined accordingly.

MEKNÈS PROVINCE includes the *cercles* of Azrou, El Hajeb, Khénifra and Meknès-Banlieue. Pop. (1960) 577,137. To the east is Fès province, to the west Rabat. The Middle Atlas mountains, inhabited largely by Berber shepherd tribes, dominate the province. Azrou and Ifrane are mountain resort towns.

(A. AM.; X.)

**MEKONG** (Chinese LAN-TS'ANG CHIANG; Thai MAE NAM KHONG), one of the greatest rivers of Asia, rises in Tsinghai province in the Tibetan highlands and travels about 2,500 mi. in a generally southerly direction to the South China sea. For the first 750 mi. of its course the Mekong's catchment area is restricted to a narrow zone, where there are few tributaries of any size. For most of this distance the Mekong is paralleled by equally great rivers, as little as 20 mi. apart in places: the Salween to the west and the Yangtze to the east. Mountain ranges often exceeding 15,000 ft. separate the three deep valleys. In the Chinese province of Yünnan the catchment area widens and the Mekong receives several minor tributaries on either bank. The country is still ruggedly mountainous but less elevated than farther north; settlements are more numerous, although they generally avoid the valley itself. South of latitude 22° N. the river forms the international boundary between Burma and Laos, and Thailand and Laos. From the 20° parallel it flows in Laos until, after crossing latitude 18°, it again divides Thailand and Laos. Settlement is sparse in these hilly areas. Isolated rice-growing alluvial plains support higher densities of population and give rise to towns such as Luang Prabang (royal capital of Laos and limit of navigation) and Vientiane (administrative capital of Laos). Villages line the narrow river plain which extends from Vientiane to Savannakhet. In this stretch the river is navigable, but south of Savannakhet the Mekong is again entrenched in a rocky gorge containing several sections of rapids which hamper the development of navigation. Powerful boats can pass between Savannakhet and the confluence of the Nam Mune at medium water. The Mune is the principal right-bank tributary of the Mekong. It drains the Korat plateau of northeast Thailand and joins the Mekong at Pakmun, below which the Mekong again flows through Laos. It branches above Khong, the western branch then forming the frontier between Laos and Cambodia for a short distance. Left-bank tributaries draining the slopes of the plateaus of Laos and Vietnam include the Nam Theun, Se Noi, Se Bang Hieng and Se Kong-Se San-Srepok. Below the town of Khong the Khone falls, which drop 72 ft. in 6½ mi., are a major obstacle to navigation but represent considerable hydroelectric potential. From this point the river flows southward through Cambodia. As far as Kratie the Mekong continues in a slightly incised rocky course before turning west and southwest and entering its alluvial plain. This widens below Kompong Cham to join the flood plain of the Grand Lac (Tonlé Sap), the seasonally fluctuating lake in the heart of Cambodia. The Tonlé Sap acts as a natural flood protection for the Mekong delta. At high level (in midsummer) water from the Mekong flows through the channel (just above Phnom Penh) into the Tonlé Sap, which expands from about 1,050 sq.mi. to about three times that extent. As the Mekong floods subside, the Tonlé Sap re-establishes its normal flow toward the Mekong. The lake is an important fishery, and among the most productive in the world, yielding as much as 26 tons of fish per square mile.

At Phnom Penh (*q.v.*), the capital of Cambodia and a major port and trade centre on the river, the Mekong turns southeast and south and starts its deltaic course, throwing off distributaries, chief among them being the Bassac. Settlement is relatively dense in the alluvial sections of the Mekong basin, particularly in the delta proper, most of which lies within South Vietnam and constitutes one of the great rice-growing areas of Asia. Considerable use is made of the river for irrigation within the delta, but works are on a small scale. The main towns within the delta are Phnom Penh, Vinh Long, Can Tho and Tra Vinh. Saigon (*q.v.*), the capital of South Vietnam, lies to the east of the

delta proper. Settlement is most dense in the centre and east of the delta, which has been longest developed. The Plaine des Jones in the northeast of the delta is sparsely occupied, however, because of its swamps and alum soils. The western and southern parts of the delta are still undergoing colonization with the help of swamp drainage works and communication canals.

The regime of the Mekong is characteristically monsoonal, the mean low rate of discharge at Phnom Penh being of the order of 60,000 cu.ft. per second, and the mean maximum 1,377,000 cu.ft. per second. Peak discharge occurs between August and November, falling off rapidly to a low rate from January to May.

(B. L. C. J.)

**MELA, POMPONIUS,** of Tingentera (Algeciras?) in southern Spain, the earliest Latin geographer, who wrote *De Chorographia*, a short handbook for the general reader, about A.D. 43 or 44. According to Mela the earth, at the centre of the universe, was divided into five zones; the two temperate ones were habitable, but only one of them (the northern one) was known. The surrounding ocean cut into it in four seas, the most important of them the Mediterranean. Mela followed the coast line of the Mediterranean anticlockwise from the Straits of Gibraltar and listed islands (books i and ii). Then (book iii) he moved clockwise round the ocean coasts of Europe, Asia and Africa (of which he knew little); he mentioned islands at convenient intervals, but often neglected the interior.

Mela laid no claim to originality; his information, in fact, was frequently obsolete. Thus he repeated a theory (abandoned generations earlier) giving the Danube both an Adriatic and a Black sea mouth. His style showed echoes of Sallust's geographical passages and he aimed at being readable. Thus he avoided technical details, like distances and orientations, and, though he occasionally gave bare lists, he usually selected the significant and in a short phrase indicated the interest of places mentioned. Less was said of familiar regions than of distant countries, where even fabulous material was freely admitted.

Mela was used by the elder Pliny and is occasionally cited by later writers.

*See* C. Frick (ed.), *De Chorographia* (1880). (E. Ba.)

**MELAMPUS,** in Greek mythology, a seer, son of Amythaon and Eidomene, who as a child received understanding of the language of birds after two young snakes, whose lives he had saved, licked his ears when he was asleep. He helped his brother Bias to marry Pero, daughter of King Neleus of Pylos, by attempting to steal the cattle of King Phylacus of Phylace. Imprisoned by Phylacus, Melampus was released after overhearing the conversation among some woodworms, which enabled him to foretell the fall of a roof. Eventually he received the cattle as a reward for curing the impotence of Phylacus' son Iphicles. According to an unrelated legend, Melampus cured the insanity of the daughters of Proitus, prince of Tiryns; he and Bias then married two of them. Pausanias says there was a shrine to Melampus at Aegosthena (Megaris) and an annual festival. The Melampodidae, a family or school of seers, existed in historical times. Fragments survive of a poem about Melampus called *Melampodeia*, wrongly ascribed to Hesiod.

**MELANAU,** an indigenous, proto-Malayan people of Sarawak (*q.v.*). Numbering about 45,000 in the 1960s, they occupy the Rajang delta and the lower tidal reaches of the Oya, Mukah, Balingian, Bintulu and other rivers in the third and fourth divisions of Sarawak. A brachycephalic people of medium height, with broad faces, black hair and cinnamon-coloured skin, they are allied ethnologically to various communities of the middle and upper Rajang river (e.g., Kanowit, Tanjong, Skapan, Kejaman), and are the descendants of the ancient inhabitants of this part of Borneo.

Formerly they were a long-house people with a distinctive culture but, following long domination by an aristocracy of Brunei Malay origin and Muslim faith, the Melanau have largely deserted their traditional ways. Thus at mid-20th century about 74% of the Melanau were Muslims, 2% Christians and the remainder pagans. (The term Melanau is of Brunei Malay origin; the Melanau themselves use the phrase *A Liko*, meaning "the people of the river." The name *Liko* is now often used to refer to pagan Melanau.) Despite the widespread adoption of a Malay style of living the Melanau language is still in general use.

Although there are some fishing villages, most Melanau obtain their livelihood from the manufacture of sago, their main cash crop. A village consists of a collection of separate family houses strung out along both banks of a tidal reach of river. Each family has a trampling platform at the river's edge on which crude flour is produced from the rasped pith of the sago palm. This is the work of women, while the felling and rasping of sago logs is the responsibility of men. The manufacture of sago is a cottage industry, the usual working unit being a man, his wife and their children.

Melanau society is cognatic or bilateral; there is also a rank system. Among the Melanau of the Oya river, for example, there are five rank categories (*bangsa*), each with its own traditional kind of marriage payment. These *bangsa* are arranged hierarchically; a child takes the rank of his father and marriage is not strictly proper between members of different *bangsa*. The traditional culture attracts great anthropological interest in its spirit medium cults and death rituals. *See* also Borneo; Descent, Systems of: *Descent Systems in Asia*.

*See* H. S. Morris, *Report on a Melanau Sago Producing Community in Sarawak* (1953); *Sarawak Annual Report 1961* (H.M.S.O., 1962).

(J. D. Fn.)

**MELANCHTHON, PHILIPP** (1497–1560), German theologian, reformer and educator, was born at Bretten in Baden on Feb. 16, 1497. His father, Georg Schwarzerd, was an armourer under the Palatinate princes; his mother, Barbara Reuter, a niece of Johann Reuchlin (*q.v.*), was shrewd, thrifty and affectionate. Reuchlin, famed Hebraist and humanist, supervised Philipp's education, recommending Johann Unger as a private tutor and then directing him to the Pforzheim Latin school, where he studied under Georg Simler and Johann Hiltebrant, both Reuchlinists. In recognition of Philipp's achievements in the Greek classics, Reuchlin, following a contemporary custom, named him Melanchthon (the Greek form of *Schwarzerd*, "black earth"). He went in 1509 to Heidelberg, where he took the B.A. degree, and in 1512 to Tübingen, where he earned the M.A. The only other academic distinction he accepted was the B.D. from Wittenberg (1519). While at Heidelberg and Tübingen, Melanchthon was influenced by studying Rodolphus Agricola, John Wessel and William Ockham, and he began to question many of the truisms of scholastic theology. His wide reading in the Greek classics and Hebrew Scripture strengthened his critical outlook, and prepared him for an acceptance of the evangelical doctrines he encountered later at Wittenberg. At Heidelberg he did his first teaching as a tutor, and at Tübingen his first lecturing as a *Privatdozent* in the classics. These efforts were markedly successful. Before leaving Tübingen in 1518, Melanchthon had published translations of Plutarch, Pythagoras and Lucidas, a grammar on the rudiments of the Greek language, and had projected works on both Aratus and Aristotle. He was praised by Erasmus and was known to humanists as far away as England.

In 1518 Reuchlin relayed a call from the elector of Saxony for Melanchthon to teach Greek at Wittenberg. Four days after his arrival in Wittenberg, on Aug. 29, 1518, Melanchthon delivered an address on *The Improvement of Studies* that set the stage for a new educational program at Wittenberg. He proposed in effect to rejuvenate society and regenerate instruction by dropping traditional methods and secondary studies and returning to original sources. He began his own lectures with Homer and the Epistle to Titus. Luther was greatly impressed and received a fresh impulse toward the study of Greek; his translation of Scriptures, begun as early as 1517, now made rapid progress. Melanchthon helping to collate the Greek versions and revising Luther's translations. Melanchthon felt the spell of Luther's personality, and became so much a part of the evangelical movement that late in 1519 he openly broke with Reuchlin.

In 1520 Melanchthon married Katharine Krapp of Wittenberg; four children—Anna, Philipp, Georg and Magdalen—were born.

Melanchthon was first drawn into the Reformation controversy

through the Leipzig Disputation (June 27–July 8, 1519). Johann Eck reproved him for giving aid to Luther and Karlstadt during the debate, and later assailed him in a pamphlet. Melanchthon replied in a brief and moderately worded treatise, setting forth Luther's first principle of the supreme authority of Scripture in opposition to the patristic writings on which Eck relied. In 1521, during Luther's confinement in the Wartburg, Melanchthon was leader of the Reformation cause at Wittenberg. He was unable to curb the excesses of Karlstadt and the Zwickau enthusiasts who chose to inaugurate new reforms by violence. The enthusiasts' opposition to infant baptism seemed to Melanchthon not altogether irrational, and he felt that only Luther could judge whether their claims of personal inspiration were from God or Satan. In 1521 Melanchthon published his *Loci communes rerum theologicarum*, the first systematized presentation of the reformed theology. It immediately established him as a theological leader.

After the first diet of Speyer (1526), where a precarious peace was patched up for the reformed faith, Melanchthon was deputed as one of the 28 commissioners to visit the reformed states and regulate the constitution of the churches. In 1528 this resulted in the publication of *Unterricht der Visitatoren*, a set of instructions for the visitors. In addition to a statement of evangelical doctrine, it contained an outline of education for the elementary grades which was enacted into law to establish the first real Protestant public school system. Melanchthon's school plan, copied far and wide in Germany, along with his many textbooks, the training of teachers at Wittenberg, his work in establishing universities and his advice on revising school courses, earned for him the title "Preceptor of Germany."

Melanchthon was present when the protest, from which the term "Protestant" originated, was lodged in the name of freedom of conscience against the Roman Catholic majority at Speyer (1529). At the diet of Augsburg (1530) Melanchthon was the leading representative of the Reformation, and it was he who prepared the Augsburg Confession (*q.v.*), which influenced every subsequent major credal statement in Protestantism. In the confession he tried to be conciliatory without sacrificing evangelical conviction. He held conferences with papal divines appointed to adjust differences, and afterward wrote a spirited defense of the confession known as the *Apology*, one of the best writings of the Reformation.

After the Augsburg conference further attempts were made to settle the Reformation controversies by compromise, and Melanchthon, from his conciliatory spirit and facility of access, appeared to the defenders of the old faith the fittest of the reformers with whom to deal. Despite frequent charges of collaboration with Roman Catholicism, Melanchthon staunchly upheld the evangelical doctrines of justification by faith and scriptural authority. For the sake of unity, he accepted papal government, although he would not accept any inherent papal superiority. His views on the papacy were appended to the Smalkald Articles (1537) in an *Appendix on the Papacy*.

The year after Luther's death, when the battle of Mühlberg (1547) had given a seemingly crushing blow to the Protestant cause, an attempt was made to unite the Evangelicals and Romanists in the provisional agreements of the Augsburg Interim. Melanchthon refused to accept the Interim until justification by faith was ensured as a fundamental doctrine. Then, for the sake of order and peace, he declared that those principles which did not violate justification by faith might be observed as *adiaphora* or nonessentials. He allowed the necessity of good works to salvation, but not in the old sense of meriting righteousness; and he accepted the seven sacraments, but only as rites that had no inherent efficacy to salvation, and so on. Melanchthon was bitterly criticized for his stand on the Interim, though he never really swerved from his own former views nor from those of Luther as expressed in their previous writings. His later years were occupied with controversies within the Evangelical church and fruitless conferences with his Romanist adversaries. He died in his 63rd year, on April 19, 1560, and his body was laid beside that of Martin Luther in the Schlosskirche at Wittenberg.

Melanchthon's ready pen, clear thought and elegant style made him the scribe of the Reformation, and the representative of the evangelicals at numerous colloquies. He never attained entire independence of Luther, though he gradually modified some of his positions. These modifications centred around the Eucharist, man's part in conversion and the place of good works.

As late as 1530 Melanchthon agreed with Luther on the Lord's Supper. At Marburg (1529) he objected to the "memorial" view of Zwingli and Oecolampadius, but in that same year his own view began to shift from Luther's "consubstantiation" to a more spiritual concept. The changes that Melanchthon introduced in 1540 in the tenth article of the Augsburg Confession indicated that his view on the Eucharist paralleled Calvin's. After Melanchthon's death, many of his followers were attacked as crypto-Calvinists.

Melanchthon also came to believe that man has a part in conversion. At first, following Luther's cardinal doctrine of grace, Melanchthon seemed to reject free will. In the *Loci* of 1521 he renounced Aristotle and philosophy in general, since "philosophers attribute everything to human power, while the sacred writings represent all moral power as lost by the fall." He pushed the Augustinian doctrine of irresistible grace close to fatalism. However, his *Commentary on Colossians* (1527) implied a rejection of predestination, and he did not mention predestination in the Augsburg Confession. In the *Apology* of 1531 he spoke of the mercy of God being offered to all. By 1532 in the *Commentary on Romans* he spoke of man's struggle to accept or reject the love of God. In the 1535 *Loci* he pointed out that man must at least accept the gift of God's salvation, and that man is therefore responsible for his destiny. This view is clearly expressed in *De Anima* (1540). "God draws, but he draws him who is willing." Melanchthon held that in justification there is a certain causality, though not worthiness, in the recipient, and that man's activity is concurrent as a cause with the Holy Spirit and God's word.

Because of his interest in ethics, Melanchthon increasingly emphasized good works as the inevitable fruits of faith. Luther was disposed to make faith itself the principle of sanctification. Melanchthon laid more stress on law. In his visitation articles of 1528 he urged pastors to instruct people in the necessity of repentance and to bring the threat of the law to bear upon men in order to instill faith. This brought upon him the opposition of the Antinomian Johannes Agricola. In the *Loci* of 1535 Melanchthon sought to put the fact of the coexistence of justification and good works in the believer on a secure basis by declaring the latter "necessary" to eternal life. In the *Loci* of 1543 he did not say that good works were necessary to obtain salvation, and in the Leipzig Interim he declared that good works in no way implied that eternal life is merited by the worthiness of our own actions. For the sake of public order Melanchthon was led to lay more and more stress upon the law and moral ideas, but his evangelical position was that man is saved by faith and that good works are the "necessary" expression of faith, for good works flow from faith.

The principal works and correspondence of Melanchthon are contained in the *Corpus Reformatorum*, 28 vol. (1834–60), edited by K. G. Bretschneider and E. Bindseil, to which must be added *Supplementa Melanchthoniana* (1910– ) by O. Clemen *et al.*

*See* also references under "Melanchthon, Philipp" in the Index.

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**MELANESIA,** one of three great geographical divisions of islands in the Pacific ocean (*see* OCEANIA). Lying to the northeast of Australia–New Guinea, Melanesia (Gr. *melas*, "black" and *nesos*, "island") embraces the Bismarck archipelago, the Louisiade, Solomon, Santa Cruz, New Hebrides and Loyalty islands, New Caledonia, Fiji and intervening groups (*see* PACIFIC ISLANDS).

**Native Population.**—Because the majority of Melanesians

have dark skins, they have been regarded by many as Negroes. Genetic variation, however, permits light-brown-skinned individuals, who prevail in some communities. Hair form ranges from straight to very curly, the latter being more common; the characteristic frizzy appearance is deliberately cultivated. From group to group differences in nose form, stature and ruggedness of face are considerable. Common features are large jaws with shovel-shaped incisor and large molar teeth. Melanesians appear to represent an old, rather primitive southeast-Asian strain of *Homo sapiens* that has been overlaid in varying degrees by newer strains also coming from southeast Asia (*see* NEGRITO; NEGRO).

**Language.**—In the interior of the Solomons, New Britain and New Guinea, the languages spoken are collectively known as Papuan (*q.v.*), although their relations to one another are largely unknown. On the coasts of these islands and throughout the rest of Melanesia the languages (usually known as Melanesian) all belong to the Malayo-Polynesian family, which includes the languages of Indonesia, the Philippines, aboriginal Formosa, Malaya and Madagascar. All derive from a common ancestral language which was probably spoken 4,000 to 5,000 years ago along the south China coast (*see* MALAYO-POLYNESIAN LANGUAGES).

Speakers of Papuan languages were the first to come to Melanesia, inhabiting the larger islands. Four thousand years ago Malayo-Polynesian speakers began coming in as sea gypsies, living largely as traders and fishermen, settling on the smaller islands and along the coasts of the larger islands. Here and there they merged with their Papuan-speaking predecessors. This process continued, resulting in a complicated patchwork of small groups speaking mutually unintelligible dialects. Carrying beyond the northern islands and their Papuan inhabitants, the Malayo-Polynesian drift peopled New Caledonia and the New Hebrides, whence came the movements that populated Fiji, Samoa and the adjacent islands of the central Pacific. This area became a centre from which most of Micronesia and all of Polynesia were settled. It also continually fed settlers back into Melanesia, where a number of languages have central-Pacific affinities and even a few Polynesian dialects are spoken. As the area of earliest human settlement in the Pacific islands, Melanesia is the most differentiated and complex.

**Economy.**—Native subsistence is based on tropical-forest agriculture, in which garden land must lie fallow 10 to 15 years; this requires dense second growth to be cleared before reuse. Important crops are taro, yams, sweet potatoes and sugar cane, while the breadfruit, coconut, pandanus and banana are cultivated fruit trees. The starchy pith of the sago palm is an important source of flour. Fishing and hunting also add to the food supply; domestic animals are generally limited to pigs, dogs and chickens. Tobacco is widely grown and used along with traditional narcotics made from pepper plants (chewed with betel nut and lime in most of Melanesia or drunk as kava [*q.v.*] in Fiji and the New Hebrides). Most of the cultivated plants are of southeast-Asian origin; tobacco and the sweet potato probably came from Indonesia, where the Portuguese introduced them from the Americas in the 16th century (*see* AGRICULTURE, PRIMITIVE).

In the sexual division of labour men are usually assigned the heavy work of garden clearing and fence building; house and canoe construction, hunting, fishing and warfare are also masculine responsibilities. Women plant, weed and harvest the gardens, gather shellfish along the shore, and manufacture mats, baskets and large clay cooking pots, which are set over a fire on three stones. Cooking is most widely done in an earth oven, a small pit lined with hot stones on which leaf-wrapped bundles of food are placed to steam. Tools are made of wood, stone, shell and vegetable fibres; the absence of suitable ores precludes metallurgy.

The subsistence economy allows for little specialization of labour; skilled craftsmen, hunters, warriors and magicians are usually part-time specialists, engaging in subsistence activities with everyone else. Differential access to resources promotes some regional specialization; here and there landless communities, their pile villages standing in lagoons, are exclusively occupied in fishing and shell gathering, bartering with their neighbours for botanical foods.

Throughout Melanesia there are extensive trading networks, one of which is the famous *kula* of the Trobriand Islands. While such practical commodities as pottery, obsidian and food are traded, most of the commerce is in prestige items: shells, used as fluid wealth in social and economic transactions; and dances and rituals, which have privately owned copyrights and are widely traded.

**Social Organization.**—Most Melanesian communities are small and parochial in outlook. Occasionally they form larger political units as in Fiji and the Trobriand Islands, but most villages are independent of one another. Peaceful intercourse between them is traditionally conducted by private individuals, following the lines of kinship, trading partnerships, and common clan and totemic affiliations (*see* TOTEMISM). Relations between communities as such are predominantly competitive in a game of hit-and-run warfare; traditionally the score has been carefully counted in heads taken or victims eaten (*see* CANNIBALISM; HEAD-HUNTING).

Common ancestry is universally recognized as a basis for group organization and affiliation. In some communities the mode of affiliation is patrilineal (through the father), in others matrilineal (through the mother) and in still others ambilineal (through either parent). Each community is divided into several such descent groups, forming local lineages. Related lineages in different communities form larger descent groups or clans. Proprietary rights in land are regularly vested in lineages or clans; and many other social, economic and political rights and immunities derive from lineage and clan membership. In the New Hebrides the intersection of patrilineal and matrilineal descent groups creates additional social divisions regulating marriages and ritual relationships (*see* DUAL ORGANIZATION; MATRILINY).

Communities are divided into several hamlets, which may be widely scattered or cluster together as wards of a single village. The organization of most productive activities centres on these hamlets. Their membership consists of a core of close relatives with their spouses and dependents, the nature of the relationships varying according to the community's principles of residential affiliation at marriage. Often the several hamlets are identified with the community's leading constituent lineages, and there is a close correspondence between the modes of residential and descent-group affiliation; but in some societies hamlet organization is independent of the lineage system and one or two prominent older men in each hamlet direct its affairs. Decisions involving the whole community are made by consultation and agreement among the several hamlet leaders, the most eminent having greater voice.

A few societies have hereditary chiefs, but in the vast majority of Melanesian communities positions of eminence and leadership are won in open competition. Prestige accrues from a combination of fighting prowess, skill in manipulating wealth, and hard work in productive activities, especially in raising pigs. A man who has demonstrated his ability to accumulate enough wealth to meet the financial obligations of his immediate dependents is attractive to older and remoter relatives as a possible future trustee of their own dependents' affairs. In the course of time he acquires a widening circle of junior kinsmen whose financial affairs he controls. At the same time he has enough wealth at his disposal to put others in his debt. This expanding circle of clients and dependents forms a labour force with whose help he can raise pigs and produce large quantities of food and goods for distribution at feasts. By utilizing his resources to underwrite community festivals or sponsor its clubhouses he achieves further eminence. Ambitious men compete to produce the most elaborate festivals, whereby they become community leaders, arbitrating disputes and playing host to visitors. Their wealth permits them to hire sorcerers to punish troublemakers and enforce their authority. With leadership based directly on the acquisition of an economically productive following of dependents and clients, large and stable political units under the authority of a paramount chief are understandably rare. Indeed, rivalry for prestige and power within a village often leads to the formation of new and independent villages by dissident factions.

**Religion.**—Customs with important religious functions in

Melanesian life are not clearly separated from those with economic, social, political, recreational or medical functions. The clubhouses are both religious and social centres; festivals serve religious ends and are also the means of competition for social prestige and political power. Rites for gardening, hunting, healing and war are conducted by those who know the necessary spells and formulas by virtue of their personal property rights in them. There is no priestly office responsible for leadership in all or even a majority of the more important rituals. Having no organized priesthood, Melanesians also lack elaborate cosmogonies or cosmologies.

There are held to be countless, vaguely anthropomorphic goblins who are easily offended and who punish trespassers with sickness or insanity. Subject to control by spells and magical formulas, some goblins are believed to serve man for both good and evil purposes: protecting gardens from thieves, making weapons more deadly, rendering warriors invincible, making or preventing rain, healing sickness, winning another's affections, or destroying an enemy's crops, fortunes and life. In addition there are spirits of the dead, said to live in their own communities; often the clan has its own spirit village to which the souls of its dead retire and from which come the souls of its newborn members. These spirits are believed to take an active interest in the welfare of their living kinsmen, but may make trouble for other people who get in their way. They, too, are held controllable by magic. Some people are thought to have the power while sleeping or in a trance to visit spirit communities, where they may acquire new knowledge or rescue the souls of sick persons. Those who are thought to have magical control of goblins and spirits hold an important means for achieving individual goals. The more such control a person is believed to have, the more successful he is likely to be in his undertakings, and the more formidable and powerful he becomes in the eyes of his fellows. The greater magical knowledge of older men gives them power to back up their political authority and also makes them the leaders of religious activities. Because danger is seen in dealing with spirits and goblins, contact with them is hedged with restrictive tabu (*q.v.*). Tabu also attaches to people in proportion to the number and power of the spirits with which they are thought to deal. It is widely believed, moreover, that women of child-bearing age are ritually unclean and therefore should be excluded from contact with spiritual power (*see* MAGIC, PRIMITIVE).

In many communities there are small, more or less secret societies whose members are held to share control of an especially potent spirit from whom they derive personal power. To gain admission, a new member or his sponsor must be prepared to make handsome payments to existing members. The more potent a society's spirit, the greater the payment demanded and the more exclusive its membership. Notably in the Banks Islands and New Hebrides, these societies are organized into a single graded series, each with its own space in the village clubhouse, men being successively initiated into higher grades as they accumulate such wealth as pigs needed to pay the initiation fee and to sponsor the associated festivities. The spirits of men who achieve the highest grades before they die may become local deities (*see* SECRET SOCIETIES, PRIMITIVE).

Festivals regularly accompany changes of social status, as at puberty and marriage. Death is the occasion for the largest of these festivals; sponsored by a near kinsman in memory of a prominent man, they often require years of preparation.

Elaborate mummeries and masked impersonations of spirits are common in Melanesia. In some communities they are associated with memorial feasts, but in others their appearance is independent of privately sponsored festivals. Among other things, the masked figures help impress children, young people and women with the spiritual powers behind the authority of the community's older men. Great effort goes into the making of masks and costumes, and it is in connection with them that much of the celebrated art of Melanesia is created (*see* MASK; BARK CLOTH).

**Post-European Conditions.**—Early contacts with Europeans were disastrous for many Melanesian communities; new diseases, firearms and forced labour took a frightful toll. Responsible European governments later ended abuses and began to provide medical and educational services. Economic development and the elimination of warfare increased peaceful intertribal contacts, with pidgin (*q.v.*) English the lingua franca. Europeans also introduced new economic wants and religious beliefs; frustrated in their wants, Melanesians themselves began to promote new religious cults. They were often called Cargo cults (*q.v.*) because of the widespread faith that a new golden age would begin with the arrival of ships bringing to Melanesians all the material goods of western civilization. The effect of World War II was to increase native discontent, and Cargo-cult ideology spread over most of Melanesia. At the same time, cult movements increasingly were oriented toward political and economic self-development, as in the Paliau movement in the Admiralty Islands and the Marching-Rule movement in the Solomons (*see* NATIVISTIC MOVEMENTS). Often defiant of European authority, these newer movements increased political tensions in Melanesia. *See* also FIJI; NEW GUINEA; NEW HEBRIDES; NEW IRELAND; SOLOMON ISLANDS; and references under "Melanesia" in the Index.

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(W. H. G.)

**MELANESIAN LANGUAGE:** *see* MALAYO-POLYNESIAN LANGUAGES.

**MELANISM** is the deposition of the black pigment melanin and possibly other associated organic pigments in the structure of living animals. The chemistry of this process is not fully understood, but it is known to depend on the metabolism of the amino-acid tyrosine. This acid, when oxidized and polymerized, forms a quinonoid polymer that becomes attached to protein to form one granule of melanin.

Black pigmentation is advantageous in many ways: (1) It is a barrier against the effects of sunlight (namely, ultraviolet rays) in humans. In mammals and birds, according to Gloger, races that inhabit warm and humid regions have more melanin pigmentation than races of the same species in cooler and drier regions. (2) It is a mechanism for the absorption of heat in cold climates in small poikilothermic (cold-blooded) animals; *e.g.*, high altitude insects.

H. B. D. KETTLEWELL

THE PROTECTIVE VALUE OF MELANISM FOR THE PEPPERED MOTH (BISTON BETULARIA) AND ITS MELANIC FORM (CARBONARIA), BOTH AT REST ON (LEFT) AN OAK TRUNK WITH LICHENS AND (RIGHT) A SOOTY OAK TRUNK WITHOUT LICHENS

(3) It affords concealment to certain animals that become active in twilight. (4) It limits the incidence of beams of light entering the eye and absorbs scattered light within the eyeball.

Industrial melanism in certain moths (the appearance of all black instead of pale coloured forms) is a striking example of rapid evolutionary change: it has taken place in less than 100 years. It occurs in moth species that depend for their survival by day on matching specialized backgrounds, such as lichened tree trunks and boughs, on which they sit motionless. Pollution, in the form of soot, falls out at the rate of up to 50 tons per square mile per month at source, and in smaller amounts (as smoke) is carried far beyond. This pollution kills lichens, and blackens the trunks, boughs and even the ground itself. In such a setting light-coloured moths, being conspicuous, are rapidly eliminated by birds, whereas melanic moths, by their camouflage, are selectively favoured. (Melanic moths are also probably physiologically hardier.) Industrial melanic moths have arisen from recurrent mutations and have spread through natural selection. Industrial melanism, first investigated in industrial areas in Britain, has also been recorded in northern and eastern Europe, the United States and Canada.

In vertebrates melanin is deposited normally in hair, feathers and scales; it is also found in the peritoneum of many animals (*e.g.*, frogs), but its role here is not understood. It can also occur pathologically, as in a melanoma, a benign pigmented mole, or a melanotic carcinoma, one of the most rapidly fatal cancers arising in previously benign pigmented moles.

*See* PIGMENT, ANIMAL: *Pigments* (*Biochromes*): *Melanins;* ANIMAL COLORATION; ALBINISM.

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(H. B. D. K.)

**MELASTOMACEAE,** a large family of dicotyledonous plants, comprising about 150 genera and 4,000 species, nearly all tropical and subtropical; the Amazon valley is especially rich in them. The family is represented in the eastern and southern United States by about 10 species of *Rhexia* (meadow beauty). A few yield dyes and many are cultivated for their ornamental flowers. Some species live in harmony with ants, the ants finding shelter within the plant. *See* MEADOW BEAUTY.

**MELBA, DAME NELLIE** (1861–1931), Australian operatic soprano, the stage name of Mrs. Helen Armstrong, née Helen (nicknamed Nellie) Mitchell, born at Richmond, near Melbourne, on May 19, 1861. She sang at Richmond Public hall at the age of six but did not study singing until after her marriage in Dec. 1882 to Charles Nesbitt Armstrong. She appeared in Sydney in 1885 and in London the following year, and then studied with Mathilde Marchesi in Paris. She made her operatic debut as Gilda in Verdi's *Rigoletto* in 1887 at Brussels under the name Melba, derived from that of her native town. In 1888 she sang Lucia at Covent Garden and the following year Ophelia in Paris, roles in which she established herself as the foremost coloratura soprano of her time. Her marriage was dissolved in 1900. Until 1926 she sang in the principal opera houses of Europe and the U.S., particularly Covent Garden and the Metropolitan Opera house, excelling in Delibes' *Lakmé*, as Marguerite in Gounod's *Faust* and as Violetta in Verdi's *La Traviata*. She was created a dame of the British empire in 1918. In 1926 she returned to Australia where she became president of the Melbourne conservatory. She died at Sydney on Feb. 23, 1931.

*See* Dame Nellie Melba, *Melodies and Memories* (1925); P. Colson, *Melba* (1932).

**MELBOURNE, WILLIAM LAMB,** 2ND VISCOUNT (1779–1848), English statesman and prime minister who was Queen Victoria's friend and political adviser during the early years of her reign, was born in London on March 15, 1779, the second son of the 1st Viscount Melbourne. His grandfather, Matthew Lamb of Brocket, Hertfordshire, had acquired a fortune and a baronetcy through law, politics and marriage in the reign of George II. The 1st viscount was an indolent, spendthrift politician and man of pleasure. He owed his continued advancement largely to the wit and beauty of his wife, who made Melbourne house one of the great London *salons*, frequented by the prince of Wales (afterward George IV) and most of the Whig grandees of the day. The paternity of several of her children was the subject of much contemporary gossip and it was widely believed that the father of her second and favourite son, William, was Lord Egremont, at whose house at Petworth, Sussex, the Lamb children frequently stayed.

After a conventional education at Eton and Trinity college, Cambridge, and for a time as a private pupil at Glasgow, William entered Lincoln's Inn and was called to the bar in 1804. The death of his elder brother in Jan. 1805 transformed his prospects; the same year he married Lady Caroline Ponsonby, only daughter of the 3rd earl of Bessborough and in Jan. 1806 was elected member of parliament for Leominster. The marriage was a tragic failure. Caroline Lamb's early waywardness and vivacity steadily degenerated into hysteria and exhibitionism and the marriage was already beginning to break down before the open scandal of her affair with Lord Byron in 1812–13. After years of alternate estrangement and reconciliation there was a separation in 1825 and Caroline retired to Brocket until her death in 1828. Their only son, George, born in 1807, grew up mentally retarded and died prematurely in Nov. 1836. The collapse of his marriage and his own profound need for feminine friendship twice led Melbourne into private indiscretion and public embarrassment. His affair with Lady Branden in Ireland was probably one of the reasons for his resignation from the Irish secretaryship in 1828. A close though probably innocent relationship with Mrs. Caroline Norton after 1830 led to an unsuccessful but damaging lawsuit against him in 1836 when he was prime minister.

By birth and marriage Lamb was closely connected with the opposition Whigs and his earliest expressions of political opinion displayed their characteristic criticisms of William Pitt the younger and George Canning, and admiration for Napoleon. But in later years of the Napoleonic Wars he supported the government and his adherence to Catholic emancipation brought him into closer contact with Canning and Lord Wellesley. The exclusion of Canning from Lord Liverpool's ministry in 1812 diminished Lamb's political prospects and he abandoned parliament for four years until he was returned for Peterborough at a by-election (1816) and in 1819 was elected for Hertfordshire. Though sitting as a Whig he was sympathetic to the enlightened conservatism of Canning and after the latter's appointment to the foreign office in 1822 Lamb became an acknowledged Canningite. His steady support for Catholic emancipation, however, led to his retirement from Hertfordshire in 1826 and for a time he was again without a constituency. When Canning became prime minister early in 1827 Lamb was appointed chief secretary for Ireland and a seat was found for him first at Newport on the Isle of Wight and then at Bletchingley. During his brief residence in Ireland he followed a conciliatory line and showed much assiduity in his work despite a reluctance to commit himself on controversial matters of policy. He agreed to stay in office when the duke of Wellington formed his ministry in Jan. 1828 but retired the following May because of the resignation of William Huskisson and the other Canningites. The death of his father in July 1828 ended his career in the house of commons and he took his seat in the house of lords as Viscount Melbourne early in 1829.

**Prime Minister.**—On the formation of Lord Grey's coalition ministry in Nov. 1830, which had few members with ministerial experience apart from the Canningites, Melbourne was appointed home secretary and was responsible for preserving order during the political unrest that accompanied the passage of the Reform act of 1832. He declined to seek fresh powers to curb the agitation of the political unions but in upholding the sentences passed on the agrarian rioters of 1830–31, and later on the Tolpuddle unionists of Dorset in 1834, he showed an administrative firmness that demonstrated his strong social conservatism. On the crucial issue of parliamentary reform he gave reluctant support, defending the bill more on grounds of necessity than from any innate

belief in its virtue. Over Ireland, which came under the general supervision of the home office, he was content to leave the initiative in policy to the more dynamic and uncompromising chief secretary, Lord Stanley. Nevertheless, while admiring Stanley's abilities and believing, like many others, that Stanley would be the future leader of the party, his own inclination was for a policy of greater concession toward Ireland and the Roman Catholics. When the Irish question brought about the collapse of the ministry in the summer of 1834, the king's choice of Melbourne as successor to Lord Grey was not unexpected. With Stanley's secession there was no obvious heir to the premiership; Lord Lansdowne and Lord Althorp were both unwilling to take on the responsibilities of leadership; and Melbourne had consistently shown himself one of the most moderate and conciliatory members of a deeply divided cabinet. He declined the king's proposals for a coalition with Wellington, Sir Robert Peel and Stanley, and the return of Althorp as leader of the house of commons enabled him to carry on the ministry substantially intact. In November, however, the elevation of Althorp to the peerage in succession to his father, Earl Spencer, led to discussions with the king on the state of the government. The loss of Althorp was a heavy blow and Melbourne, with his usual detachment, made no attempt to conceal his difficulties from the king, but there is no evidence that he engineered the dismissal of his own ministry. William IV had for some time been alarmed by some of its members and policies and though Melbourne expressed his readiness to continue, the king seized on the first plausible pretext since 1832 to dismiss a ministry that had become obnoxious to him. On Nov. 15 he invited Peel to form a ministry.

The new Conservative ministry gained about 100 seats at the subsequent general election, but still lacked a majority and Melbourne returned to office in April 1835. While again rejecting the king's suggestion for a coalition he now felt free to reconstitute his ministry on a new basis. The marquess of Wellesley and Lord Brougham, who had alienated him by their conduct over Ireland the previous session, were left out and Lord John Russell became the new leader of the commons. Though the unofficial Lichfield House compact between Russell and Daniel O'Connell had been instrumental in overthrowing Peel's ministry, Melbourne dissociated himself from any alliance with the Irish nationalists and O'Connell was not immediately offered any office or appointment. The government, however, barely possessed a working majority in the commons and in the house of lords faced a strong Conservative opposition which did not always adhere to Peel's moderate tactics in the lower house. When the remaining items in the Whig reform program were taken up again, they encountered considerable obstruction. The English Municipal Corporations bill, which had the approval of Peel, was passed in 1835, but the Irish Tithe bill, after a struggle lasting over several sessions, only passed into law when the appropriations clauses, to which the Whigs were pledged by their action in 1835, were finally abandoned in 1838. The Irish Municipal Corporations bill, after similar concessions, became law in 1840. To further sweeping reforms Melbourne was not prepared to commit himself and he discouraged the proposals for the ballot and a revision of the corn laws which the more radical members of his party were beginning to urge.

The general election of 1837, occasioned by the death of the king, was strongly contested by the opposition and their gains brought the parties to a position of virtual equality. When their majority was reduced to five on the Jamaica question in May 1839 the government resigned, and though Queen Victoria's refusal to accept Peel's proposals for the removal of some of the ladies of her bedchamber brought the Whigs back to office, a succession of losses at by-elections further weakened their parliamentary position. Continued budgetary deficits, industrial depression and the growing difficulties of the government in foreign and colonial affairs, together with the lack of any inspiring policy, lost them credit both in parliament and the country and the "free trade" budget of 1841 was widely regarded as a last desperate measure to regain their fortunes. When defeated on the sugar duties Melbourne wished to retire rather than expose the ministers of the crown to certain defeat at the polls, but he was overruled by the cabinet. The general election of 1841 produced the expected Conservative majority and the Whig ministry resigned in Aug. 1841.

The six years of Melbourne's effective premiership had witnessed a steady deterioration in the strength and prestige of the government. Part of this was caused by circumstances outside his control. After the fundamental measures of 1832–35 there was a natural decline in Whig reforming impetus and the renewed confidence of the opposition, aided by two general elections within three years, caused much of the government's legislation to be amended or blocked, particularly in the house of lords. But Melbourne failed to give the firm direction which alone could have extricated his party from their mounting difficulties. His tendency to regard small measures as useless and large measures as dangerous kept him from initiating a fresh departure in government policy and his conservative views on the constitution made it impossible for him to adopt the proposals of his radical followers. His role in the cabinet became that of chairman rather than of leader. Yet he was not without reserves of energy, as his handling of Brougham and Wellesley in 1835 demonstrated; and his determined support of Lord Palmerston on the Syrian question in 1840 carried his divided cabinet past a dangerous crisis. If not an ambitious man, he was proud, and though he disliked controversy, he enjoyed power.

**Adviser to Victoria.**—After 1837 he was given an additional motive for remaining in office by the accession of Victoria, for whom he became private secretary for a time. The queen, headstrong, inexperienced and unmarried, found him a sagacious and worldly-wise political tutor and the affection of his sovereign did much to fill Melbourne's empty and ravaged private life. In some respects, however, this unusual personal relationship disabled Melbourne from exercising the degree of guidance which was his responsibility as chief adviser to the crown. He did little to avert the tragic mismanagement of the Lady Flora Hastings affair in 1839 and over the bedchamber question he allowed the cabinet to be drawn into a doubtful constitutional position. Both incidents gave him great concern and from 1839 to 1841 he did his best to smooth the way for the seemingly inevitable advent of a Conservative ministry. Even so, it was Victoria's marriage and the growing influence of Prince Albert that were mainly instrumental in weaning the queen from her Whig partisanship and ending the estrangement between her and Peel. Melbourne's dependence on the queen's friendship was exhibited in his continued correspondence with Victoria after Peel became prime minister. Sensible and harmless as his letters were, and much as he resented the intervention of Baron Stockmar to end them, his saner judgment obliged him to admit the impropriety of the practice.

With his departure from office in 1841 Melbourne's political career came virtually to a close. A paralytic stroke in Oct. 1842 left him greatly enfeebled and depressed, and his conduct was increasingly marked by eccentricities of speech and behaviour. At the meeting of Whig peers at Lansdowne house in May 1846 he spoke in favour of accepting Peel's bill to repeal the corn laws but his political influence had vanished and he was offered no post in Russell's Whig ministry formed in June 1846. He died at Brocket on Nov. 24, 1848.

**Character.**—Melbourne had a generous and attractive personality. He was handsome, intelligent and well-read, an engaging companion and an amusing conversationalist. Fundamentally, however, he remained a tragic and vulnerable figure; his jocularity, cynicism and profanity were merely protective devices to enable him to deal with ordinary men and extraordinary situations. His detachment and irony, lack of enmity and lack of enthusiasm sprang from the same root. Kindness, good humour and sociability alone made life tolerable for him and he constantly wondered why others could not recognize those sovereign virtues. He could indulge the vanities and frailties of the world but not its seriousness and pomposities. Though his affectation of indifference led the public to underestimate the real application he gave to the business of administration, his intellectual pursuits, particularly in literature and theology, often seemed to have the more genuine interest for him. The skepticism with which he viewed most human endeavours was defensible as a philosophy

but in politics it had a corroding effect on him. With his erudition, intellectual curiosity and speculative powers, Melbourne might have been a considerable author, scholar or theologian. In the political career which family and social position thrust upon him, he achieved a late and somewhat fortuitous eminence but his character and temperament prevented him from using his high office to any great purpose.

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(N. G.)

**MELBOURNE,** second largest city in Australia and capital of the state of Victoria, stands on the northern shores of Port Phillip bay, a spacious landlocked harbour in the southeast corner of the continent. The climate is temperate, with an average annual rainfall of 25.66 in. and mean temperatures of 10°–20° C. (50°–68° F.). Pop. (1961 census): city, 76,810; metropolitan area, 1,911,895, an increase of 387,800 over the 1954 census.

Melbourne resembles Los Angeles rather than Liverpool in the spread of its population, being a sprawling rather than a compact city. Its red-tiled suburbs extend more than 30 mi. along the shores of the bay, and some inland suburbs are more than 20 mi. from the city. Wide streets, spacious parklands and large house allotments have so extended the metropolis that the population density is barely ten to the acre—one of the lowest in the world.

The heart of the city is on the north bank of the Yarra river, 3 mi. from the bay. It is dissected into square blocks by long main streets, 99 ft. wide. The main shopping streets are Swanston, Elizabeth and Bourke (in which is Myer's, one of the largest stores in the world). In Collins street are the head offices of four of Australia's six nationwide banking companies and the board rooms of many other leading Australian companies; Queen street has the slim glass offices of many insurance companies and Flinders street has one of the world's largest railway passenger terminals. Most of the public buildings were completed or commenced between 1860 and 1890; and for decades the domes of the law courts and the exhibition building, the spires of St. Patrick's and St. Paul's cathedrals, the steeples of churches and the towers and turrets of hotels and halls dominated the city skyline. Although Melbourne emulated Chicago and New York in the craze for skyscrapers in the late 1880s, its tallest halted at the 11th or 13th story by decree of the city council; and it was not until 1958 that there was a 20-story office building that could match the highest pinnacles of the old public buildings. The changing skyline stands out in Melbourne, for the city is circled by parks and sports fields that include the Flemington racecourse (scene of the Melbourne Cup) and the Melbourne cricket ground (site of the 1956 Olympic games).

Melbourne has a university that opened in 1855 with 15 students and by the early 1960s had more than 13,000, a Royal Melbourne Institute of Technology with an even larger enrollment, and a second university known as Monash at Clayton. The public library has a vast octagonal reading room modeled on that of the British museum and nearly 700,000 books, including many rare works of the first European printers. Adjacent buildings house the museum of applied science, the national museum and the national gallery with its famous collection of paintings bought in Europe under the bequest of Alfred Felton, a Melbourne merchant. Literary figures who have lived in Melbourne include Richard Hengist Horne, author of "Orion"; Fergus Hume, author of *The Mystery of a Hansom Cab*; Henry Handel Richardson; Marcus Clarke; Adam Lindsay Gordon; and Rolf Boldrewood. Five commonwealth prime ministers—Alfred Deakin, S. M. (later Viscount) Bruce, James Henry Scullin, Robert Gordon Menzies and John Joseph Curtin—either spent their youth in Melbourne or later represented its constituencies. Natives of the city who won fame abroad include Dame Nellie Melba and Percy Grainger in music, Lord Baillieu, Harry Bridges and W. S. Robinson in industry and many fellows of the Royal Society.

Melbourne's rise in the 19th century as a great city was influenced by geographical factors. It had a sheltered and central harbour on a coast with few natural harbours and it was closest to the gaps that led through the Great Dividing range (Eastern highlands [*q.v.*]) to the rich hinterland of Victoria. Over the century Melbourne carved from a shallow harbour and swampy river flats an excellent port, where ships can berth at the river wharves close to the city or at the piers of Williamstown and Port Melbourne in Hobson's bay. As a port Melbourne is nearly as large as Sydney, and it has been able to attract trade from Mallee and Wimmera, Murray valley and Gippsland, and from the Riverina (New South Wales) with a system of railways and highways that radiates from its wharves. The city has an airport at Essendon.

The main overseas exports are flour, wool, oats, fruit, meat and dairy products. The produce of the inland farms and sheep runs were, with gold, the early staples of Melbourne's commerce, but factories, employing a larger proportion of the population in Melbourne than in any other Australian city, have become its mainstay in the 20th century. The largest group makes motor cars, farm machinery, railway rolling stock, electrical equipment, machine tools, radio and television sets and other engineering products. Other important manufactures are clothes, textiles, paper, chemicals, glass, rubber, leather and foodstuffs, and in the second half of the 20th century their diversity was being steadily increased by new factories. Apart from factories, warehouses and shops, the city is an important administrative centre, with the Victoria government departments and some of the federal departments—for the city was the federal capital from 1901 to 1927. It is governed by a 33-member council working through committees. Melbourne is also recognized as the hub of Australian finance, being the seat of far more major companies than any other city.

Named after the British prime minister, Lord Melbourne, the site was inhabited only by roaming aborigines until the Tasmanian pastoralists and the pioneers John Batman and John Pascoe Fawkner crossed the narrow Bass straits in 1835 (*see* VICTORIA: *History*) in search of new places for settlement. The first census in May of the following year recorded 177 people, who lived in bark and timber huts, plowed wheat paddocks in what are now city streets and drew their water from the river. As thousands of sheep came overland from Sydney and across the sea in schooners and ketches from Tasmania, Melbourne became the port for wool and tallow, carted from distant homesteads over rutted bush tracks. It was then part of the colony of New South Wales and governed from Sydney, but in 1851 the territory south of the Murray river became the colony of Victoria and Melbourne its seat of government. In that same year rich goldfields were discovered in the hills to the west of Melbourne, and the fame of Ballarat, Bendigo, Clunes and other diggings attracted several hundred thousand migrants from Liverpool, Hamburg, Canton and other distant ports. Melbourne, as main port for the goldfields, became a new San Francisco. In the 1850s its wharves held one-third of the world's current gold output, its population reached 100,000 and its bay and winding river were packed with tall-masted ships. As the goldfields waned the wheatlands were settled, small industries were established in the city behind a tariff wall and the transition from gold port to commercial and industrial city was swift and smooth. There were nearly 500,000 people 55 years after the first huts were built; few cities of the world achieved so much so quickly. Moreover, few cities became so large with such a sparsely populated hinterland; in 1891 Melbourne held over 40% of Victoria's population and the centralizing tendency continued, until by the 1960s it held over 60%.

Melbourne was the largest Australian city from the time of the gold rushes until the early years of the 20th century, when it was surpassed by Sydney. It fell further behind until after World War II when it began a remarkable recovery, attracting a large share of the capital and migrants coming from overseas. Once overwhelmingly British in its stock, except for a small colony of Chinese, it became the most cosmopolitan city in Australia. The large Italian communities in the old inner suburbs, the American factories in the new outer suburbs, the stream of locally made cars on the highways—these are the symbols of the new Melbourne.

*See* also references under "Melbourne" in the Index.

(G. N. B.)

**MELCHERS, (JULIUS) GARI** (1860–1932), U.S. portrait and figure painter, was born at Detroit, Mich., on Aug. 11, 1860, the son of a sculptor. At 17 he was sent to Düsseldorf, Ger., to study art under Gebhardt, and after three years went to Paris, where he worked at the Académie Julien and the École des Beaux Arts. Attracted by the pictorial side of the Netherlands, he settled at Egmond. His first important Dutch picture, "The Sermon," brought him honourable mention at the Paris Salon of 1886. He became a member of the National Academy of Design, New York city; the Royal Academy of Berlin; Société Nationale des Beaux Arts, Paris; International Society of Painters, Sculptors and Engravers, London; and the Secession society, Munich.

Besides portraits, his chief works are: "The Supper at Emmaus"; "The Family"; "Mother and Child," Art Institute of Chicago; the decoration at the Library of Congress, Washington, D.C., "Peace and War." Melchers' portrait of Pres. Theodore Roosevelt is in the Freer Gallery of Art, Washington. He died on Nov. 30, 1932, at Belmont, near Fredericksburg, Va.

**MELCHETT, ALFRED MORITZ MOND,** BARON (1868–1930), British politician and industrialist who was one of the founders of the firm of Imperial Chemical Industries, was born at Farnworth, near Widnes, Lancashire, on Oct. 23, 1868, the son of the famous chemist Ludwig Mond (*q.v.*). He was educated at Cheltenham and St. John's college, Cambridge, and afterward at Edinburgh university. After a brief interlude at the bar, he entered the firm of Brunner, Mond and company, becoming a director in 1895, and subsequently chairman of the Mond Nickel company and a director of the South Staffordshire Mond Gas company and various other companies. In 1926 he was responsible together with Sir Harry McGowan for the merger of several such chemical companies to form the huge Imperial Chemical Industries. He was elected to parliament in 1906 as Liberal member for Chester, losing his seat in 1910, but the same year was elected for Swansea and created a baronet. On the formation of Lloyd George's ministry in 1916 Mond became first commissioner of works, and in 1921 minister of health. He lost his seat at the general election of 1923, but was returned for Carmarthen in Oct. 1924. In Jan. 1926, profoundly disagreeing with Lloyd George's land policy, Mond transferred his allegiance to the Conservative party. He was created a peer with the title of Baron Melchett in 1928. In 1928 he organized the Mond-Turner conference, at which problems of industry and labour were discussed by a group of employers under his leadership and by representatives of the Trades Union congress general council. He published many articles on the alkali trade in scientific and economic journals; his most important work was *Industry and Politics* (1927), a capable and well-informed defense of capitalism. Lord Melchett died in London on Dec. 27, 1930. (H. G. N.)

**MELCHITES** (MELKITES), derived from the Greek transliteration of a Syriac word meaning "royalist," which is used of two groups of Christians in Syria and Egypt: (1) Historically, those who, instead of holding Nestorian or Monophysite doctrine, shared the theological position of the Byzantine emperor, which was that defined in 451 at the Council of Chalcedon (*see* COUNCIL). (2) In modern times, certain Uniates of the Byzantine rite (*see* ROMAN CATHOLIC CHURCH: *Organization: The Catholic Eastern Rites*).

**MELCHIZEDEK** (in the Douai version of the Bible MELCHISEDECH) is a figure who assumed importance in biblical tradition because he was both king and priest, was connected with Jerusalem and was revered by Abraham, who paid a tithe to him. He appears as a person only in Gen. xiv in the story about Abraham's defeat of the coalition of kings under Chedorlaomer. Elsewhere in the Bible (Ps. cx, 4; Heb. v–vii) he is mentioned as a type or symbol by which other persons are interpreted.

In Gen. xiv, 18–20 Melchizedek meets Abraham on his return from battle, gives him bread and wine (which has been interpreted as a type of the Eucharist) and blesses him in the name of "God Most High." In return Abraham gives him a tithe of the booty. Melchizedek is an old Canaanite name meaning "My King is Sedek." Salem, of which he is said to be king, is surely Jerusalem (Ps. lxxvi, 2). The god whom he serves as priest is "El Elyon," again a name known from Canaanite provenance, probably designating the high god of the pantheon. There are reasons to think that "El Elyon" was especially venerated in Jerusalem during its pre-Israelite history, though in biblical times the name was assimilated by Israel and used as an appellation for their covenant God, Yahweh.

That Abraham should so recognize the authority and authenticity of a Canaanite priest-king is startling; nothing similar is reported in biblical literature. This story in Gen. xiv probably reached its final formulation during the early Davidic monarchy, and it could serve as an apology for the anointed king and his Jerusalem cultus: here the ethnic and religious father of Israel pays tribute to a Jerusalem king. The event anticipates the time when the seed of Abraham should themselves bring tithes to the priests of Jerusalem who minister in the sanctuary of the Davidic capital.

Ps. cx uses Melchizedek as a type of a king who is also a priest. The occupant of Judah's throne is described in verse 4 as possessing forever by God's own oath a priesthood of the kind that Melchizedek held.

It is because the church in New Testament times read Ps. cx Christologically (Acts ii, 34, etc.) that the figure of Melchizedek was applied to Christ and used to interpret his work in ch. v–vii of Hebrews. Its writer translated Melchizedek as "king of righteousness" and Salem as "peace," so that he is a foreshadowing of Christ as the true king of righteousness and peace (vii. 2). That Abraham, who is the ancestor of Levi, paid tithes to Melchizedek is taken as proof that the priesthood of Christ is superior to that of the Levitical priesthood (vii, 4 ff.). Using a rabbinical exegesis accepted and understood in its time, the Epistle to the Hebrews argues from Melchizedek to Christ by way of Ps. cx to show the validity, eternity and meaning of Christ as priest.

(J. L. MA.)

**MELCOMBE, GEORGE BUBB DODINGTON,** BARON (1691–1762), English politician, whose calculated exploitation of parliamentary influence and assiduous office-seeking typified the spirit of English political life during the first half of the 18th century. Educated at Winchester and at Exeter college, Oxford, he entered Lincoln's Inn in 1711 and represented Winchelsea, a borough controlled by his family, in the first of George I's parliaments. He was immediately chosen as envoy extraordinary to Spain, a post in which he showed much good sense and application, and which he retained until the end of 1717. In 1718 he returned to England and re-entered parliament. Two years later his uncle, George Dodington, who had held several minor administrative posts under William III and Anne, died and bequeathed him a considerable fortune. At this point, Bubb (as he then was, this having been his surname at birth) assumed his uncle's surname and henceforth always signed himself simply "George Dodington," though by his contemporaries and by posterity he is usually styled Bubb Dodington.

The political shifts that characterized Dodington's public life are explained by the parliamentary votes he inherited from his uncle, controlling the representation of Winchelsea, Weymouth and Melcombe Regis, and usually Bridgewater also. This meant that however often he changed sides, his influence made him an ever-present, though always minor, figure in politics during the reign of George II. He sat for Bridgewater from 1722 to 1754 and for Weymouth thereafter until his elevation to the peerage. His rewards were the offices of lord lieutenant of Somerset (1721–44), lord of the treasury (1724–40) and treasurer of the navy (1744–49, 1755–56 and 1757). In April 1761 he was made Baron Melcombe. He died at Hammersmith on July 28, 1762.

In politics he was a ridiculous figure, justly satirized as the subject of Hogarth's "Chairing the Members." But he was also a wit and a good scholar; Thomson's "Summer" was dedicated to him, Fielding addressed an epistle to him and Edward Young a satire. He was a leading spirit of Sir Francis Dashwood's "Hell-fire" club.

Melcombe's diary was published in 1784. *See* also L. Sanders, *Patron and Place-hunter* (1919); John Carswell, *The Old Cause* (1955).

(B. J. R.)

**MELEAGER** OF GADARA (*c.* 140–*c.* 70 B.C.) is famous as an epigrammatist and as the compiler of the first of the collections that make up the *Greek Anthology* (*see* ANTHOLOGY). He lived in Tyre and, in his old age, in Cos, and he was an adherent of the Cynic philosophy. He wrote works, now lost, in the Cynic manner in imitation of Menippus (*q.v.*), but his Cynicism was probably literary. Collections of various kinds had been made before, but Meleager's was the first large anthology of epigrams, containing poems by some 50 writers and a considerable number of his own. He introduced it with a poem which compared each writer to a flower and entitled it *Stephanos* ("Garland"). The contributions of Meleager himself do not rank high. There is a want of variety in his themes and, though he shows cleverness in handling the commonplaces of eroticism, he rarely shows originality or true feeling. The period was unpropitious to poetry, and his language and style were influenced by the rhetoric of his day.

BIBLIOGRAPHY.—Edition of the *Greek Anthology* with Eng. trans. by W. R. Paton, in the Loeb series, 5 vol. (1916–18). *See* also A. S. F. Gow, *The Greek Anthology* (1958); J. Geffcken in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. xv, col. 481–488 (1931). (AR. CA.)

**MELEAGER,** in Greek mythology, the leader of the Calydonian boar hunt, an event which, like the voyage of the Argonauts and the Trojan War, was a famous joint undertaking of the heroic age. The *Iliad* relates how Meleager's father, King Oeneus of Calydon, had omitted to sacrifice to Artemis, who sent a wild boar to ravage the country. Meleager collected a band of heroes to drive it away, and eventually killed it himself. The Calydonians and the Curetes then quarreled over the spoils and war broke out between them. As long as Meleager fought for the Calydonians they were successful, but he withdrew after his mother Althea cursed him for causing the death of her brothers. The Curetes then besieged Calydon and were on the point of taking it when Meleager finally yielded to the entreaties of his wife, Cleopatra, and repulsed them. The *Iliad* does not describe Meleager's death, though mentioning that it took place before the Trojan War. According to Bacchylides, who recounts a dialogue between Meleager and Heracles in Hades, Althea caused his death by burning the log whose span of life was coterminous with his. Euripides' play *Meleager*, of which only fragments survive, brought a new character, Atalanta (*q.v.*), into the story: her lover Meleager gave her the best of the spoils of the boar, which his mother's brothers took away from her, so he killed them. Ovid in the *Metamorphoses* expands Bacchylides' reference to the log by relating how when Meleager was born Althea heard the Fates saying that the child would live only as long as the log then burning on the fire. Althea extinguished and preserved the log, only to sacrifice her son in his prime of life because he had killed her brothers.

*See* Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. x, col. 466–478 (1931).

**MELETIOS PEGAS** (1549–1601), patriarch of Alexandria, was the most capable theologian among the defenders of Orthodoxy in the 16th century. Born in Candia (Iraklion) of a good Cretan family, he studied in Venice and Padua and became the founder and head of a school for classical Greek at the Angarathos monastery in Candia; he was later hegumen there. Exiled by the Venetians for his anti-Latin views, he spent some time on the Sinai peninsula and from 1579 was assistant to the patriarchate in Alexandria and Constantinople. On June 5, 1590, he was consecrated patriarch of Alexandria. In March 1597 he went to Constantinople as patriarchal vicar, but returned in 1598 to Alexandria where he died on Sept. 14, 1601.

At first an opponent of the new Moscow patriarchate (1589), Meletios agreed to it only with reservations (1592). He upheld Orthodoxy in east Poland and the western Ukraine by writing to encourage its leaders, particularly the prince of Ostrog. His letters to King Sigismund III of Poland and the west Russian school brotherhoods tried to prevent the extension of the union of Brest-Litovsk (by which the Orthodox Church on Polish-Lithuanian territory was united with the Roman Catholic, *i.e.*, the present Ruthenian Church; 1596). He was the teacher and patron of Cyril Lucaris (*q.v.*), his personal representative in Poland, though probably without sharing Lucaris' Protestant sympathies. Meletios' writings are primarily polemics against Catholicism, especially against the papacy and the *filioque* clause in the creed.

BIBLIOGRAPHY.—There is a fairly complete list of Meletios' works in P. Meyer, *Die theologische Literatur der griechischen Kirche im 16. Jahrhundert*, pp. 59–69 (1899); letters ed. by E. Legrand (1902). *See* also W. Regel, *Analecta byzantino-russica* (1891); A. Pichler, *Geschichte des Protestantismus in der orientalischen Kirche im 17. Jahrhundert* (1862). (F. V. L.)

**MELETIUS, SAINT,** OF ANTIOCH (d. 381), bishop of Antioch from 360, gave his name to the Meletian schism in the church of Antioch in the 4th century. (For the other Meletian schism *see* MELETIUS of Lycopolis.) Meletius appears to have come from Little Armenia but is not heard of before 358 when he succeeded Eustathius, the champion of Nicaean orthodoxy, as bishop of Sebaste. It is difficult to assess his theological position, but he was elected bishop of Antioch when that church, tired of ecclesiastical strife, was anxious to choose a moderate person, not too deeply involved in either camp. He soon, however, incurred the displeasure of the Arian emperor Constans by a sermon on the generation of the Word, which caused his immediate banishment (360). His departure from Antioch had a double effect: the appointment of an Arian bishop, Euzoius, and the formation under the orthodox of a Meletian party. This confused situation continued until an attempt was made to secure peace in the reign of Julian the Apostate (362). But the recognition and consecration of Paulinus, a famous ascetic, as bishop of Antioch left Meletius out of account. His followers refused to accept any other bishop and the Meletian party continued. The death of Julian and the accession of Jovian (363) brought both Meletius and Athanasius back from exile. Basil of Caesarea, a consistent supporter of Meletius, hoped that Paulinus and Meletius would come to terms, but Meletius refused any advances. Paulinus therefore was recognized as bishop and the Meletian party remained. The close links between Alexandria, Rome and Milan resulted in a hostile attitude toward Meletius, and Basil's efforts for ten years to secure the dismissal of Paulinus were ineffective. In 378, however, the Arian emperor Valens was succeeded by the orthodox Gratian, so the exiled anti-Arian bishops returned and with them Meletius. It was proposed at first that both Paulinus and Meletius should rule together, but when Paulinus refused to agree, Meletius was declared bishop. He presided at the Council of Constantinople (381), during the course of which he died. It was expected then that Paulinus would be recognized as bishop, but the orthodox Flavian was elected and consecrated. This perpetuated the schism for another 20 years. At last as a result of a council at Caesarea the West accepted Flavian and the struggle ended.

No other 4th-century controversy involved so completely the policy of the emperors, the advocacy or enmity of Church Fathers or the attitude of Rome, or threatened for so long the peace of the church. Meletius' feast day is Feb. 12.

BIBLIOGRAPHY.—F. Cavallera, *Le Schisme d'Antioche* (1905); L. Duchesne, *Early History of the Christian Church*, vol. ii (1912); P. Battifol, *Le Siège apostolique* (1924); G. Bardy, "Le Concile d'Antioch (379)," *Revue Bénédictine*, 14:196–213 (1933). (A. O.)

**MELETIUS** OF LYCOPOLIS (fl. early 4th century A.D.), bishop of Lycopolis in upper Egypt, and originator of the rigorist Meletian schism. (For the other Meletian schism *see* MELETIUS, SAINT, of Antioch). During a lull in the Diocletianic persecution *c.* 306, Peter, bishop of Alexandria, laid down conditions for the readmittance of lapsed Christians to the church which were regarded as too lax by Meletius, who stirred up trouble and was excommunicated. On the renewal of persecution, Peter was martyred and Meletius sent to the mines. When he returned he organized a schismatical church in opposition to Alexander, Peter's successor. The situation was dealt with by the Council of Nicaea (325); Meletius was forbidden to ordain or to consecrate and was restricted to Lycopolis. His clergy were to be admitted to a rank inferior to those of the bishopric of Alexandria. When Athanasius became bishop (328) Meletius again went into schism and after his death his followers continued a rigorous monastic movement until the 8th century.

*See* L. Duchesne, *Early History of the Christian Church*, vol. ii (1912). (A. O.)

**MELFI,** a town of the province of Potenza, region of Basilicata, southeastern Italy, is situated at an altitude of 1,742 ft. in the Apennines about 45 km. (28 mi.) N. of Potenza town by road. Pop. (1961) 18,208. It lies at the foot of the volcanic mass of Monte Vulture. Despite earthquakes in 1851 and 1930 some important monuments remain. They include the Romanesque cathedral with its campanile (1153, rebuilt 1281); the Norman castle (1281), an irregular quadrilateral surrounded by a deep ditch; and the Romanesque church of S. Lorenzo (13th century). The railway station, 2 mi. from the town, is on the Potenza-Foggia line. Melfi is an important agricultural, forestry and tourist centre, producing large quantities of cereals, oil, wine and fruit, especially apples.

Of Roman origin, the town was taken from the Byzantines by the Normans who, for a period, made it their capital. Frederick II (*q.v.*) assembled parliament there, which passed the famous constitutions of Melfi (1231). It was the favourite residence of the Swabian kings, but later it declined, passing successively to the Caracciolo, Philip of Orange, the Doria, and to the Bourbons in the 19th century, becoming part of the kingdom of Italy in 1861.

(M. T. A. N.)

**MELIACEAE** (mahogany family), a large family of dicotyledonous plants with 50 genera and about 1,500 species, chiefly trees, and pantropic in distribution. The leaves are mostly pinnate and the family is readily distinguished by having the stamens borne on the inside of or at the apex of a distinct staminal tube. Some of the genera are rich in species, such as *Turraea* in Africa and Asia, 90 species; *Trichilia* in Africa and the Americas, 230 species; *Guarea* in tropical America, 170 species; *Aglaia,* Indo-Malaysia, perhaps 300 species; and *Dysoxylum,* Indo-Malaysia, about 100 species. The langsat or lansone (*Lansium domesticum*) is an important Malayan fruit tree, widely cultivated, while other genera, such as the new world mahoganies (*Swietenia* species), African mahoganies (*Khaya* species), cigar box cedar (*Cedrela* species) and others, yield important commercial timbers. The chinaberry or pride of India (*Melia azedarach*) is widely planted in the warmer parts of the United States, and is naturalized in the south. *See* also MAHOGANY.

*See* H. Harms, "Meliaceae," in Adolph Engler and Karl Prantl, *Die natürlichen Pflanzenfamilien,* 2nd ed. (1940).

(E. D. MI.; W. L. S.)

**MELICERTES,** in Greek mythology, the son of the Boeotian prince Athamas and Ino, daughter of Cadmus. Ino, pursued by her husband, who had been driven mad by Hera (enraged because Ino had taken care of the infant Dionysus), threw herself and Melicertes into the sea from a high rock between Megara and Corinth. Both were changed into marine deities—Ino as Leucothea, Melicertes as Palaemon. The body of the latter was carried by a dolphin to the Isthmus of Corinth and deposited under a pine tree. There it was found by his uncle Sisyphus, who had it removed to Corinth, and by command of the Nereids instituted the Isthmian games and sacrifices in his honour.

It is uncertain whether Melicertes is Greek ("honey cutter," *i.e.,* "beekeeper," perhaps a minor deity presiding over apiculture) or Phoenician (Melqart). In either case, it is not easy to see why he should be called "wrestler" or why his legend is Boeotian and his cult Isthmian. At Rome, he was sometimes identified with Portunus (*q.v.*).

**MELILITE.** The melilite group of silicate minerals comprises sorosilicates of aluminum, calcium, magnesium and other metals. These minerals show extensive atomic substitution, important end-members being gehlenite, $Ca_2Al_2SiO_7$, åkermanite, $Ca_2MgSi_2O_7$ and hardystonite, $Ca_2ZnSi_2O_7$. Substitution by sodium, iron, potassium and manganese also occurs. Melilite usually forms in short tetragonal prisms of variable colour, sometimes honey coloured, whence the name from the Greek *meli* ("honey"). The crystal structure consists of twisted sheets of oxygen tetrahedra, linked together by calcium ions. Melilite is rare, occurring as sodic åkermanite in some basic rocks such as melilite-basalt, as gehlenite at limestone contacts, and as hardystonite in ores. It crystallizes from many artificial melts and commonly occurs in slags. (J. V. S.)

**MELILLA,** chief town of a Spanish military enclave (*presidio*) on the Mediterranean coast of Morocco, 135 mi. E.S.E. of Ceuta, the other Spanish *presidio.* Pop. (1960) 79,056. Melilla is separate and distinct from Moroccan territory; it is represented in the Spanish *Cortes* by its mayor. The old town is built on a huge rock connected with the mainland by a rocky isthmus. The new town, on the west and south, has an entirely European and modern aspect. The equipment of the port, completed in 1914, and the occupation of the country behind it by Spain meant a rapid development of the town, which numbered hardly 3,000 inhabitants in 1895. The rich iron-ore mines of Beni-bou-Ifrour, situated ten miles from Melilla, with which they are linked by railway, give rise to an important trade.

The Phoenicians, then the Carthaginians and the Romans, had a settlement at Melilla, called Rusaddir. A Berber town succeeded it, conquered in 1497 by Spain, in whose possession it remained. Melilla was, with Ceuta, the most important of the ports or *presidios* which Spain revived on the coast of Morocco, but until the beginning of the 20th century it remained closed and the history of the town was one long series of sieges, of which the last, that of 1893, necessitated an army of 25,000 men. In 1909 the Spaniards, after a hard campaign, occupied the massif of Gourougou and the hinterland of Melilla, and made themselves masters of the whole region between Oued (wadi) Kert and Moulouya. In 1921 the Rifi tribes, in revolt under the leadership of Abd-el-Krim (*q.v.*), inflicted upon them a costly defeat and pressed them back to the walls of Melilla. The east Rif was reoccupied in 1926 following the Franco-Spanish campaign which forced the submission of Abd-el-Krim. (G. L. M.; X.)

**MELILOTUS:** *see* SWEET CLOVER.

**MÉLINE, FÉLIX JULES** (1838–1925), French statesman, a leading exponent of economic protectionism, was born at Remiremont, Vosges, on May 20, 1838. Known as a lawyer and as a republican under Napoleon III, he was elected a deputy for the Vosges in 1872. He was re-elected in 1876 and served as undersecretary for justice under Jules Simon (1876–77). He demanded protection for French industries and played a major role in drafting the protectionist legislation of the years 1890–1902. He was minister of agriculture under Jules Ferry (1883–85) and later president of the chamber (1888–89), when he was one of Gen. Georges Boulanger's fiercest opponents. Prime minister and minister of agriculture from April 29, 1896, to June 14, 1898, Méline arranged the exchange of visits between the Russian emperor Nicholas II and Pres. Félix Faure; refused to allow a rehearing of the Dreyfus case in 1897; and sought to effect a coalition of moderate republicans and conservatives against the Radicals and Socialists in the chamber. After the elections of May 1898, the new majority of left-wing republicans insisted that he should rely exclusively on them. This led to his resignation. He was elected to the senate in 1903 and was again minister of agriculture (1915–16). Méline died in Paris on Dec. 20, 1925.

*See* G. Lachapelle, *Le Ministère Méline* (1928).

**MELISSUS** (5th century B.C.), a Greek philosopher of the Eleatic school (*q.v.*), was a native of Samos, whose fleet he commanded against the Athenians in 441/440 B.C. His philosophy consisted in a clear but for the most part unoriginal defense (in prose) of Parmenides' doctrine that reality is a single undifferentiated whole. (*See* PARMENIDES.) While Zeno had defended Parmenides indirectly, by refuting those who claimed that "things" and change were real, Melissus preferred to do so positively by the same kind of deductive arguments as Parmenides had used. The argument of fragment eight, that changing qualities must be only apparent, is used virtually unaltered by Plato and Descartes. At two points, however, he departed from Parmenides: (1) instead of existing in an eternal or timeless present, "the one" (reality), he claimed, had and will have infinite duration; and (2) instead of being a finite sphere, "the one" was infinite in extension. Melissus is also said to have made "the one" incorporeal, but either this needs interpreting and qualifying or his having made it infinite in extension must be suspected. Unfortunately our knowledge comes from Aristotle, who underrated the ability of Melissus, or from sources dependent on Aristotle.

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**MELITO OF SARDIS** (d. before A.D. 190), bishop of Sardis (Sardes) in Asia Minor, was the author of a number of books in Greek, of which only fragments survive except for the almost complete text of a homily on the passion of Christ which was first published in 1940 after a papyrus discovery. Eusebius in his ecclesiastical history gives the titles of 20 of Melito's books. In the only extant work, eternity and time, Christ's divine and human nature, the gospel, Israel and the church are contrasted in highly rhetorical antitheses. Little is known of Melito's life. *See* also APOLOGISTS, EARLY CHRISTIAN: *Early Apologists*.

*See* Campbell Bonner, *The Homily on the Passion by Melito* (1940) for text and Eng. trans.; for fragments *see* M. J. Routh, *Reliquiae sacrae*, vol. i, 2nd ed. (1846). (E. Mo.)

**MELITOPOL,** a town in the Zaporozhye *oblast* of the Ukrainian Soviet Socialist Republic, U.S.S.R., stands on the right bank of the Molochnaya river, about 19 km. (12 mi.) N. of the Molochnaya lagoon. Pop. (1959) 94,670. The settlement of Novo-Aleksandrovka grew up in the late 18th century with the arrival of Cossacks, Dukhobors, Mennonites and other colonists. In 1841 it became the town of Melitopol. By 1904 it had 17,300 inhabitants. Its importance as an agricultural centre has persisted, mainly because of the many orchards in the area and of its position on the railway and highway from Moscow to the Crimea. Modern Melitopol has large engineering plants, producing diesel engines, compressors and other machinery, as well as food and clothing factories. (R. A. F.)

**MELLITUS** (d. 624), first bishop of London and third archbishop of Canterbury, was sent to England by Pope Gregory I in 601. Saeberht, king of Essex, a nephew of Aethelberht of Kent, was baptized in 604 and Aethelberht built a church in London, Saeberht's chief town, where Mellitus was appointed bishop. He joined with Laurentius of Canterbury and Justus of Rochester in a letter urging the Irish bishops to adopt the Roman Easter computation. He attended a synod held in Rome in 610. On Saeberht's death his three pagan sons drove Mellitus out (616); he fled to Gaul with Justus but on the death of Laurentius (*c.* 619) succeeded him at Canterbury. Mellitus died on April 24, 624.

**MELLON, ANDREW WILLIAM** (1855–1937), U.S. banker and public official, secretary of the treasury from 1921 to 1932, was born in Pittsburgh, Pa., on March 24, 1855, and studied at Western university (now the University of Pittsburgh). He entered his father's banking house, which later developed into the Mellon National bank, the Union Trust company and the Union Savings bank, all of Pittsburgh. President of the Mellon National bank, he became an officer or director in various financial and industrial corporations and also engaged in the development of many industrial enterprises.

In discussions concerning reduction of the national debt ($24,000,000,000 in 1920, as a result of World War I expenditures), Mellon held that continuance of the high wartime tax rates would discourage business expansion and hence reduce revenue. He also was a strong advocate of reduction of the surtax rates on incomes. Congress repealed the excess-profits tax and gradually lowered the income tax rate until in 1926 the maximum surtax was reduced to 20%. Further reductions in tax rates were later made; by June 30, 1928, the national debt had fallen to $17,604,000,000.

As chairman ex officio of the World War I foreign debt commission, Mellon had a large share in formulating the policy of the United States in regard to funding the war debts of foreign governments owed to the U.S. government. After the onset of the depression in 1929, he was continued in office until Feb. 1932, when President Hoover appointed him ambassador to England, enabling him to withdraw as secretary of the treasury. In 1937 he gave his valuable art collection and a gallery in Washington, D.C., to the nation. Mellon died at Southampton, L.I., on Aug. 26, 1937.

**MELLOPHONE:** *see* HORN.

**MELO, FRANCISCO MANUEL DE** (1608–1666), one of the most talented and many-sided figures of the 17th century in Portugal, won fame as a poet, moralist, historian and literary critic besides serving as a soldier and diplomat. He was born of aristocratic parentage at Lisbon on Nov. 23, 1608. He studied the classics and mathematics at the Jesuit College of Santo Antão, showing a precocious talent. He then entered the army and also, as an accomplished aristocrat, took part in the life of the royal court in Madrid. At Madrid he formed a friendship with Quevedo and earned the favour of the powerful minister Count Olivares. In 1639 he was appointed colonel of one of the regiments raised for service in Flanders, and in June took a leading part in defending La Coruña against a French fleet commanded by the archbishop of Bordeaux. He came safely through the naval defeat in the English Channel suffered by the Spaniards at the hands of the Dutch admiral, Martin Tromp, and on the outbreak of the Catalan rebellion acted as chief of staff to the commander in chief of the royal forces; his *Historia de la guerra de Cataluña* became a Spanish classic. On the proclamation of Portuguese independence in 1640 he was imprisoned by order of Olivares, and when released hastened to offer his sword to John IV. He traveled to England, where he spent some time at the court of Charles I, and thence passing over to Holland assisted the Portuguese ambassador to equip a fleet in aid of Portugal, himself bringing it safely to Lisbon in Oct. 1641. For the next three years he was employed in various important military commissions. For reasons still obscure (perhaps some love affair or some suspicion of his loyalty to the newly restored Portuguese monarchy), he was arrested on Nov. 19, 1644, and was in prison or under police supervision for about 11 years. His sentence was commuted into one of exile to Brazil in 1655 but, owing to the death of John IV in 1656, he remained there for only three years, writing, and restoring his fortunes by participation in the sugar trade.

During his imprisonment he had continued to write incessantly: he finished and printed his history of the Catalan war in 1645, and published some verse in 1649 and the popular, much reprinted, discourse on marriage—though he himself never married—*Carta de Guia de Casados* in 1650. He also wrote sections of his series of historical episodes, *Epanáforas de Vária História* (1660), some of the dialogues on social and literary topics, *Apólogos Dialogais* (published posthumously, 1721), poetry and the letters which, after amendments to content and style, were published under the title *Cartas Familiares* (1664). He returned home in 1658; in 1663 Afonso VI charged him to negotiate with the papacy about the provision of bishops for Portuguese sees. On his way back to Portugal (1665) he published his *Obras Métricas* at Lyons. His early Spanish verses in this volume are influenced by Gongorism (*see* GÓNGORA Y ARGOTE, LUIS DE), but his Portuguese sonnets and verse epistles are notable for their power, sincerity and perfection of form. His verse comedy, the *Auto do Fidalgo Aprendiz* (included in the *Obras Métricas*) is considered by some to be an anticipation of Molière's *Le Bourgeois Gentilhomme*. Melo died at Alcántara on Oct. 13, 1666.

A full list of Manuel de Melo's works is included in Edgar Prestage's detailed study of his life and work, *Dom Francisco Manuel de Melo, Esboço biográfico* (1914). (E. P.; N. J. L.)

**MELODRAMA,** a term with different meanings in music and in the theatre. In music the word melodrama signifies lines which are spoken to a musical accompaniment. Early examples of this are Georg Benda's (*q.v.*) *Ariadne auf Naxos* and *Medea* (both performed 1775); Jean Jacques Rousseau (*q.v.*) wrote another variant of this, *Pygmalion*, in 1762 (performed 1770). Later melodramas were written for the concert hall, such as Richard Strauss's setting of Tennyson's *Enoch Arden* and the three works of Arnold Schoenberg, *Kol Nidrei* (1939), *Ode to Napoleon* (1943) and *A Survivor From Warsaw* (1947). In Italian the term *melodramma* signifies serious opera, replacing the earlier term *dramma in musica*. It has no connection with the English word "melodrama" either in its musical or dramatic sense, the Italian for the latter being *melologo*.

In the theatre, melodrama describes a type of stage play which has developed since the end of the 18th century, more particularly in Europe and America, but which has spread wherever western theatre (as distinct from oriental) has flourished. This type

of play concerns stock characters, painted in black and white. The plot treats the vicissitudes suffered by the virtuous at the hand of the villainous, but ends happily with virtue triumphant. To this extent it resembles neoclassical tragicomedy and such genres as *comédie larmoyante*. It differs from them in the violence of its assaults upon the emotions and in the sensational character of its incidents and its spectacular staging. It differs from them also in its lack of consistent interaction between character and incident; characters do not develop. Some melodramas have included music and singing, but the term may be used of those in which they do not occur.

The melodramatic stage play is generally regarded as having developed in France as a result of the impact of Rousseau's *Pygmalion* on a society exposed to the influences of the English Gothic novel and of *Sturm und Drang* and romanticism from Germany at a time of violent political and social revolution. French melodrama of this age included music and singing and spectacular effects. Its best-known exponent, Guilbert de Pixérécourt, is responsible for developing the genre. His *Coelina, ou l'enfant du mystère* (1800) was translated as *A Tale of Mystery* (1802) by Thomas Holcroft and established the new genre in England. It was not utterly new to England, however; the restrictions of the Licensing act of 1737 were habitually evaded by combining drama with music, singing and dancing, which produced such hybrids as *Blackbeard the Pirate* (performed 1798). *The Castle Spectre* (performed 1797) by "Monk" Lewis makes the same kind of use of sensation and mystery.

Another dramatist whose melodrama affected other countries was August von Kotzebue (*q.v.*). His position in Germany was the equivalent of that of De Pixérécourt in France. Kotzebue's *Menschenhass und Reue* (performed 1789) became in England the famous *The Stranger* (performed 1798); he also provided the original of Sheridan's *Pizarro* (performed 1799). In the early 19th century melodrama spread throughout the European theatre, most frequently in translation, but it led to imitation in many cases. It flourished even in Russia, where the authorities welcomed it as diverting attention from more serious issues.

During the 19th century, music and singing were gradually eliminated, but as technical developments in the theatre as a whole made greater realism possible more emphasis was given to the spectacular. Snowstorms, shipwrecks, battles, train crashes, conflagrations, earthquakes and horse races were all represented with ever greater verisimilitude, which included live animals on the stage whenever their presence might contribute to the entertainment of the audience. Among the best known and most representative of the melodramas popular in England and America are Dion Boucicault's (*q.v.*) *The Octoroon* (performed 1859) and *The Colleen Bawn* (performed 1860). More sensational were *The Poor of New York* (performed 1857), *London by Night* (1844) and *Under the Gaslight* (performed in New York, 1867). To stage such plays was to develop the mechanical and technical resources which were later to be taken over by the realistic theatre of the naturalists. The naturalists were anticipated, too, by the issues and social evils touched upon, however perfunctorily and sentimentally in melodrama. Edward Fitzball's dramatization of *Uncle Tom's Cabin* (performed London, 1853) is typical of melodrama combining the spectacular with sentimental treatment of a social problem. In the second half of the century a type of melodrama developed which had some affinity with serious naturalistic drama. Such was the work of Victorien Sardou (*q.v.*) and his followers, and such plays as *The Silver King* (performed 1882) by Henry Herman and Henry Arthur Jones (*q.v.*).

*See* also DRAMA: *Modern Drama.*

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**MELODY,** the organization of successive musical sounds in respect of pitch (Gr. *melodia*, "a choral song," from *melos*, "tune," and *ode*, "song"). In its most primitive state it is inseparable from rhythm; but it can develop freely without the aid of harmony, which removes it into another category. Thus a "melodic" scale is a scale based on a modal rather than on a harmonic system.

Attempts to define the term are found in the writings of several ancient Greek philosophers and music theorists. Aristotle (384–322 B.C.) accepts a common philosophical classification of melodies into three groups: (1) ethical melodies; (2) melodies of action; and (3) passionate melodies. A distinction of another kind is made by Aristoxenus (late 4th century B.C.), who states that the order (or lack of order) in melodious and unmelodious compositions resembles that in the arrangement of letters in language, since only certain arrangements of given letters will produce a syllable. Pseudo-Euclid (2nd century A.D.), known as Cleonides, indicates four methods of forming a melody: (1) *agoge*, conjunct motion (*see* 5[*a*] below); (2) *ploke*, disjunct motion (*see* 5[*b*] below); (3) *petteia*, the repetition of a single note; and (4) *tone*, the prolongation of a single note.

In the middle ages the word "melody" was often used synonymously with "song" or "plainsong." Odo of Cluny (d. 942) showed that the monochord could be made to produce melody, which in this context means plainsong, or more specifically an antiphon. In France during the 12th and 13th centuries the creation of melodies was brought to a high standard by the trouvères and troubadours, who were imitated in Germany by the minnesingers and, less successfully, by the meistersingers. Renaissance composers, for all their occupation with polyphony (*see* 4 below), always based their music on melodic ideas and strands that were woven together in a texture of great beauty and complexity. In both sacred and secular music, one voice part was occasionally allowed to stand forth as a *cantus firmus; i.e.*, as a solid melody that could nevertheless be decorated. The growing importance of solo song was responsible for the new refinement of melody, which coincided happily with the emergence of opera and cantata.

The conception of melody as "tunefulness" belongs to the 19th century and depends on symmetries of harmony and rhythm that seldom occur in music written before the 16th century and are accidental, if frequent, potentialities in older folk music. By the beginning of the 20th century a melody was considered to be the surface line in a series of harmonies. Harmonic rationality and symmetrical rhythm thus combined to produce a tuneful melody that helped to generate the sonata form.

A large number of resources are used to produce the melodic surface of music. They include:

1. A *theme*, which is a melody not necessarily complete in itself, except when designed for a set of variations, but recognizable as a pregnant phrase or clause. Thus a fugue subject is a theme, and the expositions and episodes of the sonata forms are more or less complex groups of themes.

2. A *figure*, which is the smallest fragment of a theme that can be recognized when transformed or detached from its surroundings. The grouping of figures into new melodies is the main resource of "development," or "working out," in the sonata forms besides being the means by which fugues are carried on when the subjects and countersubjects are not present in their entirety. In 16th-century polyphony, melody often consists of figures broken off from a *cantus firmus*.

3. A *sequence*, which is the repetition of a figure or group of chords at different levels of pitch. A "real sequence" repeats the initial group exactly and therefore changes its key (for example, in the first movement of Beethoven's Waldstein sonata, op. 53, bars 5–8 are a step in real sequence below bars 1–4). A "tonal sequence" repeats the figure within the key and modifies details accordingly, tolerating things that would be inadmissible in the initial group (*e.g.*, in the first movement of the Waldstein sonata the theme, with a brilliant counterpoint above, is treated in tonal sequence 40 bars from the end). Repetition at the same pitch is not sequence.

4. *Polyphony*, which is harmony made of melodic threads. Some classical melodies are polyphonically composite, requiring an inner melody, which appears through transparent places in the outer melody, to complete the sense. This well suits the pianoforte with its evanescent tone, but it is even more frequent in music for earlier keyboard instruments, as in the keyboard works of J. S. Bach. Beethoven often divides a melody between voices

(*e.g.*, bars 35–42 of the first movement of the Waldstein sonata).

5(*a*). *Conjunct motion*, which is movement along adjacent degrees of the scale. (*b*) *Disjunct motion*, which is movement proceeding by intervals of more than one step, often tends to produce arpeggio types of melody, *i.e.*, melodies that trace out a chord.

Conjunct and disjunct melodies are strongly contrasted in the music of ancient civilizations. Japanese music is predominantly conjunct, its melodies proceeding by small adjacent or scalic intervals, while Chinese music employs wider intervals. The use of wider intervals in melody is believed to be a sign of musical evolution toward a relaxed or static emotional state as opposed to the tension generated by melodies built on a succession of small intervals. This is illustrated by a comparison of the arpeggiolike melodies in works of Mozart and Beethoven with the severity of plainsong or Gregorian chant.

*Melody types* is a term used by mid-20th-century writers to describe the melodic formulae, figurations, progressions and rhythmic patterns used in the creation of melodies in certain forms of non-European and early European music. These melody types are often characteristic of one mode or another (*see* MODES, MUSICAL) and they provide a means of forming melodies radically different from that based on the 19th-century conception of melody as being original or inspired. They include the Greek *nomoi* (literally "laws") and, in a broader sense, the melody types of folk music.

*See* also references under "Melody" in the Index.

*See* W. Panckert, *Ursymbole melodischer Gestaltung* (1932); A. H. Fox-Strangways, "Tune," *Music and Letters* (Jan. 1922).

(D. F. T.; X.)

**MELON,** the trailing plant or the fruit of the muskmelon (*q.v.*) or the watermelon (*q.v.*).

**MELORIA,** the site of two naval battles of the 13th century, is a rocky islet off the coast of Italy, almost opposite Leghorn (Livorno). Both battles were features of the long-standing rivalry between Genoa and Pisa (*qq.v.*).

In the first battle, on May 3, 1241, the fleets of the Holy Roman emperor Frederick II and of Pisa attacked a Genoese squadron and captured the English, French and Spanish prelates on their way to the Lateran council summoned by Pope Gregory IX.

The second battle was fought on Aug. 6, 1284. Genoa and Pisa had been at war for suzerainty over Corsica for two years. The Genoese sent out 58 ships under Oberto Doria, to be reinforced by 30 others from Sardinia under Benedetto Zaccaria. The Pisan fleet, commanded by the *podestà* Albertino Morosini with Ugolino della Gherardesca and Andreotto Saraceno, was numerically superior to Doria's squadron, though estimates of its strength vary from 72 ships to 103. When the Pisans and Doria's squadron were locked in battle, Zaccaria's squadron emerged from concealment behind the islet and took the Pisans by surprise on the flank. Most of the Pisan fleet was sunk, about 25 of its ships were captured, and Morosini and hundreds of Pisans were taken prisoner; Ugolino escaped. Pisa never recovered its naval power.

**MELOS** (modern MILOS), a Greek island of the Aegean sea, at the southwest corner of the Cyclades group, lies 75 mi. due east of the coast of Laconia. It is about 14 mi. from east to west, 8 mi. from north to south. Area about 61 sq.mi.; pop. (1961) 4,910. The greater portion is rugged and hilly, culminating in Mt. (Profitis) Ilias in the west (2,538 ft.). It is of volcanic origin, with tuff, trachyte and obsidian. In one of the caves on the south coast the heat is still great, and there are hot sulfurous springs. The harbour, a crater with depths from 70 to 30 fathoms, entered from the northwest, cuts the island in two, with an isthmus 1¼ mi. broad. Sulfur is found on Mt. Kalamos and elsewhere. In ancient times the alum of Melos was reckoned next to that of Egypt (Pliny, *Natural History*, xxxv, 15 [52]). The Melian earth was employed as a pigment by ancient artists. Millstones, salt and gypsum are still exported. Orange, olive, cypress and arbutus grow throughout the island; grapes, cotton and barley are cultivated. Above Adhamas, the harbour town, lie Milos (Plaka), the chief town, Kastro, on a hill above, and other villages. The ancient town occupied the slope between the village of Tripiti and the landing place at Klima. Archaeological remains include a Roman theatre, town walls and other buildings, one with a fine mosaic excavated by the British school at Athens in 1896. Numerous fine works of art have been found on this site, notably the Aphrodite of Melos in 1820 (familiarly known as the Venus of Milo, now in the Louvre), the Asklepios now in the British museum and the Poseidon and an archaic Apollo housed in the National Archaeological museum, Athens.

The position of Melos, between Greece and Crete, and its possession of obsidian made it an important centre of early Aegean civilization. At that time the chief settlement was at Phylakopi on the northeast coast. There the excavations of the British school cleared many houses, including a palace of Mycenaean type. There was also a town wall. The antiquities found were of three main periods, all preceding the Mycenaean age of Greece. Much pottery was found, including examples of a peculiar local style, with decorative designs, mostly floral, and also considerable deposits of obsidian. There are some traditions of a Phoenician occupation of Melos. In historical times the island was occupied by Dorians from Laconia. In the late 7th and 6th century B.C. it again produced a remarkable series of vases, of large size, with mythological subjects and orientalizing ornamentation, and seems at that time to have been the centre for important schools of goldsmiths and gem engravers (the "island gems").

Melos sent a contingent to the Greek fleet at Salamis but held aloof from the Delian league, and remained neutral during the Peloponnesian War. But in 416 B.C. the Athenians attacked the island and compelled the Melians to surrender, slew all men of military age, enslaved the women and children and introduced 500 Athenian colonists. Lysander restored the island to its Dorian possessors, but it never recovered its prosperity. Later there were many Jewish settlers in Melos, and Christianity was introduced early. Under Frankish rule the island formed part of the duchy of Naxos, except for the years 1341–83 when it was a separate lordship under Marco Sanuto and his daughter.

Antimilos or Andimilos, 5¼ mi. N.W. of Melos, is an uninhabited mass of trachyte. Kimolos (Argentiera), less than one mile northeast, was famous in antiquity for figs and fuller's earth and contained a considerable city, the remains of which cover the cliff of St. Andrew. Polinos or Polivos (anc. Polyaigos) lies rather more than a mile southeast of Kimolos. It was the subject of dispute between the Melians and Kimolians but has long been almost uninhabited. (X.; J. Bo.)

**MELOZZO DA FORLÌ** (1438–1494), Italian painter, a figure of cardinal importance in the history of Italian painting, was born at Forlì (Romagna) in 1438. He is mentioned in his native town in 1460 and 1464, and between 1465 and 1475 probably was active at Urbino, where he came into contact with Piero della Francesca, the main source of his pictorial style, the architect Bramante, and the Flemish and Spanish painters employed by Federigo da Montefeltro. Alongside Justus of Ghent and Alonso Berruguete, Melozzo worked on the decorations of the *studiolo* and library of the ducal palace. The principal relics of this activity are the panels of "The Liberal Arts," conjecturally executed from his cartoons. About 1475 Melozzo moved from Urbino to Rome, where he may also have worked temporarily somewhat earlier. His first major work in Rome was a fresco in the library of Sixtus IV in the Vatican, now in the Vatican gallery. Completed in or soon after 1477, this shows the investiture of Platina as librarian to the pope.

Records of payments of 1480 and 1481 relate to subsidiary frescoes and decorative paintings in the library. In 1478 Melozzo became a member of the Compagnia di S. Luca, and about 1480 executed his most important work, a fresco of "The Ascension" in the SS. Apostoli. The central Christ from this work survives in the Quirinal, and fragmentary groups of angels are in the Vatican gallery. These athletic figures amply account for the reputation Melozzo enjoyed among Giovanni Santi and other contemporary writers as an exponent of perspective and foreshortening. Melozzo seems to have left Rome in 1484, on the death of Pope Sixtus IV, after completing the decoration of a chapel (destroyed) in Sta. Maria in Trastevere, and returned there in 1489. Probably during this second Roman period he prepared cartoons for mosaics in Sta.

Croce in Gerusalemme. In 1493 he was painting in the Palazzo Comunale at Ancona, and later in the year returned to Forlì, where he died on Nov. 8, 1494.

At some time before 1484 he designed the cupola frescoes in the Cappella del Tesoro at Loreto (executed wholly by assistants), and after 1493 the decoration of the Cappella Feo in S. Biagio at Forlì (destroyed in 1944). In the latter he was assisted by his pupil Marco Palmezzano. Little of his work has been preserved and none of his great decorative schemes survives intact. Melozzo's pre-eminence as a fresco painter in Rome is comparable with that of his contemporary Andrea Mantegna in north Italy. (J. W. P.-H.)

**MELROSE,** a small burgh of Roxburghshire, Scot., lies on the right bank of the Tweed, 37 mi. S.E. of Edinburgh by road and a few miles east of Abbotsford, the country home of Sir Walter Scott. Pop. (1961) 2,133. Melrose figures in Scott's novels *The Abbot* and *The Monastery*, as "Kennaquhair." The beauty of its situation between the Eildon hills and the Tweed, the literary and historical associations of the district and the famous ruins of Melrose abbey attract great numbers of visitors. It is also an agricultural market town. Skirmish hill commemorates the faction fight of 1526, in which the Scotts defeated the Douglases and Kers. The market cross, dated 1642 but with a much older shaft, stands in the triangular market place. Across the river are Gattonside, the monks' garden, still famous for its fruit, and Allerly, the home of Sir David Brewster, the noted physicist.

The original Columban monastery, colonized from Lindisfarne, was founded in the 7th century at Old Melrose, about 2½ mi. E., in the loop of a bend of the Tweed. It was burned by Kenneth I MacAlpin in 839 during the wars between Scot and Saxon and, though rebuilt, was deserted in the middle of the 11th century. The chapel, dedicated to St. Cuthbert, continued to attract pilgrims, but the building was finally destroyed by English invaders.

In 1136 David I founded an abbey dedicated to the Virgin, a little higher up the Tweed, the first Cistercian settlement in Scotland, with monks from Rievaulx in Yorkshire. Lying on the direct invasion route from England, the abbey was frequently assaulted and in 1322 was destroyed by Edward II. Rebuilt, largely by means of a gift of Robert Bruce, it was nearly burned down in 1385 by Richard II. Erected once more, it was reduced to ruin by the earl of Hertford (afterward the Protector Somerset) in 1545. Later the Reformers dismantled much of what was left. The adaptation of part of the nave as a parish church and the use of the stones for house building in the town did further damage. The ruins, then the property of the duke of Buccleuch, were presented to the nation in 1918. Of the conventual buildings, apart from the church, nothing has survived but a fragment of the cloister with a richly carved round-headed doorway and some fine arcading. North of the abbey precinct a 15th- to 16th-century house has been turned into an abbey museum. The cruciform abbey church is in the Decorated and Perpendicular styles, with pronounced French influence, due probably to the master mason John Morow, or Morreau. The south front is still beautiful. The west front and a large portion of the north half of the nave and aisle have perished; but the remains include the rest of the nave, the two transepts, the chancel and choir, the two western piers of the tower and the sculptured roof of the east end. From east to west it measured 258 ft. The nave is 69 ft. wide and the width of the transepts from north to south is 115½ ft. Sir Walter Scott immortalized the east window in *The Lay of the Last Minstrel*, but the south window with its flowing tracery is even finer. In the carving of windows, aisles, cloister, capitals, bosses and doorheads no design is repeated. The heart of Robert Bruce was buried at the high altar, and in the chancel are the tombs of Sir William Douglas, the Knight of Liddesdale (1300–53); James, second earl of Douglas (1358–88), the victor of Otterburn; Alexander II (1198–1249); and Michael Scot "the Wizard" (?1175–*c.* 1232), though some authorities say that this is the tomb of Sir Brian Layton, who fell in the battle of Ancrum moor (1544). At the door leading from the north transept to the sacristy is the grave of Joanna (d. 1238), queen of Alexander II.

Near Newstead, an eastern suburb, was the great Roman fort of Trimontium. Darnick tower (1 mi. W.) is a well-preserved Border peel tower originally built in 1425 and rebuilt in 1569.

The muniments of the abbacy, preserved in the archives of the earl of Morton, were edited for the Bannatyne club and published in 1837 under the title of *Liber sancte Marie de Melros*. Among the documents is one of the earliest specimens of the Scots dialect. The *Chronica de Mailros*, preserved among the Cotton manuscripts, was printed at Oxford in 1684 and by the Bannatyne club in 1835.

*See* A. E. Henderson, *Melrose Abbey, Then and Now* (1936).

**MELROSE,** a city of Middlesex county, Mass., U.S., is located 7 mi. N. of Boston. The territory now known as Melrose was originally part of Charlestown and was settled in 1633. Later known as North Malden and then Pond Feilde, the area took its present name from Melrose, Scot., and became a separate town in 1850. It was incorporated as a city in 1899. The Reading road, the old Indian trail from Chelsea to Reading, became a main thoroughfare to the north, and Main street in Melrose still follows its route. The Reading stage was the first means of public transportation to serve the town. Early industries included the manufacture of boots and shoes, needles, and picture moldings. In the late 19th century several factories were established, but by the second half of the 20th century Melrose was primarily a middle-class residential community with no large-scale manufacturing. Melrose was one of the first cities in Massachusetts to establish a planning board. For comparative population figures *see* table in MASSACHUSETTS: *Population.* (L. G. BA.)

**MELROSE PARK,** a village of Cook county, Ill., U.S., 12 mi. W. of the Chicago loop. Founded as a part of Maywood in 1869, it became Melrose Park in 1893. It is a mixed residential and industrial community, with over 100 industrial plants. The Proviso yards of the Chicago and North Western railway, a large railroad yard for the handling of freight cars, are in Melrose Park. For comparative population figures *see* table in ILLINOIS: *Population.* (WA. B. H.)

**MELTON MOWBRAY,** an urban district and market town of Leicestershire, Eng., is situated 15 mi. N.E. of Leicester by road. Pop. (1961) 15,914. Its dominant feature is the church of St. Mary, Early English and Decorated and considered to be one of the finest in the county. Nearby is Anne of Cleves' house and the Bede house (1640); Egerton lodge is a fine Victorian mansion possessing a delightful public park. Melton Mowbray is primarily associated with fox hunting (the Quorn) and food products (pies, sausages, stilton cheese and canned and packeted foods for pets). There are also a factory for producing rubber thread, a large joinery and iron foundry. An engineering research station and information centre has been established jointly by industry and the government. The depot of the royal army veterinary corps, where army horses and guard dogs are trained, is located at Melton Mowbray. (W. E. BR.)

**MELUN,** a town in the Parisian basin, capital of the *département* of Seine-et-Marne, France, on the northern edge of the forest of Fontainebleau, 28 mi. (45 km.) S.S.E. of Paris by road. Pop. (1962) 26,061. Melun is divided into three parts by the Seine river. The oldest part lies on the island, which was inhabited in Roman times. Its buildings include the 11th-century Romanesque church of Notre Dame, which received its charter in 827; the church of St. Aspais, destroyed in 1420 and rebuilt in the 15th and 16th centuries; the town hall, built in 1848 on the site of an old mansion and of a former convent, the turret of which was used in the modern building; and the tower of the former church of St. Barthélemy, which dates from the 16th to 18th centuries and now stands alone on the square of the *préfecture*. The fine château of Vaux-le-Vicomte is 4 mi. N.E. of the town. Melun is an agricultural centre for the region. Its principal industries are the manufacture of wooden screens and pharmaceutical products.

During the Gallic Wars, Melun (Lat. Melodunum) was taken (52 B.C.) by Labienus, who then attacked Lutetia (Paris) from the right bank of the Seine. It was several times pillaged by the Normans and later became the favourite residence of the kings of France. In 1359 Melun was given by Joan of Navarre to her brother, Charles the Bad, but it was recaptured by the dauphin Charles and Bertrand du Guesclin. In 1420 the town put up a

heroic resistance against the English and the Burgundians. It was occupied by the League in 1589 and retaken by Henry IV in 1590. St. Aspais and the left-bank district were severely damaged during World War II.

**MÉLUSINE,** tutelary fairy of the house of Lusignan, daughter of Elinas, king of Albania, and the fairy Pressine; for shutting her cruel father up in a mountain she was condemned to change every Saturday into a serpent from the hips down. She married Raymondin of Poitiers and built him Lusignan and other castles. Breaking his promise never to see her on Saturdays, Raymondin discovered her secret and she disappeared forever; however, she was heard lamenting on the towers of Lusignan whenever death threatened her descendants, whence the popular saying, *pousser des cris de Mélusine.* (This meant originally to lament in anticipation of family misfortune, but is now often applied to screams in apprehension of personal pain.) Mélusine has been fancifully identified with the goddess of childbirth, Mater Lucina.

The legend was related in a long prose romance written by Jean d'Arras for John, duke of Berry (1387), and in verse by the poet Couldrette (early 15th century).

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**MELVILLE, ANDREW** (1545–1622), Scottish scholar and Reformer, who gave the Scottish church its Presbyterian character and brought international reputation to the Scottish universities, was born on Aug. 1, 1545, at Baldovy in Angus. Educated at Montrose, he laid the foundation of his notable proficiency in Greek under Pierre de Marsilliers. At St. Andrews university from 1559, he astonished his teachers by using the Greek text of Aristotle. In 1564 he entered the University of Paris, devoting himself to Greek, Latin and Hebrew, and to philosophy. In 1566 he migrated to Poitiers, where he was both student of law and regent in the college of St. Marceon. In 1569 he went to Geneva to study under Theodore Beza and the group of experts who staffed the academy there. He accepted the chair of humanity (*i.e.,* Latin) and began to study Syriac.

Melville returned to Scotland in 1574. The universities were the first to experience his renovating hand. As principal of Glasgow university (1574–80), as visitor to Aberdeen (1575) and as principal of St. Mary's college, St. Andrews, from 1580, he gave all three universities a fresh lease of life, introducing methods which he had learned from Petrus Ramus in Paris and Theodore Beza in Geneva. Empty classrooms became crowded with students from home and overseas, and many were trained who became teachers in the educational institutions of the Reformed churches abroad.

But it was the plight of the Scottish church in the days of the regencies that called forth all Melville's powers. John Knox had died two years before his return and Melville stepped almost at once into the vacant leadership. The later saying, "John Knox made Scotland Protestant, Andrew Melville made it Presbyterian," has more substance in it than most of such easy generalizations. His ruling passion was the preservation of the independence of the church from state control, which entailed the elimination of all the nonconciliar elements (tulchan bishops, etc.) from its constitution. The *Second Book of Discipline* (1578) was largely his work and he had the satisfaction of seeing it, after a stern struggle in which he suffered virtual banishment in 1584–85, largely incorporated in the act of settlement of 1592. When James VI in 1597 began to undermine the charter he had granted, Melville led the resistance, defending the liberties now legally established against all encroachments of king and court. The general assembly at Aberdeen in 1605 was the critical moment of the struggle. Despite its prorogation by the king, the assembly met and was constituted. In deference to a royal order of dismissal it transacted no business except fixing the date of the next meeting. But 14 ministers were sentenced to various forms of imprisonment and banishment for their "defiance." In 1606 Melville and seven other ministers of the Church of Scotland, who had not been commissioners to the assembly, were summoned by James (by then James I of England) to a conference in London to find a way out of the impasse. They told him frankly that the only way to settle affairs was to call a free general assembly. Subjected to constant Episcopalian propaganda, Melville retaliated in a satirical Latin poem. He was promptly committed to the Tower of London and detained there for four years. He was then allowed to accept an invitation to a chair overseas, that of biblical theology in the University of Sedan, in which he spent 11 busy and fruitful years with little contact with his native land. He died at Sedan in 1622 at the age of 77. *See* also SCOTLAND, CHURCH OF; SCOTLAND: *History.*

*See* T. McCrie, *Andrew Melville,* 2nd ed. (1823); J. MacKinnon, *A History of Modern Liberty,* vol. iii (1908). (H. Wa.)

**MELVILLE, GEORGE WALLACE** (1841–1912), U.S. arctic explorer and naval engineer, was born in New York city on July 31, 1841, and educated at the Brooklyn Polytechnic institute. In 1861 he entered the United States navy as third assistant engineer and served throughout the Civil War. His first venture into arctic regions was as engineer of the "Tigress" in search of the ill-fated "Polaris." In 1879 he accompanied George W. de Long (*q.v.*) on his famous polar voyage in the "Jeannette." When the ship was crushed in the ice Melville was in charge of the only boat load of men that survived. They found help on the Lena river after a boat and sledge journey of many hundreds of miles. In the arctic night he led an expedition 500 mi. along the north Siberian shore in search of De Long and other survivors, and recovered the bodies and records of De Long's boat load. The incredible hardships of the expedition are modestly told in Melville's *In the Lena Delta* (1884). (*See* also ARCTIC, THE.) Melville was again chief engineer of the flagship "Thetis" in the historic Greely relief expedition of 1884.

In 1887 he was made engineer in chief of the U.S. navy. He retired in 1903, having been commissioned rear admiral in 1899. His ability as head engineer during a period when a new and more modern navy was being constructed made his services of much importance. He designed the machinery of 120 naval ships of more than 700,000 h.p.; three of them, the "San Francisco," "Columbia" and "Minneapolis," were for a time the fastest ships afloat. He introduced the triple screw, made the departure from horizontal to the more efficient vertical boilers and introduced boilers of the water-tube type. He carried out tests of oil fuel and predicted its future importance. Many minor improvements and a general reform of the entire naval engineering department are attributed to him. He died on March 17, 1912.

*See* W. L. Cathcart, "George Wallace Melville," *Amer. Soc. of Naval Engineers, Journal,* vol. xxiv, pp. 477–511 (1912); *U.S. Naval Institute Proceedings,* vol. 74, p. 613 (May 1948); *Cassier's Magazine* (Sept. 1903).

**MELVILLE, HENRY DUNDAS,** 1ST VISCOUNT (1742–1811), British careerist politician who held various ministerial offices under the Younger Pitt and whose adroit control of Scottish politics earned him the nickname of "King Harry the Ninth." He was born on April 28, 1742, at Arniston, Midlothian, the fourth son of Robert Dundas (d. 1753), lord president of the Scottish court of session. He was educated at Edinburgh university and admitted to the bar (faculty of advocates) in 1763. He served as solicitor general for Scotland (1766–75), sat in parliament for Midlothian from 1774 (and after 1790 for Edinburgh), and was lord advocate from 1775 to 1783, becoming also treasurer of the navy (1782–83). Under William Pitt, whose trusted lieutenant he soon became, he was a member of the committee for trade (1784–86), treasurer of the navy (1784–1800), a commissioner of the board of control for Indian affairs (1784–93), and president of the board (1793–1801). He also held the offices of home secretary (1791–94), secretary of state for war (1794–1801), and first lord of the admiralty (1804–05). In 1802 he was created Viscount Melville and baron of Dunira. A forceful speaker in parliament, he was also an energetic and industrious administrator who brought great improvements in navy finance and Indian government. As a war minister he was less successful. Suspicions as to his financial management of the admiralty led to his impeachment in 1806; though this ended in an acquittal and nothing more

than formal negligence lay against him, he never again held office. He died on May 28, 1811, at Edinburgh.

*See* H. Furber, *Henry Dundas, First Viscount Melville, 1742–1811* (1931); C. Matheson, *Life of Henry Dundas, First Viscount Melville* (1933). (I. R. C.)

**MELVILLE, HERMAN** (1819–1891), U.S. author, was born in New York city on Aug. 1, 1819, the third child of Allan and Maria Gansevoort Melville. His father, of Scottish descent, was then a prosperous importer, but in 1830, having suffered losses, he moved to Albany, N.Y., where his wife's relatives made efforts to help him. In 1832 he died, deeply in debt. The burden of supporting the family of four boys and four girls fell on the first-born son, Gansevoort. During the panic of 1837 his business also failed. Mrs. Melville moved to Lansingburgh, now a part of Troy, N.Y. She and her family were in fairly desperate straits. Herman's brothers would presently make their way in the world, Gansevoort as secretary to the U.S. legation in London (where he died in 1846) and Allan as a lawyer. Thomas, the youngest, eventually became a sea captain. For Herman, at 19, the sea offered self-support, and a life certain to be more exciting than the schoolteaching he had already tried. Shipping on a Liverpool trader in June 1839, he was back in the U.S. the following October. The experiences of this voyage were later to furnish him with material for his partly autobiographical novel *Redburn, His First Voyage* (1849). On Jan. 3, 1841, Melville again went to sea, in the whaler "Acushnet," bound from New Bedford, Mass., for the south seas. In both sea ventures Melville was doubtless influenced by the experiences of the many members of his family, on both sides, who had shipped before the mast.

Having had enough of whaling, Melville jumped ship at Nuku Hiva, Marquesas Islands, July 9, 1842. With a companion, Richard Tobias ("Toby") Greene, he made his way into the interior of the island where they soon found themselves the captives of the supposedly cannibalistic tribe of the Taipis. But the natives treated their guests most hospitably. Out of his experiences of the scant four weeks spent in the valley, Melville later compounded his first book, *Typee* (1846), by which his fame was established as "the man who had lived among cannibals." Two weeks after Toby escaped Melville also broke away from his island paradise and signed on the Australian whaler "Lucy Ann" (Aug. 9, 1842).

The adventures of the short voyage which followed—it ended at Tahiti, Sept. 20, 1842—his brief imprisonment in the island calaboose (for refusing to return to the ship), his escape with "Doctor" Long Ghost and their subsequent ramblings about the nearby island of Eimeo, furnished Melville with the substance of his second and most hilarious book, *Omoo*. In it he exaggerated, for the purposes of comedy, his part in the minor mutiny which got him and his shipmates into trouble with the acting British consul, but there are other passages which show Melville's distress at the degradation of native life and his scorn for the hypocrisy of the missionaries. The social criticism in *Omoo* aroused the wrath of pious readers and reviewers when it appeared in 1847.

Melville's next voyage, aboard the whaler "Charles and Henry," covered approximately the southern Pacific route which he described in his third book, *Mardi* (1849). Then followed, from May to August 1843, a stay at Lahaina, on Maui (one of the Sandwich Islands), and at Honolulu. When Melville shipped as an ordinary seaman on the frigate "United States," Aug. 17, 1843, he embarked on a new series of adventures which were to supply him with the materials, supplemented with those of other voyagers, for *White-Jacket* (1850), the deepest and richest of the five books that preceded *Moby Dick*.

After being discharged at Boston on Oct. 14, 1844, Melville returned to his mother's home where by wintertime he had begun the composition of *Typee*. His brother Gansevoort, acting as his agent in London, persuaded John Murray to take *Typee* for his Home and Colonial Library. (Murray disliked fiction and supposed he had contracted for an entirely factual narrative.) For the most part reviewers were pleased with the novelty of *Typee* and its frank and straightforward style. *Omoo* followed the next year. With the sense of security afforded by the fame of his two books Melville married in Aug. 1847 Elizabeth Shaw of Boston, daughter of the chief justice of Massachusetts. The young couple settled in New York city, where Melville was taken up by the Duyckinck brothers, whose literary circle was the most interesting and influential in the city. Melville read widely at this time (as he continued to do the rest of his life), making up for the deficiencies in his education which had taken him only part way through Albany academy. He borrowed from Evert Duyckinck's fine library the authors who were to have the most powerful effect on him—Carlyle, Sir Thomas Browne and Rabelais.

Early in 1847 Melville began *Mardi*, which was intended to be a sequel to *Omoo*. By the end of the year he had resolved to make the second part a political and moral allegory which would contain references to the ideas about contemporary western civilization and the nature of literature, religion and philosophy. Melville sent his hero, Taji, on a voyage with King Media through the island states of Mardi (the world), in which the countries bear transparent names for England, France, the United States and the lesser western nations. Traveling with the two are a poet, a philosopher and a historian. The conversations of this company evidently relieved the young novelist of the new intellectual burden he was carrying, but the critics were not pleased. Melville retreated to what they had liked before, turning out in rapid succession *Redburn* and *White-Jacket* (whose "man-of-warish" style he regarded highly). In order to make satisfactory arrangements for the publication of *White-Jacket*, Melville went to England in 1849, returning in 1850 after a brief trip to the continent. Though this trip lasted only three months, its effects on Melville's later writing were extensive.

Home again, Melville began work on *Moby Dick*. In the fall of 1850 he bought a farm near Pittsfield, Mass., in a region he had known and loved from boyhood. He named his place "Arrowhead" and it was in this house that *Moby Dick* was completed a year later. There was time for visits from New York friends and especially for hours in the company of Nathaniel Hawthorne, his neighbour and newfound friend. Hawthorne's example gave him courage to write the mighty book he was determined to write. The many levels of meaning and the allegorical significance of *Moby Dick* owe much to Hawthorne's influence. A mixed reception greeted *Moby Dick* in 1851. Most reviewers were puzzled by it; some were abusive; only a few sensed its power. The dominant theme of the nature of evil and the author's ambiguous attitude toward nature and God were out of tune with the optimistic, romantic, Transcendental temper of the age, and its symbolistic style ran counter to the new realism in fiction writing.

But Melville had not finished what he had to say about man's place in the cosmic scheme of things. He plunged at once into the writing of *Pierre* (1852), which was to tell his readers what happens to a young man who tries to live by heaven's time in this world where the accepted measures are prudence, compromise and casuistry. In *Moby Dick* Melville permitted his readers to know, through the mind of the narrator, Ishmael, how he viewed the monomaniac vengefulness of Captain Ahab, but in *Pierre* he provided no such compass. His attitude toward his hero wavers and in the end Pierre's tragedy shows him not so much a modern Hamlet (probably Melville's intention) as a self-deluded youth who believes, as one critic said, that he is motivated by Agape while all along it is "Eros that is impelling him." Though *Pierre* is a partial failure, it anticipated the use of depth psychology by 20th-century novelists.

There is evidence that Melville suffered a near breakdown after finishing *Pierre*, but he continued to write steadily through 1856. He published two novels: *Israel Potter* (1855), the story of a soldier in the American Revolution who suffers extreme hardship, and *The Confidence-Man* (1857), a sharp allegorical satire on mid-century American concepts and attitudes. Melville also contributed a dozen stories and sketches to *Putnam's* and *Harper's*, collecting six of them in *The Piazza Tales* in 1856. Outstanding among these pieces are "The Encantadas," a series of sketches about the Galápagos, a group of mysterious barren islands on the equator; "Bartleby," a moral allegory; "Benito Cereno," perhaps his best short story; and "The Bell Tower," another allegorical piece. The subjects of these stories differ notably from the

metaphysical themes of *Moby Dick* and *Pierre*. They show that Melville was preoccupied with man's isolation, with pride and individual courage, with human failure and the possibility of recovery by reconciliation to defeat. They mirror his mind and reveal his effort to work his way to solid ground after his struggles with the form and matter of the two novels which preceded them.

To regain his health, again precarious, Melville journeyed to Europe and the Holy Land in 1856–57, stopping briefly on the voyage out to visit Hawthorne, then consul in Liverpool. After his return to the United States in May 1857, Melville lectured intermittently in the east and middle west. Unsuccessful in obtaining a government appointment, he sold his Pittsfield farm to his brother Allan in 1863, and moved to New York city. In Dec. 1866 he was made a district inspector of customs, which humble post he held until Dec. 1885, when, through family bequests, he and his wife were comfortably circumstanced. Their first son, Malcolm, had died by his own hand in 1867; their second boy, Stanwix, died after a long illness, in 1886, alone in a hospital in San Francisco. An unmarried daughter, Elizabeth (Bessie), lived with her parents. The fourth child, Frances, married Henry B. Thomas in 1880. From this marriage the family line, though not the Melville name, descended.

Melville ceased to be a "public" writer after the appearance of his poems about the Civil War, *Battle-Pieces*, in 1866. In 1876 he published a long narrative poem, *Clarel*, filled with memories of his visit to the near east but in essence a series of conversations about religion, science and politics. Two other volumes of verse were privately printed toward the end of Melville's life, *John Marr and Other Sailors* (1888) and *Timoleon* (1891). Among the projects, completed and half-finished, which Melville left at his death, three works are notable: the two travel-diaries (of 1849 and 1856–57) and the superb short novel *Billy Budd, Foretopman*.

Melville had so long lived in obscurity in New York that the newspaper notices of his death, on Sept. 28, 1891, were scanty. The *Press* was correct in observing: "Probably, if the truth were known, even his own generation had long thought him dead, so quiet have been the later years of his life."

Yet during Melville's silent years and for three decades after his death he had a kind of subterranean reputation. Following the centennial of his birth in 1919 and the publication of the first biography, R. M. Weaver's *Herman Melville, Mariner and Mystic* (1921), an extraordinary revival of interest in his work occurred, comparable in extent to the "recovery," in the same years, of Donne and the other metaphysical poets and of G. M. Hopkins. Melville took his place as one of the greatest of American writers, and *Moby Dick*, at least, was read the world over. Within 30 years a veritable library of Melville scholarship and criticism was published.

**Melville's Nature.**—Melville's temperament was complex and this complexity accounts for the shifts and changes in his themes and in his prose style. Fundamentally he was a rebel and a questioner, in revolt against many of the accepted social and moral standards of his time and in search of answers to metaphysical questions which have always baffled inquiring minds. At times convivial, Rabelaisian even in the stories of his adventures which his friends delighted to hear him tell, enjoying good food, good wine and good talk, he was at other times withdrawn and solitary. By birth and inclination a patrician, he was also passionate in his "ruthless democracy"; a man who had lived with the dregs of humanity in the forecastle yet could write in *Moby Dick:* "But this august dignity I treat of, is not the dignity of kings and robes, but that abounding dignity which has no robed investiture. Thou shalt see it shining in the arm that wields a pick or drives a spike; that democratic dignity which, on all hands, radiates without end from God." In revolt against the surviving Calvinism of his day, as well as the narrow evangelical piety which supported its missionaries handsomely in the South seas, Melville could never drive from his mind the glory and the misery which Christ's sacrifice brought into the world. Though he rejoiced in having written a wicked book when *Moby Dick* was finished, he makes one of his characters in *Clarel* say (25 years later) of the Christ:

> [Thou] shalt the Medusa shield replace;
> In beauty and in terror too
> Shalt paralyze the nobler race.

Melville's conviviality and zest for adventure are shown in *Typee, Omoo, Redburn* and *White-Jacket*. For the first time, in these books the common sailor had a voice which spoke of his trials and his daydreams, the excitement of seeing strange lands and peoples, the filth of port cities as well as the élite companionship of the maintop. Small wonder that his readers wanted Melville to continue in this vein and were puzzled when he decided, in *Mardi*, to explore the "world of mind." This first excursion into ideas is largely concerned with a criticism of existing states and speculation about the ideal social order. Entwined with it is Taji's quest for the ideal (whether of beauty or of truth it is difficult to say) by means of which, for the first time, Melville struggles with a theme that in varying forms would reappear in *Moby Dick, Pierre, The Confidence-Man* and *Billy Budd*. He states it thus in *Pierre:* "Ah, if man were wholly made in heaven, why catch we hell-glimpses? Why in the noblest marble pillar that stands beneath the all-comprising vault, ever should we descry the sinister vein?"

**The Deeper Novels.**—In *Moby Dick* this theme is incarnated in Captain Ahab's vengeful search for the white whale, who represented for him all the evil in the world, "visibly personified and made practically assailable." If he can strike his harpoon into Moby Dick, he may be able to destroy him and what he symbolizes. At least he will strike through the mask of sinister whiteness to the agent or the principal within or discover (desperate thought) that "there is naught beyond." But Ahab's Promethean quest changes to personal vengeance on the sea beast who has maimed him. He turns from the creative principle of light to the false god of fire whose "right worship is defiance." In the end he and his ship and its crew are destroyed by Moby Dick. Only Ishmael, the narrator, survives, one to whom Ahab's quenchless feud at first seemed also to be his. He deserves to survive because he has learned that in this world "there is a wisdom that is woe; but there is a woe that is madness." Let man not look too long in the face of the unholy fire.

In *Pierre, or the Ambiguities* Melville was much less sure of his bearings, but again the theme is that of a man whose native resolution to follow his faith is corrupted and defeated. At times Melville seems to jeer at his hapless and feckless hero, but he is more certain than in *Moby Dick* that the fault lies in heaven where the corrosion of evil first touched man's nature. Heaven gives perplexed man no answer to this ambiguity. "Silence is the only Voice of our God." Once again before *Billy Budd* Melville touched this theme which had obsessed him for many years. But in this final effort before the silent years set in, *The Confidence-Man*, the theme is muted to a series of variations on the idea that when we lose that confidence between man and man which holds society together, we become the victims of the confidence man with his nostrums and plausible falsehoods.

The power of the narrative and the beauty of the prose of *Billy Budd* suggest that in the last months of his life Melville finally arrived at a satisfactory resolution of his problem. When young Billy, "the handsome sailor," is impressed from the "Rights of Man" and taken on board the British seventy-four, H.M.S. "Indomitable," we catch a glimpse of Adam before his expulsion from Paradise. In the world of good and evil which he now enters, the good is represented by the father figure of Captain Vere, the evil by the master-at-arms, Claggart, who accuses Billy of mutiny. But when Billy kills Claggart in a reflexive defense of his honour, Vere is the one who must ask the court, "How can we adjudge to summary and shameful death a fellow-creature innocent before God and whom we feel to be so?" And Vere tells his fellow officers that the verdict must be death. The agony is Billy's; the tragedy is the captain's. He knows that in this world we fight at command, though for the law and the rigour of it we are not responsible.

In *Moby Dick* and again in *Billy Budd* Melville reached the heights of which he was capable as a writer of prose. Allusive, eloquent, highly figurative, subtly symbolic, it was strong enough to carry the mighty theme for which it was constructed.

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**MELVILLE, SIR JAMES** (1535–1617), Scottish diplomatist, whose *Memoirs* are a valuable authority for the history of his period, was the third son of Sir John Melville, laird of Raith, who was executed for treason in 1548. In 1549 he went to France as a page of Mary Stuart, and at the battle of St. Quentin in 1557 was taken prisoner. He subsequently conducted various diplomatic missions for Henry II of France. On Mary's return to Scotland in 1561 she gave Melville an appointment in her household, and employed him as special emissary to reconcile Elizabeth I to her marriage with Henry Lord Darnley. After Mary's imprisonment Melville again conducted several diplomatic missions, and won the confidence of James VI when the king took over the government. In 1603 he retired to Halhill where he wrote *Memoirs of My Own Life* (first published 1683), the chief interest of which lies in the first-hand account of the rival queens, Mary and Elizabeth. Melville died at Halhill on Nov. 13, 1617.

See *The Memoirs of Sir James Melville*, ed. by A. F. Steuart (1929).

**MELVILLE, JAMES** (1556–1614), Scottish Reformer, nephew of Andrew Melville (*q.v.*), was born on July 26, 1556. He was educated at Montrose and St. Leonard's college, St. Andrews. From 1575 he was one of the regents of Glasgow university and from 1580 professor of oriental languages at St. Andrews. In 1584 he joined the other banished leaders of the Scottish Presbyterian party in London for a short time. From 1586 to his death he took an active part in church organization and controversy. In 1589 he was moderator of the general assembly and on several occasions represented his party in conferences with the court. Despite his antagonism to James VI's episcopal schemes, he appears to have retained the king's respect. He answered, with his uncle, a royal summons to London in 1606 for the discussion of church policy. The conference speedily degenerated into a trial. While Andrew was sent to the Tower of London, James was placed in easy detention within ten miles of Newcastle upon Tyne. In 1613 negotiations were in progress for his return to Scotland, but his health was broken and he died at Berwick in Jan. 1614.

The importance of James Melville, in comparison with leaders of similar standing in the church of his day, lies in his careful preservation of documents and the racy style of the connecting narrative, making the Edinburgh manuscripts of his *Diary* and its continuation a frequently consulted and much quoted source for the history of the period. It has been published twice, in 1829 in a limited edition for the Bannatyne club (ed. by G. R. Kinloch) and in 1842 for the Wodrow society (ed. by Robert Pitcairn). (H. Wa.)

**MELVILLE, LAKE,** a tidal extension of Hamilton inlet on the Labrador coast of Canada. Separated from the inlet by The Narrows, it is 66 mi. long and 12 mi. wide. Adjoining lakes and bays include Goose bay and Grand lake, both at the southwestern end, and the Backway, Lake Melville's outlet to the Atlantic prior to the Ice Ages, east of The Narrows. Depths are greatest in the southeastern half, probably exceeding 1,000 ft. Lakeside settlements include Rigolet, Happy Valley, Northwest River and Goose Bay airport, built as a military air base during World War II and later used as a rescue base and emergency field for transatlantic flights. (J. D. I.)

**MEMEL:** *see* KLAIPEDA.

**MEMLING** (MEMLINC), **HANS** (*c.* 1430–1494), Flemish painter whose art was significant to Bruges amid political and commercial decline. Memling was a skilled artist before he settled at Bruges. He probably served his apprenticeship at Cologne, and later worked under Rogier van der Weyden. The inventories of Margaret of Austria, made in 1524, describe a triptych of which the central panel was by Rogier, the wings by "Master Hans." Another clear proof of the connection of the two masters is afforded by an altarpiece ordered for a patron of the house of Sforza. It is now in the Brussels gallery. The date of it is fixed at about 1460–62 by the apparent ages of Francesco Maria Sforza, Bianca Visconti and their son Galeazzo, whose portraits appear upon it. The central portion of the triptych was obviously done in the studio of Rogier; the wings appear to be by Memling, and were probably done by him in Rogier's workshop. Moreover in Memling's later work certain figures seem borrowed directly from pictures by Rogier. Memling, therefore, may have stayed in Brussels working under Rogier before going to Bruges. He resided at Bruges from about 1465 until his death.

The earliest work which can be dated is the triptych in the collection of the duke of Devonshire at Chatsworth hall, Derbyshire. It was painted for Sir John Donne of Kidwelly, who, with his wife and daughter, appears in the foreground as donor kneeling before the Virgin enthroned. On the wings are two saints. Sir John was one of the English courtiers who attended the marriage of Margaret of York to Charles the Bold which took place in Bruges in 1468. The picture was commissioned on that occasion. In the background of the left wing the artist painted himself peering behind a column. He seems to be about 35 years old and it may be surmised that he was born about 1430. This picture is typical of Memling's art. His later works are painted in the same style.

The great "Last Judgment" altarpiece in St. Mary's church at Danzig is generally ascribed to Memling. It was ordered by Angelo Tani, the representative of the Medici in Bruges, and was finished in 1472. Destined for Florence, the ship that carried it was made a prize of war by Danzig vessels in 1473. It is a picture measuring about 72 sq.ft. with more than 150 figures.

In 1477 Memling was under contract to furnish an altarpiece for the guild chapel of the booksellers of Bruges, now preserved, under the name of the "Seven Griefs of Mary," in the gallery of Turin. The effect of the whole is chaotic. Peter Bultync ordered a similar picture, the "Seven Joys of Mary," for presentation to the guild of the tanners in 1480. This panel is now in the Munich Pinakothek. All of Memling's pictures that have survived in Bruges, except one, are in the chapter house of the Hospital of St. John. Of these the first in order of date is the great triptych of 1479. The subject of the central panel is "The Mystic Marriage of St. Catherine." On the wings are "The Martyrdom of St. John the Baptist," and "The Vision at Patmos." In the background is a view of Bruges. On the back of the wings are shown the donors, two brothers and two sisters of the hospital, presented by their patron saints.

In the same year he painted another triptych on a smaller scale and finely finished. An inscription on the frame states that it was painted for John Florcins. The central panel represents the "Adoration of the Magi," that on the left "The Nativity" and the other panel "The Presentation in the Temple." The triptych, when closed, shows the figures of St. John the Baptist and St. Veronica. Another triptych, painted in 1484 in honour of St. Christopher, is in the Municipal gallery at Bruges.

A beautiful diptych, painted in 1487 for Martin van Nieuwen-

hove, is now in the Hospital of St. John. The left panel shows "The Virgin and the Child," the right has a portrait of the donor with his hands clasped in prayer and an open breviary before him. This is one of Memling's finest portraits. The portraits of the donors on Memling's pictures are distinguished and lifelike, as are the groups of the family of James Floreins—father, mother and children—which fill the noble altarpiece in the Louvre. As single portraits the busts of Burgomaster Moreel and his wife (in the museum of Brussels) and their daughter the "Sibyl Zambetha" (1480) in the hospital at Bruges are outstanding.

Memling was favoured as a portraitist by Italians. The Antwerp museum has the portrait of the medalist, Niccolo Spinelli, who was engaged as a seal engraver by Charles the Bold from 1467 to 1468. He is depicted holding a medal against a landscape background. In the Altman collection, Metropolitan Museum of Art, New York, a pair of portraits represent Thomas Portinari and his wife; in the J. P. Morgan collection is the Machiavellian "Man With a Pink." These four are early pictures. The portraits of a married pair of mature age, formerly at Milan, are now divided between the Berlin and the Louvre galleries. They are full of character and expression as is the portrait of an old man in the Altman collection, New York.

BY COURTESY OF NATIONAL GALLERY, LONDON

"A YOUNG MAN AT PRAYER" BY HANS MEMLING. IN THE NATIONAL GALLERY, LONDON

It has been suggested that three panels of equal size (one dated 1487) may have been framed together: a Madonna (at Berlin); and two, representing St. Benedict and a praying donor, at the Uffizi. The latter came from the Sta. Maria Nuova hospital in Florence. If they belong together the young donor was doubtless named Benedict, and he may be Benedetto Portinari, whose family was closely associated with Bruges and the Sta. Maria Nuova hospital. The portrait of a young man, again probably an Italian, in the Dun collection, has a distinct personality and a determined expression. The Madonna pictures possess unusual charm. One of the earliest is the full-length standing Virgin (1472) in the Liechtenstein collection. The Virgin of the "Annunciation" in the Lehman collection, New York, is one of the finest.

The masterpiece of Memling's later years, a shrine containing relics of St. Ursula in the museum of the Bruges hospital, is supposed to have been ordered and finished in 1489. The delicacy of its minature figures, the variety of its landscapes and costume, the marvelous patience with which its details are given are all matters of enjoyment to the spectator. There is a later work of the master, a large "Crucifixion," with scenes from the Passion (1491) in the Lübeck cathedral. As the close of Memling's career nears, it is observed that his practice has become larger than he can compass alone, and the labour of disciples is substituted for his own. Moreover, it is hard to distinguish which work may be attributed to his studio and which to his followers. Memling's influence is felt in the work of his contemporaries and in that of the next generation.

Memling died on Aug. 11, 1494, at Bruges. The trustees of his will appeared before the court of wards at Bruges on Dec. 10, 1495, and it is gathered from records of that date and place that Memling left behind several children and a considerable property.

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**MEMMINGEN,** a town of Germany in the Swabia district of the *Land* (state) of Bavaria, which after partition of the nation following World War II became part of the Federal Republic of Germany. It is situated 48 km. (29 mi.) S. of Ulm by road on the Ach, a small tributary of the Iller. Pop. (1961) 29,801. There are remains of the fortifications; the Gothic church of St. Martin has finely carved choir stalls; and the Frauenkirche has late Gothic wall paintings. The Renaissance town hall dates from 1580 and there are old patricians' houses, guild houses and burghers' houses (Fuggerbau). Ottobeuren (4½ mi. S.E.) has an important Benedictine abbey, founded 764. Memmingen is on the railway from Ulm to Kempten. Its industries include brewing and the production of textiles, chemicals, electrical machinery, tobacco and foodstuffs. First mentioned in 1010, Memmingen originally belonged to the Guelph family and later to the Hohenstaufens. In 1286 it became a free city of the empire, and remained so until absorbed by Bavaria in 1803.

**MEMNON,** in Greek mythology, son of Tithonus and Eos (Dawn) and king of the Ethiopians. Although mentioned in Hesiod and the *Odyssey*, he is instead a post-Homeric hero. After the death of Hector he went to assist his uncle Priam against the Greeks. He performed prodigies of valour, but was slain by Achilles after he had himself killed Antilochus, the son of Nestor and the friend of Achilles. His mother, Eos, removed his body from the field of battle, and it was said that Zeus, moved by her tears, bestowed immortality upon him. His mother wept for him every morning, and the early dewdrops were said to be her tears. His companions were changed into birds, called Memnonides, that came every year to fight and lament over his grave, which was variously located. The story of Memnon was the subject of the lost *Aethiopis* of Arctinus of Miletus; the chief source from which knowledge of him is derived is the second book of the *Posthomerica* of Quintus Smyrnaeus (itself probably an adaptation of the works of Arctinus and Lesches). As an Ethiopian, Memnon was described as black, but was noted for his beauty. The fight between Achilles and Memnon was often represented by Greek artists. Later, the story was rationalized.

In Egypt the name of Memnon was connected with the colossal statues of Amenhotep III near Thebes, two of which still remain. The more northerly of these was partly destroyed by an earthquake in 27 B.C. and the upper part thrown down. A curious phenomenon then occurred. Every morning, when the rays of the rising sun touched the statue, it gave forth musical sounds like the twang of a harp string. This was supposed to be the voice of Memnon responding to the greeting of his mother Eos. After the restoration of the statue by Septimius Severus (A.D. 170) the sounds ceased. The sound is attributed to the passage of air through the pores of the stone, chiefly caused by the change of temperature at sunrise.

**MEMOIRS:** *see* AUTOBIOGRAPHY; BIOGRAPHY.

**MEMORIAL DAY** (DECORATION DAY), in the United States, a holiday observed in the northern states on May 30, originally in honour of soldiers killed in the American Civil War but subsequently also in honour of those who fell in later wars. Before the close of the Civil War, May 30 was also celebrated in several of the southern states. In the north there was no fixed celebration until 1868, when (on May 5) Commander in Chief John A. Logan of the Grand Army of the Republic issued a general order designating May 30, 1868, "for the purpose of strewing with flowers or otherwise decorating the graves of comrades who died in defense of their country during the late rebellion"; Logan did this "with the hope that it will be kept up from year to year." The May 30 date was made legal in Rhode Island in 1874, Vermont in 1876 and New Hampshire in 1877. By the second half of the 20th century it was recognized in all the states and territories except Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina and Texas. The May 30 celebration in Virginia was regarded as a Confederate Memorial day. Confederate Memorial days are celebrated in Louisiana, Tennessee and Arkansas on June 3 (birthday of Jefferson Davis); in Alabama, Florida, Georgia and Mississippi on April 26; and in North Carolina and South Carolina on May 10. (A. McQ.)

**MEMORY.** In its most complete form, memory implies a capacity to make use of events and experiences which are treated

as belonging to the past life of the person who now describes and uses them. In this fully literal sense, what is remembered can be given a more or less sharply defined position in time and a setting of related events and experiences.

Two less complete forms of memory are also generally recognized. In these something belonging to the past life of the person or animal concerned is brought into use again or "repeated," either in a form of words (reciting something learned by heart) or as a style of bodily behaviour (carrying out a series of skilled movements). In such cases, as a rule, no specific personal reference is made and no temporal mark is assigned. The second of these two cases, involving the re-employment of learned bodily movements, was called "habit memory" by Henri Bergson, and this descriptive term is often used. It is however misleading, for most instances of skilled movement are not "habits," although they are obviously possible only when there is a basis of earlier learning. All the many views about memory appear to accept, without specifically stating, the fact that whenever and however the past is used over again, it is in attempts to deal with some immediately present situation. Memory is thus based upon earlier perceptual activity and also normally requires some current perceptual activity to set it into operation.

From the earliest speculation about remembering to most of the latest experimentally based views, it is assumed that the critical problems are concerned with how events and experiences can be retained so that they can be reproduced, either in their original mode or with the help of signs and symbols which are regarded as equivalent to that mode. Memory is thus usually considered to function perfectly in proportion to its literal accuracy of reduplication. The ordinary man and the scientist alike generally suppose that when anything happens which affects the behaviour of an organism with a central nervous system, it leaves behind some "trace" or group of traces. So long as these traces last they can in theory, under appropriate conditions, be restimulated, and then the event or experience which first set them up will be remembered. The experimental psychology of remembering—and all modern experts claim to base their views upon experiment—sets out to discover methods for establishing the requisite conditions for the persistence and length of persistence of traces and for their restimulation.

**Ebbinghaus.**—In fact, in this as in other fields of psychology, controlled experiments came very late upon the scene. It was not until after the publication of Hermann Ebbinghaus' book *Über das Gedächtnis*, in 1885, that they began to be taken seriously. Ebbinghaus, strongly influenced by Gustav Theodor Fechner, the German founder of psychophysics, and by contemporary physical science, introduced two master principles. The first was that all exact experiment upon mental events must be repeated, under as nearly the same environmental conditions as may be possible, a great number of times. Accidental manifestations will then be canceled out and the statistical uniformities will appear which indicate the basic laws of mental activity. The second was that all material to be used in psychological experiments must be set in a form that is devoid of meaning. If this is not done, the people who are experimented upon will have different initial biases of which nothing quantitative can be known.

In the case of memory, Ebbinghaus satisfied his first principle by carrying out heroically protracted experiments upon himself, in the course of which he established his famous "curve of forgetting." This shows that there is a rapidly accelerating early decay of memory during the first 24 hours or so after learning, followed by a very much slower drop, so that what can be remembered after five to ten days shows exceedingly little further decline for long periods. Other experimenters have since shown that, in the statistical sense, memory for many kinds of meaningful material follows the same general course, though the initial loss may be less rapid and the subsequent decay more prolonged.

To satisfy his second principle, Ebbinghaus hit upon the device of the nonsense syllable—an initial and a final consonant, with a vowel interposed so as to indicate a sound for which there is no meaningful word in the language that is being used. Nonsense syllables were welcomed by experimental psychologists because it seemed that they could be used, with major and minor differences of detail, in many varieties of experiment to show such things as the effects of the amount of material to be memorized, of the lapse of time between memorization and recall, and of the specific results of interpolated activities of various controlled kinds before recall; to measure what were called "association strengths" between any two or more different members of a nonsense series; to establish economical methods of memorization and the normal results of different groupings of the material to be remembered, and of periods of practice.

**Later Methods.**—To study these, and many related questions, conventional methods were established in the period following Ebbinghaus. These were: (1) the learning method, counting the number of repetitions required for a first correct reproduction of the series used; (2) the saving method, counting the number of repetitions similarly required after known intervals; (3) the prompting method, using imperfect memorization and counting the number of times and places at which prompting is required for perfect recall; (4) the scoring method, using prescribed intervals after the original presentation, or number of presentations, of the series, then exposing one syllable and requiring recall of another one, the "score" being the proportion of right answers in the whole series. Reference to any reputable textbook of experimental psychology will yield details of these conventional methods and of their principal established results.

It will be noticed that the Ebbinghaus technique—and exactly the same is true of the great mass of research modeled upon it—subscribed to the view that memory is ideally an exact reproduction. "Right" recall, upon which all the main generalizations established by nonsense-syllable experiments depended, was literally accurate recall. The truth is that, except under the special conditions laid down by the experimentalist himself, the circumstances which call memory into play can rarely be satisfied by literal reduplication. The exclusive use of meaningless material in psychological experiment, although it may have many advantages in the laboratory, suffers from most serious drawbacks as soon as it is taken outside. Normally, when memory is effective in the constantly changing environment within which human beings live, what is remembered has to be altered, adjusted, in a way distorted, to serve immediate or prospective interests.

**Psychoanalytic and Gestalt Approaches.**—A move toward less readily controlled approaches began near the end of the 19th century. Perhaps the most influential exponent was Sigmund Freud. Rather surprisingly his theory of memory, as formally expounded, remained fundamentally associationist, but in fact he was strongly preoccupied with common changes, their directions, significance and condition in the material of recall. His activities of repression, of sublimation, transformation, distortion and symbolization are far removed from anything contemplated by Ebbinghaus or his more faithful followers.

Somewhat later the Gestalt psychologists, with a wholly different outlook in their concern with normal mental functioning and their determination to find firm experimental foundations for their views, laid great stress upon the study of changes in the material of recall. They claimed experimental backing for the view that memorized material remained in a sense active, even when it was not being openly used, and that it developed toward some kind of better articulated structure or *Gestalt*, the terminal or approximately terminal stages of this development being common to all normal remembering.

**Studies in Animal Behaviour.**—Obviously most learning and all subsequent use of material or movements learned involve memory, at least in one of the two less complete forms already described. At the same time as the psychoanalytic and Gestalt movements were gathering strength, there were lively developments in the study of learning problems, especially by experiment and particularly in animal behaviour. These have continued and many of them have had a profound effect upon the ways in which outstanding problems of memory are most frequently regarded. In I. P. Pavlov's "conditioning," for example, the conditioned response may have demonstrably different properties from those of the original reflex, and it can be evoked by conditions different,

within a determinable range, from the original ones. Many investigations on the behaviour of animals when placed in a maze demonstrated that behaviour based upon earlier learning, and impossible apart from this, can nevertheless take highly flexible forms and did much to establish both the basic conditions and the limitations of such flexibility. F. C. Bartlett perhaps was the first to publish a full-scale study, experimental and theoretic, of remembering treated as an essentially constructive function. In doing this, however, he was synthesizing or summing up changed approaches and views that were already in rapid growth.

**World War II and After.**—World War II brought new streams of influence upon the psychological scene. For practical reasons considered almost everywhere to be of the first importance, many types of machines capable of exercising continuous automatic control and recording were designed, made and put into use. Some of the most intriguing of these had to do with the transmission of information. Often enough the messages communicated from one place to another must be received and stored in some form, and then sooner or later brought out of storage and used over again. The experts responsible for the design and use of these machines began to wonder, from their special mathematical and physical points of view, whether possibly the central nervous system might normally operate somewhat after the manner of electronic computers. There grew up, principally in the United States, but also during the same period in Great Britain, the views which are generally known as "cybernetics" and "theory of information." (*See* also CYBERNETICS; INFORMATION THEORY.)

By the early 1960s it was uncertain whether this latest of all approaches, in its bearing upon memory, would develop fundamentally new and different experiments and ideas or whether, as has often happened in other directions in the history of psychology, it would do little more than introduce a new and perhaps more exact vocabulary for the expert. The critical questions remained as they had been ever since remembering began to be investigated: how to understand and reconcile the conflicting demands for the accurate and literal reinstatement of events and experiences at the time when they "go into storage," and the equally urgent requirement that when they come "out of storage" it should be in forms sufficiently flexible to meet the challenges of a constantly changing world. Questions of the nature and location of the persistent effects of original experiences ("traces") had been subjected to an enormous amount of study and research. There were still no completely assured answers. It became more and more likely that they are organized into patterns of response which spread widely in the central nervous system and that they are, or at any rate are indicated, by-directions and -pathways of electrical conduction. But how these generate the meaningful behaviour of remembering is unknown and their location, if, in any strict sense, they can be said to possess one, remains a matter for vigorous dispute.

One of the odd things about memory is that it is apt to be highly specialized: the same person may consistently remember some classes of experience well and others ill. If he can find a way of coding the material that he normally recalls badly in terms of that which he can cope with well, his practical efficiency may be increased. Many attempts have been made to invent generalized codes to improve all-round capacity to remember, and these have been called mnemonic systems. In fact, mnemonic devices, all of which depend upon the use of some method of coding of what is to be remembered, may be very useful in limited fields and especially if the coding is made up by the person who is going to use it. In completely generalized and impersonal ways they are apt to break down, largely because of their inevitable complexity and ambiguity, and their importance has declined. *See* ASSOCIATION, MENTAL; CONDITIONING; LEARNING; *see* also references under "Memory" in the Index.

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**MEMPHIS,** the ancient capital of Egypt, 14 mi. S. of Cairo on the west bank of the Nile. The modern villages of Al Badrashayn and Mit Rahinah cover part of the site. Early kings built palaces there and constructed tombs in the desert plateau nearby; the name Memphis is properly applied to the whole area of the Old Kingdom pyramid fields, 20 mi. long, from Abu Roash to Dahshur, including Giza, Abu Sir and Saqqarah (*q.v.*). It was one of the "pyramid towns" that served the royal cult, that of Pepi I, named Men-nofer ("the beauty [of Pepi] abides"), which later gave its name to the city (Gr. Memphis; Assyrian Mempi; Hebrew Moph or Noph; late Egyptian and Coptic Menfe); one name for the city was Hikuptah, "mansion of the soul of Ptah," whence came Aigyptos, "Egypt," applied by the Greeks to the whole country.

Memphis occupied an important position at the head of the delta. Tradition, retailed by Herodotus and Manetho, ascribed its foundation to Menes (*q.v.*), the first king of united Egypt. The archaic palace, called White Walls, was the residence of Zoser and perhaps of earlier kings. The temple of the primeval creator-god Ptah, which lay south of it, was at all times one of the greatest in Egypt. Art and craftsmanship flourished, and the Memphite school which produced the superb reliefs of the Saqqarah mastabas and the masterly portraiture of the pyramid age was still preeminent in the Saite period, nearly 2,000 years later.

In the Middle Kingdom, though the royal residence moved elsewhere, Memphis remained an important administrative centre, and in the New Kingdom it was the chief garrison city and the base for Asiatic campaigns. Ships were fitted out in its dockyards. In the large international quarter of the city there were temples to Baal, Astarte and other foreign deities. In 730 B.C. it was captured by Piankhi the Napatan, and thereafter suffered siege by the Assyrians, by Cambyses the Persian, by Inaros and by Artaxerxes III (Ochus), but its prosperity continued. In Hellenistic times the city had a population of 700,000 and a perimeter of 18 mi. The temple of Hephaistos, as the Greeks called Ptah, enjoyed a great reputation, as did the medical school of the temple of Imhotep, Zoser's deified architect. The bull Apis, epiphany of Ptah, continued to receive rich burial in the Serapeum at Saqqarah and its oracle was venerated by the Roman emperors. With the founding of Alexandria, however, the ruin of both Memphis and Heliopolis had begun; they were destroyed by the Arabs, and the medieval builders of Cairo used the ruins as a stone quarry.

In modern times hardly anything is left of the great city. Excavations carried out over half a century by Flinders Petrie, the University of Pennsylvania, the Egyptian Antiquities service and others have recovered scant remains of the temple of Ptah, the palace of Merneptah, the embalming house of the Apis bulls and other once-famous buildings. All that the visitor can see are a few stones among the palm trees and fields, an alabaster sphinx and a recumbent colossus of Ramses II.

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**MEMPHIS,** a city and seat of Shelby county, Tenn., U.S., on the lower Chickasaw bluff on the Mississippi river in the extreme southwestern corner of the state. Pop. (1960) city 497,524; standard metropolitan statistical area (Shelby county) 627,019; in 1963 Crittenden county was added to the SMSA resulting in an adjusted 1960 pop. of 674,583. For comparative population figures for the city *see* table in TENNESSEE: *Population*. Whitehaven, Millington, West Memphis (Ark.) and Germantown are its main suburbs.

**History.**—Founded in 1819 by several rich proprietors from middle Tennessee and named for the ancient Egyptian city, Mem-

phis by 1860 had a population of 22,623, making it the sixth city in size in the south, and had become a serious economic competitor of St. Louis and New Orleans. Its growth resulted from the expansion of cotton raising in the south-central states and from its transportation facilities by railroad and river. It was incorporated in 1826 and chartered as a city in 1840. A railroad connecting it with the Atlantic (at Charleston, S.C.) was completed in 1857 and it had become second to New Orleans as a cotton market. A cosmopolitan metropolis, with a third of its residents from Ireland and Germany, it had a mercantile aristocracy; though, as an old river town, it had an underworld which rivaled Natchez-under-the-Hill. Occupied by Union forces early in the American Civil War, Memphis soon became a centre for contraband trade which attracted many enterprising Yankees. Its population doubled within the decade and its improved economic position gave it justifiable hopes of becoming the "New York of the south."

In the 1870s three epidemics of yellow fever devastated Memphis, killing 8,000 residents. The Irish died, the Germans left, the city became bankrupt and surrendered its charter and the population dropped to 33,000 in 1880. But shortly thereafter drastic sanitary reforms were carried out and the debt was paid. At the start of the 20th century Memphis stood second to New Orleans in the south, its economic recovery deriving largely from its central location; it became the largest hardwood lumber market in the world, the fifth wholesale grocery market in the United States (ahead of St. Louis) and it led New Orleans in the value of its industrial output. But the set back of the 1870s enabled Atlanta and Dallas ultimately to surpass it. The cultural consequences of the fever epidemics were more serious. Memphis became a provincial town peopled by recent migrants from the adjacent countryside in Mississippi, Arkansas and Tennessee. In 1918 less than 2% of its white residents had been born in the city. Old in time, it was as new and as provincial in cultural continuity as the younger cities of the new south. In the 1920s it had the reputation of being the most vice-ridden city in the nation and was notorious for the number of its murders.

Its comparative economic advance did not continue in the 20th century; in 1930 it had dropped to sixth place among southern cities. By the second half of the 20th century it had passed Atlanta and Birmingham but remained well behind the Texas cities. As the leading metropolis of the mid-south it attracted increasing numbers of northerners and increasing amounts of northern capital. After 1930 Memphis won national awards for safety, sanitation and noise abatement. Much of this progress took place under Edward H. ("Boss") Crump. Elected as a reform mayor in 1909 when the commission form of government was inaugurated, Crump was ousted by the courts in 1915 for his failure to enforce the state prohibition law. With the victory of the candidates he supported in the municipal election of 1927, the "Crump ticket"—Watkins Overton and Clifford Davis—his local power became absolute and through it his control of the state. For 20 years his local candidates, hand-picked by himself, received no opposition in four out of five municipal elections. In effect, he was an extralegal city manager. After his death in 1954 his machine was broken up, though some of its members continued to hold office, and elections again became spirited contests between rival candidates.

**Population Characteristics.**—The nonwhite population dropped from 48% in 1900 to 37.1% in 1960; the number of northern-born and local-born residents increased considerably. In 1960 the population of the city was 62.1% native-born white, 0.8% foreign-born white and 37.1% nonwhite.

**Commerce and Industry.**—Memphis is a major cotton and inland hardwood lumber market, wholesale centre, producer of mixed feeds and distributor of drugs and chemicals. It serves an extensive agricultural area noted particularly for its cotton but also increasingly an area of diversified crops, including corn, alfalfa, truck produce, soybeans and livestock. A dam across a chute of the river provides a $50,000,000 harbour with adjacent industrial sites. A four-lane highway bridge across the Mississippi was completed in 1949, providing better access to the west. Its trading area extends in all directions and is easily accessible by railroads, highways, airlines and rivers. One of Memphis' main advantages is the distance which separates it from other large cities—St. Louis to the north, New Orleans to the south, Birmingham and Atlanta to the east and the Texas cities to the southwest. Consequently many national firms have established branch offices or factories there.

**Education.**—Facilities for higher education include Southwestern at Memphis, a Presbyterian college established in 1848; LeMoyne, a Congregational Christian college, established in 1871; Christian Brothers, a Roman Catholic college for men, established in 1871; Memphis State university established in 1909; and several divisions of the University of Tennessee, the largest of which is the college of medicine, dentistry and pharmacy.

**Parks and Recreation.**—The city has over 70 public parks and a free zoo. It is the site of the Cotton carnival, a week-long festival held every May. Memphis is the home of the "blues," a form of jazz (*q.v.*) associated particularly with W. C. Handy, which immortalized Beale street.

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(G. M. CA.)

**MEMPHREMAGOG, LAKE,** an elongated finger lake that crosses the U.S.-Canadian border about 5 mi. N. of Newport, Vt. Extending about 27 mi. from Newport to Magog, Que., the lake is only one to two miles wide for most of its length, but there are several large embayments. These include Fitch bay on the east shore about 17 mi. south of Magog and Sargents bay on the west shore about 10 mi. south of Magog. A small-scale hydroelectric development has grown at the north end of the lake where it drains by way of the Magog and St. Francis rivers into the St. Lawrence. Depths average 50–75 ft. with shallows at the south end. The deepest part, about 350 ft., is at the narrows near the entrance to Fitch bay. Lake Memphremagog is well stocked with fish and is used by small pleasure boats. There are floatplane anchorages near Magog and Newport. The surrounding country is rolling wooded upland with poor soil. Local deposits of copper and asbestos have been exploited intermittently, but the importance of the area lies in its dairy, pulp wood and timber industries and the rapidly growing tourist trade. The first settlers came from Connecticut, New York and Massachusetts in the last decade of the 18th century. (F. K. HE.)

**MEN,** a moon-god worshiped widely in Asia Minor in Roman times, but also in Attica from the 3rd century B.C. on. His name is usually found with a cult title, often an adjective denoting a locality, sometimes the words *tyrannos, ouranios* or the like. His most frequent attributes are the pine cone, bucranium (ox skull) and chicken. A temple of Men has been excavated at Antioch in Pisidia (modern Yalvac, in central Turkey). The origin of Men is obscure, but he may be connected with the Zoroastrian moon-god Mao. His image, known chiefly from coins, is a male figure with a crescent moon behind the shoulders.

*See* W. Drexler, "Men," in W. H. Roscher, *Ausführliches Lexikon der griechischen und römischen Mythologie;* M. Hardie, "The Shrine of Men Askaenos at Pisidian Antioch," *Journal of Hellenic Studies,* vol. xxxii, pp. 111–150 (1912).

(E. N. L.)

**MENA, JUAN DE** (1411–1456), Spanish poet, was born at Córdoba, and died at Torrelaguna. His chief work is *El Laberinto de Fortuna* (1444), long-known as *Las Trezientas* (since in its final form it contains 300 stanzas); it is a Dantesque allegory, but carried in its time a political message for John II. Its heavily rhythmical *arte mayor* metre (lines of 12 syllables) is often monotonous, but there are passages of rare power and music. Mena's language, rich in Latinisms and rhetorical devices, had great influence; in this, in his imitation of Virgil and Lucan, and in his references to classical personages, he took an important step toward the Renaissance.

*See* M. R. Lida de Malkiel, *Juan de Mena, poeta del prerrenacimiento español* (1950).

(C. C. SH.)

**MENA, PEDRO DE** (1628–1688), Spanish baroque sculptor, creator of numberless statues and busts of polychromed wood for churches in Spain and Latin America, was born in Granada on Aug. 20, 1628. He was a pupil of his father, and from 1652 to

1657 was an assistant of Alonso Cano. Mena's style, thoroughly indebted to Cano, is more theatrical and realistic, in keeping with the late baroque. His faces tend to be less forceful. In 1658, Mena went to Málaga and began work on 40 choir stalls, finished in 1662, for the cathedral. Technically highly proficient, he achieved there individuality, vitality and lifelikeness. In 1663 he visited Madrid and Toledo, and was named sculptor of Toledo cathedral. One of his most stirring works, a St. Francis (Toledo cathedral) with keen upward gaze and half-open mouth, suggests ascetic ecstasy. Many of his sculptures at Málaga, to which he returned in 1664, were destroyed in the riots of 1931, including his masterful "Virgin of Bethlehem" at Santo Domingo church, which combined dignity and playfulness, seriousness and extrovert grace, typical of Andalusia. The Virgin of Sorrows and the *ecce homo* were favourite themes. He died in Málaga, Oct. 13, 1688. Compared with him, José de Mora (1642–1724), the other Granadine pupil of Alonso Cano, may be called more exquisite and precious.

*See* Ricardo de Orueta, *Pedro de Mena* (1914); George Kubler and Martin Soria, *The Art and Architecture of Spain and Portugal and their American Dominions 1500–1800* (1959). (M. S. S.)

**MENABREA, LUIGI FEDERICO,** Conte (1809–1896), Italian statesman of the latter years of the *Risorgimento*, was born at Chambéry in Savoy, then part of the kingdom of Sardinia-Piedmont, on Sept. 4, 1809. He joined the Piedmontese army as officer of engineers and from 1839 taught at the military academy of Turin. Entering politics in 1848, he was elected deputy to the Piedmontese parliament as a left-wing Liberal but later his views became more moderate. He served as colonel of engineers in the war of 1859 against Austria (*see* Italian Independence, Wars of), being promoted to lieutenant general in 1860. In the same year, shortly before Savoy was ceded to France, he was made senator for life.

After the formation of the new kingdom of Italy, Menabrea served as navy minister in Bettino Ricasoli's cabinet (June 1861–March 1862) and as minister of works in Luigi Carlo Farini's (Dec. 1862–March 1863) and in Marco Minghetti's (March 1863–Sept. 1864). On Oct. 3, 1866, he signed the peace treaty of Vienna with Austria, whereby Venetia was ceded to Italy. He became prime minister on Oct. 27, 1867, when Garibaldi's march on Rome was collapsing. Having failed to persuade the French to consent to an Italian occupation of Rome, he resigned on Nov. 19, 1869. He was subsequently ambassador in London (1870–82) and in Paris (1882–92). He died at St. Cassin, near Chambéry, on May 26, 1896.

**MÉNAGE, GILLES** (1613–1692), French man of letters, well-known in his lifetime as a scholar and as a critic and after his death as the eponym of a book of anecdotes, was born at Angers on Aug. 15, 1613. A lawyer's son, he practised at the bar in Angers and, from 1632, in Paris. There he began about 1639 to frequent Mme de Rambouillet's circle of Précieuses, under whose influence he fell and whose ideals he was to defend. Gradually abandoning the law for the church, he attached himself to the future cardinal de Retz from 1643 to 1652, then to the finance ministers Abel Servien and Nicolas Fouquet, to whose memory he remained remarkably loyal after Fouquet's disgrace. His *Mercuriales* or "Wednesday meetings," at which poets and critics discussed literary matters, began in 1656. Mme de Sévigné and Mme de La Fayette enjoyed his society, but his gallant attentions to ladies provoked much ridicule, and his malice many enmities (the pedant Vadius in Molière's *Les Femmes savantes* is a caricature of him). He died in Paris on July 23, 1692.

Ménage's writings include controversial tracts (from 1636 onward), a book on the pleasures of civil law (1644), insipid poems in Latin, Greek, French and Italian (1st ed. 1656; 8th ed. augmented, 1687), a history of women philosophers (1690) and numerous commentaries on ancient and modern authors, as well as two more valuable philological works, *Les Origines de la langue françoise* (1650) and *Observations sur la langue françoise* (1672). After his death his friends published his jokes, retorts, miscellaneous judgments and curious observations as *Menagiana* (1693; 3rd ed., 4 vol., 1715), an entertaining compilation that was read with pleasure throughout the 18th century.

For the *Mercuriales* see the *Chronique des chapons et des gelinottes du Mans*, ed. by F. Lachèvre (1907). *See* also H. Ashton, *Ménage et ses élèves* (1920); A. Adam, *Histoire de la littérature française au XVII^e siècle*, 5 vol. (1948–56).

**MENAHEM,** king of Israel, seized the throne *c.* 752 B.C., after the death of Zechariah, whose reign lasted only six months. Events of his reign are related in II Kings xv, 14–22. From his headquarters at Tirzah, the old royal city of Israel, he advanced against Shallum ben Jabesh, a rival aspirant to the throne who maintained royal state in Samaria for a month, and slew him. He was not accepted by the district of which Tappuah was the centre, and made his position good only by bitter fighting, after which he inflicted barbarous punishment on those who would have thwarted him. Toward the end of his ten-year reign the peoples of Syria formed an anti-Assyrian coalition. Tiglath-pileser III advanced against the rebels and crushed them.

The Assyrian king, in an inscription recording his successes, names among the kings who paid tribute Menahem of Samaria. The narrative in II Kings xv confirms this, and indeed suggests that Tiglath-pileser advanced against Israel itself. The inscription is silent on this latter detail, and probably Menahem thought it wise to pay tribute before this pass was reached. Menahem was succeeded by his son Pekahiah.

**MENAI STRAIT,** a channel of the Irish sea, separating the island of Anglesey from Caernarvon, north Wales, extends 15 mi. from Beaumaris to Abermenai and varies in breadth from 200 yd. to 2 mi. It is famous for the suspension and tubular bridges which cross it. The suspension bridge carries the Holyhead road from Bangor. It was designed for stagecoach traffic by Thomas Telford and was begun in 1819, being completed in 1826. The length of roadway between the piers is 580 ft., the total length being 1,265 ft., and the height above the spring tide high-water level is 100 ft. The bridge was reconstructed and widened in 1938–41. The tubular bridge by Robert Stephenson, which carries the Midland region's main railway line from London to Holyhead, was built in 1846–50. The bridge, 1,841 ft. 5 in. long, is supported by the central Britannia tower, which is 230 ft. high and rests on a rock in mid-channel; two side towers; and an abutment on each shore.

The origin of the Menai strait has been much discussed (*see* E. Greenly, "Geology of Anglesey," *Memoirs of the Geological Survey*, 1919). The channel consists of an eastern and a western reach joined by a middle reach, 2 mi. long, having a north to south direction. The two longer arms are typical valleys, belonging to a system of parallel valleys upon the Menaian platform. In preglacial times the location of the strait was marked by three rivers corresponding to the later reaches. In late glacial times the western and eastern reaches came into existence, but the water of the latter was dammed back by the Ogwen glacier from the mainland, thus forming a long glacial lake which overflowed into what is now the middle reach, following the line of the southward flowing river, the valley of which it quickly deepened and thus emptied the lake. Postglacial subsidence and scouring by the tides have completed the work. (E. G. Bow.)

**MENANDER** (2nd century B.C.), the greatest of the Indo-Greek kings and the one best known to western and Indian classical authors, was born in a village called Kalasi, "not far from Alasanda" (Alexandria of the Caucasus). For about 20 years, from *c.* 155 B.C., he ruled an area stretching from the Kabul valley in the west to the Ravi in the east, and from the Swat valley in the north to Arachosia in the south. Pompeius Trogus and Justin refer to him as a king of India. Plutarch calls him a king of Bactria and Strabo includes him among the Bactrian Greeks "who conquered more tribes than Alexander." It is possible that he ruled over Bactria and it has been suggested that he helped the Seleucid Demetrius II against Parthia.

Strabo quotes Apollodorus of Artemita as saying that the conquests in India by the Bactrian Greeks were achieved mostly by Menander and that he probably advanced beyond the Hypanis (Beas) as far as the Imaus or Isamos river (either the Jumna or Son). Patanjali's grammatical treatise the *Maha-bhashya* and Kalidasa's drama *Malavikagnimitra* refer to an abortive Yavana

invasion about the middle of the 2nd century B.C. It was probably Menander who led military expeditions into Rajputana and central India and advanced in the valley of the Ganges as far east as Patna. The evidence suggests that these adventures were unsuccessful and the only inscription referring to Menander has been found in Bajaur in the Swat valley.

Menander, whose name has survived in Buddhist literature as Milinda (the other Indian forms of his name are Minedra and Menadra), is known from the Pali work *Milindapanha* ("The Questions of Milinda") as the Yavana king who was converted to Buddhism by Nagasena after a prolonged and intelligent discussion. (*See* MILINDAPANHA.) It is probable that the wheel on some coins of Menander is connected with Buddhism. Plutarch's statement that when Menander died his earthly remains were divided equally among the various cities and that monuments were to be erected to enshrine them, is reminiscent of the story of the Buddha.

Menander's coins are found in large numbers, attesting to both the duration of his reign and to the flourishing commerce of an extensive kingdom. A few coins in gold are generally attributed to him but he issued coins mainly in silver and copper. Pallas Athene is the chief deity represented on them. Menander used two epithets, *soter* ("saviour") and *dikaios* ("just"), on his money. *Dikaios* coins seem to have been struck toward the close of his reign since on them Menander looks older than on the *soter* coins. It is possible that the epithet *dikaios,* which is translated as *dhramika* in the Kharosthi legend on his coins, is connected with his adoption of the Buddhist faith.

According to Buddhist tradition he handed over his kingdom to his son and retired from the world, but from Plutarch it appears that he died in camp while on a campaign. *See* INDIA-PAKISTAN, SUBCONTINENT OF: *History.*

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**MENANDER** (342/341–292/291 B.C.), Athenian dramatist who was recognized by ancient critics generally as the supreme poet of Greek New Comedy. During his life his success was limited; although he wrote more than 100 plays he won only eight victories at the Athenian dramatic festivals. Later, Latin adaptations of his plays by Plautus and Terence carried the influence of his work to medieval and modern times, while the originals remained lost, apart from excerpts and quotations. Finds of papyri during the 19th and 20th centuries have recovered substantial portions of continuous Greek text, which are illuminated by the parallel progress of archaeological research into the theatrical antiquities of the period.

As with many ancient authors, the known facts of Menander's life are few and not very informative. He is said to have been of good family, the son of Diopeithes, of the deme (district) Cephisia; and to have lived the life of a man of means. On attaining the age of 18, he duly registered for his two years of military training as an *ephebos,* in which he had the company of Epicurus of Samos, who was to become founder of the school of philosophy that bears his name. Toward the end of this period, in 321, Menander produced his first play, *Orge* ("Anger"), and the close observation of human behaviour that is evident from his work is in conformity with the record that he was a pupil of the philosopher Theophrastus; it is uncertain what factual basis lies behind the tradition that gives credit for his education to the comic poet Alexis of Thurioi, who is described as his paternal uncle; the relationship may have been presumed from a kinship recognized in their work. At the Lenaean festival of 316, Menander won with the *Dyskolos* (or "Misanthrope," by its alternative title), and gained his first victory at the Dionysia in the next year. From his early childhood Athens had been under Macedonian domination, and Diogenes Laertius records that the poet narrowly avoided prosecution through his friendship with Demetrius of Phalerum, a fellow pupil of Theophrastus, who was expelled from his governorship of Athens in 307. It is also known that when the *Imbrioi* was written for production in 301 (though produced later) Menander had written more than 70 plays. He probably spent most of his life in Athens, for he is said to have declined an invitation to Macedonia, as well as to Egypt, where his rival Philemon worked for a time; Pausanias, the geographer, noted his tomb on the road from the Piraeus, and it is said that he was drowned there while swimming.

In his later years, or soon after his death, a statue of Menander by Cephisodotus and Timarchus, the sons of Praxiteles, was set up in the theatre of Dionysus; this work, of which only the base survives, is likely to have been the source of many of the numerous later likenesses. A well-known relief in Rome (Lateran museum, 487), of which there is a replica in Princeton University Art museum (no. 51–1), shows the poet seated and apparently looking for inspiration at a mask of one of his characters as he composes a scene. Among the anecdotes about Menander, there is one told by Plutarch in the *De gloria Atheniensium* which may preserve some truth about his methods of composition: a friend remarked that the Dionysia was approaching; had Menander not written his play? "Yes" said Menander "I have the structure worked out: I need only set the lines to it."

**Features of the New Comedy.**—Comedy had changed greatly in the century that separates Menander's dramatic debut from the earlier plays of Aristophanes in the 420s. It had very largely abandoned the satirical treatment of public issues and prominent men (personal references in Menander are brief, rare and generally regarded as a sign of early date); it had turned instead to the private world of fictional ordinary people, and in so doing ceased to be contemporary and became universal. The language of comedy no longer displays the elaborate verbal pyrotechnics of the 5th-century writers. Menander rarely rises to the poetic, and writes for the most part a refined version of current spoken Attic. The role of the chorus, already greatly reduced in the later plays of Aristophanes, is now regularly confined to the performance of interludes, recorded in the written copies only by the heading "chorus" (*chorou*); the *Dyskolos,* for example, is divided by four such interludes into five parts or acts, and it is probable that this shape was normal in Menander's time. The mask, a relic of the remote origins of drama in religious cult, was still retained, and elaborated to provide the range of characters required by a comedy of manners. Apart from their consequences for production and acting, masks and certain standardized details of costume also helped an audience without playbills to recognize the characters for what they were, but did not prevent a poet who wished to do so from portraying variations within or against the type; one of Menander's innovations is likely to have been the sympathetic treatment of the traditional braggart soldier, as with Polemon in *Perikeiromene* ("The Rape of the Locks").

**Principal Known Works.**—Large parts of *Perikeiromene, Epitrepontes* and *Samia* and important fragments of two other plays were discovered in a codex found by G. Lefèbvre at Aphroditopolis in 1905, and published in 1907; it is in Cairo museum, no. 43,227. Rediscovery had begun in 1844, with some fragments found by C. Tischendorff in the monastery of St. Catherine on Sinai, first published in 1876 and now in Leningrad. The *Dyskolos,* the only complete play to be recovered, was first printed in 1958 from some leaves of a papyrus codex acquired in Egypt for the Bodmer library at Le Grand Cologny, near Geneva. These and many other discoveries, in addition to the older fragments, are supplemented by what can be detected of Menander's work in Latin adaptations. Plautus took from him *Bacchides* (*Dis Exapaton*); *Cistellaria* (*Synaristosai*); *Stichus* (*First Adelphoi*); *Aulularia* (Greek title uncertain); and a good case can be made for other ascriptions. Terence, who is in general a more faithful follower of Menander, derived four of his six plays from him: *Andria* (*Andria,* with additions from *Perinthia*); *Heautontimorumenos* (same title); *Eunuchus* (*Eunouchos,* with additions from *Kolax*); *Adelphoe* (*Second Adelphoi,* with a scene from Diphilus, *Synapothneskontes*).

**Dramatic Qualities.**—Menander learned much from classical tragedy and from earlier comedy, which were read, studied and regularly performed in his time; and especially from Euripides, both directly and through the influence which Euripides had exerted on comedy since his own day. "No play of Menander is without its love-interest" said Ovid in the *Tristia*, and in outline those now known may seem novelettish, with stern fathers, young lovers, greedy *demimondaines*, the recognition of long-lost children and the intrigues of cunning slaves. But Menander's nicety of touch in working out a basically simple plot is clearly visible in the *Dyskolos*. Here he portrays the trials of a rich young man from the city in winning the hand of the country girl with whom he fell in love at first sight while out hunting, a theme developed with an admirable variety of incident, in which the young poet exploits the romantic colour of an attractive country setting and contrasts the outlook of the two groups of city and country people from which his characters are drawn. The most developed character study is that of Knemon, the girl's unapproachable father, whose gruff misanthropy provides the title; the portrait recalls that of the suspicious skinflint who became Euclio as adapted by Plautus in the *Aulularia*, and, by a further remove, Harpagon in Molière's *L'Avare*. Though he is capable of comedy in lighter vein (as in the lively ending of the *Dyskolos*), Menander's greatest achievement is surely to be seen in the subtle clash and contrast of character and ethical principle in such plays as *Perikeiromene* and *Second Adelphoe*.

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**MENANDER PROTECTOR** (fl. second half of 6th century A.D.), Byzantine historian whose fragments are a valuable authority for the 6th century, especially on geography and ethnography, held military office (*protiktor*), which was perhaps honorary. He studied law, abandoned this, and then at the suggestion of the emperor Maurice (582–602) he wrote a history modeled on Agathias (*q.v.*). It begins at the point where Agathias left off, and the surviving text includes the period from the arrival of the Kotrigur Huns in Thrace in 558 down to the negotiations with the Avars about Sirmium in 582. Considerable fragments are preserved in the excerpts of Constantine Porphyrogenitus and in the Suda lexicon.

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**MENANGKABAU** (MINANGKABAU), a powerful Malayan people inhabiting the Padang highlands of central Sumatra. Under early Indian influence they became the centre of the Hindu-Malayan empire of Malayu, a state which once dominated most of the plateau area, and sent colonists to the west coast of the Malay peninsula (Negri Sembilan). In the 1960s Indian tradition was still strong in their material culture and mythology.

The Menangkabau have much in common with the coastal Malay, but differ radically in social organization. Despite the fact that they are converts to Islam, the position of women is high and a matrilineal system exists. The smallest unit in this scheme is the community house, in which a head woman, her sisters, their daughters and their children live. Several of these houses make up the clan, within which no marriage is allowed. Sons always remain members of the mother's house but they are only visitors in the homes of their wives. Descent and inheritance are through the mother's line. Several clans make up the *negari*, or phratry—the largest native element of government. Each house is represented in the clan council by a male member, and each clan likewise participates in the larger unit.

BY COURTESY OF CHICAGO NATURAL HISTORY MUSEUM

A TYPICAL COMMUNITY HOUSE OF THE MENANGKABAU PEOPLE ON SUMATRA

The family house is a large rectangular structure, raised high above the ground, with a saddle-shaped roof. A main room occupies much of the structure. Adjoining this are living compartments, each occupied by a woman, her children and her husband when present. The Muslim religion allows four wives and divorce is easy. If a man avails himself of the privilege of plural marriage, he must arrange his affairs so as to devote equal time to each spouse.

Much of the wealth—especially land and heirlooms—belongs to the house or family, but individual possessions are allowed and many of the men are traders to neighbouring islands. Despite the fact that the Menangkabau are now Muslims and that some have made the pilgrimage to Mecca, many basic Malayan religious ideas persist. Mediums combine their activities, such as soul-catching and magic, with simple curative practices. Professional magicians, with trained accomplices, furnish charms and formulas and carry out ceremonies intended to bring rain or sunshine, to compel love, or to confound enemies. Magical formulas are mixtures of pagan and Muslim ideas.

The Menangkabau have extensive, terraced fields and garden plots in which they raise irrigated rice, tobacco and cinnamon, as well as fruits and vegetables. They are excellent wood carvers and metalworkers and produce the finest weaving found in Indonesia. Although they numbered only about 3,000,000 in the 1960s, the Menangkabau played an important role in the Indonesian independence movement, and several members filled important positions in the government. *See* also SUMATRA; MALAY.

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**MÉNARD, LOUIS NICOLAS** (1822–1901), French writer whose vision of ancient Greek religion and philosophy influenced the Parnassian poets (*q.v.*), was born in Paris, Oct. 19, 1822. He was educated at the Collège Louis-le-Grand and the École Normale. A gifted chemist as well as a painter and historian, he was an early investigator of collodion (*q.v.*), a substance later much used in photography and medicine. He was a socialist republican and was condemned to prison in 1849 for his *Prologue d'une révolution*, but escaped to London and lived in exile, returning to Paris in 1852. Thereafter he devoted himself to classical studies, the fruits of which include his *Poèmes* (1855),

*Polythéisme hellénique* (1863), his doctorate thesis *La Morale avant les philosophes* (1860) and *Histoire des Grecs* (1884–86). He spent several years painting in Barbizon and exhibited several canvases in the Salons (1857–69). In 1871 he supported and defended the Commune and in 1876 published *Rêveries d'un païen mystique*, which expounds his philosophy. He later held academic chairs in decorative art and universal history. He died in Paris, Feb. 9, 1901. His poems pale beside those of Leconte de Lisle and José María de Heredia, both of whom he influenced considerably: his short novel *La Légende de Saint-Hilarion* (1875) inspired Anatole France's *Thaïs* (1890). His importance can best be seen in his historical and critical works, which demonstrate his belief in the truth and power of polytheism.

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**MENASHA,** a city of Winnebago county, Wis., U.S., 94 mi. N.W. of Milwaukee, with the adjoining city of Neenah forms one industrial community, often called Neenah-Menasha. Both cities overflow into the surrounding rural areas. The Fox river there issues from Lake Winnebago in two channels, each providing water power. Neenah developed on the south, Menasha on the north channel; and each city has part of Doty Island, the land between. Permanent settlement of both began in the 1840s. Neenah was incorporated in 1873 and Menasha in 1874. Neenah was at first known for its flour mills; but beginning about 1870 papermaking gradually became its chief occupation. Menasha's industry has always been more diversified: in early days it was best known for lumber and woodenware, in the 20th century the largest among its many enterprises are papermaking and printing. The presence of Lake Winnebago helped in the creation of beautiful parks and residential areas, while sailboating and yachting are popular recreations. In the language of the Winnebago Indians Neenah means "water"; Menasha, "waves." For comparative population figures *see* table in WISCONSIN: *Population.* (W. F. RY.)

**MENCIUS** (Latinized form of MENG-TZU, "Master Meng"; private name K'o) (371–289 B.C.?), Chinese philosopher, whose life is strikingly similar to that of Confucius (*q.v.*). Like Confucius, he was born in what is modern Shantung province, lost his father at about the age of three (according to tradition), lived in a period of political chaos, social and cultural disorganization and intellectual conflict, became a professional teacher, served briefly as an official (in the state of Ch'i from 319 to 312 B.C.), traveled for about 40 years from state to state advocating reform, and finally was disappointed and retired.

Unlike Confucius, however, he had a teacher, either Confucius' grandson Tzu Ssu or his pupil. He was more self-confident, asking, "If Heaven wishes peace and order for the world, who is there besides me to bring it about?" He was highly argumentative, very dogmatic, and at times radical. Like Confucius, he idolized the legendary sage-emperors but also declared that "it is better not to have any history than to believe all histories." He was relentless in attacking opposite schools and staunchly defended Confucius as a sage and master. There is no information about his family, except the traditional stories that his mother moved twice to be near a school so that her son could imitate scholars and that, as an object lesson, she cut the cloth she was weaving when the boy interrupted his school and returned home.

The keynote to Mencius' philosophy is his doctrine of the original goodness of human nature, the first such in Chinese history. According to him, "Human nature follows the good just as water seeks the lower level." "All men originally have the feeling of commiseration, the feeling of shame and dislike, the feeling of deference and compliance, and the feeling of right and wrong," he asserted. These are the "four beginnings" of love, righteousness, propriety and wisdom, respectively. "They are not drilled into us from outside. We are originally provided with them." This can be shown by the facts, he said, that children naturally love their parents and that when men suddenly see a child about to fall into a well, a sense of distress and alarm is instinctively aroused in them. This doctrine of original goodness is diametrically opposed to that of his junior contemporary, Hsün-tzu (*q.v.*), and has been a basic doctrine in Confucianism in the last 2,000 years.

Since man is originally good, it follows that he possesses "native knowledge" of the good and "native ability" to do good. If one "develops his mind to the utmost," he can fulfill his nature, establish his destiny, and serve Heaven. Evil and failure are not due to man's original nature but to one's "losing the originally good mind," "self-destruction and self-abandonment," or "lack of effort." Consequently, one must seriously "seek for the lost mind," which is the end of education.

Since love is inborn, one who fulfills his nature will "embrace all in his love." Mencius bitterly attacked the egoism of Yang Chu, who "would not pluck a single hair to benefit the world." But he insisted that the practice of love must start with the family, and strongly opposed Mo Ti's doctrine of universal love (*see* MO TI) which to him meant that "no peculiar affection is due a father. To acknowledge no father . . . is to be a beast." Instead he taught the doctrine of "love with distinctions," that is, that there must be an order or gradation in love, starting with filial piety. Actually this does not contradict universal love, for he desired to "treat with respect the elders in my family, and then by extension also the elders in other families."

Mencius regarded filial piety as fundamental to all the virtues, especially those in the five human relations—affection between father and son, righteousness between sovereign and minister, attention to their separate functions between husband and wife, proper order between old and young, and good faith between friends. The most filial deed is honouring parents, and the most unfilial is to have no posterity. He thought the way of the wife is to obey. At the same time, he stressed that all men are equal, because moral nature and moral power are inherent in all. Therefore everyone is "complete in himself," and "All men can become sage-emperors like Yao and Shun."

Because his age was in great disorder, he emphasized righteousness equally with love, saying that "love is man's mind and righteousness man's path." These two are to be the guiding principles in government. He freely lectured the feudal rulers on "benevolent government" and vigorously advocated righteousness as opposed to utility and profit. He wanted to overcome "the way of the despot" or the way of force by the "kingly way" or the way of moral power.

Following Confucius, he maintained that only good men should rule. A ruler's right to rule comes from the mandate of Heaven, which is revealed in the conditions and sentiments of the people. To him in a state "the people are the most important, territory is secondary, and the ruler the least important." Bad rulers are to be overthrown, by revolution if necessary, for they have lost Heaven's mandate.

For practical measures, he recommended establishment of schools, promotion of agriculture, permanent property for the people, restoration of the ancient nine-square system with eight families each cultivating one square but jointly cultivating the ninth for the state, equal distribution of wealth, little punishment, light taxes, and protection of the old and the weak.

His teachings are found in the *Book of Mencius* (*Meng-tzu*) compiled after his death. They have been regarded as orthodox Confucianism and have exerted tremendous influence on Chinese thought, especially on neo-Confucianism. He was China's greatest sage after Confucius in the neo-Confucian hierarchy. *See* also CHINESE PHILOSOPHY; CONFUCIANISM.

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**MENCKEN, HENRY LOUIS** (1880–1956), U.S. writer and controversialist, for two decades the most pungent critic of American life, was born in Baltimore, Md., on Sept. 12, 1880. After attending the Baltimore Polytechnic institute he became a reporter on the *Baltimore Morning Herald*, later joining the staff of the *Baltimore Sun*.

From 1908, when the *Smart Set* magazine hired him to do its book reviewing, until 1929, when the stock market crash made his caustic wit seem out of place, he jabbed his pen at many an Ameri-

can weakness. He often used literary criticism as a point of departure, though he wrote enough reviews and miscellaneous essays to fill six volumes of aptly titled *Prejudices* (1919–27). In literature he fought against what he regarded as the fraudulent successes of the time (the Harold Bell Wrights, for example) and for the recognition of such newcomers as Theodore Dreiser and Sinclair Lewis. His most famous forum for this and other causes was the *American Mercury*, which he helped to found in 1924, after leaving the *Smart Set*, and edited until late 1933. On both the *Smart Set* and the *American Mercury* he was associated closely with George Jean Nathan (*q.v.*).

Before 1929 Mencken's influence on the literary world was great, but his effect on American culture in general was equally marked, if it can be judged by the rage he aroused. In mid-career he could—and did—publish an entire book made up of denunciations of him. He jeered at organized religion, he ridiculed business and the middle class, and he called the sensitive south "the Sahara of the Bozart." Yet many readers found it refreshing, after hearing others eulogize their nation, to read in Mencken that the American people constituted "the most timorous, sniveling, poltroonish, ignominious mob of serfs and goose-steppers ever gathered under one flag in Christendom since the end of the Middle Ages." (H. L. Mencken, "On Being An American," *Prejudices: Third Series*, Alfred A. Knopf, Inc., New York, 1922.)

Mencken's view of life changed little during his career. In the '30s and '40s he altered considerably less than the world around him, with the result that his influence almost disappeared. Few people found the great depression a subject for satire of any sort, yet he was as satirical about Roosevelt as he had been about Hoover. Similarly, when the German culture he had enjoyed began to be marred by Hitler and fascism, Mencken was slower than some of his public to realize it and to take the fact seriously. But he still had another contribution to American culture to make. This took a surprising form, and one that survived his lessened popularity. In 1919 he had published a solid volume, *The American Language*, an attempt to bring together examples of American, rather than English, expressions and idioms. The book at once attracted attention. It grew with each reissue through the years, and in 1945 and 1948 Mencken published a substantial supplement. By the time of his death, he was the leading authority on the language of his country.

However memorable his role as a literary or social critic, or even as a linguistic scholar, Mencken always thought of himself as a newspaperman. Throughout most of his life he had worked for the *Baltimore Sun*, doing everything from police reporting to national political news. Much of the liveliest writing in his autobiographical trilogy, *Happy Days* (1940), *Newspaper Days* (1941) and *Heathen Days* (1943), is devoted to his experiences in journalism. He died in Baltimore on Jan. 29, 1956.

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**MENDE**, a town of southeastern France, on the Lot river, capital of the *département* of Lozère and of the Gévaudan region, 210 km. (131 mi.) S.S.E. of Clermont-Ferrand by road. Pop. (1962) 7,647. It is crossed by several main roads. The administrative departments of Lozère are housed together in one building, the Cité des Carmes. Mende has a tribunal of the first instance and is the seat of an assize court and of a modern chamber of commerce. It has been the seat of a bishop since the 10th century. The town also possesses a *lycée*, a technical college and a museum (archaeology, folklore, speleology). Historical monuments include the Pont Notre-Dame (13th century), the town hall (with 17th-century Aubusson tapestries) and a former consulate house (now the municipal library). The wool industry, from which until the 19th century the town's wealth chiefly derived, has almost died out. A pottery studio continues the craft traditions of the Gévaudan. Because of its position on the road to the Gorges du Tarn (17½ mi. away), the Cévennes, the Monts d'Aubrac and the Montagnes de la Margeride, Mende has come to depend strongly on the tourist trade.

Mende (Mimate, Memde) grew up around a hermitage. Bishop Aldebert surrounded the town with ramparts of which traces can still be seen, notably the Penitents' tower (12th century). Pope Urban V began in 1369 to build the Cathedral of Notre Dame, which was destroyed by the Huguenots in 1580 (when they sacked the town) and rebuilt at the beginning of the 17th century. Bishop François de la Rovère (della Rovere), nephew of Pope Julius II, built the great tower in florid Gothic style; the cathedral chapter raised the little tower. (B. B.; ML. P.)

**MENDE** (MENDI), a west African people sharing, with minor differences in custom and dialect, a common culture and a language of the Mande-fu group of Mandingo languages. They occupy about 12,000 sq.mi., mostly in the central and southeast part of Sierra Leone. Including a smaller group in the adjacent area of Liberia, the Mende numbered about 750,000 in the 1960s.

The Mende grow rice, mainly on uplands, as their staple crop, the principal implements used being a simple hand hoe and machete. Cultivation is carried on by farming households that formerly included domestic slaves. It was customary for the latter to be settled in satellite villages around the master's town. A form of shifting agriculture is practised and land is allocated by family heads who are also the principal intermediaries in the ancestral cult, involving sacrifices made to dead members of the group. Men do the heavy work of felling and clearing the forest and women weed the crop. Households provide mutual aid, or the whole village turns out to help each farm in turn; a working bee, involving the young men, is another method of getting the cultivation done. Women have several industries of their own (including spinning and dyeing) and engage widely in petty trade.

Marriage is contracted mainly by payment of bridewealth (*q.v.*), but plural marriages are the prerogative of chiefs and other influential men who comprise the ruling class of the numerous individual chiefdoms into which the Mende are divided. Only secular forms of authority are in the hands of the chief and community life is largely controlled by various secret societies (particularly the Poro society) that claim supernatural power. In addition to their part in maintaining law and order, these associations have such functions as educating boys and girls, and regulating marriage and sexual conduct. Men masked as "spirits" are prominent in these activities; women also hold important offices. *See* also MANDINGO; SIERRA LEONE; LIBERIA; AFRICAN LANGUAGES; SECRET SOCIETIES, PRIMITIVE.

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**MENDEL, GREGOR JOHANN** (1822–1884), Austrian Augustinian monk whose discoveries of the first laws of heredity laid the foundation of the science of genetics, was born Johann Mendel, in Heinzendorf, which was then in Austrian Silesia, on July 22, 1822. His interest in natural science developed early. After two years' study at the Philosophical institute at Olmütz (Olomouc), Czech., he entered the Augustinian monastery at Brünn, Aus. (later Brno, Czech.), in 1843, taking the name Gregor. He was ordained a priest in 1847. During the period of his monastic training he taught himself a certain amount of science. From 1849 he acted for a short time as a reserve teacher of Greek and mathematics in the *Gymnasium* at Znaim (Znojmo), near Brünn. In 1850 he took the examination for certification as a regular teacher, but failed, his lowest marks being given, ironically, in the biology and geology parts. He was then sent by his abbot to the University of Vienna, where he studied physics, chemistry, mathematics, zoology and botany (1851–53). In 1854 Mendel returned to Brünn and taught natural science in the technical high school there until 1868, although he never succeeded in passing the examination for a teacher's licence. In that year he was elected abbot of his monastery.

The experiments that led to his discovery of the basic principle of heredity and subsequently to the science of genetics were begun in the small monastery garden in 1856. He worked for himself but in an atmosphere conducive to scientific interests. Among his colleagues at the high school were several men active in science,

some of whom founded in Brünn in 1862 the Natural Science society (Naturforschenden Verein), in whose meetings Mendel took an active part. The libraries of both monastery and school contained essential scientific books, especially on agriculture, horticulture and botany, subjects in which Mendel's interest had been aroused by experience in his father's orchard and farm. That Mendel himself bought new books in these fields as they appeared is shown by his marginal notes in the works of Charles Darwin that appeared in the 1860s and 1870s. But it is certain that he had begun his experiments before Darwin's first book was published and before the essential role assigned to heredity as the basis of evolutionary change had been widely recognized. In fact, when he reported the results of his experiments to the Natural Science society on Feb. 8 and March 8, 1865, he referred to his field of interest as "plant hybridization," and after indicating his familiarity with the work of his predecessors in this field, he boldly stated that "among all the numerous experiments made, not one has been carried out to such an extent and in such a way as to make it possible to determine the number of different forms under which the offspring of hybrids appear, or to arrange these forms with certainty according to their separate generations or definitely to ascertain their statistical relations." It was this formulation by Mendel of the essential requirements for the experimental study of heredity and his provision of experimental data satisfying these requirements, both for the first time, that led him to the solution of a problem that underlies not only the understanding of heredity and of evolution but of biological processes generally.

Mendel crossed varieties of the garden pea that had maintained under his observation constant differences in such single alternative characters as tallness and dwarfness, presence or absence of colour in the blossoms and axils of the leaves and similar alternative differences in seed colour, seed shape, position of the flowers on the stem and form of the pods. In each cross (such as that between tall and dwarf) he found only one of the alternative types (referred to by him as the dominant character) in the hybrids; but when these produced (by self-fertilization) a second generation, both grandparental types always reappeared in the same constant proportion, about three-fourths with the dominant character, one-fourth with the recessive. He proved, by individually testing these second-generation hybrids, that about one-fourth of them resembled, in the single character under observation, one of the pure parent varieties from which it was descended, one-fourth resembled the other pure variety, and one-half resembled, both in appearance and in breeding behaviour, the first generation hybrid.

Mendel's explanation of these results was stated by him as follows: "it is now clear that the hybrids form seeds having *one or the other* of the two differentiating characters." The essential feature of his hypothesis was that the occurrence of the visible alternative characters of the plants, in the constant varieties and in their descendants, is due to the occurrence of paired elementary units of heredity, now known as genes, which he symbolized by letters, assuming them to occur in alternative forms *AA* and *aa* for the constant parental varieties, *Aa* in the hybrids. Where the character of one parent, such as tallness, appeared in the hybrid to the exclusion of the other (*Aa* resembling *AA*) he called this the dominant; the other (such as dwarfness) found in *aa* individuals was termed the recessive. (For the behaviour of these in heredity, *see* GENETICS.) The novel feature of his interpretation, amply confirmed by subsequent observations on other plants and on animals, including man, and later on microorganisms, is that these units obey simple statistical laws, chief of which is that in the reproductive cells of the hybrids half transmit one parental unit, such as *A*, and half transmit the other, such as *a*. The separation of alternatives in the reproductive cells, now known as Mendel's first law, or the principle of segregation, adequately accounts for the results when single pairs of alternative characters are observed through several generations, and serves reliably as a basis of prediction. He showed, moreover, that when several pairs of alternative characters are observed, the several pairs of elements enter into all possible combinations in the progeny. In the pea varieties at his disposal he observed that the seven pairs of differentiating characters recombined at random, according to the law or principle of independent assortment, and he worked out the arithmetical or statistical consequences of this principle and confirmed them by experiment.

It is known now that his principle applies only to units (genes) that are transmitted in different "linkage groups" or chromosomes in which genes are organized. Likewise the dominance in the hybrid of one of the alternative characters, which was true of all seven pairs observed by Mendel, proves on wider experience not to be true of all alternatives. But neither of these limitations affects the fundamental truth of the system of particulate heredity by units or genes, which he was the first to prove. This system in the early years of the 20th century, while it was being tested and confirmed, was called Mendelism; it proved to be of general application and is one of the basic principles of biology.

This theory and the description of the experimental results from which it was deduced were presented in two papers that Mendel read at meetings of the Natural Science society early in 1865 and published in detail in the transactions of the society in 1866. The article, entitled "Versuche über Pflanzenhybriden," seemed to have had no effect whatever on the biological thinking of his time in Brünn or elsewhere, although his publication reached the principal libraries in Europe and America. Perhaps typical of the reception given Mendel's monumental publication was that of K. W. von Nägeli, professor of botany at the University of Munich; from Nägeli's correspondence with Mendel it appears that the eminent botanist neither fully understood the spare, mathematical logic of Mendel's paper nor adequately appreciated the implications of the monk scientist's revolutionary discoveries.

Mendel continued his research, attempting to test his theory by experiments with other plants. He published one further paper in 1869, but the plant he chose to investigate—the hawkweed (*Hieracium*), which Nägeli encouraged Mendel to work with—was inherently unsuited to serve as test material and no corroboration of Mendel's principles was obtained. In this genus the embryo is formed from the ovum without fertilization (somatic parthenogenesis). Although Mendel's interest and work in botany, bee culture and meteorology continued almost until his death, science ceased to occupy the central position in his life, for his election as abbot of his monastery in 1868 brought with it a host of administrative duties and a protracted struggle with the Austrian government over the taxation of the monastery.

Mendel died on Jan. 6, 1884, respected and loved by his fellow monks and townsmen but unknown as the great biological scientist that he was.

Fame came to him only after his death. In 1900 three other European botanists, K. E. Correns, E. Tschermak von Seysenegg and H. de Vries, independently obtained results similar to Mendel's and in searching the literature found that both the experimental data and the general theory had been published 34 years previously. What followed is now a part of the history of genetics: confirmation and extension of his theory by biologists in many countries, and its incorporation as the basis of a rapidly developing science with primary influence on the understanding of evolution, development, physiology, biochemistry, medicine, agriculture and social science. Its influence on these fields was surveyed at the 50th anniversary of the "rediscovery," especially in the volume issued by the Genetics Society of America as a result of its 1950 meetings.

*See* also GENETICS; GENETICS OF POPULATIONS; HEREDITY; EVOLUTION, ORGANIC; etc.

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**MENDEL, LAFAYETTE BENEDICT** (1872–1935), U.S. nutritionist and biochemist, who was one of the first investigators to show the nutritive value of vitamins and proteins, was born in Delhi, N.Y., on Feb. 2, 1872. He attended Yale university, receiving a bachelor's degree in 1891 and a doctorate of philosophy

in 1893. He worked as an assistant in the Yale physiological chemistry laboratory in 1893–94 and then spent the following two years in Europe, studying at Breslau and Freiburg. He returned to Yale in 1897 as a member of the faculty, retiring as professor of biochemistry in 1935. He was a member of the board of editors of the *Journal of Biological Chemistry* in 1911–35 and also was an editor of the *Journal of Nutrition*. He died at New Haven, Conn., Dec. 9, 1935.

Much of Mendel's work was done in collaboration with Thomas B. Osborne at the Connecticut Agricultural Experiment station. In 1913 they reported, at almost the same time similar results were being published by E. V. McCollum and M. Davis, that a water-soluble factor in milk and a fat-soluble factor in cod-liver oil and butter were necessary for the growth, development and maintenance of animals. These factors came to be known as the two major groups of vitamins. Mendel and Osborne also pointed out the different nutritive value of food proteins according to their relative content of the amino acids required for the synthesis of body proteins.

Mendel helped revolutionize the existing theories of nutrition and by emphasizing the principles of strict controls on foods under study helped establish the modern science of nutrition. His publications include *Changes in the Food Supply and Their Relation to Nutrition* (1916) and *Nutrition, the Chemistry of Life* (1923).

(R. Le.)

**MENDELE MOKHER SEFARIM** (pseudonym of Shalom Jacob Broyde or Abramovich) (1835?–1917), Russian Jewish author, the founder of both modern Yiddish and modern Hebrew narrative literature and the creator of modern written Hebrew, was born at Kopyl, Belorussia, possibly in 1835. He adopted his pseudonym, which means "Mendele the Itinerant Bookseller," in 1879. After his father's death he led a wandering life, part of the time in the company of a beggar, till he settled in 1853 at Kamenets Podolskiy (Khmelnitski), Ukraine. There the young man, who had written poems and a play at the age of 16 in Hebrew, became accepted among established Hebrew writers and published his first article, on the reform of Jewish education, in the first volume of the first Hebrew weekly, *Ha-Maggid* (1856). At Berdichev, where he lived from 1858 to 1869, he began to publish fiction both in Hebrew (a short story, 1863, the major novel *Ha-avot we-ha-vanim*, 1868) and in Yiddish (first story, "Dos Kleine mentshele," 1864, in the Yiddish periodical *Kol Mevasser*, founded at Mendele's suggestion). He also adapted into Hebrew H. O. Lenz's *Gemeinnützige Naturgeschichte* (3 vol., 1862–72). Disgusted with the woodenness of the Hebrew style of his time, which closely imitated that of the Bible, Mendele for a time concentrated on stories and plays of social satire in Yiddish. His greatest work, *Kitsur massous Binyomin nashlishi* (1875, Eng. trans. *The Travels and Adventures of Benjamin the Third*, 1949) is a panorama of Jewish life in Russia. After living in Zhitomir (where he was trained as a rabbi), from 1869 to 1881, he became head of a traditional school (Talmud Torah) at Odessa, and was the leading personality (known as "Grandfather Mendele") of the emerging literary movement. In 1886 he again published a story in Hebrew (in the first Hebrew daily paper *Ha-Yom*, which then began to appear) but in a new style which was a mixture of all previous periods of Hebrew. While continuing to write in Yiddish he gradually rewrote most of his former Yiddish works in Hebrew. His stories, written with lively humour and gentle satire, are an invaluable source for studying Jewish life in eastern Europe at the time when its traditional structure was giving way. He died at Odessa on Dec. 8, 1917. *See* also Hebrew Literature.

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(C. Rs.)

**MENDELEVIUM.** The synthetic chemical element mendelevium has the symbol Md and the atomic number 101. It occupies a position in the periodic system of the elements as the twelfth member of the actinide series, a transition series similar to the rare-earth elements, which includes the heaviest known elements and in which an inner electron shell (the 5f shell) is being filled (for an account of its discovery, *see* Transuranium Elements). The first isotope identified was $Md^{256}$, which has a half life of approximately one hour.

The chemistry of mendelevium was studied by means of the tracer technique, and it appeared to have the predominant oxidation state III in aqueous solution. Its ion-exchange and elution properties were investigated, and it seemed to behave in the manner expected for an actinide element homologous to the rare-earth element thulium.

(G. T. Sg.)

**MENDELÉYEV** (Mendeléeff or Mendelejeff), **DMITRI IVANOVICH** (1834–1907), Russian chemist, arranged the chemical elements in the periodic table according to their atomic weights and predicted the existence of the elements gallium, scandium and germanium before their discovery. The youngest of a family of 17, he was born at Tobolsk, Siberia, on Feb. 7 (new style; Jan. 27, old style), 1834. After attending the gymnasium of his native place, he went to study science at St. Petersburg, where he graduated in chemistry in 1856, subsequently becoming *Privatdozent* (official but unpaid lecturer) and pursued further studies abroad with Henri V. Regnault and Robert W. Bunsen. He became professor of chemistry in the technological institute at St. Petersburg in 1863, and three years later succeeded to the chair in the university. In 1890 he resigned the professorship and in 1893 became director of the bureau of weights and measures, a post which he occupied until his death at St. Petersburg on Feb. 2 (N.S., Jan. 20, O.S.), 1907.

Mendeléyev's name, like that of Lothar Meyer (*q.v.*), is best known for his work on the periodic law (*q.v.*). Various chemists had traced numerical sequences among the atomic weights of some of the elements and noted connections between them and the properties of the different substances; but it was left to him to give a full expression to the generalization, and to treat it not merely as a system of classifying the elements according to certain observed facts, but as a "law of nature" which could be relied upon to predict new facts. Thus in 1871 he was led by certain gaps in his tables to assert the existence of three new elements so far unknown to the chemist, and to assign them and their compounds definite properties. These three he called eka-boron, eka-aluminum and eka-silicon. His prophecy was completely vindicated within 15 years by the discovery and study of gallium in 1875, scandium in 1879 and germanium in 1886. Again, in several cases he ventured to question the correctness of the "accepted atomic weights," on the ground that they did not correspond with the periodic law, and here also he was justified by subsequent investigation. Mendeléyev also devoted much study to the nature of solutions, which he looked upon as homogeneous liquid systems of unstable dissociating compounds of the solvent with the substance dissolved. He investigated the thermal expansion of liquids and devised a formula for its expression. As far back as 1861 he anticipated T. Andrews' conception (1869) of the critical temperature of gases by defining the absolute boiling point of a substance as the temperature at which cohesion and heat of vaporization become equal to zero and the liquid changes to vapour, irrespective of the pressure and volume. He also gave much time to the study of the nature and origin of petroleum.

Mendeléyev's best-known book is *The Principles of Chemistry*, which was written in 1868–1870, and went through many subsequent editions in various languages (Eng. ed., 2 vol., 1905). He was awarded the Davy medal of the Royal society in 1882, and in 1905 he received its Copley medal.

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**MENDELSOHN, ERIC** (1887–1953), German architect, was born at Allenstein in East Prussia on March 21, 1887, and became one of the most prominent German architects. He employed at different times many methods of construction and a wide selection of materials. Among his works may be mentioned the Mosse-

haus, Berlin (in collaboration with R. Neutra and R. P. Henning), with its interesting interplay of horizontal and vertical lines, completed in 1923; the Potsdam observatory (Einstein tower), 1920–21, a poetic conception, moulded rather than erected, which illustrates the dynamic tendency of contemporary architecture; the Mosse-Pavillon at the Pressa exhibition, Cologne, 1928; the Hotel Blackpool, England, 1937; World University project, Berkeley, Calif., 1942; and the Maimonides Health centre, San Francisco, Calif., 1950. In 1933 he left Germany. He became a British subject in 1938 and a U.S. citizen in 1948. Mendelsohn died in San Francisco, Calif., on Sept. 15, 1953.

*See* G. A. Platz, *Die Baukunst der neuesten Zeit* (1927); A. Whittick, *Eric Mendelsohn* (1940).

**MENDELSSOHN, MOSES** (1729–1786), Jewish philosopher, a rationalist of the German *Aufklärung* (Enlightenment) and a man of letters whose prestige was a vital factor in the emancipation of the Jewish communities and their assimilation to the German *bourgeoisie*, was born at Dessau, in Anhalt, on Sept. 26, 1729. Known in Jewry as Moses Dessau, he was the son of the scribe Menachem Mendel Dessau. Under the local rabbi David Fränkel he studied the Bible, the Talmud and the philosophy of Maimonides, whose distinction between truths of reason and truths of revelation deeply influenced him. When Fränkel moved to Berlin in 1743, the boy followed him and there, despite poverty, began to learn not only standard German (instead of Yiddish) but also Latin, French and English. Locke's *Essay Concerning Humane Understanding* (which he read in Latin) and the 3rd earl of Shaftesbury's works impressed him almost as much as did the philosophy of Leibniz, to which he came through that of Christian Wolff. He obtained a post in 1750 as tutor to the children of the silk manufacturer Isaac Bernhard; and in 1754 Bernhard took him into the business, which gave him an adequate income for the rest of his life.

In 1754 Mendelssohn had his momentous meeting with Lessing (*q.v.*). The latter, who had been criticized for portraying a noble-hearted Jew in his play *Die Juden* (1749), saw Mendelssohn as the incarnation of his ideal. Mendelssohn lent him a manuscript in which he extolled Leibniz' system and tried to relate it to Spinoza's and Lessing had it printed as *Philosophische Gespräche* (1755). In the same year Mendelssohn published his *Briefe über die Empfindungen*, stressing the importance of sensation as an activity of the soul. When Lessing went to Leipzig, Mendelssohn remained in Berlin collaborating with C. F. Nicolai (*q.v.*) on the *Bibliothek der schönen Wissenschaften* and *Briefe, die neueste Literatur betreffend*. The Jews of Berlin engaged him to write their letters of congratulation to Frederick the Great on the successes of the Seven Years' War, but Frederick was displeased by critical reviews of his poems. However, when Mendelssohn won the academy's prize of 1763 with an essay on the demonstrability of metaphysical propositions as compared with mathematical, the marquis d'Argens (J. B. de Boyer) induced the king to grant him the status of *Schutzjude; i.e.*, to exempt him from the disabilities to which Jews were subject. The essay, Mendelssohn's first work to be printed under his name (1764), made him famous, but he enhanced his reputation further with *Phädon* (1767), a dialogue modeled on Plato's *Phaedo*, in which, contrary to the fashionable materialism, he defended the doctrine of the immortality of the soul on Leibnizian grounds.

J. C. Lavater, who had visited Mendelssohn in 1763, provoked a crisis by sending him, in 1769, his translation of a work of Charles Bonnet with a dedication in which he challenged Mendelssohn either to refute Bonnet's arguments for Christianity or to become a Christian. This impelled Mendelssohn, who hated religious controversy, to reaffirm his Judaism. The ensuing controversy led him to a nervous collapse in 1771. To restore his mind he began translating the Psalms in 1774. Then he thought of a German version of the Pentateuch, to be printed in Hebrew characters so that the Jews could read it as a bridge between their religious studies and German culture. This work, with commentaries by other scholars, appeared between 1780 and 1783 and served its purpose well, though some rabbis banned it. Meanwhile Lessing's *Nathan der Weise* (1779) had its central figure drawn from Mendelssohn.

Asked to compose a petition for the Jews of Alsace, Mendelssohn persuaded Christian Wilhelm von Dohm to undertake it. Dohm's *Über die bürgerliche Verbesserung der Juden* (1781) did not confine the plea for Jewish emancipation to Alsace, but paradoxically asked that the state should uphold the synagogue's right to excommunicate. As this caused a hostile reaction, Mendelssohn wrote a preface (1782) to a German version of Manasseh ben Israel's *Vindiciae Judaeorum* and denounced excommunication as intolerant. An anonymous writer thereupon accused him of betraying Judaism, since excommunication is part of the Mosaic law. *Jerusalem, oder über religiöse Macht und Judenthum* (1783) was Mendelssohn's answer: the right to use force, he maintained, belongs to the state for the control of actions only, but belongs neither to the state nor to the church for the control of thought; the use of excommunication was permissive when the Mosaic law was the law of a Jewish state but is so no longer. He also explained that, whereas theological truths are attainable by the use of God-given reason, God has granted to the Jews specifically a revealed legislation to govern their conduct so that they shall not depart from rational principles. There must therefore be no dogma, but only reason and the observance of the revealed moral and ceremonial precepts. Applauded by liberals, *Jerusalem* was attacked by J. G. Hamann (1784).

When the "critical" philosophy of Kant was gaining ground, Mendelssohn produced his *Morgenstunden* (1784), adhering to the "natural" theism of Leibniz. His last years were embittered by a controversy with F. H. Jacobi, who alleged that Lessing, shortly before his death (1781), had avowed himself a Spinozist. Mendelssohn, who had consistently denounced Spinoza's pantheism, was deeply grieved. He died in Berlin on Jan. 4, 1786.

For Mendelssohn's historical importance *see* JEWISH PHILOSOPHY; JUDAISM. By his marriage (1762) with Fromet Guggenheim, he had four sons; Jacob, who died young, the bankers Joseph and Abraham and the engineer Nathan; and three daughters, Dorothea, Henriette and Recha. Abraham was the father of the composer Felix Mendelssohn-Bartholdy; Dorothea, who became a Catholic, was married first to Simon Veit, then to Friedrich von Schlegel. Moses Mendelssohn's collected works were published in seven volumes in 1843–45.

**MENDELSSOHN-BARTHOLDY, (JAKOB LUDWIG) FELIX** (1809–1847), German composer, conductor and pianist, who was one of the principal figures in the romantic movement in music. Grandson of the Jewish philosopher Moses Mendelssohn, he was born at Hamburg on Feb. 3, 1809. Moses Mendelssohn, born in poor circumstances, had diligently made his way upward in a career of learning, and his son Abraham, who founded a banking house at Hamburg, was similarly successful. Abraham married Lea Salomon of Berlin, by whom he had three children; the first, Fanny, and the second, Felix, grew to be inseparable. Their father had them baptized Lutheran Christians, and he too became a Christian shortly afterward, motivated by the fact that the social position of Jews in Germany at that time was always subservient. The name Bartholdy was part of the adopted name of the composer's maternal uncle, Jakob Salomon Bartholdy, a Protestant, who suggested to Abraham Mendelssohn this addition to his surname when he had been converted.

Felix Mendelssohn was prodigiously precocious. At the age of nine he appeared in public in Berlin as a pianist. He had already begun to study composition there under C. F. Zelter, Goethe's admirer and friend. He was in the full tide of composition when 11, set on the course he was to follow to the end. Though this wealthy young musician may have been tempted to lead the life of a dilettante, his short career was rigorously dedicated to the exploration of his interpretive and creative gifts. They were fully declared while he was still a youth; he produced the flawless Octet for strings in his 17th year, followed by the *Midsummer Night's Dream Overture*, first performed at Stettin early in 1827. He was thus made aware of his remarkable innate talents from the first. Mercifully, he had something of Mozart's sense of fun to keep him young in spirit and a delighted sensitivity toward simple enjoyment that kept his mind alert and fresh.

In 1821 Zelter took the boy to visit Goethe. Mendelssohn at

12 thus began the travels that were to take him far afield. Goethe had heard Mozart play; he had come to know Beethoven, whom he first admired, then feared; he could recognize genius in a musician and he listened to the youth carefully. Zelter had begged him not to overpraise and he obeyed, though manifestly moved. For both the towering literary figure and the youthful musician it was an extraordinary moment. They were to become fast friends. The next year Mendelssohn was in Switzerland and in 1825 he met Cherubini, Meyerbeer, Rossini and others in Paris. At home in Berlin, with a large garden for work and play and an orchestra assembled by the family to perform his music in the evening, he worked at composition to some purpose. He had already begun to overwrite, a menace that was to prove ineradicable. His mother became alarmed at his unceasing application. In 1825 there came the Octet, in 1826 the *Midsummer Night's Dream Overture* and with those works he became a composer in his own right. Weber died that year and ten months later Beethoven. Mendelssohn, now 18, wrote a comic opera, *Die Hochzeit des Camacho*, which had a single performance in Berlin in 1827; the score was subsequently lost. More impressive were the Second String Quartet in A minor, op. 13, a work of notable maturity for so young a composer, and the B♭ major Piano Sonata, op. 106; in each work the influence of Beethoven was apparent. Investigating old music, Zelter had bought the score of the *St. Matthew Passion* and about 1820 interested Mendelssohn in it. Mendelssohn came to see more in that music than Zelter did and performed it at the Singakademie, Berlin, in 1829, with the result that the work became widely known. On the other hand Mendelssohn was not a musicologist and in some ways grievously misrepresented the *St. Matthew Passion*, compressing it and modernizing Bach's instrumentation. Nevertheless, posterity has reason to be grateful for the fact that he resuscitated a forgotten masterpiece and laid the foundation for a revival of interest in Bach's music. In 1829 occurred another significant event, one that, after the visit to Goethe, was a turning point in Mendelssohn's cultural development as definitive as his meeting with the music of Bach. That April he left for England, the country that in time was to become his second home.

In London in May 1829 he conducted his C minor Symphony with great success at a Philharmonic society concert. He then went north, visited Sir Walter Scott, was deeply moved by the ruined chapel of Mary Stuart in Holyrood, had the idea of a "Scottish" symphony, and eventually went farther north, where the island of Staffa in the Hebrides immediately inspired in him the opening notes of the *Hebrides* (or *Fingal's Cave*) *Overture*. Within less than a year he was back in Berlin and before long started out for Italy. Here again impressions were acutely registered as his receptive mind stored up material for future elaboration. He led an active social life and was working hard. The *Hebrides Overture*, glimpsed during the previous year, was written. The *Italian* and *Scottish* symphonies were started.

By the end of 1831 Mendelssohn was in Paris, where he met Chopin. In April 1832 he was in England again, socially successful as never before, completing the final version of the *Hebrides Overture*. In 1833 the *Italian Symphony* was finished and in the same year Mendelssohn conducted the Lower Rhine festival at Düsseldorf. Later he was appointed general music director at Düsseldorf and left Berlin to live there. Gradually he was being drawn into the organizational side of music. In 1835 he left Düsseldorf for Leipzig, where he became conductor of the Gewandhaus concerts and where he met Schumann. He had started the oratorio *St. Paul* in the previous year. During the winter of 1835 Mendelssohn's father died, leaving him in despair. The oratorio, which Abraham had much wanted to hear, was finished and was performed in 1836 in Düsseldorf (at Liverpool later in the year). In 1837 he married a French woman, Cécile Jeanrenaud. Five children were born and his friends were interested to note that marriage altered him in no way either for better or for worse. Within a few months after his marriage he was off again to London.

He was rapturously received, as was now habitual. During this visit an oratorio on the subject of Elijah was planned. He was increasingly in demand, yet somehow found time to compose. The Violin Concerto, a perfect example of his art at its most refined level, was begun in 1838; the admirable D minor Piano Trio, op. 49, belongs to the next year; and in 1840 the *Lobgesang* ("Hymn of Praise"), in the unusual form of three instrumental movements followed by a choral movement, was produced in Leipzig and Birmingham. Mendelssohn had now reached a high pitch of creative output and his sense of responsibility brought with it a toll of spent energy.

He was director now of the music section of the academy of arts in Berlin. The king of Prussia demanded music for Racine's *Athalie* and for Shakespeare's *Midsummer Night's Dream*, and to his exquisite boyhood overture Mendelssohn added the necessary incidental music. This was performed at Potsdam in 1843. But at this time his doctors were worried. Mendelssohn's professional climax came three years later with the production in Birmingham of *Elijah*, one of the greatest dramatic works for the concert platform ever to have been created until then. The banality that had haunted him in the works written since his two youthful masterpieces is present in *Elijah*, but this work also has an inspired dramatic force. Mendelssohn, having savoured the triumph of his latest work, went back to Germany and immediately began fresh works. Then, in 1847, his sister Fanny died. Within six months Mendelssohn became seriously ill and on Nov. 4, 1847, he died at Leipzig at the age of 38.

Mendelssohn had become accepted by his contemporaries as a symbol of mingled elegance and strength. It was not a purely personal elegance though that had counted in his popularity; the elegant young man matured into a handsome adult musician who charmed Queen Victoria and Prince Albert and who might have been expected to progress into a patriarchal old age surrounded by admiring audiences. But there was elegance also in his fresh music (for example, in his two early masterpieces) and in the smaller forms of song, piano pieces and some of the slighter forms of chamber music. This charm of manner was rescued from mawkishness by both a Teutonic and a Jewish intensity, by deliberateness of aim and strength of utterance, shown in the symphonies and still more in *Elijah*. It may be advanced that in an age in which elegance was represented by Chopin and romantic fervour by Schumann, Mendelssohn contributed little of either quality that influenced the course of music. To a large extent that is true. Mendelssohn represents most of all, and in a way neither Chopin nor Schumann did, the virtues of domestic music, of music-making in the home. This intimate type of music was a predecessor of Paul Hindemith's *Hausmusik*. Mendelssohn's innovations were relatively small. He was content to follow tradition without attempting greatly to enlarge the bounds of expression that had sufficed hitherto. His signal contribution was the refinement of his technique, in orchestration especially; and in that he was equal to the most accomplished composers of his day. He had gifts for drawing and water colours and he happened also to have outstanding literary gifts. His correspondence is therefore the most vivid and interesting of all 19th-century composers.

An assessment of the position of Mendelssohn's music in the second half of the 20th century reveals a fairly constant interest, though of necessity it is less than during his lifetime. The survey is incomplete since it does not take account of the private performances, which, in the case of a composer whose music had a domestic appeal, was once and still is strong. The shorter piano pieces, notably the *Lieder ohne Wörte*, which had been eagerly accepted by Victorian young women, continued to interest amateurs though these picturesque pieces were seldom heard in public. The chamber music possibly enjoyed the same kind of hidden popularity though this continued to figure, even if comparatively rarely, in concert programs. Of the symphonies the *Italian* and the *Scottish* held their own, together with sporadic appearances of the *Reformation Symphony*, which, however, relied more on the phonograph for its continued existence.

In western Europe, with the exception of Mendelssohn's own country and his adopted England, his works underwent a partial eclipse after World War II and his influence on the technique of composition was infinitely less than that of his contemporaries, Wagner, Brahms and Liszt. By the middle of the 20th century there was a tendency to regard him as an academic figure. His rep-

utation stands on the *Midsummer Night's Dream* music, the *Hebrides Overture*, the Violin Concerto and *Elijah*, which, of all his oratorios, continued to be given, while *St. Paul* and the interesting and experimental *Lobgesang* and *Lauda Sion* did not. Though *Elijah* was fairly frequently performed in Germany its true home remained England, where it first appeared.

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**MENDEN,** a town of Germany in the *Land* (state) of North Rhine-Westphalia, which after partition of the nation following World War II became part of the Federal Republic of Germany. It lies in the Hönnetal or valley of the Hönne, a tributary of the Ruhr, 12 km. (7.5 mi.) S.S.E. of Unna by road. Pop. (1961) 27,526. Old buildings include the Roman Catholic church of St. Vincent (1345), the electoral administrative building (1600), the chapel on the Rothenburg (1685) and the orphanage (1720). Menden is a rail junction on the Unna-Iserlohn line. Metal goods, wire, tubes, electrical and lighting equipment, baby carriages and church furniture are manufactured. Menden was a pre-Carolingian settlement before becoming part of the duchy of Saxony. It then passed in turn to Westphalia, Hesse and Prussia. (P. Ko.)

**MENDÈS, CATULLE** (1843–1909), a prolific French poet, playwright and novelist remembered for his friendships with the Parnassian and Symbolist poets. A Jewish banker's son, he was born in Bordeaux on May 22, 1843. He moved to Paris (1859) and in 1861 founded *La Revue fantaisiste*, which rallied the Parnassians, and, with X. de Ricard, edited *Le Parnasse contemporain* (1866, 1871 and 1876) which gave its name to the literary movement the history of which he recounted in *La Légende du Parnasse contemporain* (1844). He met the young Mallarmé in 1864 and facilitated the publication of his verse, later introducing him to the work of Wagner, whose cause he championed in *Richard Wagner* (1886) and *L'Oeuvre wagnérienne en France* (1899). His poetry—*Philoméla* (1864), etc.—his 20 plays and his 50 novels are no longer read, but his criticism, particularly *Le Mouvement poétique français de 1867 à 1900* (1903), although biased, still interests literary historians. He was librettist for Chabrier's *Gwendoline* (1886) and *Briséis* (1899), André Messager's *Isoline* (1887), Jules Massenet's *Ariane* (1906), etc. His marriage (1866) to Gautier's daughter, Judith, herself a poet, ended in divorce. He died in an accident at St. Germain on Feb. 9, 1909.

*See* J. Cocteau, *Portraits-Souvenir* (1939). (E. M. So.)

**MENDÈS-FRANCE, PIERRE** (1907– ), French statesman distinguished for his efforts to invigorate the fourth republic and the Radical party, was born in Paris on Jan. 11, 1907. After studying at the Collège Turgot, the Paris faculty of law and the École Libre des Sciences Politiques, he became a barrister. He was a Radical-Socialist deputy for the Eure *département* from 1932 to 1940 and undersecretary of state for finance under Léon Blum from March to June 1938. After serving in the air force during World War II and being imprisoned by the Vichy government, he escaped in June 1941, reached London in Feb. 1942 and joined the Free French air force. From Nov. 1943 to April 1945 he served under Gen. Charles de Gaulle, first as commissioner for finance and then as minister of national economy; he resigned because his colleagues rejected his austere financial and economic policies.

A deputy again from June 1946, Mendès-France came to the fore as a severe critic of successive governments' policies toward economics, the Indochina war and North Africa. When disaster threatened in Indochina he became premier on June 19, 1954, and implemented his policies for the French withdrawal from Indochina as well as from Tunisia. He refused to commit his government to the project for the European Defense community (E.D.C.), but worked for a new method of rearming the Federal Republic of Germany after the national assembly on Aug. 30, 1954, had refused to ratify the E.D.C. treaty. The prospect of applying equally drastic policies to economic and Algerian affairs caused his fall on Feb. 5, 1955. He then worked to capture the Radical party and at first succeeded. A leader of the left-centre Front Républicain in the general elections of Jan. 2, 1956, he was deputy premier in Guy Mollet's government from Feb. 1 to May 23, 1956, when he resigned on Mollet's refusal to adopt a liberal policy in Algeria. He was not re-elected to the national assembly in Nov. 1958. His influence in the Radical party declined and in Feb. 1959 he left it, later joining the Unified Socialist party formed in 1958 by people who had seceded from the Socialist party in protest against its support for De Gaulle. (P. W. C.)

**MENDICANT,** in the Christian church, is a member of a religious order that—in contrast to the monastic orders—originally forbade the ownership of property, even in common. The two great founders of the orders of mendicant friars were St. Dominic (*q.v.*), who founded the Dominican order in 1216, and St. Francis (*q.v.*) of Assisi, who founded the Franciscan order in 1210. Within a generation of their deaths, their institutes had spread all over Europe and into Asia, and their friars could be numbered by tens of thousands. In all the great cities of western Europe friaries were established, and in the universities theological chairs were held by Dominicans and Franciscans. And when, later in the 13th century, the other great mendicant orders of Carmelites, Austin Friars and Servites arose, their propagation showed that the possibilities of the mendicant movement had not been exhausted by the Dominicans and Franciscans. Lesser mendicant orders sprang up in all directions and in such numbers that the second Council of Lyons in 1274 found it necessary to suppress all except the orders named above.

The mendicant movement clearly responded to widely spread and deeply felt needs of the time. These needs found expression not only within the church but also in a number of more or less heretical and revolutionary sects (*e.g.*, Cathari, Waldenses, Albigenses) that inveighed against the wealth of the clergy and preached the practice of austere poverty and a return to the simple life of Christ and the apostles.

Probably the most crying need was that of priests to minister to the great city populations, at that time growing up with such rapidity, especially in Italy. During the 10th–12th centuries the church had been organized on the lines of the prevailing feudal system, and the effects of the system were felt throughout the ranks of the lower clergy. The social fabric was built up not on the towns but on the great landlords. When the centre of gravity began to move, first of all in Italy, to the towns, and crowded populations began to be massed together in them, the parochial systems broke down under the weight of the new conditions, and the people were in a state of spiritual and moral, no less than physical, destitution. So, when the friars established themselves in the poorest localities of the towns and brought religion to the destitute and the outcasts of society, assimilating themselves to the conditions of life of those among whom they worked, they satisfied a need with which the parochial clergy were unable to cope.

The friars responded not only to the new needs of the age but also to its new ideas—religious, intellectual, social, artistic. It was a period of religious revival and of reaction against abuses that followed in the wake of the feudal system; and this religious movement was informed by a new mysticism—a mysticism that fixed its attention mainly on the humanity of Christ and found its practical expression in the imitation of his life. A new intellectual wave was breaking over western Europe, symbolized by the university and the scholastic movements; and a new spirit of democratic freedom was making itself felt in the growing commercial towns of Italy and Germany.

The idea of poverty was St. Francis' root idea, and there is little doubt—though it has been disputed—that it was borrowed from him by St. Dominic and the other mendicant founders. St. Francis did not intend that begging and alms should be the normal means of sustenance for his friars; on the contrary, he intended them to live by the work of their hands and to have recourse to begging only when they could not earn their livelihood by work. But as the friars soon came nearly all to be priests devoted to spiritual ministrations, and the communities grew larger, it became increasingly difficult for them to support themselves by personal work; and so the begging came to play a greater role than had been contemplated by St. Francis. But his idea certainly was that his

friars should not only practise the utmost personal poverty and simplicity in their life but that they should have the minimum of possessions—no lands, no funded property, no fixed sources of income.

The maintaining of this ideal has proved unworkable in practice. In the Dominican order and the others that started as mendicant it has been mitigated or even abrogated. Among the Franciscans it was the occasion of endless strife and was kept alive only by dint of successive reforms and fresh starts, each successful for a time, but doomed always, sooner or later, to yield to the inexorable logic of facts. The Capuchins (*q.v.*) made the most permanently successful effort to maintain St. Francis' ideal; but even among them mitigations have had to be admitted. In spite of all mitigations, however, the Franciscans have nearly always presented to the world an object lesson in evangelical poverty by the poorness and simplicity of their lives and surroundings.

The surviving mendicant orders are: Dominicans (*q.v.*); Franciscans (*q.v.*); Augustinians (*see* AUGUSTINIAN HERMITS); Carmelites (*q.v.*); Trinitarians (*q.v.*); Mercedarians; Servites (*q.v.*); Minims; Hospitallers of St. John of God; and the Teutonic Order (*q.v.*). (E. C. B.; X.)

In India, from early times, detachment from the world and the practice of austerities have been regarded as conducive to a spirit of godliness and ultimately to a state of ecstatic communion with the deity. On these grounds it was actually laid down as a rule for a man solicitous for his spiritual welfare to pass the last two of the four stages (*ashrama*) of his life in such conditions of renunciation and self-restraint. These tendencies have been most extensively cultivated in connection with the Shiva cult.

Of mendicant and ascetic orders, the following may be mentioned: (1) *Dandis* or staff bearers, who worship Shiva in his form of Bhairava, the "terrible." (2) *Yogis*, adherents of the Yoga (*q.v.*) philosophy and the system of ascetic practices enjoined by it with the view of mental abstraction and attainment of union with God. (3) *Sannyasis*, devotees who have renounced earthly concerns and entered the fourth *ashrama*. (4) *Paramahamsas*, those in the highest order of asceticism, who have attained union with the Ultimate Reality.

Mendicancy was characteristic of the early Buddhist monks and is still practised in the Theravada countries of southeast Asia, especially Burma.

*See* also ASCETICISM; TERTIARIES; ORDERS AND CONGREGATIONS, RELIGIOUS; and references under "Mendicant" in the Index.

**MENDIP HILLS,** a range of hills in Somerset, Eng., extend 23 mi. northwestward from the valley of the Frome. They involve fold structures and consist mainly of Carboniferous limestone, though the high Black Down (1,068 ft.) area has considerable tracts of Old Red Sandstone. Eastern Mendip is lower and crossed by a network of roads, including two main roads from north Somerset to Wells and Shepton Mallet. Western Mendip forms a plateau 6 mi. wide and over 800 ft. high. Farther west the isolated Wavering down and Bleadon hill continue the upland toward the Bristol channel. At the foot of the steep southwestern face of Mendip a line of settlements at Axbridge, Cheddar, Draycott, Westbury and Wells overlook the river Yeo section of the Somerset levels. On the limestone, swallow-holes and underground drainage are common and there are many caves, several of which in Cheddar and at Wookey Hole, 2 mi. N.W. of Wells, are easily accessible. The Mendip hills were an important area of settlement in prehistoric times; earthworks exist at Burrington, Dolebury warren, Priddy and Charterhouse on Mendip and considerable traces of early human occupation have been found in the caves.

There is evidence of a Roman road along the plateau, which may have linked the Fosse way, to the southeast, with an important area of Roman occupation near Charterhouse on Mendip where an earthwork known as the Amphitheatre overlooks lead workings in which pigs of lead inscribed with the names of emperors of the 1st and 2nd centuries have been found. Mineral working continued in Mendip until modern times. (FK. WR.)

**MENDOZA, ANTONIO DE** (1490–1552), a noted Spanish administrator, was born in Granada; his father, Iñigo López de Mendoza, was captain general of the Christian forces that invested Granada in 1492. The Mendoza family, representing the highest Castilian aristocracy, was distinguished for a lineage that dated back to the Roman and Gothic periods of occupation, and for the warriors it contributed to the Christian reconquest of Spain. Mendoza was educated as befitted his rank and, after demonstrating his competence as a military commander, was entrusted with several important diplomatic missions by the emperor Charles V. He executed these assignments, which included the post of ambassador to Hungary, with great distinction, and after serving as a chamberlain of the queen he was given the appointment of governing New Spain as the first viceroy. He arrived in Mexico in 1535 and served there for 15 eventful years.

His rule in New Spain, though following in the turbulent wake of the conquest and marked by Indian uprisings and intrigue and rivalry among subordinates, was a notable success. As an administrator he proved astute in resolving complex problems, and exhibited a tireless energy, a keen sense of justice and high personal integrity. Mendoza established basic political and economic policy which endured until the colonies gained their independence, promoted explorations (New Mexico, California, Philippine Islands), instituted laws designed to moderate the harsh services required of the Indians and made substantial contributions to the religious, intellectual and cultural life of New Spain. He introduced the printing press, promoted the building of schools and hospitals and encouraged the improvement of agricultural methods, stock raising and mining. His statesmanship is reflected in his ordinances, his communications to the emperor and his recommendations to his successor, Velasco. Mendoza was promoted to the viceroyalty of Peru in 1551, but, broken in health, he died in Lima in 1552.

(J. L. TR.)

**MENDOZA, DIEGO HURTADO DE** (1503 or 1506–1575), Spanish diplomat, humanist, poet and soldier, historian of Philip II's suppression of the Moriscos of Granada, and a member of one of the great Peninsular families, was born at Granada. Although a brother-in-law of the executed *comunero* leader Juan de Padilla, he was successively entrusted by Charles V, between 1537 and 1552, with the posts of ambassador to England, Venice, and Rome, representative at the Council of Trent and governor of Siena. While in Italy he consorted with notable Cinquecento figures, intervened in the election of Pope Julius III, sat for Titian, and amassed the famous library eventually bequeathed to the Escorial, procuring copies of Cardinal Bessarion's manuscripts and sending an agent to Greece for others. Mendoza's clearest title to a place in literary history (since the revived attribution to him of the picaresque *Vida de Lazarillo de Tormes* remains inconclusive) is his *Guerra de Granada* (Lisbon, 1627; modern ed. by M. Gómez Moreno, 1948), written at Granada in banishment from the court of Philip II. The austere objectivity of this history of the suppression of the Morisco rising of 1568–71, in which set pieces imitated from Tacitus and Sallust alternate, in a style modeled largely on that of the latter, with eyewitness reports of the excesses committed by both sides, is thought to account for its foreign and long-delayed publication. His poems (modern ed. by C. M. Batchelor, Havana, 1959) include lyrics in which the influence of his kinsman Garcilaso de la Vega and of Ausiàs March (*qq.v.*) is patent, and others in the traditional Castilian metres. He died in Madrid on Aug. 14, 1575.

*See* A. González Palencia and E. Mele, *Vida y obras de Don Diego Hurtado de Mendoza* (1941–43); A. Vàzquez and R. Selden Rose, *Algunas Cartas de Diego Hurtado de Mendoza* (1935). (F. S. R.)

**MENDOZA, PEDRO DE** (1487–1537), first Spanish governor of the Río de la Plata region in Argentina and founder of Buenos Aires, was born in Guadix, Spain, into the nobility. During his youth he served as an officer in the Spanish armies campaigning in Italy. When Charles V (Charles I of Spain), spurred by reports of great wealth in Peru, decided on the conquest of Río de la Plata, he selected Mendoza to command the expedition. Mendoza sailed on Aug. 24, 1535, with about 2,650 persons aboard 11 vessels, adding 3 more ships in the Canary Islands.

After many adventures along the Brazilian coast, the expedition arrived at the Río de la Plata early in 1536 and founded Buenos

Aires. The Indians in the area at first helped feed the colonists, but soon turned against them and began an incessant attack.

Sick and disheartened and failing to get word from a small expedition that he had sent to explore in the direction of Peru, Mendoza determined to return to Spain. He died en route on June 23, 1537, and was buried at sea.

The settlers who remained abandoned Buenos Aires in 1541 and moved to Asunción, Paraguay, founded earlier by a group of Mendoza's men. Buenos Aires was not settled again until 1580. (F. L. Hn.)

**MENDOZA, PEDRO GONZÁLEZ DE** (1428–1495), Spanish cardinal, important for his influence on Castilian internal and foreign affairs under Henry IV and Isabella the Catholic, was born at Guadalajara on May 3, 1428. A humanist and diplomat as well as politician, he studied at Salamanca university and became successively bishop of Calahorra (1454) and Sigüenza (1467) and cardinal archbishop of Seville (1473). From 1482 he occupied the primatial see of Toledo. He was the fifth son of the famous marqués de Santillana, Iñigo López de Mendoza, for whom he translated Homer and Sallust into Castilian. Mendoza also wrote political, theological and legal works, but he is mainly famous as a political cleric who exercised great influence on Castilian affairs under Henry IV, whom he defended somewhat hesitatingly against the rebel nobles, and under the Catholic kings. He was instrumental in securing the Castilian throne for Isabella the Catholic; he fought personally for her victorious cause at Toro (1476) and later got his powerful family to take the field for her against the invasion of Afonso V of Portugal. Mendoza, who enjoyed a great reputation in his day, founded the university college of Santa Cruz at Valladolid. He died at Guadalajara on Jan. 11, 1495. (P. E. R.)

**MENDOZA,** a province of western Argentina, bounded north by San Juan, east by San Luis and the province of La Pampa, south by La Pampa and the province of Neuquén and west by the republic of Chile. Pop. (1960) 825,535. Area 58,239 sq.mi. The Andes form the western boundary and a considerable part of the territory is covered by the great Cordillera, its foothills and flanking ranges. The eastern part is an arid, sandy, level plain with extensive saline basins, having no vegetation other than coarse grasses and thickets of low, spiny mimosas and "chañar" (*Gourliaea decorticans*). The fertile, populated districts border on the Cordillera, particularly in the north where several streams from the snow-clad summits supply water for irrigation. The secondary ranges in this part of Mendoza are the Sierra de los Paramillos, which enclose the Uspallata valley, and the Sierra del Tunuyán. Farther south the country becomes more arid and sparsely populated, and unsubdued tribes of Indians for a long time prevented its exploration. In this region the Sierra de Payén and Sierra del Nevado (otherwise known as the Sierra Quero Matro Pellón) extend in a northeasterly direction. With the exception of the Río Grande in the southwest, which forms the principal source of the Colorado, all the rivers of the province flow east and south into the great saline depression of western Argentina, which includes a great part of Mendoza, San Luis and La Pampa. The Mendoza, Tunuyán, Diamante and Atuel, with their numerous tributaries, all discharge into the sluggish river which flows from the Huanacache lagoons on the San Juan frontier southward to the marshes and lagoon of La Pampa. The upper part of this brackish, swampy stream is called the Desaguadero, and the lower the Salado. With the exception of the elevated districts of the Andes, the climate is hot and dry.

Mendoza was settled by Spanish colonists from Chile as far back as 1559 but later development was hindered by its remoteness from the Río de la Plata. This isolation was broken in 1884 by the completion of the Argentine Great Western railway to the provincial capital. Subsequently the Transandine railway was built (connecting with the Chilean railway system) and branches of the Pacific and Western railways were extended to many parts of the eastern plain.

In addition to Mendoza, the capital of the province, the principal towns are San Rafael, Godoy Cruz, Rivadavia, Luján, Colonia Alvear, Junín and Lavalle. There are several popular resorts in the mountains, notably Villavicencio (thermal springs), Cacheuta (mineral baths) and Potrerillos (skiing).

Agriculture is the principal occupation where irrigation can be used but less than 2% of the total area of the province is cultivated. Mendoza has a high reputation for its raisins and wines, and also produces peaches, apples, pears and many other fruits. Alfalfa (lucerne) is an important product, grown for fattening the cattle driven through the province to the Chilean markets. A wide variety of minerals is found, such as wolfram and sulfur, and the province ranks high among the Argentine states in the production of petroleum. (Ge. P.)

**MENDOZA,** Argentine city and capital of the western province of Mendoza (*q.v.*). Pop. (1960) 109,149. The city is located at 2,970 ft. elevation on a broad plain at the foot of the secondary Andean range, Sierra de los Paramillos. Although the climate is dry, irrigation has covered the surrounding area with gardens, orchards and vineyards. The intensive cultivation supports a population of 250,000 in the immediate vicinity of the capital, known as greater Mendoza. Water for irrigation and for the urban area comes from the Mendoza, or Luján, river, 15 mi. south of the city, via a natural channel called El Zanjón which traverses the city.

The city was founded and relocated several times in the early 1560s by Spaniards arriving from Chile, and its early history was intimately linked with Chile. Not until 1776 did control of this region known as Cuyo pass from the local Spanish administration in Chile to the newly created viceroyalty of Río de la Plata at Buenos Aires. During the movement for independence from Spain, Mendoza was the headquarters of Gen. José de San Martín and the expeditionary force which he organized to cross the Andes to Chile in 1817.

In 1861 the city was totally destroyed by earthquake with an estimated loss of 12,000 lives. Two years later a new city was planned in close proximity to the ruins. Consequently broad tree-lined streets and numerous public squares and parks characterize the modern Mendoza. On the west side of the city is the attractive General San Martín park of 150 ac. with a large artificial lake, while the same name is given the principal north-south avenue of the city.

Several theatres, a number of museums commemorating the colonial and independence eras, the national university of Cuyo and the institutes of ethnology and agriculture are some of the cultural aspects of Mendoza.

The wine and raisin industry is the principal one of the city while the surrounding irrigated districts produce fruit, vegetables, alfalfa and cereals. Its commercial importance is assured by direct rail lines and highways which link it to the principal Argentine ports such as Rosario, Buenos Aires and Bahía Blanca. A highway follows the former railroad bed to Chile via Paso de Bermejo, 12,917 ft. above sea level, but there is little economic orientation toward the neighbouring country. The city has an airport. (Js. R. S.)

**MENEDEMUS** (338?–265 B.C.), Greek philosopher, the founder of the Eretrian school, was born, of a noble but impoverished family, at Eretria (he is to be distinguished from Menedemus of Pyrrha, a member of the Academy in Plato's lifetime). During a military expedition to Megara he formed a lifelong friendship with an older man named Asclepiades. They attended the lectures of Stilpo (*see* Megarian School of Philosophy) and later joined themselves to the school founded by Phaedo at Elis. This school was transferred by Menedemus to his native town and so came to be called Eretrian. After a time Menedemus took a leading part in public affairs. His policy of placating whichever Macedonian prince was in the ascendant secured a relative freedom for Eretria for many years; but about 273 B.C. his regime was overthrown, and he was driven into exile by patriots who charged him with subservience to Macedonia. Six years later his policy was vindicated, for Antigonus took the city; but Menedemus, in grief at his inability to repair the harm done by his successors, eventually took his own life. He was a man of austere life and keen wit. His philosophy seems to have owed something to the teaching and example of Socrates, as

filtered down through the Megarian school. Skill in dialectic was highly valued, but was imparted to the pupil with an ethical purpose. In logic, he followed Stilpo in pronouncing the use of "is" as a copula to be illegitimate and, for reasons connected with this, denied the validity of both negative and complex propositions.
(D. J. A.)

**MENELAUS,** in Greek mythology, the younger son of Atreus (*q.v.*) and king of Sparta, the abduction of whose wife, Helen (*q.v.*), led to the Trojan War. During the war Menelaus served under his elder brother Agamemnon (*q.v.*), the commander in chief of the Greek forces. After the fall of Troy Menelaus recovered Helen and brought her home. Their daughter Hermione married Achilles' son Neoptolemus. Menelaus figures largely in the *Iliad* and the *Odyssey*, where he is promised a place in the Elysian fields after his death because he is married to a daughter of Zeus. The 7th–6th-century poet Stesichorus introduced a refinement to the story followed by Euripides in his *Helen:* it was a phantom who was taken to Troy, while the real Helen went to Egypt, where Menelaus, wrecked on his way home from Troy, rescued her after the disappearance of the phantom Helen who accompanied him. (*See* EURIPIDES: *The Extant Plays: The Romantic Plays.*) Pausanias (2nd century A.D.) says there was a shrine to Menelaus at Therapnae where he and Helen were buried.

**MENELIK II** (1844–1913), emperor of Ethiopia from 1889 to 1913 and creator of the modern Ethiopian state, was the son of King Haile Malakot of Shoa who died when his son was only 11 years of age. Menelik's adolescence and early manhood fell within the reign of the brilliant but tragic Theodore (1855–68) who kept him a virtual prisoner. During the upheavals shortly before Theodore's violent end in 1868, Menelik escaped from Magdala and proclaimed himself king of Shoa. He was subsequently one of three claimants to the imperial throne, but it was his Tigrean rival, John IV, who eventually seized power. Menelik thought it prudent to come to terms with John and, for the sake of Ethiopian unity, recognized him as "King of Kings." Their spheres of influence were carefully assigned, Menelik's in the southern and John's in the northern half of the empire, and it was agreed that upon John's death Menelik should succeed him. During John's 17-year reign Menelik greatly expanded his southern domains and effectively subdued the Gallas, so that by the time of the emperor's death in the battle against the dervishes at Metamma (1889) Menelik had emerged as the strongest man in Ethiopia. Despite some intrigues he was now able to assume the imperial crown for which he had waited with so much patience.

The seat of power had now decisively shifted from the north to the Shoa province. Menelik was, therefore, content to allow the Italians a free hand in the Massawa-Asmara-Keren region. The new emperor, who had previously negotiated with the Italians and received supplies of arms from them, signed the treaty of Uccialli (1889) under which the Italian presence in the new territory of Eritrea was formally recognized. Disagreements arising from the conflicting Italian and Amharic versions of the treaty soon vitiated the Italo-Ethiopian concord, and despite Menelik's patient statesmanship the conflict was only resolved by the Italian defeat on the battlefield of Aduwa (Adua; 1896). The subsequent treaty of Addis Ababa abrogated the ill-fated Uccialli agreement, recognized the independence of Ethiopia, and, surprisingly, confirmed the Italians in their possession of Eritrea.

The aims of Menelik's enlightened policy were threefold: (1) to contain the European powers on the borders of his country; (2) the permanent conquest and control of the Muslim and pagan areas in the south; (3) internal administrative reforms—including the ageleng problem of eliminating all centrifugal forces.

After the incorporation of the southern Awash valley, the Sidama and Janjero areas, and the kingdom of Kafa, Menelik placed the centre of the Muslim east, Harar, under his trusted kinsman, Ras Makonnen (father of the future emperor Haile Selassie), for from there it was possible to control the vast Galla and Somali areas.

With his newly built capital as far south as Addis Ababa, Menelik had shaped another empire, different in form and composition from its predecessors. Under his reign the prestige of the country had grown and the foundations of a modern state had been laid. After five years' serious illness Menelik died in 1913.

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(E. U.)

**MENÉNDEZ DE AVILÉS, PEDRO** (1519–1574), Spanish sea captain and founder of St. Augustine, Fla., was born at Avilés, Asturias, on Feb. 15, 1519, and ran away to sea at the age of 14. In 1549 he was commissioned by Charles V to drive away the pirates from the coasts of Spain and the Canary Islands, and in 1554 he was appointed captain of the Indies fleet. But because of intrigues in the Casa de Contratación, the governing board of the American trade, he was transferred to supervise the supplies of the Spanish troops in Flanders in 1557. By 1563 his enemies were powerful enough to cause his arrest, but after 20 months in jail he regained royal favour. Philip II subsequently granted him a contract to found and govern a colony in Florida for the purpose of safeguarding Spanish sovereignty against the encroachment of French Huguenots. Menéndez de Avilés sailed in July 1565 with a vessel of 600 tons, 10 sloops and 1,500 men. On Aug. 28 of the same year he entered and named the Bay of St. Augustine and built a fort there. He took the French Ft. Caroline (Sept. 20, 1565) and killed the French force, whose bodies he hung on trees with the inscription "Not as Frenchmen, but as Lutherans." The French revenge came in 1568 at Ft. San Mateo (formerly Ft. Caroline), when Capt. Dominique de Gourgues inscribed over his Spanish victims "Not as Spaniards, but as murderers." Menéndez de Avilés had returned to Spain in 1567 and after one more voyage to Florida died in Santander on Sept. 17, 1574. (U. S. L.)

**MENÉNDEZ PIDAL, RAMÓN** (1869– ), Spain's ranking modern humanist, was born in La Coruña on March 13, 1869. He was professor of Romance philology (Madrid, 1899–1939), head of Centro de Estudios Históricos, founding editor of *Revista de filología española* and president of the Spanish Academy (1929–39 and after 1948). Throughout all his works Menéndez Pidal stresses the native roots of Spanish culture (Basque substratum, Gothic and Arabic ingredients), also its conservatism and continuity, at the expense of obvious links with neighbouring countries. His vast and meticulous research includes critical editions of charters (*Documentos lingüísticos*, 1919) and medieval texts (*Reyes Magos, Cid, Roncesvalles, Yúçuf, Elena y María, Fernán González, Crónica troyana*), and monographs on folklore (balladry, legends), literary history (chronicles, epics, lyric), stylistics (Columbus, Teresa de Ávila, Cervantes, Lope de Vega), place-names, etymology and historical grammar. Laymen find accessible his *Los españoles en la historia y en la literatura* (two essays, 1951; partial English translation, 1950); specialists turn to his *Manual de gramática histórica* (revised edition, 1941), the annotated editions of *Primera crónica general* (1906–55) and *Cantar de Mio Cid* (1908–11, 1944–46), *Orígenes del español* (3rd ed., 1950), *La España del Cid* (2 vol., 1929; Eng. trans., 1934), and *Romancero hispánico* (2 vol., 1953).
(Y. M.)

**MENÉNDEZ Y PELAYO, MARCELINO** (1856–1912), Spanish critic and historian, one of Europe's great literary scholars, was born at Santander on Nov. 3, 1856. Educated at Barcelona university, he became professor at Madrid (1878) and director of the Biblioteca Nacional (1898). His keen critical perception and his vast learning continue to make such synoptic works as *Historia de los heterodoxos españoles* (1880–82), *Historia de las ideas estéticas en España* (1883–91), *Antología de poetas líricos castellanos* (1890–1908) and *Orígenes de la novela* (1905–15) indispensable reading for the study of Spanish and (in certain cases) of other literatures, particularly for the medieval field and for the modern field up to 1800. Menéndez y Pelayo possessed a deep classical culture and his reading included much of the literature and the scholarship of western Europe. Within these wide bounds he sought to place and evaluate the Hispanic contributions. His own style of writing, elegant and supple, was well suited to meet the many different demands made upon it. Although the passage of time has caused certain views and conclu-

sions to become outdated and has limited the value of some of his early ideological works. Menéndez y Pelayo has put all Hispanists in his permanent debt. The carefully prepared *Edición nacional* of his complete works, begun in 1940, includes such unfinished and previously unpublished compilations as *Bibliografía hispanolatina clásica* and *Biblioteca de traductores españoles*. The Biblioteca de Menéndez y Pelayo in Santander (where he died on May 19, 1912), which houses his large private collection and publishes its own *Boletín*, has for long been one of Spain's best-known research centres.

*See* M. Artigas y Ferrando, *La Vida y la obra de Menéndez Pelayo* (1939); Pedro Laín Entralgo, *M. P. Historia de sus problemas intelectuales* (1944). (F. W. Pt.)

**MENES** (Mena), the name of the founder of the 1st dynasty of ancient Egypt, *c.* 3100 B.C. Manetho began his king list with Menes; Herodotus calls him the first king of Egypt; and both affirm that he founded Memphis. His name heads the native lists of Abydos and the Turin canon, and his funerary cult was maintained till late in dynastic history. It is not certain which of several kings of the early Archaic period who are known by their Horus names bore the personal name of Menes; it may have been Narmer, whose monuments indicate that he united the northern and southern kingdoms, or Aha, whose funerary monument appears to be the earliest at Saqqarah. Manetho preserves the tradition that he came from Thinis, reigned 62 years and was killed by a hippopotamus.

*See* A. H. Gardiner, *Egypt of the Pharaohs* (1961); W. B. Emery, *Archaic Egypt* (1962). (M. S. Dr.)

**MÉNESTREL DE REIMS, RÉCITS D'UN,** an anonymous chronicle written *c.* 1260, purporting to deal, in a medley of traditional stories, fables and historical facts, with the first crusade and events in the Holy Land, France, England, Flanders and the Holy Roman empire. Without chronological order and popular in conception, its style is free and lively. Eight manuscripts are known.

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**MENGELBERG, (JOSEF) WILLEM** (1871–1951), Dutch conductor, was born at Utrecht on March 28, 1871. He studied at the Cologne conservatory and in 1891 became musical director at Lucerne. In 1895 he went to Amsterdam to conduct the Concertgebouw orchestra, which under his direction became one of the most famous in Europe. From 1907 to 1920 he conducted the Museum concerts at Frankfurt am Main as well as the Amsterdam series. He appeared in London from 1913 onward, notably with the London Symphony orchestra. He first conducted the New York Philharmonic orchestra in 1905 and returned to the U.S. to conduct this orchestra between 1922 and 1930. He also toured extensively with his Amsterdam orchestra. Mengelberg was admired as a conductor of the works of Beethoven, Richard Strauss (who dedicated *Ein Heldenleben* to him) and Gustav Mahler. In 1945 the Dutch council found him guilty of collaboration with the Nazis and he was exiled from the Netherlands. He died at Remüs, near Scuol, Switz., on March 21, 1951.

**MENGER, KARL** (1840–1921), a leading Austrian economic theorist, known principally for having originated the explanation of economic phenomena developed by the Austrian school of economics, was born Feb. 23, 1840, in Neu-Sandec, Galicia. He received his doctor's degree from the University of Cracow and then accepted a position in the Austrian civil service. In 1873 he became a professor of political economy at the University of Vienna where he remained, with brief interruptions, until 1903. In his most important work, the *Grundsätze der Volkswirtschaftslehre (Foundations of Political Economy)* (1871), Menger used homely language and simple illustrations to show how the utility principle connected use value with scarcity. He also emphasized the fundamental role played by "marginal utility" in the determination of economic value. He thus contributed remarkably to the revolution that took place in the 1870s in the theory of value utilized by economists to explain the formation of prices and incomes. Later he employed the marginal utility principle in important writings on money and its value. Menger published two works on methodology in the course of his controversy with the German historical economists who rejected his method of proceeding from an understanding of the behaviour of the individual to an explanation of economic phenomena in terms of universally valid principles. He died in Vienna on Feb. 26, 1921.

*See* also Economics: *The Marginal Utility Analysis.*

For his collected works *see* London School of Economics, *Series of Reprints of Scarce Tracts in Economic and Political Science*, no. 17–20 (1934–36). (J. J. S.)

**MENGS, ANTON RAPHAEL** (1728–1779), German painter, whose style is the epitome of neoclassicism, was born in 1728 at Aussig in Bohemia and studied first under his father in Dresden. In 1741 he went to Rome, where he copied Raphael's "Stanze" in miniature for August III of Saxony. Appointed a court painter in 1744, he worked on religious subjects and portraits, the latter especially in pastel. In 1755 he settled in Rome, where he entered into close relations with J. J. Winckelmann. At this period he was commissioned by the duke of Northumberland to copy Raphael's "School of Athens." The completion of Mengs's fresco "Parnassus" at the Villa Albani in 1761 created a sensation in Rome and established the ascendancy of neoclassical painting. In 1760, Mengs visited Naples to execute an altarpiece for the king, and afterward he worked in Madrid, partly on the decoration of royal palaces. From 1769 to 1772 he was in Rome decorating the *Camera dei Papiri* in the Vatican. He was in Rome again when he died in 1779.

Mengs was widely regarded as the greatest living painter, and at Madrid his art completely triumphed over the rococo style of his rival, G. B. Tiepolo. His theoretical writings were influential and are essential to the understanding of neoclassicism.

See *The Works of A. R. Mengs*, ed. by J. N. d'Azara, 2 vol., Eng. trans. (1796); P. F. Schmidt in Thieme-Becker *Allgemeines Lexicon der Bildenden Kunstler*, vol. xxiv with full bibliography (1930). (F. J. B. W.)

**MENG-TZU,** also spelled Mengtze and Mengtsz, town in the southeastern part of Yünnan province, China, 130 mi. S.S.E. of K'un-ming, on a spur of the railroad linking K'un-ming with the port of Haiphong in North Vietnam; 23° 20′ N., 103° 23′ E. Meng-tzu is in a fertile, cultivated basin on the high plateau at an elevation of 4,300 ft. Its climate, tempered by the high altitude, is equable and healthful despite the subtropical latitude. Meng-tzu developed after 1888 as a treaty port and the centre of French overland trade between Yünnan and Tonkin. The principal export commodity of Meng-tzu is tin mined at nearby Ko-chiu. At first the tin was shipped along the Red river by small steamers and junks. In 1910 the trade shifted to the Yünnan-Tonkin railroad built by the French. The railroad was destroyed during World War II, but was reopened to traffic in 1958.

In 1957 Meng-tzu was made the capital of the Hung Ho (Red river) Hani-Yi autonomous *chou* (district), a national autonomous area whose population of 1,480,000 (1953 est.) included 260,000 Hani and 380,000 Yi. The Hani and Yi are minorities of the Tibetan-Burman language branch. The population of Meng-tzu *hsien* (county) was about 190,000 in 1953. (T. Sd.)

**MENHADEN,** the common name for several Atlantic coastal fishes belonging to the genus *Brevoortia*, of the herring family (Clupeidae); they are also called pogy, mossbunker and fat backs. Menhaden are characterized by a deep body, a sharp-edged belly, a large head (almost one-third the length of the body) and by the rear margins of the scales being edged with long comblike teeth instead of being smooth. Adults average 12 to 15 in. in length and two-thirds to one pound in weight. Menhaden, of which several species have been recognized, chief among them being the American or Atlantic menhaden (*B. tyrannus*), occur from Nova Scotia to Argentina. They travel in dense schools. When feeding they swim with their mouths agape and their gill openings widespread to strain out the minute plants and animals of the plankton. Because of the wide range of temperatures over their extensive range, menhaden may be found spawning at one place or another throughout the year. Their eggs, which are cast into the open sea, are

buoyant, 1.5–1.8 mm. in diameter and hatch in about two days. The young grow rapidly and mature at about three years.

Menhaden are manufactured into oil and into a meal which is used mainly as animal feed. The meal shows promise as an inexpensive and readily obtainable source of protein for human consumption, chiefly as a protein additive to grain flours. Menhaden constitute a large portion of the U.S. catch, more than 2,000,000,000 lb. being taken annually, chiefly in purse seines (*see* also FISHERIES). (L. A. WD.)

**MÉNIÈRE'S DISEASE,** a disease of the inner ear, was first described by Prosper Ménière, a French otologist, in 1861. It usually appears in middle life and causes hearing impairment, noises in the ear (tinnitus) and episodic vertigo. The condition becomes bilateral in about 10% of the cases. The attacks of dizziness, which usually constitute the main complaint, vary greatly in frequency, duration and severity. Such attacks are not, however, limited to Ménière's disease and diagnosis is based on the characteristic disturbances of hearing. These are low-pitched tinnitus, inner-ear hearing impairment for low tones, decreased tolerance for loud sounds, distortion of pitch (diplacusis) and a sense of fullness; the hearing disturbances fluctuate widely in severity. Tests conducted on persons with only one affected ear show that as the intensity of sound increases above the threshold of hearing, the loudness increases more rapidly in the diseased ear until it may appear to equal or exceed the loudness perceived in the normal ear. This is known as "recruitment." Speech discrimination remains impaired despite an increase in loudness. Hearing impairment tends to progress in time but seldom results in total loss of hearing.

The attacks of dizziness begin rapidly, sometimes abruptly with falling, and usually end rapidly. Consciousness is not lost. The onset may be without warning or when auditory symptoms are greatest. Hearing often improves afterward. Nausea is usual, sometimes with pain in the ear, perspiration, vomiting and diarrhea. Dizzy spells tend to decrease in later years.

The inner ear on postmortem examination shows dilatation of the endolymphatic spaces, the inner fluid compartment containing the sense organs. The cause is not definite. The theory most accepted is that a change occurs in the chemical constituents of the endolymph due to a disturbance of its secretory mechanism. Treatment has been based on various theories including disturbed nervous control, changes in electrolyte balance and allergy.

*See* also EAR, DISEASES OF: *Diseases of the Inner Ear;* VERTIGO AND DIZZINESS. (J. R. L.)

**MENINGES AND CEREBROSPINAL FLUID.** The meninges (singular, meninx) are three membranous envelopes, pia mater, arachnoid and dura mater, that surround the brain and spinal cord. The cerebrospinal fluid is the fluid that fills the ventricles of the brain and the space between the pia mater and the arachnoid. The chief function of meninges and cerebrospinal fluid is to protect the central nervous system. (X.)

Inspection of a fresh brain and spinal cord would reveal their softness and delicacy and would indicate the considerable amount of damage that might be done by physical forces that in other parts of the body would be innocuous. It is not surprising to find, therefore, that great protection has been given to the central nervous system. A large share of this protection comes from the skull and vertebral column; an important part comes also from the meninges and from the cerebrospinal fluid.

**Meninges.**—*Pia Mater.*—The pia mater is the meningeal envelope that is directly applied to the surface of the brain and spinal cord and firmly adherent to them. It is a very thin membrane composed of fibrous tissue lined on its outer surface by a sheet of flat, polygonal cells believed to be impermeable to fluid. The pia mater is pierced by blood vessels that pass through it to reach the brain and spinal cord. It follows these blood vessels for an undetermined distance into the depth of the brain, where it adheres closely to the nervous tissue and is separated from the blood vessels by a small space, called the perivascular space.

*Arachnoid Mater.*—Over the pia mater and separated from it by a space called the subarachnoid space is a second meningeal envelope of the central nervous system, the arachnoid mater. This membrane is very thin and is remarkable for its delicacy and transparency. It is composed of fibrous tissue and, like the pia, is covered by flat, polygonal cells also believed to be impermeable to fluid. Unlike the pia, the arachnoid does not follow the irregularities of the surface of the brain, and so it is to be visualized as a loosely fitting sac with a variable distance, in certain regions relatively large and in others minute, between its walls and the surface of the nervous system.

In the region of the brain particularly, a large number of fine filaments pass from the arachnoid through the subarachnoid space to blend with the tissue of the pia mater. These filaments are called arachnoid trabeculae. They are remnants from embryological life of the common origin of the arachnoid and pia mater, and they have the frail structure characteristic of these two of the meninges. Because of their common embryological origin and because they are thin and delicate membranes, the pia mater and arachnoid are called collectively the leptomeninges.

*Dura Mater.*—The outermost of the three meninges is the dura mater, a strong, thick and dense membrane also referred to, because of its thickness, as the pachymeninx. The dura mater is composed of dense fibrous tissue, and its inner surface is covered by flattened polygonal cells like those present on the surfaces of the pia mater and arachnoid. The arrangement of the dura mater is more complex than that of the leptomeninges. It can be regarded most simply as a sac that envelops the arachnoid and that has been modified to serve several functions.

Within the skull the dura mater surrounds and supports the large venous channels carrying blood from the brain toward the heart. It also is prolonged into several partitions or septa which may be regarded as lending support to the brain. One of these, called the *falx cerebri,* is a sickle-shaped partition lying between the two hemispheres of the brain. Another, the *tentorium cerebelli,* provides a strong, membranous roof over the cerebellum. A third, the *falx cerebelli,* projects downward from the *tentorium cerebelli* and lies between the two hemispheres of the cerebellum. The outer portion of the dura mater over the brain serves as a covering or periosteum of the inner surface of the bones of the skull.

Within the vertebral canal, the dura mater splits into two sheets. These are separated by a space, called the epidural space, which is filled with fat and thin-walled veins. The outer of these two sheets of the dura mater constitutes the periosteum of the vertebral canal. The inner sheet of dura mater, like the dura mater over the brain, is separated from the arachnoid by a narrow space, called the subdural space, which is filled with fluid.

In a few places, however, the subdural space is absent and the arachnoid is intimately fused with the dura mater. The most important area of fusion between these two meninges is in the walls of the large venous channels of the dura mater. There elongations of the arachnoid, like fingers, penetrate the dura mater and project into the veins. These fingerlike processes of the arachnoid are known as arachnoid villi or arachnoid granulations. They may be seen with the unaided eye in certain instances, protruding into a venous channel that has been laid open; and with the microscope it can be determined that they are separated from the venous blood only by the thin lining of the vein. Essentially similar structures are present in the walls of the larger veins of the spinal region. The function of these structures, the arachnoid villi, is discussed below.

**Cerebrospinal Fluid.**—The fluid that fills the ventricles of the brain and the subarachnoid space is known as the cerebrospinal fluid. Several questions must be answered for a proper understanding of this fluid. What are its principal physical and chemical characteristics? Where is it formed? What is its pathway of circulation and its site of absorption? What are its functions?

The cerebrospinal fluid is clear and watery. It normally has from one to ten white blood cells per cubic millimetre and contains, at approximately the concentrations found in blood plasma, all the important constituents of the plasma except protein. Sugar, urea, uric acid, lactic acid, amino acids, creatinine, sodium, potassium, calcium, chloride, phosphate and carbonate are present. The protein concentration of the fluid, however, is only about

0.4% that of the plasma. It is because of its low protein content that the fluid as a first approximation may be regarded as a practically protein-free filtrate of the blood; in the formation of the fluid, the large protein molecules of the plasma are filtered out.

The fluid is formed in major part by the chorioid plexuses of the four ventricles of the brain. These plexuses can readily be seen by opening the ventricles; they are then evident as relatively large, reddish, tufted organs with a large surface exposed to the cavity of the ventricles. On microscopic examination the plexuses are found to be rich in blood vessels, which are separated from the cavity of the ventricles by a single layer of cells of secretory type. Since the only conceivable source of the fluid is the blood, as is true for all the fluids of the body, the very rich blood supply of the plexuses must lead to the supposition that they are important in its formation; this supposition was substantiated by a great deal of investigation. Many authorities, however, believe that there is a second source of cerebrospinal fluid. In the discussion of the pia mater, above, it was pointed out that there are spaces, the perivascular spaces, around the blood vessels of the brain. These spaces communicate with the subarachnoid space, which lies between the pia mater and arachnoid. The perivascular spaces are filled with fluid derived from the blood vessels that they surround, and this fluid is believed to flow slowly into the subarachnoid space to be added to the cerebrospinal fluid that has originated in the chorioid plexuses of the ventricles.

Since the cerebrospinal fluid is being formed continuously by the chorioid plexuses and the blood vessels with their perivascular spaces, it is obvious that there must be a mechanism for its absorption. This occurs in major part through the arachnoid villi, which have been described as projecting like fingers into the large veins lying within the dura mater of the brain. The fluid in the subarachnoid space of the head may be visualized as seeping through the arachnoid villi into the large venous channels to be returned in this way to the general blood circulation. A small amount of fluid is also believed to be absorbed by the arachnoid villi in the spinal regions and an undetermined but small amount into the veins that traverse the subarachnoid space.

An attempt might be made to follow the pathway of circulation of the cerebrospinal fluid by adding a small amount of dye to the fluid in the lateral ventricles of the brain. If this were to be done, and if tracing this coloured fluid were possible without disturbing the brain, the following observations could be confidently expected: The fluid would be seen to leave each of the lateral ventricles by way of a circular opening, called the interventricular foramen, to enter the third ventricle. In the third ventricle the colour would be diluted by the fluid formed by the chorioid plexus of this ventricle. From the third ventricle the fluid would be seen to flow into the fourth ventricle by way of a narrow tube called the aqueduct of Sylvius. In the fourth ventricle the colour of the fluid would again be diminished by the fluid derived from its chorioid plexus. From the fourth ventricle the fluid could be seen escaping into the subarachnoid space by way of three openings in the pia mater, which covers the roof of the ventricle. It would then circulate slowly and sluggishly, most of it toward the top of the brain, the smaller part through the spinal subarachnoid space to be absorbed largely by the arachnoid villi in these two areas.

The cerebrospinal fluid serves several purposes. It affords protection to the central nervous system, helping to support the weight of the brain, tending to distribute equally the force of blows and serving as a lubricant between the skull and vertebral column and the brain and spinal cord. In addition to these rather obvious purposes, it has another important mechanical function. Because of their rigidity, the skull and vertebral column have an almost invariable capacity and both are completely filled with the central nervous system and its blood vessels and with cerebrospinal fluid. Variation in the volume of any one of these constituents must be met by reciprocal compensation in the volumes of the others. The cerebrospinal fluid, therefore, through alteration in its quantity, permits changes in the volume of the central nervous system and its blood vessels. Because changes in its volume probably occur relatively slowly, it serves to protect the central nervous system from sudden changes in the amount of blood coming to it. The fluid serves still another purpose, probably of considerable functional significance: All the organs of the body, except the central nervous system, have lymphatic vessels whose function is to drain away a part of the fluids collecting in the tissues. The perivascular spaces appear to fill this need within the brain and spinal cord. Fluid leaves the capillaries of the central nervous system to nourish its cells, and that part, with its products of metabolism, not returned directly to the blood flows through the perivascular spaces to the subarachnoid space to be absorbed by way of the arachnoid villi. *See* also BRAIN; SKULL; SPINAL CORD.

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**MENINGITIS,** an inflammation of the meninges (the membranes covering the brain and spinal cord; *see* MENINGES AND CEREBROSPINAL FLUID). It can be caused by infection or irritation from many different sources. The term meningitis usually is associated, however, with the direct infection caused by the bacterium *Neisseria meningitidis*, commonly called the meningococcus. Meningitis also can result from improper spinal injections of air or serum, head injuries and overuse of alcoholic beverages. Meningitis due to infection can be classified into two main groups: (1) suppurative (pus-producing) and (2) nonsuppurative, also called aseptic. The suppuratives in turn consist of two types: (*a*) primary, *i.e.*, meningococcal meningitis, in which the meninges are the primary site of infection; and (*b*) secondary, *i.e.*, all other meningitides caused by pus-producing organisms, in which the infection spreads to the meninges from other sites. The nonsuppurative group includes meningismus and other conditions in which the symptoms generally resemble meningitis and an association can sometimes be shown with viruses, such as those of mumps, herpes simplex and infectious mononucleosis.

The importance of meningitis as a threat to health was reduced considerably by the advent of sulfonamides, penicillin and other antimicrobials. Before these drugs became available, epidemics of meningitis occurred at irregular intervals. Death then occurred in about 40%–50% of the cases; by mid-20th century the fatality rate was under 5%. Incidence of the disease also was decreased by modern therapeutics to about 25 cases per 100,000 population.

**Meningococcal Meningitis.**—This, the main form of meningitis during epidemics, is also called epidemic meningitis, cerebrospinal fever, spinal meningitis and spotted fever. Meningococcal meningitis was first recognized as a specific disease by Gaspard Vieusseux at Geneva, Switz., in 1805 and the *Neisseria meningitidis* microorganism was first described by Anton Weichselbaum of Vienna in 1887.

There are four serological groups of the meningococcus, based on agglutination reactions. They have been designated, according to the recommendation of the International Committee on Nomenclature and Taxonomy, as A, B, C and D. Group A has been shown to be chiefly responsible for epidemics, whereas B and C usually occur in sporadic cases; group D is rare. Though experimental infection can be produced in some animals by special techniques, the meningococcus causes spontaneous infection only in man. Meningococcal meningitis occurs all over the world. A few sporadic cases are reported every year but epidemics of considerable proportion have occurred, usually about every 8 to 12 years.

Meningococcus infection may occur at any season, although most cases occur in late winter and spring. It is primarily a disease of youth and especially of children under 10 years, though all ages may be affected. The disease is spread by carriers who harbour the meningococcus in the nasopharynx and disseminate it by droplet infection. Relatively few of the persons exposed contract meningitis; factors involved are individual susceptibility as well as the virulence and amount of the meningococcus transmitted. Incubation is believed to take place in about 2–10 days. A few carriers of virulent microorganisms are more dangerous in spreading the disease than are many carriers of less invasive

strains. Chronic carriers, who usually harbour groups B or C, are probably responsible for sporadic cases in susceptible individuals.

*Clinical Picture.*—There are three stages in meningococcus infection. At first the meningococcus is harboured in the nasopharynx, where it may multiply abundantly, often without causing any symptoms. If the infection proceeds no further, such a person is actually a temporary carrier.

The second stage is meningococcemia; *i.e.*, invasion of the blood by the meningococcus. Typically this involves a toxemia, fever and an increased white cell count in the blood. The meningococcus can usually be cultured from the blood at this stage. A rash often develops as the capillaries become damaged by the cocci; in severe cases the rash may be hemorrhagic (hence the old name of spotted fever). The spots may be 1–2 mm. in diameter initially and may eventually grow to 1 cm. The meningococcemia may be so overwhelming that a large part of the body becomes covered with hemorrhagic splotches and death may occur in a few hours. On the other hand, the meningococcemia may be so mild that the disease never progresses further.

In the majority of cases the third stage of infection, meningitis, develops. The meningococci localize in the meninges, where they produce intense inflammatory changes and an exudate (pus).

The first symptom of meningitis usually is vomiting. A severe, bursting headache develops because of inflammation of the meninges and because the cerebrospinal fluid pressure increases. Stiffness of the neck then develops, due to irritation of the spinal nerves supplying those muscles. The degree of stiffness varies, but often the head is retracted (opisthotonos) and in small children the head and spine may be drawn backward like a bow. Deep reflexes are exaggerated; in infants there may be bulging of the fontanelles; convulsions may occur in infants and small children.

*Complications.*—The purulent cerebrospinal fluid sometimes becomes so thick that the passages between the ventricles of the brain and the spaces in the spinal meninges become blocked, causing fluid to accumulate. The resulting increase in pressure may produce an internal hydrocephalus that causes death unless relieved.

Swelling of the optic nerve may produce temporary blindness; swelling of the acoustic nerve may cause a transient deafness. If the nerve sheaths become infected, the blindness or deafness becomes permanent. Loss of hearing in small children may result in deaf-mutism.

Herpes simplex (cold sore; *see* SKIN, DISEASES OF) frequently accompanies meningitis. Polyarthritis is common in the septicemic stage. Involvement of the brain itself (encephalitis) is uncommon and mental sequelae are unusual.

*Anatomical Picture.*—There is congestion of the choroid plexus, as well as of the meninges. The purulent exudate accumulates between the layers of the meninges; it lies along the blood vessels and in the depressions between the different parts of the brain and often fills the ventricles and extends down the spinal canal.

In fulminating septicemic cases, which are fatal within a few hours of onset, extensive hemorrhage and destruction of the adrenals are often found. Such a picture is known as the Waterhouse-Friderichsen syndrome.

*Diagnosis.*—The septicemic stage is usually recognized during epidemics, but at other times the fever and rash may be confused with those of other infections. Diagnosis depends upon finding the meningococcus in the blood or cerebrospinal fluid.

Since early diagnosis is of the greatest importance because of the danger of fulminating developments, blood cultures should be made as soon as infection with meningococcus is suspected. If meningeal symptoms develop, cerebrospinal fluid should be drawn without delay in order to identify the causative microorganism. The objective with each procedure is to apply specific treatment as soon as possible.

Normal cerebrospinal fluid is clear. As meningeal infection develops, the fluid becomes increasingly cloudy, chiefly because of the increased number of leucocytes present. A smear of the spinal fluid or its centrifuge sediment is stained and examined microscopically for the presence of meningococci, which are seen singly or in pairs either inside or outside the leucocytes. Sometimes they are few in number and occasionally they are not seen.

*Treatment.*—Specific treatment, which should begin as promptly as possible, consists of the administration of one of the appropriate sulfonamides or antibiotics. Most authorities regard sulfadiazine as the drug of choice. If the patient is too ill to take it by mouth, a soluble salt can be given intravenously. Most of the sulfonamides are carried by the blood to the meninges and so intraspinal administration of these drugs is seldom required. Clinical improvement usually becomes evident in 24–48 hours, but treatment should be continued to forestall relapse.

Penicillin is also effective in the treatment of meningococcus infection. Since it does not diffuse into the cerebrospinal fluid as readily as sulfadiazine, it may be administered intraspinally as well as intravenously. Some strains of meningococci not completely susceptible to penicillin may respond to a sulfonamide and vice versa.

In fulminating cases suggestive of the Waterhouse-Friderichsen syndrome, corticosteroids are given in addition to the usual drugs in an attempt to replace the products of the adrenals.

*Prevention.*—Successful immunization against meningococcus infection had not been accomplished at mid-20th century but infection has been prevented by giving sulfadiazine to persons exposed to the disease and carriers of the meningococcus have been cleared of the bacterium by administration of sulfadiazine.

**Secondary Suppurative Meningitis.**—Meningitis caused by *Hemophilus influenzae* type b is the most common suppurative (purulent) meningitis not caused by the meningococcus. In nonepidemic times the number of cases caused by this organism may exceed those caused by the meningococcus. It is a disease of infants and young children and rarely occurs in older persons. The clinical picture is similar to that caused by the meningococcus, except there is no rash. The tiny rodlike microorganism usually occurs abundantly in the purulent cerebrospinal fluid.

Other bacteria can cause meningitis if they reach the meninges. Many of these inflammations follow head or spine injuries, boils, middle ear infections and sinus or tonsil involvement. In all of these the causal organisms are usually found abundantly in the cerebrospinal fluid and they can be isolated and identified by bacteriological means. Treatment is by sulfonamides or an appropriate antibiotic.

**Nonsuppurative Meningitis.**—The nonpurulent forms of meningitis are those in which the white cell count in the spinal fluid is less than 2,000 per cu.mm. In the purulent forms, such as meningococcus meningitis, the count may be as high as 20,000.

In tuberculous meningitis, which usually occurs secondary to a tuberculous lesion elsewhere, the infection is carried to the meninges by the blood stream. In children such a spread usually arises from the primary lesion. After the primary lesion is walled off the spread is less likely to occur. In adults, blood stream invasion usually follows the development of active secondary foci or follows miliary spread. The symptoms are those of any acute meningitis, though the course is less rapid than with the meningococcus. The cerebrospinal fluid remains clear or opalescent. A web of fibrin often forms in the fluid on standing, and it is in this web that the causative organism, *Mycobacterium tuberculosis*, can be demonstrated most easily.

Lymphocytic meningitis (acute aseptic meningitis) is a rather common, usually mild virus infection that occurs most frequently in children and young adults. Recovery is the rule.

Syphilitic meningitis may occur as a very uncommon complication of early syphilis.

Meningismus, a symptom complex with headache and stiff neck, occurs in the early stages of a number of infectious diseases, such as measles, mumps, influenza, typhoid fever, pneumonia and typhus. This syndrome is transitory and is found most frequently in children.

*See* also references under "Meningitis" in the Index.

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**MENIPPUS** OF GADARA (first half of the 3rd century B.C.), a Cynic philosopher celebrated as the founder of a serio-comic literary genre which found many imitators both Greek and Latin and can be traced as a contributory element in the development of Latin satire. He is said to have been at one time a slave in Pontus (perhaps at Sinope) and later to have made a fortune by begging or by usury and to have become a citizen of Thebes. In Thebes he may have come under the influence of the Cynic Crates, of whose brother-in-law he is said to have been the pupil. According to Diogenes Laertius he was robbed of his money and hanged himself in despair; the suicide is not incompatible with Cynicism, but the motivation is suspect.

The writings of Menippus are lost, but some impression of their character can be gained from his imitators, particularly Varro in the fragments of the *Saturae Menippeae*, Seneca in the *Apocolocyntosis* and Lucian in *Menippus* and other works. They represent an innovation in the presentation of philosophic ideas aimed at reaching wider classes of the population. The serious form of dialogue or essay is abandoned and the Cynic criticism of institutions, conventions and ideas is conveyed in a mocking satiric style and in a variety of striking and unusual settings. Some of these settings, such as the descent into Hades, the auction, the symposium, were used also by his successors. Particularly characteristic of the new genre is the strange mixture of verse with prose, which is best illustrated in Seneca's *Apocolocyntosis*.

*See* D. R. Dudley, *A History of Cynicism* (1937). (Ar. Ca.)

**MENISPERMACEAE,** the moonseed family, comprising about 70 genera and 400 species of dicotyledonous, woody or herbaceous, largely twining vines, chiefly tropical, and so named because of the half-moon-shaped seeds. They have alternate simple but sometimes lobed leaves, small inconspicuous flowers, male and female on different plants, and drupaceous fruits. Because *Cocculus* and *Menispermum* have attractive foliage and fruits on the female plants they are used for covering walls and arbours. The South American arrow poison curare (*q.v.*) is derived from certain species of the Menispermaceae.

(J. M. Bl.)

**MENKAURE** (MENKURE; Gr. MYKERINOS), "the Horus Kaikhet," king of ancient Egypt *c.* 2530 B.C., built the third and smallest of the three pyramids of Giza. He was the son and successor of Khafre (Chephren) and, according to the Turin papyrus, reigned for 18 (?28) years. Herodotus preserves the tradition that, unlike his predecessors, he was a pious king. His sister-wife, Khamerernebty II, is depicted with him in a lifesize statue-group, now at Boston. His pyramid and mortuary temple were unfinished at his death; his successor, Shepseskaf, finished the stonework of the latter in mud brick. In it were found some of the finest sculptures of the pyramid age. (M. S. Dr.)

**MENKEN, ADAH ISAACS** (1835?–1868), U.S. actress and poet, was born probably near New Orleans, La., in 1835. Facts concerning her family name and early life are obscure. She was left in poverty at an early age, however, and appeared on the stage in New Orleans and other U.S. cities. In 1856 she married Alexander Isaacs Menken, and thereafter bore his name through various matrimonial ventures. In 1864 she appeared at Astley's theatre in London as Mazeppa, a performance of an athletic dramatic type suited to her fine physique. She previously played the role in the United States and was widely celebrated for her daring act of appearing almost nude, strapped to a running horse. In England and France she became a close friend of many literary men—Algernon Swinburne, Charles Reade, Charles Dickens (to whom she dedicated in 1868 a volume of verse, *Infelicia*), Théophile Gautier and Alexandre Dumas the elder. Paris saw her for 100 nights in *Les Pirates de la Savane*, and she also played in Vienna and London. She died in Paris on Aug. 10, 1868.

**MENLO PARK,** a city of California, U.S., 31 mi. S.E. of San Francisco on the San Francisco peninsula; linked by Dumbarton bridge with the east shore of San Francisco bay. The second town to be incorporated in San Mateo county, in 1874, it disincorporated two years later and reincorporated in 1927. It occupies portions of an historic Spanish land grant and was named after Menlough, County Galway, Ire., former home of two settlers who, in 1854, purchased the original land holdings. (For comparative population figures *see* table in CALIFORNIA: *Population.*)

Menlo Park has some industry but is essentially a residential community. It has attracted national attention through its suburban professional-administrative zoning planned for executive offices in landscaped surroundings. One of these, headquarters of *Sunset Magazine*, has become a major tourist attraction. Also located there is the Pacific Coast centre of the U.S. geological survey, and Stanford Research institute, affiliated with nearby Stanford university, specializing in economic and scientific research for government and industry. (S. B. Kn.)

**MENLO PARK,** an unincorporated community of Middlesex county, N.J., U.S.; the site of the New Jersey Edison Memorial State park and museum, on the grounds of the experimental laboratories where Thomas A. Edison perfected many of his inventions. Nearby is the 131-ft. Edison memorial tower, on the spot where the first incandescent bulb was made. The tower is octagonal and is made of coloured concrete, with commemorative tablets listing his inventions. It is capped by a light bulb 14 ft. high and 9 ft. across; a perpetual light was placed at the base of the tower in 1929.

Menlo Park was established as a rural crossroad in the 17th century after the founding of East Jersey colony in 1674. It was a part of Raritan township (named after the Raritan division of Leni-Lenape Indians) which in 1954 was renamed Edison township in honour of the inventor. Menlo Park has been an evolving suburban section of the township since World War II; its population in the early 1960s was about 1,500.

It is adjacent to Metuchen, 7 mi. N.E. of New Brunswick, and 6 mi. due west of Staten Island. The township is the site of more than a score of nationally known industries, and is annually visited by thousands of people interested in the works of Edison.

(D. N. A.; M. P. M.)

**MENNONITES,** a Christian body of religionists taking their name from Menno Simons. The chief bodies are the Mennonite Church, the General Conference Mennonite Church, the Mennonite Brethren Church of North America, the Old Order Amish Church and the Hutterian Brethren. The headquarters of the largest body, the (Old) Mennonite Church, is at Scottdale, Pa., the site of the denomination's publishing house, the Herald press. Mennonites are found chiefly in North America—about 170,000 in the United States, 60,000 in Canada and 10,000 in Mexico—though there are also around 40,000 in the Netherlands, 12,000 in Germany and an estimated 40,000 in the U.S.S.R.

**History.**—*Origins.*—The Mennonites are descended from the 16th-century Anabaptist movement founded by Conrad Grebel (*c.* 1498–1526) at Zürich, Switz., on Jan. 21, 1525, as the left wing of the Zwinglian Reformation (*see* ANABAPTISTS; GREBEL, CONRAD). Grebel rejected the state-church concept and insisted on a free church, voluntarism in matters of faith, believer's baptism, pacifism or nonresistance based on the New Testament (Matt. v, 38–48) and the rejection of the oath (Matt. v, 33–37). Nine years later in the Netherlands a similar movement arose, founded by Obbe Philips, its adherents being called Obbenites. Menno Simons (*q.v.*), a Roman Catholic priest who was converted to the Obbenite faith, united with the group in 1536, was baptized by Philips and the next year was ordained as an elder or bishop in the Obbenite Brotherhood. The two movements of Grebel and of Philips thrived briefly until persecution almost annihilated them. The Swiss Brethren, as Grebel's group was called, spread into Alsace and south Germany and into Austria,

where the Hutterian Brethren had been established in 1528, taking their name from an early leader, Jakob Hutter, a Tirolean who was burned as a heretic in 1536. The Austrian Anabaptists lived communally and held to a community of goods, which they based on Acts iv, 32–37. The Dutch Anabaptists (called Mennists) within the first decade spread into the Rhineland, across north Germany to the delta of the Vistula river in the Danzig area, and became much more numerous than the Swiss and south German Anabaptists. Beginning in 1789 thousands of Mennonites of Dutch extraction fled from Prussia to south Russia, where they established in the Ukraine German-speaking colonies that ultimately flourished. These "Russian" Mennonites of Dutch ancestry were joined in later years by German Mennonites of Swiss extraction, who also settled in the Ukraine.

*United States.*—The first American colony of Mennonites settled in Germantown, Pa., in 1683 to escape persecution in Europe. They became pioneers in Pennsylvania, Virginia, Ohio, Indiana and elsewhere, living hardy and useful lives, holding to freedom of conscience, refusing to swear an oath and opposing slavery and warfare. The traditional pattern was a free or self-supported ministry; not until after 1900 did a substantial number of congregations begin to give support to their elders (bishops) and preachers.

The Mennonites' doctrine of nonresistance was the occasion of some difficulty during the Revolutionary and Civil wars and World War I, and their view of nonconformity often occasioned misunderstanding with the rest of the community. As a whole they are strict biblicists, some of them observing foot-washing as a literal ceremony (John xiii, 1–17). After 1890 the three largest bodies began to establish academies, colleges and seminaries. All branches united in 1920 in a relief and humanitarian organization, the Mennonite Central committee. Their leading colleges are at Goshen, Ind.; Newton, Kan.; and Harrisonburg, Va. In 1958 the two largest bodies established the Associated Mennonite Biblical Seminaries at Elkhart, Ind.

By the mid-20th century Mennonites were beginning to emerge from their cultural isolation. They set up agencies, some associated with missions, to give hospital care and social service to the poor in the United States and abroad. The young people of the churches often give two years of social service on a subsistence allowance, working in general and psychiatric hospitals and in institutions for handicapped children and adults, and teaching in schools of remote areas where teachers are needed. The church operates missions in America and abroad, as well as an international radio program called the "Mennonite Hour." The men of the denomination have organized disaster units which serve in emergencies created by floods, storms and fires, often in conjunction with the Red Cross. Although the members of the church do not accept military service because of their belief in biblical nonresistance, they work in mental hospitals and other such institutions and act as experimental subjects in research on malnutrition, radioactive materials and the like.

After 1850 the transition from the German language to English, the adoption of such institutions and practices as Sunday schools and evangelistic services, together with problems associated with the acculturation process, led to a number of divisions among the Mennonites; some branches were also imported from Europe. The largest single body is the (Old) Mennonite Church with about 90,000 baptized members, most of them in the United States. Following are the General Conference Mennonite Church (55,000); the Mennonite Brethren (28,000); and the Old Order Amish (20,000). Most extreme are the Hutterian Brethren, who still live communally and practise community of goods, and who have 3,000 members in the United States (South Dakota, Minnesota and Montana) and 9,000 in Canada.

**Polity.**—It is difficult to classify Mennonite church polity for two reasons: the several bodies of Mennonites vary somewhat among themselves, and Mennonites do not fit well into a classification such as congregational, synodal or episcopal; their polity has elements of all three. There are bishops in most groups, but the conferences (synods) generally determine the standards of the groups; a bishop may be relatively mild or severe in the way he carries out the directives of the conference. The congregations have a considerable amount of autonomy. For most groups in the last four centuries there have been three kinds of officers in the congregations: (1) the bishops or elders, who serve as full pastors over one or more congregations and are district overseers; (2) the preachers, whose main task is to proclaim the Word of God from the pulpit; and (3) the deacons, who assist the bishops in the administration of baptism and the Lord's Supper, who bear some responsibility for the discipline of the church under the supervision of the bishop and who care for the alms funds of the churches. In a number of countries, including the United States after 1930, there was a growing tendency, as the congregations began to employ seminary-trained men, to have a single pastor in each congregation and to allow him to absorb some of the duties that had formerly belonged to the bishop and the deacon. In some groups the office of bishop was actually abolished. In the largest group, the (Old) Mennonite Church, the basic unit of authority in regard to disciplinary standards is the district conference, which may represent the congregations in part of a state or in two or more states. The district conferences also appoint the members of the boards of the church (education, publication, missions), as well as the delegates to the general conference of the group, which is legally only advisory in character but has considerable prestige. The General Conference Mennonite Church is more strongly congregational than the larger body, but its boards are subject to its general conference, in contrast with practice in the (Old) Mennonite Church. All bodies of Mennonites stress the brotherhood character of the church and oppose any sort of hierarchy; many groups, for example, address even a bishop only as "brother."

In the 20th century the 400,000 Mennonites of the world created the Mennonite World conference, an organization that is nonlegislative in character but that has much prestige and exerts a unifying influence.

**Worship.**—Historically the Mennonites employed congregational singing in their worship, with no musical instruments permitted; the ministers preached simple sermons, based entirely on the Bible; the worshipers knelt for prayer; the first prayer in each service was a silent prayer; and the minister always concluded his audible prayer with the Lord's Prayer (Matt. vi, 9–13). The more progressive groups now use the organ in worship, prayer is offered while standing or seated, the old silent prayer has been discontinued and the service in general tends to resemble those of other Protestant churches. In many of the groups communion is observed two to four times each year. Baptism is generally by affusion (pouring); the Mennonite Brethren are the only large group who baptize by immersion. The congregations of the more conservative groups still observe foot-washing and the holy kiss, men and women being segregated for these two ceremonies. Women worshipers wear a special veil called the prayer veiling.

**Doctrine.**—Mennonites hold to the same doctrines of God, man, sin, salvation, prayer, holiness, the Bible as God's Word and the like as do the major Free Church bodies. The distinctive doctrines in the Anabaptist-Mennonite tradition have to do with the church as a brotherhood, with the ethic of absolute love and nonresistance and with the Christian life as earnest discipleship to Christ. The semiofficial creed of the largest body, written at Dordrecht, Holland, in 1632 and adopted by the American Mennonites in 1725, teaches believer's baptism, the rejection of the oath, nonresistance and church discipline, including excommunication of the impenitent.

**Distinctive Aspects.**—Although the Mennonite Church arose in Switzerland as the left wing of the Reform movement of Zwingli, its members today are often associated with the Quakers because of their pacifism. They are also in some respects a Baptist group because of their practice of believer's baptism. But what makes the more conservative groups such as the Old Order Amish (named for Jacob Ammann, a late-17th-century Swiss Mennonite bishop who insisted on strict literalism in interpreting the confession of faith) best known is their garb and their "nonconformed" way of life. This nonconformity is based on a biblical text (Rom. xii, 2). Amish men wear broad-brimmed black hats;

beards; home-made plain clothes after a fashion of their own, fastened with hooks and eyes instead of buttons; and no jewelry of any kind. The women wear plain bonnets, large full dresses with capes over the shoulders, shawls and black shoes and stockings. This cultural nonconformity, thought of by the Amish as a simple obedience to the Bible, is actually the maintenance of a 17th-century European rural costume. The Amish worship in private homes, shun telephones and electric lights and drive horse and buggy rather than automobile. They conduct their services in Palatine German with an English admixture, commonly called Pennsylvania Dutch. They are strongly represented in Lancaster county, Pa.; Holmes county, O.; and Elkhart and Lagrange counties, Ind.

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(J. C. WR.)

**MENNO SIMONS** (*c.* 1496–1561), leader of the Anabaptists in Holland during 25 of their most difficult years, was born *c.* 1496 at Witmarsum, Friesland. He was ordained priest and was curate at Pingjum, near his native birthplace, when he began to read Luther's tracts, to study the New Testament and to question infant baptism. The execution, in 1531, at Leeuwarden, of the tailor Sicke Freerks, who had been rebaptized at Emden, introduced further questions. Menno was not satisfied with the inconsistent answers which he got from Luther, Bucer and Bullinger. In 1531 he exchanged his curacy for a living at Witmarsum. Anabaptism of the Münster type repelled him (*see* ANABAPTISTS), but on Jan. 30, 1536, he left the Roman communion and joined the Anabaptist movement. There were now four parties among the Anabaptists: the favourers of the Münster faction; the Batenburgers, extremists; the Melchiorites, followers of Melchior Hoffman; and the Obbenites, followers of Obbe Philips. For a time Menno remained aloof from both Melchior Hoffman and Obbe Philips, but before the year was out, yielding to the prayer of the leaders of the Obbenites, he became their minister. Obbe, though regarded as the actual founder of the Mennonites, later left the body.

Menno repudiated the formation of a sect; those who had experienced the "new birth" were to him the true Christian church. His Christology was in the main orthodox, though he rejected terms (such as Trinity) which he could not find in Scripture, and held a Valentinian doctrine of the celestial origin of the flesh of Christ. His church discipline was drawn from the Swiss Brethren. Neither baptism (by pouring on the head) nor the Lord's Supper (with the accompaniment of feet-washing) conferred grace; they were divine ordinances which reflected the believer's inward state. Marriage with outsiders was prohibited. Oaths and the taking of life were absolutely forbidden; hence the magistracy and the army were unlawful callings for the Mennonite; but magistrates were to be obeyed in all things not prohibited by Scripture.

Menno was an active missioner and his changes of place, often compulsory, are difficult to trace. He was apparently much in East Friesland till 1541; in North Holland, with Amsterdam as centre, from 1541 to 1543; again till 1545 in East Friesland (where he held a disputation at Emden with Jan Laski in 1544); till 1547 in South Holland; next, about Lübeck; at Wismar in 1553–54 (holding disputations with Martin Micronius at Norden); lastly at Wüstenfelde, a village between Hamburg and Lübeck, where he died about Jan. 31, 1561.

The collection of Menno's *Opera Omnia Theologica* (1681), in Dutch comprises 24 tractates, his best-known work being his *Fundament-Boek* of 1539–40. His complete writings were published in English at Elkhart, Ind., in 1871. *See* also MENNONITES.

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(J. C. WR.)

**MENOMINI** (MENOMINEE), an American Indian tribe centred (20th century) in northeast Wisconsin around the town of Neopit. They are classed as one of the Central Algonkian tribes of the Woodland culture area (*see* ALGONKIAN TRIBES). Approximately 3,000 persons of varying degrees of Menomini ancestry were on the tribal roll in the 1960s.

Early French visitors translated the tribal name as Folles Avoines ("people of the false oat"), referring to the wild rice (*Zizania aquatica*) used as a staple food by upper Great Lakes tribes. In 1639 the missionary-voyager Jean Nicolet first reported their existence along the northwest side of Lake Michigan not far from their modern location. They had a fairly settled village economy based on gathering wild rice, fishing, hunting and a limited amount of gardening. During the prolonged French–Indian and French–British wars the Menomini generally sided with the French with whom they intermarried considerably. Under the impetus of the fur trade they scattered in mobile bands over a wide territory, particularly for the winter hunts.

In 1815 a U.S. Indian agency and trading post was established at the site of Green Bay, Wis. A series of treaties followed in which the Menomini progressively sold their rights in lands, and settlers moved in. In 1852 the U.S. moved 2,002 members of the dwindling tribe to a reservation of about 400 sq.mi. on the upper Wolf and Oconto rivers. This reservation was soon left as an island of valuable forest. Beginning in 1872 a tribally owned lumber mill operated under government supervision, providing jobs and income that held the Menomini together. About 25,000,000 ft. of lumber were being cut yearly, giving an annual income per household of over $2,000 in the 1960s. Of the 550 households on the reservation, about one in ten was deriving additional income from farming; some were running minor businesses or dancing for tourists; many continued to supplement their larder with more primitive food sources found on the reservation. Penetration by Christianity has left only a few tribesmen who hold the traditional faith or who are adherents of the newer peyote religion (*see* PEYOTISM). Many Menomini are well-educated, and numbers work in city industries or otherwise live outside the tribal lands. Since 1934 the Menomini have had a tribal constitution and a largely self-governing tribal board and council. A government policy of planned withdrawal was started in 1953, with the object of bringing federal wardship to an end and merging the reservation community into the general milieu of the area. Effective April 30, 1961, U.S. trusteeship was reported terminated over Menomini lands in Wisconsin.

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(F. M. KG.)

**MENON, KRISHNA** (VENGALIL KRISHNAN KRISHNA MENON) (1897– ), controversial Indian political figure, was born on May 3, 1897, at Calicut (Kozhikode), Malabar district. He came of modest middle-class parentage and after early education in India studied at the London School of Economics and at the Middle Temple. He became an ardent socialist and served as a Labour member of the St. Pancras Borough council from 1934 to 1947, but his political interests in England were, of course, subservient to his main purpose—the struggle for freedom in India—and as secretary of the India league from 1929 he strove tirelessly in this cause. His long and intimate friendship with Jawaharlal Nehru (*q.v.*) began in those days; he represented Nehru and the Indian nationalist movement at many international meetings.

With the coming of Indian independence in 1947, Krishna Menon was appointed high commissioner of his country in London. He returned to India in 1952 after 27 years' residence in

England, becoming a member of the Indian parliament in 1953, minister without portfolio in 1956 and minister for defense in 1957. He represented India in the general assembly of the United Nations from 1952 to 1960 and there established himself as a highly controversial celebrity. His darkly handsome Mephistophelian appearance—a forbidding scowl often changing to an irresistible smile—combined with his limp and his histrionic eloquence to make him a striking figure on the international stage. His vigorous presentation of the anticolonial and neutralist policies of his government won him many admirers in the UN, but the harshness with which he expressed his opinion of the United States and its policies was undoubtedly a grave disservice to Indian–U.S. understanding. On the other hand, his many constructive interventions in the diplomatic work of the UN, often at times of great difficulty, were seldom given the credit they deserved.

On the Indian political scene Krishna Menon's performance was scarcely less controversial. He brought new vigour to the ministry of defense and introduced many far-reaching changes, but his policies and methods were the target of heavy criticism. His influence on the prime minister was felt by many to be unfortunate, and the military reverses suffered by India at the hands of the Chinese in the Himalayas in 1962 were widely and vehemently, if debatably, attributed to his policies. In the face of overwhelming opposition he had to relinquish the ministry of defense on Oct. 31, 1962. He then devoted himself to left-wing political activity in parliament.

**MENOPAUSE** (CLIMACTERIC), a term that implies the final cessation of menstruation and therefore the end of a woman's reproductive life. The popular term "change of life" is neither descriptive nor accurate for it tends to indicate a physical, mental and sexual deterioration, whereas deterioration does not occur.

**Time of Onset.**—In about half of all women, menopause begins between the ages of 45 and 50 years. Although the average age for onset is about 48 years, menopause may begin as early as age 40 or be delayed to the early 50s. Although the age of onset is probably determined by the hereditary background of the individual, good nutrition and health habits tend to postpone onset.

A premature menopause, *i.e.*, one that takes place spontaneously before the age of 40, occurs in about 8% of women. An artificial menopause may be induced by removing the ovaries by surgery or by destroying them with X-rays or radium.

**Causation.**—The natural life of the ovaries is about 35 years. The menopause is brought on by a progressive decline in ovarian function. This decline is a normal result of aging and is accelerated as the menopause approaches. During the reproductive years follicles in the ovaries mature and release their ova periodically under hypothalamic-pituitary stimulation. In the years immediately preceding the menopause, however, first some follicles and later all follicles fail to rupture and release their ova. The failure to ovulate results in a disturbed menstrual pattern. A woman may miss a period or two and suspect pregnancy. A medical examination, however, will establish the proper diagnosis. The continued decline in ovarian activity may provoke prolonged intervals between periods or grossly irregular bleeding episodes. The length of the periods may vary and the flow may become either more scant or profuse. In a fortunate small minority the periods cease abruptly.

As the ovaries decline in function, they produce smaller and smaller amounts of the hormone estrogen; this decline in estrogen initiates subtle rearrangements in the hormonal activity of the glands that control the reproductive function. The decrease in output of estrogen disturbs the neurovascular mechanism of the hypothalamus and probably initiates the vasomotor changes that may provoke the characteristic hot flashes of the menopause. The metabolism of the pituitary gland is altered and increasing amounts of follicle stimulating hormone (FSH) appear in the blood and urine. Rearrangements in the hormonal activity of the adrenal and thyroid glands also take place, for the metabolic activities of all these glands are interrelated. These physiologic adjustments are usually made without physical or mental disturbances in most women. (*See* also ENDOCRINOLOGY.)

**Symptoms.**—Hot flashes are the only characteristic symptoms of the menopause. They often appear before its obvious onset and their duration is usually limited to two or three years. The young woman who has her ovaries removed for disease or other reasons will develop flashes within a week following the operation.

The hot flash usually begins as a sense of warmth over the upper chest. It then spreads to the neck and face and may extend over the entire body, sometimes giving rise to a prickling sensation. The woman is acutely aware of blushing, which usually is disturbing to her, particularly in company. The flashes may recur frequently during the night and may interfere with sleep. Occasionally, she may awaken because of a chilly sensation and may perspire freely.

A variety of other symptoms can and do occur, although many are entirely unrelated to the changes incidental to the menopause. Nervousness, headaches and dizziness are common complaints. However, the fear of aging, the altered pattern of life and changing family relationships precipitate many disturbing symptoms.

Many women complain of weight gain. Occasionally this is related to decreased thyroid function. However, in most cases it is brought about by decreased physical activity and by increased food intake as a substitute for many emotional and social satisfactions. The menopause need not be associated with any unusual changes in physical appearance and fitness.

Libido is a variable thing at this time of life and is not directly concerned with the menopause. Frequently women acquire an exaggerated need for sex gratification after the possibility of pregnancy has disappeared.

**Treatment.**—Medical management of the menopause has improved markedly in recent years. It can be divided into three facets: (1) education, (2) periodic examination and (3) the substitution of estrogenic hormone when this is desirable.

Providing information to women concerning the physiologic function of their reproductive organs will make them aware of the limited duration of their reproductive years, the important transitional years leading into the menopause and the happy carefree years that will follow. The menopause need not be a harbinger of old age. The woman in the climacteric, because of her makeup and the vicissitudes of her environment, enters middle life with an uneasy and uncertain tread. It is a time for introspection, of inventories, of soul searching. It is a period of boredom, of phobias, of cancer fears. An intelligent understanding of the problems she may face and the proper medical guidance, if necessary, will prevent serious sequelae.

Every woman, including those of menopause age, should have a health examination at least once a year. At this time she should be screened for cancer by having a smear taken for uterine cancer and by receiving an examination for breast cancer. She also should be instructed on the proper method for making a self-examination for breast cancer. (*See* GYNECOLOGY: *Tumours: Cervix;* CANCER: *Identification of Cancer: Symptoms and Cause of Certain Common Cancers.*)

Lastly, the administration of the estrogen hormone may be indicated and desirable for the prompt relief of symptoms. Estrogen should be taken only under the direction of a physician and can be taken indefinitely without harmful side effects. It will stop flashes and will retard the shrinkage of the tissues of the external genitalia, which otherwise may become irritated and infected. Studies indicate that estrogen also may slow the development of atherosclerosis and osteoporosis, bone decalcification, and may influence the aging process favourably.

*See* also HORMONES, VERTEBRATE; RADIOLOGY; REPRODUCTIVE SYSTEM: *Female.* (M. E. Ds.)

**MENOTTI, GIAN CARLO** (1911– ), Italian–U.S. composer known for his effective, realistic operas on librettos of his own, was born at Cadegliano, Italy, on July 7, 1911. He studied at Milan and in 1927 emigrated to the U.S., where he continued his studies at the Curtis Institute of Music, Philadelphia (1927–33). His first opera, *Amelia Goes to the Ball*, was successfully produced in Philadelphia on April 1, 1937. His subsequent operas, *The Old Maid and the Thief* (radio, 1939) and *The Island God* (New York Metropolitan opera, 1942), were less successful, and he then turned to chamber operas based on melodramatic librettos.

His first opera of this type, *The Medium* (1946), a tragedy on spiritualism, was followed by a comic scene, *The Telephone* (1947); both are frequently revived. *The Consul* (New York, 1950), a dramatic operatic version of a political situation, won the Pulitzer prize and later was performed throughout Europe. His television opera *Amahl and the Night Visitors* (1951), a poetic Christmas story, came to be presented annually on Christmas eve. With *The Saint of Bleecker Street* (1954), he won a second Pulitzer prize. He also wrote a grand opera, *Maria Golovin* (Brussels, 1958), the libretto for Samuel Barber's opera *Vanessa* (1958), the opera *Labyrinth* (television première, 1963) and the comic opera *The Last Savage* (Paris, 1963). Among his instrumental works are a symphonic poem *Apocalypse* (1951) and a Violin Concerto (1952). Although Menotti's career was made entirely in the U.S., he retains his Italian citizenship. (N. Sy.)

**MENSA** and MARYA, seminomad pastoral tribes of Africans occupying part of the Ethiopian highlands included in Eritrea, and the adjacent coast plains of the Red sea, the Marya chiefly in the valley of the Khor Anseba, the Mensa dwelling farther north. These tribes claim Arab origin, tracing their descent from an uncle of the Prophet. Under Ethiopian rule they were Christians, but became Muslims in the 19th century; they are Tigre-speaking. On the death of a Marya the head of every dependent *tigré* or slave family must give his heirs a cow. The tribes punish an illegitimate birth by putting parents and child to death. *See* also CUSHITIC PEOPLES; AFRICA: *Ethnography (Anthropology): Northeast Africa: The Horn: Semitic-Speaking Peoples.*

**MENSHIKOV, ALEKSANDR DANILOVICH,** PRINCE (1670?–1729), Russian statesman, who for many years was Peter the Great's closest collaborator and who after Peter's death set himself up as his successor in all but name, was born in obscurity and may well have spent some of his youth selling pies in the streets of Moscow. He never received any formal education and barely knew how to sign his name. A bombardier in the Preobrazhenski regiment by 1693, he subsequently became one of Tsar Peter I's orderlies. He took part in the Azov campaigns and accompanied the tsar on his foreign tour in 1697–98. In 1700 he was still only a sergeant, but the Northern War (*q.v.*) offered full scope to his gifts: courage, energy, organizing ability and strategic instinct. These, together with his predilections, which were those of a confirmed westernizer, brought him advancement. In 1703 Peter appointed him first governor of St. Petersburg; in 1705, during the operations in Lithuania, he commanded the cavalry; in 1706 he was appointed commander-in-chief in Poland. In 1706 also he was rewarded with the title of prince for winning the battle of Kalisz. In 1709, at the battle of Poltava, he commanded the Russian left flank and was promoted field marshal; in 1711 his troops occupied Courland; in 1712 he commanded the Russian armies in Pomerania; in 1713 he campaigned in Holstein; and in 1714 he was back in St. Petersburg. During his service abroad he also dealt with many issues of domestic policy.

The first irregularities to be revealed in Menshikov's conduct were arbitrary confiscations perpetrated in Poland in 1711; in 1712 he was implicated in charges against a protégé of his for illicit transactions in grain; and other investigations produced evidence of gross abuse by Menshikov himself. Time and time again, however, he got away with a heavy fine, which he could well afford to pay. He owed his impunity to Peter's exceptional indulgence for him. Moreover, the personal ascendancy that Menshikov was losing over Peter was being replaced by that of Catherine (Marfa Skavronskaya), Peter's wife since 1707, who had been Menshikov's servant and knew how to plead for him. Even so, in 1724 Peter deprived him of the presidency of the military "college" (a post that he had held since 1719) for misappropriation of funds.

On Peter's death (1725) Menshikov engineered the proclamation of Catherine as empress (*see* CATHERINE I) and reinstated himself as president of the military commission. He then set up the secret supreme council and gained control of it. Having obtained Catherine's consent (March 1727) to a marriage between his daughter Maria and Peter I's grandson, Peter Alekseevich, he persuaded the empress to sign a will that contained two main provisions on the succession: it made Peter's accession to the throne conditional on his marrying Maria Menshikov and it appointed a council of regency. Catherine died in May 1727, and Peter II's betrothal, preceded by Menshikov's appointment as generalissimo, took place on June 5 (new style; May 25, old style), but the marriage did not follow. The 12-year-old Peter lent himself to the designs of A. I. Osterman and the Dolgoruki family. In Sept. 1727 Menshikov was stripped of his dignities and offices and exiled to Ranenburg. In April 1728, on a charge of treasonable intelligence with Sweden, he was deprived of his possessions and exiled with his family to Berezov in Siberia, where he died on Nov. 23 (N.S.), 1729. (L. R. LR.)

**MENSHIKOV, ALEKSANDR SERGEEVICH,** PRINCE (1787–1869), commander of the Russian forces in the Crimea in the first half of the Crimean War, was born in Sept. 1787. Beginning his active service in the army in 1809, he took part in the Russian campaigns against Napoleon from 1812 to 1814 and achieved the rank of major general in 1816. He also participated in the Russo-Turkish War of 1828–29. In 1830 he was appointed governor general of Finland; and in 1836 he became head of the naval ministry. In 1853, during the conflict over the holy places in Palestine, he was sent on a special mission to Turkey, where his overbearing manner and harsh demands contributed to the breakdown of negotiations and to the beginning of the Crimean War. Subsequently appointed supreme commander of the Russian land and sea forces in the Crimea, he had but little success: he met defeat at the hands of the British and French forces in the battle of the Alma on Sept. 20, 1854; and his attempt to relieve Sevastopol failed when he suffered severe losses at the battle of Inkerman on Nov. 5 (*see* CRIMEAN WAR). Relieved of his command in March 1855, he was later appointed military governor general of Kronshtadt. He died in St. Petersburg on May 12 (new style; April 30, old style), 1869. (B. J.)

**MENSTRUATION.** This phase of the female reproductive cycle is unique among normal bodily processes in that it involves a loss of blood. The appearance of menstrual bleeding is the most obvious and the most abrupt event in the menstrual cycle and is used for indicating the onset of successive cycles.

**Frequency and Duration.**—Tradition has it that the human cycle is a lunar month in length (Lat. *mensis,* a month). Actually the cycle ranges from three to five weeks in length. Most cycles are evidently from 27 to 30 days long, but only 10% to 15% are exactly 28 days in length. It is well to remember that such statistics indicate probabilities; more important for the individual is the extent to which the time relations may vary. While some women are more "regular" than others, the majority are likely to err by several days in predicting the onset of the next flow. All who have kept accurate records for ten years or more have noted unexpected changes in cycle length; one of 32 days may follow one of 26 days.

Abrupt changes of climate, serious emotional disturbances and similar factors may shorten or lengthen a cycle. Irregularity characterizes the early years after the establishment of the function of menstruation (menarche), which occurs in most girls between the ages of 12 and 16. The menarche is variable since many factors are involved; it may make its normal appearance as early as 9 years or as late as 18. Similarly, scanty or profuse flows or irregular cycles usually occur toward the end of the childbearing period; *i.e.*, during the menopause (*q.v.*), or climacteric, which most frequently begins between the ages of 45 and 50. It ordinarily spreads over a year or two and involves various disturbances in endocrine balance. The blood vascular system is upset so that "hot and cold flashes" and irregularities in the pulse appear. Periods of insomnia and depression are common. The complete cessation of menstruation is usually followed by years of good health and increased vitality.

**The Menses.**—The menstrual discharge (menses or catamenia) consists of secretion and cellular debris as well as blood from the lining of the womb (uterus). The discharge often begins gradually, becomes more profuse for a day or two and then gradually diminishes. The average duration of the flow is four days, but it may continue for a week. Blood comprises one-half to two-

thirds of the discharge; the total blood loss is usually somewhat more than an ounce (37 ml.) but may be less. Rarely seven ounces of blood may be lost without other indications of abnormality. The discharge does not normally clot.

**Uterine Changes.**—The lining of the womb, called the endometrium, is a moist mucous membrane with many microscopic glands and an unusually rich blood supply. It is constantly changing during the menstrual cycle.

The process of menstruation is ushered in by a reduction in the flow of blood to the surface of the endometrium, associated with a lowered content of ovarian hormone in the circulating blood. This preliminary phase lasts from one to several days and some women note such signs of the impending flow as mental depression, nervousness or weariness (premenstrual tension). Transplants of endometrium are pale at this time and the blood flow in the smallest vessels (capillaries) may cease for minutes at a time. The membrane shrinks, for there is less blood in it and it is losing tissue fluids and secretion. In time, constrictions can be seen in the small vessels (arterioles) that carry blood to the surface. The reduction in the circulation results in serious injury to many cells near the surface. This applies especially to the cells of the glands.

When the arterioles open up again, the walls of their smaller branches give way under the pressure and blood passes out into the tissue. Blisters or lakes of blood often are formed. They soon break and the blood that flows out does not clot; it has been changed by contact with the injured cells of the endometrium. This bleeding does not last for many minutes because the arterioles soon constrict again and their ends become sealed by degenerated cells. Since these changes in the arterioles do not occur at the same time throughout the entire endometrium one region may bleed on one day, another on the next. Blood-soaked areas of endometrium gradually crumble away, leaving blood vessels and glands projecting from a raw wound surface. Under abnormal conditions the end of a superficial arteriole may open up and spout blood directly into the cavity of the womb, with the result that serious loss of blood occurs. Small veins normally remain open and blood seeps from them, especially on the later days of menstruation. Rhythmic contractions of the muscular wall of the womb gradually expel the discharge. The contractions may be strong enough to cause pain (dysmenorrhea).

The blood supply of the endometrium is so arranged that the basal half or more does not suffer from a reduced circulation, and after the initial arterial bleeding in any area, the blood again circulates through the intact part of the endometrial membrane. A day or more before the external flow has ended the processes of repair are well under way. A new surface is formed in a few hours by the migration of cells from the torn ends of the glands.

**Symptoms.**—Although general bodily changes occur just before and during menstruation, many women experience no particular discomfort and their regular activities are not hampered. The basal metabolic rate and temperature fall somewhat, skin secretions and saliva change more or less and the capillary vessels of the skin bleed more readily. Bleeding from the nose, mouth, lungs or other organs is present in rare instances. Such vicarious menstruation may occur in the absence of the normal flow. These various conditions may be the result of the entrance into the general circulation of substances derived from the injured cells of the endometrium. The general effects would naturally vary as the extent of the injury to the endometrium varied, according to whether more or less absorption from the endometrium occurred and in relation to the effectiveness of the defense mechanisms of the body.

**Ovarian and Hormonal Relations.**—In the course of the human menstrual cycle an egg usually ripens and is liberated from the ovary, ready to be fertilized. The time of this event (ovulation) in the cycle is variable; although it frequently occurs near the middle of the cycle, there are records of ovulation as early as 10 days and as late as 18 days after the onset of a menstrual flow. From 10 to 14 days after ovulation, regressive changes appear in the endometrium. The typical constrictions in the arterioles, the cell injury and the bleeding in the endometrium may, however, occur even though no egg has matured or left the ovary. Such anovulatory cycles often involve a normal menstrual flow at the expected time, although there have been no preparations in the endometrium for an egg. Anovulatory cycles are common for several years after the menarche and during the menopause.

All the essential features of menstruation can be produced in the absence of the ovaries by suddenly stopping the administration of estradiol—the hormone, produced in the ovary, that stimulates the growth of the endometrium. Both ovulatory and anovulatory menstruation can be explained on the hypothesis that they are produced by rhythmic changes in hormone levels. All menstrual cycles are modifications of the pregnancy cycle, for the hormonal changes differ only in degree. In all mammals cyclic changes more or less like those of pregnancy are present when conception has not occurred. In primates the changes occur even when no egg has been liberated. After conception, there is often a show of blood at about the time of an expected menstrual flow. When it occurs in women it is usually slight, but rarely it may be so profuse as to be mistaken for menstruation, introducing an error of a month in the computed time of delivery. This bleeding is always present early in pregnancy in macaque monkeys. There is evidence that it is due to spasms of arterioles in the area of the endometrium where the young product of conception has burrowed its way into the tissues. As a result, blood and injured cells are provided for the embryonic cells, which at the time are engulfing and digesting maternal cells. This hypothesis necessarily assumes that the fall in hormone level at the beginning of pregnancy is slight and that the vascular constriction is brief and confined to the vicinity of the embryo. Both bleeding and tissue destruction are accordingly much less extensive than in the nonpregnant menstrual cycle.

Menstrual bleeding does not normally appear during pregnancy. This amenorrhea may continue during the period of nursing, even until weaning; ovulation and conception may nevertheless occur during this time. Under any other conditions amenorrhea is abnormal during the childbearing period.

*See* also ENDOCRINOLOGY; GYNECOLOGY; REPRODUCTIVE SYSTEM: *Reproductive Function in Woman;* and references under "Menstruation" in the Index. (G. W. B.)

**MENSURATION** deals with methods for obtaining measures or approximate measures of length, area and volume. This discussion primarily gives formulas, proofs of which can be found in textbooks of geometry and calculus.

**Elementary Plane Areas and Lengths.**—When a unit of length has been chosen, such as inch or centimetre, the unit of area $A$ is given by the area of a square in which any side is the unit of length. In terms of such units the area of a rectangle is obtained by multiplying the number of units in its length $l$ by the number of units in its width $w$; the formula is $A = lw$. The length $L$ of the diagonal of this rectangle is given by $L = \sqrt{l^2 + w^2}$.

A parallelogram is a four-sided figure in which the opposite sides are parallel; either pair of opposite sides may be called the bases. The distance between their lines is $h$, the height (or the altitude). (Here and in what follows the distance between two parallel lines, or parallel planes, is measured along a perpendicular.) If the length of the base is $b$ the area of a parallelogram is $A = hb$. The lengths $D_1$ and $D_2$ of the diagonals of a parallelogram are related to the lengths $a$ and $b$ of two adjacent sides by the equation $D_1^2 + D_2^2 = 2(a^2 + b^2)$.

A triangle may be considered as a half of a parallelogram of the same base and altitude. The area of a triangle may therefore be calculated as $A = \frac{1}{2}hb$. If a triangle is specified by its sides $a$, $b$, $c$ the area may be calculated by

$$A = \sqrt{s(s-a)(s-b)(s-c)} \qquad (1)$$

where $s$ denotes half the distance around the triangle. If two sides of a triangle form a right angle it is a right triangle. When the lengths of these two sides (the legs) are $a$ and $b$ then $A = \frac{1}{2}ba$. The length of the third side (the hypotenuse) is $c = \sqrt{a^2 + b^2}$.

Any quadrilateral (four-sided figure) with two sides parallel is a trapezoid. Denoting by $h$ the distance between the parallel sides

and by $a$ and $c$ their lengths, the area of a trapezoid is found by

$$A = \tfrac{1}{2}(a + c)h \tag{2}$$

This is proved by observing that a diagonal divides a trapezoid into two triangles, each of which has the altitude $h$, and which have base lengths $a$ and $c$ respectively.

**General Polygons; Areas Under Rectilinear Graphs.**—To find the area $A$ of a more complicated polygon the figure is divided into triangles and trapezoids; $A$ is the sum of the areas of these parts. In particular, this applies to a figure bounded by one horizontal line (the base), two vertical lines and a broken line (the graph). This figure is divided into trapezoids by dropping perpendiculars from the vertexes of the graph to the base. The lengths $y$ of these perpendiculars (the ordinates) are denoted $y_0, y_1, \ldots, y_n$ and the distances of the feet of these perpendiculars from a fixed point on the base (the abscissas) are denoted $x_0, x_1, \ldots, x_n$. Then the area under the graph is

$$\begin{aligned} A = {} & \tfrac{1}{2}(y_1 + y_0)(x_1 - x_0) + \tfrac{1}{2}(y_2 + y_1)(x_2 - x_1) + \cdots \\ & + \tfrac{1}{2}(y_n + y_{n-1})(x_n - x_{n-1}) \end{aligned} \tag{3}$$

**Lengths of Circular Arcs.**—The circumference of a circle is $\pi$ times as long as the diameter; it is $2\pi r$ if $r$ is the radius. The number $\pi$ cannot be expressed exactly as either a common or decimal fraction but it can be approximated with any desired degree of precision. To four decimals $\pi$ is 3.1416; another approximate value is $3\frac{1}{7}$, which is too large by about 1 part in 2,500.

The ratio of two arcs $s, s_1$ of a given circle is equal to the ratio of the central angles they subtend; this is expressed as $s:s_1 = \theta:\theta_1$. When $s_1$ is a semicircle (so that $s_1 = \pi r$ and $\theta = 180°$) this proportion gives

$$s = \frac{\pi}{180} r\theta; \quad r\theta = \frac{180\,s}{\pi r} \qquad (\theta \text{ is measured in degrees}) \tag{4}$$

For practical purposes note that $\frac{\pi}{180}$ is approximated by $\frac{7}{400}$ with an error of about 5 parts in 2,000. In some scientific work angles are measured not in degrees but in radians; in radian units equations (4) become

$$s = r\theta \tag{5}$$

If the centre of the circle is not known or is inaccessible a useful approximate equation is

$$s = \frac{8}{3} l - \frac{1}{3} c \tag{6}$$

in which $c$ is the length of the chord and $l$ is the (straight) distance from the end of the arc to the midpoint. This is accurate to within 1 part in 1,000 whenever the distance between the midpoints of the arc and the chord does not exceed $\frac{1}{8}c$. If the arc is larger it may be divided into pieces and the formula applied to each piece.

**Areas of Circular Sectors and Segments.**—The area of a circle of radius $r$ is $A = \pi r^2$. A portion of a circle bounded by two radii and the arc joining their ends is a circular sector. The ratio of the area of a sector to the area of the complete circle equals the ratio of the angle of the sector to the angle of a complete revolution; thus

$$\begin{aligned} A &= \frac{1}{2} r^2\theta \qquad (\text{if } \theta \text{ is in radians}) \\ A &= \frac{\pi}{360} r^2\theta \qquad (\text{if } \theta \text{ is in degrees}) \end{aligned} \tag{7}$$

The portion of a circle bounded by an arc and its chord is called a circular segment. With the distance $h$ between the midpoints of the arc and the chord (the height), the distance $l$ from one end of the arc to its midpoint, and the length $c$ of the chord, the approximate area of the segment is

$$A = h\left[\frac{2}{5} c + \frac{8}{15} l\right] \tag{8}$$

When $h \leq \frac{1}{8}c$ the error is about 1 part in 3,000.

**Areas of Plane Curvilinear Figures.**—To calculate the area of any irregular plane figure bounded by arcs (and possibly straight line segments), rectangular axes are introduced so that every point is given by its distances from them (co-ordinates $x$ and $y$). The boundary of the figure is divided into arcs such that each is cut by a parallel to the $y$-axis in at most one point and is not cut by the $x$-axis. Each arc is represented by an equation $y = f(x)$ where $x$ runs between the values $a$ and $b$. The area bounded by the $x$-axis, the two ordinates and the curve is given by

$$A = \left| \int_a^b f(x)\,dx \right| \tag{9}$$

The area of the entire original figure is obtained by addition and subtraction of areas calculated with such equations as (9).

If a function $F(x)$ can be found of which $f(x)$ is the derivative (possibly using tables of integrals) the following is used:

$$\int_a^b f(x)dx = F(b) - F(a) \tag{10}$$

**Polynomial Approximations; Lagrange's Interpolation Formula.**—If an expression is not available for the functions $f(x)$ which represent the bounding curves, insert between the abscissas $a$ and $b$ a number of points $x_1, x_2, \ldots, x_{p-1}$ and write $x_0$ for $a$ and $x_p$ for $b$; denote the heights of the curve at these points as $y_0, y_1, y_2, \ldots, y_p$. If the points $(x_0,y_0)$, $(x_1,y_1)$ . . . are known, set up the expression for $Q^{(p)}(x)$, a polynomial (*q.v.*) in $x$ of the degree $p$:

$$\begin{aligned} Q^{(p)}(x) = {} & y_0 + \frac{x - x_0}{x_1 - x_0}\Delta y_0 + \frac{(x - x_0)(x - x_1)}{(x_1 - x_0)^2}\frac{\Delta^2 y_0}{2!} + \\ & \cdots + \frac{(x - x_0)(x - x_1)\cdots(x - x_{p-1})}{(x_1 - x_0)^2}\frac{\Delta y^0}{p!} \end{aligned} \tag{11}$$

which represents a curve passing through these points; this may be rewritten in the form

$$Q^{(p)}(x) = k_0 + k_1 x + k_2 x^2 + \cdots + k_p x^p \tag{12}$$

where the coefficients $k_0, k_1, \ldots, k_p$ are constants. Then

$$\begin{aligned} \int_a^b Q^{(p)}(x)dx = {} & k_0[b - a] + \frac{k_1}{2}[b^2 - a^2] + \frac{k_2}{3}[b^3 - a^3] + \cdots \\ & + \frac{k_p}{p + 1}[b^{p+1} - a^{p+1}] \end{aligned} \tag{13}$$

This gives an approximate value of the area defined by equation (9), and it may be made as accurate as desired by increasing $p$.

Instead of equation (11) a useful approximation is

$$Q^{(p)}(x) = \frac{y_0 q_0(x)}{q_0(x_0)} + \frac{y_1 q_1(x)}{q_1(x_1)} + \cdots + \frac{y_p q_p(x)}{q_p(x_p)} \tag{14}$$

for which $q_j(x)$ designates the product of all factors $(x - x_0)$, $(x - x_1), \ldots, (x - x_p)$ except the $j$th one. Equation (14) is the Lagrange interpolation formula.

**The Trapezoid Rule.**—A simpler although less accurate method of approximating the integral in equation (10) is obtained by joining each pair of consecutive points $(x_k,y_k)$ and $(x_{k+1}, y_{k+1})$ as determined in equation (6) by a straight line segment. The area to be found appears then as consisting of trapezoids with areas by equation (2) of $\frac{1}{2}(y_{k+1} + y_k)(x_{k+1} - x_k)$. Assuming that the intervals on $x$-axis are all equal, denoting their common length by $h$ and adding all the areas together gives what is known as the trapezoid rule:

$$\int_a^b f(x)dx = h[\tfrac{1}{2}y_0 + y_1 + y_2 + \cdots + y_{p-1} + \tfrac{1}{2}y_p] \qquad (\text{approximately}) \tag{15}$$

**Simpson's Rule.**—Instead of passing a straight line segment through two consecutive vertexes of a graph, an arc of a parabola with vertical axis may be passed through three consecutive vertexes. By direct computation or by applying the derivation given under *Polynomial Approximations*, with $p = 2$ the area under such a parabolic arc is found to be a formula of the type $\frac{1}{3}(a + 4b + c)h$ instead of equation (2); summing these expressions (the number of divisions must be even) gives Simpson's rule

$$\int_a^b f(x)dx = \frac{h}{3}[y_0 + 4y_1 + 2y_2 + 4y_3 + \cdots + 2y_{p-1} + 4y_{p-1} + y_p] \quad \text{(approximately)} \tag{16}$$

**Prisms.**—A polyhedron is a solid with a boundary that consists of plane polygons (faces). One of the simplest polyhedra is a cube; the volume of a cube with edges that are units of length is the unit of volume.

A prism is a polyhedron with two faces (bases) that are equal polygons in parallel planes; the other faces (lateral faces) are parallelograms. If all the faces of a prism are parallelograms it is called a parallelepiped; in it any pair of opposite faces may be taken as bases. If the faces are all rectangles the solid is a rectangular parallelepiped.

The distance between the bases of a prism is the altitude. All edges not on a base (lateral edges) have the same length (called length of a prism); the section of a prism by a plane perpendicular to them is a right section. The volume $V$ of a prism is given by either $V = A_b h$ or $V = A_r l$, where $A_b$ and $A_r$ respectively are the areas of a base and of a right section, and $h$ and $l$ are the altitude and the length. The lateral area is $S_L = pl$ and the total area is $S_T = 2A_b + pl$; here $p$ is the perimeter of a right section. For the special case of a rectangular parallelepiped these formulas become $V = lwh$, and $S_T = 2lw + 2wh + 2hl$; here $w$ is the width. The length $d$ of a diagonal of a rectangular parallelepiped is

$$d = \sqrt{l^2 + w^2 + h^2}$$

**Pyramids.**—A pyramid is a polyhedron bounded by a number of triangles (lateral faces) with a common vertex (vertex of the pyramid) and one other face (the base) which also may be a triangle (in which case the pyramid is also called a tetrahedron); the distance $h$ of the vertex from the base is the altitude. The volume of a pyramid is $V = \frac{1}{3}A_b h$ where $A_b$ is the area of the base. A pyramid is regular if the base is a regular polygon and the lateral faces are isosceles triangles (they are necessarily equal); their common altitude $h'$ is the slant height. The lateral surface area of a regular pyramid is $S_L = \frac{1}{2}ph'$.

A frustum of a pyramid is a part of a pyramid between its base and a plane parallel to the base; this plane cuts the pyramid in a polygon (similar to the base) called the upper base of the frustum. The distance $h$ between the bases of a frustum is its altitude. The volume of a frustum is

$$V = \frac{h}{3}[A_b + \sqrt{A_b A_u} + A_u] \tag{17}$$

where $A_b$ and $A_u$ are the areas of the two bases.

**Prismoids.**—A prismoid is a polyhedron in which all vertexes lie in two parallel planes. The faces of a prismoid that lie in these planes are the bases; should either one or two vertexes fall in one of these planes it is said that the base in that plane is reduced to a point or a segment, and that the area of such a base is zero. The lateral faces of a prismoid are quadrangles or triangles.

The distance $h$ between the parallel planes of a prismoid is its altitude. The section of a prismoid by a third plane parallel to the bases and midway between them is the midsection; its area is denoted by $A_m$. The volume of a prismoid is

$$V = \frac{h}{6}\sqrt{A_b + 4A_m + A_u} \tag{18}$$

In addition to the polyhedra considered above (which are all special cases of prismoids), the volumes of such solids as casks, that are not standard geometrical forms, can be approximated by equation (18).

**The Cylinder.**—A straight line $l$ moving in space in such a way that it remains parallel to a fixed direction sweeps out what is called a cylindrical surface. The successive positions of $l$ are called generators (rulings) of the surface. Any curve in which a plane intersects such a surface is its directrix, and a surface is often characterized in terms of a directrix. Thus a cylindrical surface with an ellipse or a hyperbola as directrix is called elliptic or hyperbolic. If a directrix is a closed curve it indicates a closed cylindrical surface.

A cylinder is a solid bounded by a closed cylindrical surface and two parallel planes that cut it. The parts of the boundary contained in these planes are the bases and the rest is the lateral surface of the cylinder. The distance $h$ between the bases is the altitude; the length $l$ of a ruling between the bases is the cylinder's length. The section by a plane perpendicular to the rulings is called a right section.

It should be seen that a prism is a special case of a cylinder (except that the movement of a straight line generating a prism is not smooth). The notions of altitude, length, lateral surface and right sections defined above for prisms apply also to cylinders; such identical formulas as $V = A_b h = A_r l$, $S_L = pl$, and $S_T = 2A_b + pl$ apply equally well to cylinders in general.

The simplest cylinder is the right circular cylinder in which the bases are circles with radius $r$, as well as being the right sections; altitude and length are identical. For this case the mensurational equations become $V = \pi r^2 l$, $S_L = 2\pi rl$, and $S_T = 2\pi r^2 + 2\pi rl$.

**The Cone.**—A straight line moving in space in such a way that it always passes through a fixed point $F$ sweeps out what is called a conical surface. Any position of the line is called a generator (ruling) of the conical surface and $F$ is called its vertex. Any curve in which a plane intersects such a surface is its directrix. A conical surface with a closed directrix is a closed conical surface (not all of its directrixes are necessarily closed). A conical surface is divided by its vertex into two parts (nappes). Any solid bounded by one nappe of a closed conical surface and a plane which cuts it in a closed directrix is a cone; the plane part of the boundary is its base and the distance $h$ of the vertex from the base is the altitude. The volume of the cone is $V = \frac{1}{3}A_b h$ where $A_b$ is the area of the base.

The simplest cone, one with a circular base in which the altitude is the line joining the vertex to the centre of the base, is called a right circular cone. The length $l$ of one of the rulings (they are all equal) is the slant height. Thus $l = \sqrt{r^2 + h^2}$ where $r$ is the radius of the base, $V = \frac{1}{3}\pi r^2 h$, and the lateral area is $S_L = \pi rl$.

A frustum of a cone is a part of a cone between its base and a plane parallel to it. The section of the cone by that plane is the upper base of the frustum and the distance $h$ between the bases is the altitude. The volume of the frustum of a cone is given by equation (17), as is the frustum of a pyramid, which is a special case of the frustum of a cone. The volume of a frustum of a circular cone is given more explicitly as

$$V = \tfrac{1}{3}\pi h[r_b^2 + r_b r_u + r_u^2] \tag{19}$$

where $r_b$ and $r_u$ are the radii of the bases. The slant height is

$$l = \sqrt{(r_b - r_u)^2 + h^2} \tag{20}$$

and the lateral and total superficial areas are

$$S_L = \pi l(r_b + r_u), \text{ and } S_T = \pi[r_b^2 + r_u^2 + l(r_b + r_u)] \tag{21}$$

**The Sphere.**—The volume of a sphere of radius $R$ is $V = \frac{4}{3}\pi R^3$; the area of its surface is $S = 4\pi R^2$. A plane through the centre of a sphere intersects its surface in a circle of radius $R$ (great circle). The surface of a sphere is thus four times the area of a great circle.

The smaller of the two parts into which the sphere is divided by a plane at a distance $H < R$ from the centre is a spherical segment of one base. The magnitude $h = R - H$ is its height and the plane part of the boundary (it is a circle of radius $r < R$) is

its base; also $r = \sqrt{R^2 - H^2} = \sqrt{2Rh - h^2}$. The volume of the segment is

$$V = \pi h^2(R - \tfrac{1}{3}h) \tag{22}$$

and its area, including the base, is

$$S_T = \pi r^2 + 2\pi Rh \tag{23}$$

The solid cut from a sphere by a right circular cone that has a vertex at the centre of that sphere is a spherical sector; it consists of a cone and a spherical segment of one base; its volume and superficial area are $V = \frac{2}{3}\pi R^2 h$ and $S_T = \pi R(2h + r)$.

Two parallel planes on the same side of the centre of the sphere at distances $H_1$ and $H_2$ from the centre $(H_1 < H_2 < R)$ cut from the sphere a solid called a spherical segment of two bases; the bases are the sections in the parallel planes. The volume of the segment is

$$V = \pi[R^2(H_2 - H_1) - \tfrac{1}{3}(H_2^3 - H_1^3)] \tag{24}$$

or, if $h$, $r_1$ and $r_2$ denote the height (distance between the planes) and the radii of the bases, $V$ is given by

$$V = \tfrac{1}{6}\pi h[3r_2^2 + h^2 + 3r_1^2] \tag{25}$$

The area of the curved part of the surface of the segment is

$$S_L = 2\pi Rh \tag{26}$$

Equations (25) and (26) also are applicable when the centre of the sphere is between the parallel planes.

**Simple Integrals.**—The mensuration of less regular solids ordinarily requires the use of calculus. Simple integration may be used if, after a suitable line has been chosen as the $x$-axis, the areas of plane sections perpendicular to that axis can be expressed as functions $A(x)$ of the abscissa of the sections. The volume of the solid is then

$$V = \int_a^b A(x)dx \tag{27}$$

where $a$ and $b$ denote the smallest and the largest abscissas of points of the body.

This formula may be simplified when the solid is generated by revolving a curve $y = f(x)$ about the $x$-axis so that the sections are circles of radius $y$. The volume of such a body of revolution is

$$V = \pi\int_a^b [f(x)]^2 dx \tag{28}$$

The area of the lateral surface that bounds the solid (it is swept out by the curve in its revolution) is

$$S_L = 2\pi\int_a^b f(x)\sqrt{1 + [f'(x)]^2}\,dx \tag{29}$$

where $f'(x)$ is the derivative of $f(x)$.

**Multiple Integrals.**—The volume of a solid that stands on a region $R$ of the $(x,y)$ plane as a base, that is bounded laterally by a cylindrical surface with rulings perpendicular to that plane, and that has as its upper boundary a surface $z = f(x,y)$, is

$$V = \int_R\int f(x, y)dxdy \tag{30}$$

The area of its upper boundary is

$$S = \int_R\int \sqrt{1 + \left[\frac{\partial f}{\partial x}\right]^2 + \left[\frac{\partial f}{\partial y}\right]^2}\,dxdy \tag{31}$$

In some cases it is necessary to subdivide the solid into parts and to apply the equations to each part separately.

**Centroids; Theorem of Pappus.**—For a region $R$ of the $(x,y)$ plane the centroid is that point with an abscissa and ordinate given by

$$\bar{x} = \frac{1}{A}\int_R\int xdydx \qquad \bar{y} = \frac{1}{A}\int_R\int ydxdy \tag{32}$$

with $A$ representing the area of $R$. For many elementary figures the determination of the centroid may be based on the idea that if $R$ is envisaged as a disk cut out of a homogeneous plate, the centroid is the centre of gravity or the point at which the disk would balance on a point of a needle. The centroid of a triangle, for instance, is the point of intersection of the medians. A theorem of Pappus states: "If a region $R$ is revolved about an axis lying in its plane but not cutting it, the volume of a solid swept out is $V = Ap$ where $p$ is the length of the path traced by the centroid."

**Approximate Determination of Volume by Empirical Method.**—The integral in equation (27) may be computed by polynomial approximation, the trapezoid rule and Simpson's rule. Thus if the sectional area $A(x)$ is expressed as a polynomial equation, (13) gives the volume. If the sectional areas $A(x_0)$, $A(x_1)$, . . . . $A(x_p)$ at equally spaced intervals are experimentally determinable, their values may be substituted for $y_0, \ldots, y_p$ in the polynomial equations. In particular, the trapezoid rule and Simpson's rule give respectively

$$V = h[\tfrac{1}{2}A(x_0) + A(x_1) + A(x_2) + \ldots + A(x_{p-1}) + \tfrac{1}{2}A(x_p)] \tag{33}$$

and

$$V = \frac{h}{3}[A(x_0) + 4A(x_1) + 2A(x_2) + 4A(x_3) + \ldots + 2A(x_{p-2}) + 4A(x_{p-1}) + A(x_p)] \tag{34}$$

If the shape of the cross section is circular or nearly so, the formula for the area is

$$A = \frac{1}{4\pi}C^2$$

where $C$ is the circumference.

*See* also CONE; CONIC SECTION; CYLINDER; ELLIPSE; MATHEMATICAL MODELS; PARABOLA; PRISM; QUADRILATERAL; SOLIDS, GEOMETRIC; SPHERE; SURFACE.

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(R. E. L.; G. Y. R.)

**MENTAL DEFICIENCY** is a condition of incomplete general development of the mental functions, in consequence of which the affected person is incapable of assuming those responsibilities expected of the socially adequate person, such as self-direction, self-support and social participation. Synonymous terms are amentia, mental defectiveness, oligophrenia and, in the U.S., feeblemindedness.

The term mental deficiency is generally used to denote limitation of development of personality, which usually includes intellectual retardation, but it may also include temperamental or emotional immaturity. The condition frequently, though not necessarily, is associated also with various physical anomalies and with social inadequacy. Mental deficiency has legal ramifications, from the standpoint of guardianship or criminal responsibility. It also is related to aptitude for responding profitably to ordinary school instruction and to capacity for displaying conventional moral and social behaviour.

**History.**—Knowledge of this condition extends back to antiquity, persons so affected being alternately thought of as possessed of demons or as *les enfants du bon Dieu*. They were sometimes destroyed, sometimes respected, sometimes treated as public fools. Some legal status was accorded them in the reign of Edward I, but most commonly until the 19th century they were more or less hapless members of society under private guardianship or neglected public charges.

The modern movement for the scientific study and social supervision of the mentally deficient began at the turn of the 19th century with the capture of the wild boy of Aveyron. J. M. G. Itard, a French physician, undertook the training of this boy in order to demonstrate the influence of physiological education. Although the results of this experiment were relatively ineffectual, they led through the efforts of Edouard Seguin, a French physician working in the U.S. later in the century, to systematic interest in the study, treatment and disposition of the mentally defective. This movement, however, has been continuously embarrassed by moral attitudes, *e.g.*, the concept of the freedom of the will, and

by the controversy over organic basis *v.* environmental amelioration of the condition.

**Causation.**—According to modern views, two factors may be distinguished in the causation of mental deficiency:

1. A biological factor, defined as a disability attributable to demonstrable defects in brain structure or chemistry that interfere with the ability of the person to respond normally to environmental stimuli. Such defects may occur as a result of inherent factors, congenital malformations or destructive processes during intrauterine or perinatal life (*see* below, *Pathoanatomic Changes*).

2. A cultural factor, which is based on a learning deficiency resulting from unfavourable environmental influences.

The two factors may operate separately or may combine in producing mental subnormality. Their interdependence is particularly evident in the milder degrees of mental deficiency, where cultural factors are difficult to separate from minor degrees of organic brain damage or organic underdevelopment.

**Classification.**—Use of mental tests, and especially the Binet-Simon measuring scale for intelligence, produced an overemphasis on the mental aspects of the condition as contrasted with its social consequences. This led some persons to assume erroneously that mental deficiency is simply a low degree of intellectual development and to disregard other mental manifestations and the qualitative (deviational) *v.* the quantitative (variational) aspects of the condition. Consequently some authorities have defined mental deficiency as the lowest percentile of the curve of distribution of human aptitudes, but with special emphasis on mental age alone, or more specifically a Binet-Simon I.Q. (intelligence quotient) below 70. This nonclinical definition of mental deficiency has induced errors of theory and practice in scientific study and social disposition. A clinical evaluation of the condition regards it as a variation in kind as well as in degree from normal human efficiency.

It is customary to consider mental deficiency from the standpoints of degree, clinical variety and causation. In the old traditional terminology, the condition is subdivided according to its severity as idiocy, imbecility and moronity, and these are further divided as low, middle and high. (The terms moronity and feeblemindedness are used synonymously in the U.S. and Great Britain respectively.) These divisions are distinguished by some students as clinically differentiable categories, and by others according to Binet mental age. In the latter concept, idiots are adult persons with Binet mental ages (M.A.) below three years, or juveniles with I.Q.'s below approximately 20; imbeciles have mental ages from three to seven years inclusive, or I.Q.'s from 20 to 50 approximately; morons have mental ages from 8 to 12 years approximately, and I.Q.'s from 50 to 70 approximately. The upper mental age limit of the moron degree is debatable and somewhat indeterminate. The I.Q. limits are likewise debatable and somewhat indeterminate since they vary with both the test system employed and the method of calculating the I.Q. (or other mental index). Both M.A. and I.Q. standards are influenced by the adult-life age "ceilings" employed as the average normal adult limit of mental development as measured by these tests. Beginning in the 1950s, mental deficiency was classified as severe (I.Q. below 50), moderate (I.Q. 50–70) and mild (I.Q. 70–85) and the use of the term mental age declined. (*See* also PSYCHOLOGICAL TESTS AND MEASUREMENTS, *Comparable Scales: Intelligence Quotients.*)

*Idiocy.*—Clinically, and most often legally, idiocy is a degree of mental deficiency so severe that the affected person is incapable of attending to his personal needs (eating, elimination, dressing), protecting himself from ordinary dangers, mastering any useful command of speech or performing any useful work. The classification includes the major anomalies of development.

*Imbecility.*—Persons classified as imbeciles are able to perform simple functions of self-help, develop some command of speech but only limited expression of ideas, and perform simple tasks under immediate supervision; they do not profit from scholastic instruction and they exercise only a limited degree of social initiative and participation. Imbeciles are intermediate between idiots and morons from the standpoint of causes, characteristics and social needs.

*Moronity.*—This represents the mildest degree of mental deficiency, and the condition is not easily distinguishable from marginal normality. While exceeding idiots and imbeciles in general ability, morons are incapable of sustained self-direction at other than simple levels of operation, succeed scholastically only up to about fourth- or fifth-grade (standard 5 or 6) achievement, perform only relatively unskilled occupational tasks, require more than ordinary social and occupational supervision and assistance, are incapable of insightful social judgment in unaccustomed situations and subsist at best at barely marginal levels of social adequacy. Numerically morons constitute the largest proportion of all the mentally deficient. Whereas idiots and imbeciles are readily detectable, recognition of the moron requires technical skill, and whereas idiots and imbeciles are principally a social burden, morons constitute a potential menace from the standpoint of their marked suggestibility, feeble inhibitions and poor judgment.

**Pathoanatomic Changes.**—The clinical varieties of mental deficiency include diverse symptom complexes, or syndromes, some of which appear to be clinical entities while others do not. Clinical classification must take into consideration the underlying pathoanatomic changes in the nervous system, which may be subdivided into malformations and destructive processes.

*Malformations.*—Malformations represent arrests or distortions of the normal embryonic development of the central nervous system. Such congenital anomalies vary in form depending on the stage of development at which the disturbance occurred. Some of them are detectable by their physical characteristics; for example, microcephalia, hydrocephalus, spina bifida, mongolian mental deficiency and cretinism. Others, clinically and pathoanatomically nonspecific, are often classified as familial mental deficiency or oligophrenia, assuming on the one hand a simple deficiency of development resulting from limited hereditary potential and, on the other, a malformation of relatively mild degree.

*Destructive Processes.*—The destructive processes are characterized by lesions such as old hemorrhage, degeneration of tissue or scar formation. They are generally associated with such factors as trauma or infection occurring in prenatal, perinatal (*i.e.*, at or about the time of birth) or early postnatal periods of life. Here are included the birth injuries, more properly described as perinatal intracranial lesions since the birth process extends from the prepartum to the early postpartum period. Also included is kernicterus, which through the influence of the Rh factor causes erythroblastosis fetalis, which in turn produces specific lesions in the brain. In this category also belong the various infections that may occur in the prenatal and postnatal periods and result in damage to the nervous system.

*Differentiation.*—It must be emphasized that the two major groups, malformations and destructive processes, though pathologically distinct are often clinically confused and may be correctly diagnosed only on examination after death. Some of the conditions (such as hydrocephalus, kernicterus and perinatal intracranial lesions) are not necessarily accompanied by mental retardation. In fact such symptoms as epilepsy and cerebral palsy may dominate the clinical picture, although frequently they are associated with mental deficiency.

*Others.*—The numerous other clinical varieties are of relatively infrequent occurrence. Among them are disorders characterized as inborn errors of metabolism and attributed to an inherited absence of some enzyme essential for normal metabolism. Three such disorders, for example, are phenylpyruvic oligophrenia (also called phenylketonuria, or PKU), in which the amino acid phenylalanine cannot be metabolized with the result that it accumulates in the blood (ultimately is excreted in the urine as phenylpyruvic acid) and mental deficiency develops; galactosemia, in which the sugar galactose cannot be metabolized to glucose because of an inherited enzyme deficiency and mental retardation occurs; and amaurotic familial idiocy, in which disturbed fat metabolism results in storage of certain lipid materials in ganglion cells, leading eventually to the degeneration of nervous tissue and consequent mental retardation. (*See* GENETICS, HUMAN: *Inborn Errors of Metabolism.*)

*Cause.*—Congenital malformations and destructive processes are generally considered to result from two major causes: (1) heredi-

tary (endogenous) and (2) accidental (exogenous).

Both genetic and intrauterine environmental factors have been held responsible for congenital malformations; there may in fact be an interplay between the two. In mongolism, it has been found that some of the patients have 47 chromosomes in their cells as compared with the normal 46, an additional small autosomal chromosome being present. This may be due to the failure of a pair of homologous chromosomes either to segregate during meiosis to give a haploid set in each gamete or in mitosis to give two cells of like chromosome constitution. Another important research study elucidated the etiology of a group of human intersexes associated with mental subnormality. Based on the recognition by M. W. Barr of the chromatin sex differentiation, this research established that the basic anomaly in the Klinefelter syndrome is the replacing of the normal XY sex chromosomes by an XXY or XXXY structure, resulting in a male person (with many female psychological attributes) and with the "Barr chromatin body" in the skin cells as in the female. A converse condition, known as Turner's syndrome, presents an undersized, mentally deficient female with poorly developed sexual characteristics; this syndrome is due to an anomalous sex chromosome structure in which the second sex chromosome normally present is in this case absent, the structure being XO. (*See* GENETICS, HUMAN: *Chromosomes, Sex Determination and Abnormalities.*)

The causation of the destructive processes is well defined, although the exact mechanism is not always clearly understood. Included here are perinatal prematurity, birth injury, perinatal asphyxia and hemolytic jaundice, the rare prenatal parasitic infection toxoplasmosis and the comparatively more frequent bacterial and viral forms of meningitis and encephalitis occurring during infancy and childhood. The group of metabolic disorders is characterized by hereditary transmission.

**Clinical Detection.**—Clinical detection of mental deficiency is of paramount importance, particularly where specific action is called for. Accurate diagnosis also is necessary for evaluation of scientific studies in this field. Such detection must not only identify the condition but also must establish the grade, clinical variety and causation. Research in mental deficiency must be considered inadequate unless the subjects of such research are clearly segregated not only as to the differential diagnosis of the condition itself but also as to its degrees, varieties and causes. Mental tests alone are inadequate for diagnosis, especially if the tests and their differentiating standards are not clearly specified.

The only satisfactory method of detecting mental deficiency is based on a comprehensive clinical appraisal that combines evidence from the patient's history with multiple evidence on his existing condition. From the history the presumptive cause of the condition in each case should be established and also the course. Since mental deficiency is a developmental deficiency it cannot be differentiated readily from other neuropsychiatric conditions without the developmental history. Moreover, the history should discount all circumstances that spuriously simulate mental deficiency, among these being sensory handicaps (hearing deficiency, for example), motor disabilities (cerebral palsy, for example), emotional disturbances, behavioural disorders and environmental deprivation. Diagnosis of mental deficiency during childhood is only tentative; much of the work on environmental amelioration of mental deficiency is subject to the criticism that the initial diagnoses may not have been adequately established.

Anthropometric and somatic considerations must not be omitted in establishing the diagnosis, since mental deficiency generally has a biological basis. Mental criteria must be sufficiently varied to include the psychobiological organism as a whole and its many facets of expression, including personality organization and emotional motivation.

Differential diagnosis and subsidiary classification of mental deficiency is no simple matter, particularly at the moron limit where pseudofeeble-mindedness and submarginal normality may result in false diagnosis. This difficulty was materially relieved by the use of the Vineland Social Maturity scale for the evaluation of the social criterion, just as the Stanford revisions of the Binet-Simon scale had a marked effect in clarifying the intellectual criterion. The measurement of intelligence must be regarded as unreliable by itself for detecting the moron degree of mental deficiency since there is a complete overlap in Binet mental ages as between the entire range of the moron and the lower range of normality. This dilemma is to be resolved only by the use of multifocal mental measurements as well as the use of other than mental criteria of the condition.

**Incidence.**—The occurrence of mental deficiency varies according to age, sex, environment and other circumstances. The reported incidence is affected by the criteria employed in defining the condition, and it is necessary therefore to generalize the available information in terms of these variables. It is commonly accepted that about 1% of the total population is mentally deficient but that this incidence is probably closer to 2% among children. It is not entirely clear whether the incidence is greater among males as compared with females, since males are more likely to attract attention and females are more likely to be domestically safeguarded. The available figures suggest a larger incidence on the part of males, varying from a one-to-one to a two-to-one relationship. Similarly, mental deficiency seems to occur more frequently in rural as compared with urban environments, apparently because in rural situations the condition may be more readily recognized even though the social criteria are less stringent. The incidence varies appreciably with geographical isolation, some remote communities having an extremely high incidence while residential urban areas have a minimum incidence. This is reflected also in different areas of a given urban setting, where mental deficiency is seen to be much commoner in some schools than in others according to social-economic segregation. The incidence varies somewhat obscurely with race and nationality, but this is influenced by the standards of detection and by the environmental opportunities for personal-social expression. There is also the question of whether differential standards should be employed for different social situations and for different racial and nationality groups. These problems are repeated when the incidence of mental deficiency is analyzed with respect to various social problems such as crime, illiteracy and social-economic status. This involves the relations of cause and effect, which are not easily separable.

**Relation to Social Problems.**—Prior to the recognition accorded to the moron in comparatively recent years the problem of mental deficiency commanded relatively little social attention except as a burden or nuisance. But with the advent of the mental-test movement, the "discovery" of the moron and the studies of marginal families such as the Kallikaks, the relation of minimal social adequacy to many aspects of social welfare became alarmingly apparent. Coincidentally, studies of juvenile delinquents and adult offenders revealed a comparatively heavy proportion of mental deficients in these groups, the proportions varying with the standards of detection and with the selective factors affecting the populations. Similar studies of poverty, illiteracy, child neglect, occupational inadequacy and limited availability for military service revealed a previously unsuspected high occurrence of mental deficiency. Thus, in World War I about 1% of the men available for military service were rejected by camp and local boards as mentally deficient, while the mentally deficient constituted approximately one-third of all discharges from military duty for neuropsychiatric conditions. The incidence of mental deficiency discovered by military authorities in World War II is not entirely clear from published evidence, largely because the standards of detection were modified, being heavily influenced by illiteracy, "traits of character" and the absorption of marginal service personnel in special training units. Moreover, World War II revealed a much higher degree of success on the part of military personnel previously institutionalized as mentally deficient than had been expected. The record of similarly handicapped civilian workers in war industries was also relatively good. The years 1900–46 have been described as an "alarmist period" in respect to the relation of mental deficiency to social ills. After 1946 there was a considerable reduction in emphasis on the influence of mental deficiency in social pathology. This was in part a result of the swing from clinical emphasis to psychometric methods of evaluation

without reference to social consequences.

**Protection, Control and Training.**—The movement for systematic social protection and control of the feeble-minded dates from about 1850 with the establishment of state and private institutions for the custody, care and treatment of the feeble-minded.

In the U.S. the movement for public institutional provision was extensive in the second half of the 19th century and gained appreciably in the first quarter of the 20th. By the 1960s, however, some states, as well as the federal government, still had no systematic provision in public institutions, while other states provided for only 5% to 10% of the estimated number of those who presumably would be benefited by public institutional care. Likewise, though the first quarter of the 20th century witnessed an advance in providing special public (ordinary) school classes for mentally deficient children, these early advances were not commensurately continued in later years. Public provision has been supplemented by the establishment of numerous private schools and semi-private institutions throughout the U.S.

In Great Britain an approach based upon an adjustment between a socially inadequate person and the demands of a highly organized culture is reflected in legislation. The Mental Health act (1959), following the recommendations of a royal commission on the law relating to mental illness and mental deficiency (1954–57), radically changed the legislative concept of mental deficiency. The changes were planned to encourage persons suffering from any form of mental illness or disability to seek help and treatment promptly; at the same time the changes ensured that adequate safeguards would be available so that patients who lack insight into their own needs or constitute a possible threat to others could be compulsorily detained upon medical recommendation. A single legal code covered all forms of mental illness and mental deficiency. The new orientation emphasized the treatment and care of the retarded person in his own cultural setting; the mental deficiency hospital would no longer segregate the patient from society but would itself be an active component in community care. The terms idiocy, imbecility and feeble-mindedness were replaced in legislation by more appropriate terms and the more severely impaired were described as "severely subnormal," this category covering cases with an intelligence quotient below 55–60 (Stanford-Binet). This definition excludes those cases that are largely due to normal biological variation; these latter patients, with treatment and training, can achieve a satisfactory level of social independence; the definition includes all the more severe cases arising from pathological causes.

In Sweden under a 1954 act a subdivision of responsibility between the board of education and the royal medical board was arranged whereby the educable retarded of I.Q. 50 and upward were regarded as "school cases" and those below this level were considered "care and occupation cases." There was an acute shortage of accommodation for the mentally deficient in the early 1960s. Small homes for children's units were being built and, where institutional care only was available, special wards for about 15 children were being organized.

In Norway developments resulted from a change of attitude in 1945; after early voluntary efforts by the Red Cross, a national program was initiated in 1952 by parliament (*storting*) and the country was divided into eight districts. The care areas have one central home, which serves as a treatment centre with psychiatric, psychological, pedagogic and social services available to the community it serves; a full community program, including daytime occupation centres, special schools, protected workshops, foster homes and social services, was planned. A central register of mental defectives, applying to institutional cases only, was started in 1946. The Emma Hjorths Hjem state institution for mental defectives became the model unit after being upgraded from a custodial asylum to a centre for research and treatment.

In Finland a mental deficiency law (1958) deals with the more severely affected individuals, the dividing line being inability to benefit from preliminary education in special schools or classes. The mental defectives are the responsibility of the ministry of social affairs, the higher-grade cases being the responsibility of the state school board. There is a program for social care of the defective, including family care and day care centres, and sterilization, which is permitted by law, appears to be done when patients are transferred from institutional to family care.

The Netherlands has long had an excellent policy of care for the mentally deficient. Large industrial centres such as Amsterdam and The Hague run comprehensive community care programs that include psychiatric social work, industrial therapy and home care. The hospitals are well designed and provide good training facilities for the patient; it is almost axiomatic that good social work succeeds in obtaining the co-operation of the patient. Hospitals are maintained by religious organizations with the support of the state.

In Belgium the prototype of the pattern of community care is in the village of Geel (*q.v.*).

Suitable care, training and supervision may be and most frequently are provided at home, especially when supplemented by special education in ordinary schools. These may also be provided in public or private institutions and schools. Remedial treatment is better directed toward the amelioration of symptoms rather than toward cure. Training should be adapted to the degree of mental deficiency and the accompanying characteristics. Amelioration may also be achieved in the resolution of the behaviour manifestations as well as in the inculcation of the optimum degrees of literacy, the maximum forms of occupational pursuits and self-direction, the inculcation of personal and occupational habits and particularly the expressive self-realization achieved through individual happiness and adjustment as far as this may be feasible. One form of social disposition that has had a limited development in the U.S., although its practicability has been amply demonstrated, is that of family care and its equivalents, hostel and colony care.

Preventive treatment is provided through the avoidance of those circumstances that are known to produce mental deficiency or to aggravate its social consequences.

Sterilization was at one time advocated as a preventive measure, but modern knowledge of genetics does not support the eugenic argument and it has come to be recognized that the practice may be fraught with far greater social danger than any transitory advantage that may be gained by its applications in selected individual cases on grounds of mental hygiene only. Several states of the U.S. have sterilization laws although such laws were declared unconstitutional in New York in 1918, Alabama in 1934 and Washington in 1942.

The most optimistic outlook is that doubtful borderline cases of mental deficiency may be elevated from marginal deficiency to marginal adequacy, that the behaviour problems may be materially mitigated by institutional and social supervision, that occupational efficiency may be materially increased through constructive oversight and that scholastic and vocational achievement may be enhanced through special education. *See* RETARDED CHILDREN; *see* also references under "Mental Deficiency" in the Index.

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(E. A. D.; N. MD.; D. H. H. T.)

**MENTAL HEALTH** cannot be defined with precision, since it is closely related to the customs and requirements of society. Since customs vary and societies differ, there is a multiplicity of variable factors. Excessive conformity may be as unhealthy as extreme deviation. What is healthy conformity in the person of limited intelligence might be unhealthy stifling to the genius. The physician is apt to think of mental health as the absence of mental illness, and such definition serves his purpose. Mental health in the broader sense suggests a degree of happiness and satisfaction, under conditions that warrant such a state of mind, and a capacity for making satisfactory personal and social relationships. These are a few of the many variables that have to be taken into account in assessing mental health.

**History.**—The mental health movement, like all social movements, did not have a single or sudden beginning. The evolution of concern for the mentally ill, influenced by medicine and an interest in social welfare and criminology, developed separately from positive mental health, which depended more on the field of education. Concern for the mentally ill has had a slow, irregular development over centuries marked by alternations of advances and regressions. In the history of medicine and in biblical writings there are ancient references to mental illness that recall modern humane attitudes. Interspersed there are instances of socially sanctioned cruelty based upon the belief that mental illness was the result of demoniac possession. Even reformers sometimes used harsh measures in treatment.

Modern public interest in the humane treatment of the mentally ill seems to have begun in the middle of the 18th century, the contributions of four men at the end of the 18th century being outstanding: Philippe Pinel and Jean Esquirol in France (*qq.v.*); William Tuke in England; and Benjamin Rush in America (*q.v.*). But even these leaders were anticipated by less well-known reformers, such as V. Chiarugi in Italy, and by the more rational approach to the understanding and treatment of the mentally ill that was characteristic in the Muslim world centuries earlier.

In the 18th century, Bedlam (Bethlehem), founded in England in 1247, and Bicêtre in Paris were representative in their use of mechanical restraint, such as leg irons, and cruel treatment. Madhouses, as they were then called, were callous to the essential humanity and sensitivity of patients; in fact, it was often believed that mental patients lacked feeling. Custodial care and the protection of the public were paramount considerations. In 1793 Pinel, then head of the Paris Asylum for Men (Bicêtre), horrified his colleagues by removing restraints and shackles from his patients. Contemporaneously, Tuke, in England, led the Quaker movement in the same direction, and this example was followed in America, where, at the Pennsylvania hospital in Philadelphia, Benjamin Rush took steps to eliminate restraints. In the early part of the 19th century the leadership in opposition to physical restraint of the mentally ill was assumed by John Connolly, an Englishman.

In the early days of the United States the mentally ill were dealt with by a variety of measures. Some were auctioned off for their care to farmers within the community, some were driven from town by court order and some were placed in almshouses. Serious abuses, of course, took place. The first state (colonial) asylum for the mentally ill in what was to become the United States was established in Williamsburg, Va., in 1766, but the extension of this type of service to other colonies and later to other states moved very slowly.

In the middle of the 19th century Dorothea Dix (*q.v.*) undertook a campaign to construct better-equipped asylums under state auspices. So vigorous was her effort that during her lifetime 32 asylums were established or enlarged in the United States and abroad. These were still asylums, however, although many assumed the name of hospital, and many of the abuses that characterized earlier years continued. The movement away from community toward state responsibility, in fact, enhanced the isolation of the institution, and this became one of its most serious handicaps. Isolation caused the family to abandon the patient and made it harder for the patient to visit and eventually return home. It removed the institution from the sight of the citizens and public officials and clothed it in mystery and dread. It allowed many abuses to grow up unnoticed. Changing the name to hospital merely obscured the fact that internally there was very little change.

It was the sad experience of one inmate of several Connecticut institutions, Clifford W. Beers, at the beginning of the 20th century that finally brought about the organization of a citizens' group for the elimination of abuses and the provision of care that would warrant the name hospital. Beers, having suffered the usual restraints and abuses, pledged, while recovering, to attack these problems. On his return home he wrote an autobiography entitled *A Mind That Found Itself* (1908), describing his own experience as a patient. While Beers was in spirit a crusader, he was still wise enough to seek and follow the best professional and scientific counsel. His book had an enormous sale.

The greatest contribution to the whole study of mental health in the 20th century came from Vienna at the time of Sigmund Freud, Carl Jung and Alfred Adler. All modern techniques of psychotherapy derive from Freud and his associates, whose work led to a vastly increased understanding of the human mind, both in sickness and in health.

**Organization and Agencies.**—*United States.*—With the counsel of such psychiatrists as Adolf Meyer, Beers founded in 1908 the Connecticut Society for Mental Hygiene and in 1909 the National Committee for Mental Hygiene, which later, in 1950, helped form the National Association for Mental Health. After 1909, therefore, there existed in the United States a body of citizens interested in the needs of the mentally ill and exerting an influence for improvement. Similar groups developed in many other countries, and within the United States a large number of state and local mental health associations were formed.

The National Association for Mental Health in the United States consists of formal affiliation between national, state and local mental health associations. It conducts an annual national campaign for funds, 5% of the proceeds of which are devoted to research. The central concern of the association is mental illness, although many other activities bearing on mental health are also carried on.

In the beginning these organized mental health activities were concentrated on improving hospitals for the mentally ill, and this continues to be of central concern. But within a decade of its beginning the National Committee for Mental Hygiene began to interest itself also in facilities for the mentally deficient, mentally disordered inmates of correctional institutions (jails and prisons), facilities of courts for the detection and handling of the mentally handicapped, and the handling of mental health problems among immigrants entering the United States. In the early 1920s it developed outpatient psychiatric clinics for children and adults. Steps were also taken to advance the teaching of psychiatry in medical schools, schools of social work and schools of nursing, in order to satisfy the increased need for personnel. It also promoted the mental health education of physicians, teachers, social workers, public health workers, police and clergy, all of whom are concerned with mental health problems.

The major governmental agency in the mental health field in the United States is the National Institute of Mental Health, in the United States public health service of the department of health, education and welfare. It operates a research centre in Bethesda, Md., and, in addition, makes grants to research centres and to university and other training centres for psychiatrists, psychologists, psychiatric social workers and psychiatric nurses, provides grants-in-aid for projects designed to facilitate the restoration of mentally ill patients to the community and makes direct grants to state governments on a matching basis to encourage mental health facilities in communities. Other federal agencies—notably the armed forces, the Veterans administration, the office of vocational rehabilitation and the office of education—also carry out certain functions in mental health.

Each state, except Alaska, operates one or more institutions for mental disorders, and many also provide outpatient services. State mental hospitals care for about 85% of the mentally ill in hospitals of the U.S. There are, in addition, in more populous

places, county and municipal mental hospitals. Each state also has a mental health authority, usually in the state department concerned with public health or with mental hospitals, which receives the above-mentioned matching grants from the National Institute of Mental Health. A number of states, beginning in 1954 with New York, established laws providing state aid to communities for the operation of mental health services. Under these laws the community creates a local mental health authority to plan and contract for local services.

Many communities also provide agencies for the social rehabilitation of patients discharged from mental hospitals. A pioneer in this service is Fountain house in New York city. (G. Ste.)

*Great Britain and the Commonwealth.*—After 1948 in Britain the hospital care of the mentally ill was almost entirely the responsibility of the central government, operating through regional hospital boards as agents for the minister of health. The boards were established under the National Health Service act of 1946. Prior to that date the mental hospitals had been administered for more than 100 years by the local health authorities of the counties and large cities. Until the early part of the 19th century, care of mental patients, mainly of a custodial nature, was in the hands of private asylums run either by charitable bodies or for profit. Then a number of serious scandals came to light, which aroused the public conscience, and a small group of members of parliament kept up a continuous agitation and stirred the government to set up official inquiries into the administration of private asylums. Out of these inquiries came a series of disturbing reports, which led, often after setbacks and delays, to several important acts of parliament, such as the County Asylums acts, which placed a duty upon local authorities to make provision for the care and treatment of the mentally sick. The middle of the 19th century saw the building of large asylums in many parts of Britain and the establishment of the lunacy commissioners, appointed by the lord chancellor, who were charged with inspecting and licensing all places where mental patients were cared for. The commissioners' functions were later taken over by the board of control.

All patients in mental hospitals were, under the Lunacy act of 1890, subject to compulsion, until the 1930 Mental Treatment act made provision for such patients to accept hospital treatment voluntarily. The Mental Health act of 1959 swept away all previous legislation relating to mental illness and mental deficiency and made it possible for patients suffering from any form of mental disorder to be treated in a hospital on a completely informal basis. The 1959 act had two main objectives: first, to eliminate so far as possible all distinction, legal and social, between mental and physical illness; second, to provide community care for all those not ill enough to need continuous medical or nursing care. Such community care is the responsibility of the local health authorities. In certain parts of Britain, notably at Nottingham, York, Oldham (Lancashire) and Worthing (Sussex), community mental health services have existed for some years. Local authorities are encouraged to build hostels and training and occupation centres for the mentally disordered and to deploy a trained staff of mental welfare officers and psychiatric social workers to work in the community in close liaison with the hospital authorities. The hospitals provide a steadily increasing number of psychiatric outpatient clinics and day hospital facilities. In pursuance of the other objective of the new act, psychiatric inpatient units would be established in existing general hospitals and included in those planned for the future.

In 1946 the several voluntary organizations concerned with mental health were fused into the National Association for Mental Health. The association operates homes for special types of mentally disordered persons, does a certain amount of aftercare work, organizes training of workers in the mental health services and undertakes educational work both within the service and among the public at large. The Mental After-Care association provides hostels for patients discharged from mental hospitals who are unable to return directly to their own homes. Psychiatric research is mainly the responsibility of the government-financed Medical Research council, but a voluntary body, the Mental Health Research fund, also works in this field.

The mental health services of the commonwealth vary greatly both in character and in extent. By the 1960s they were most advanced in Canada, where the pattern resembles that of the United States perhaps more than that of Britain. Elsewhere there was a noticeable time lag before developments in Britain could be reproduced overseas; in most of Africa, for example, the services were still rudimentary. There were indications, however, that public awareness of mental health as a major social problem was beginning to be felt in parts of the commonwealth.

*Europe.*—The care and treatment of the mentally disordered and the promotion of mental health follow a broadly similar pattern in most of the countries of western Europe. In general, the state, either through the central or the provincial government, is responsible for the provision and maintenance of establishments for the treatment and care of mentally ill and mentally defective persons. In many countries, however—France, the Netherlands and West Germany, for example—this responsibility may be delegated in part to religious bodies or other voluntary organizations.

Hospital provision for the mentally disordered in western Europe is on a lesser scale proportionately than in Britain or the United States. There is a greater tendency for such patients to remain in the community. Despite this, fully developed community mental health services are rare in most countries, though the Netherlands was a pioneer in this respect. In Amsterdam, A. Querido, the city's director of public health, developed the type of integrated community services which embraces social-psychiatric advice and treatment in the patient's own home, liaison with other social services, hospital treatment when necessary and aftercare. The Amsterdam scheme became the model for similar developments in Rotterdam, The Hague, Utrecht and, indeed, other countries.

Communal care of a somewhat different type is exemplified in the Belgian state colony for mental patients at Geel, near Antwerp, the origin of which can be traced back to the 6th century. A record of miraculous cures, especially of persons thought to be possessed of devils, turned it into a place of pilgrimage, and the inhabitants grew accustomed over the centuries to mental patients in their midst. The colony, established by a religious order, was taken over by the state in 1850, and in the 1960s comprised about 1,500 patients, living in houses indistinguishable from those of the local population. The colony has a small infirmary for those who become too disturbed to live among the community.

Alongside the governmental agencies are the voluntary bodies, to whom in the main is entrusted the work of promoting mental health and of educating the public in its attitudes toward mental disorder, usually in co-operation with the ministry of health of the country concerned. The Netherlands has a National Federation for Mental Health; in France there is La Ligue Française d'Hygiène Mentale; and in Sweden, Svenska Föreningen för Psykisk Hälsovård. As in Britain and in the United States, there was in almost every country of western Europe the same remarkable growth, in the period after World War II, of public interest in and understanding of the problems of mental health. (K. Rx.)

*International.*—In 1930 through Beers's efforts, an International Congress on Mental Hygiene was held in Washington, D.C., and concurrently with this an International Committee for Mental Hygiene was formed. This body, as a result of the Third International Congress on Mental Hygiene, was succeeded in 1948 by the World Federation for Mental Health, a federation chiefly of national, professional, voluntary citizens' and some governmental agencies, and which, by 1958, comprised more than 100 such associations in more than 40 countries. The federation enjoys a consultative relationship with several United Nations agencies and also carries on consultative services with various national groups. It conducts studies and provides education in mental health conditions and also provides education in mental health for professional groups.

UN agencies concerned with mental health are the World Health organization, the world counterpart of a national public health service; the United Nations Educational, Scientific and Cultural organization, which carries on cultural interchange and education;

and the United Nations Children's fund, which is concerned with the health of children.

**Approaches.**—There are three types of approach to mental health: restoration, protection and elevation. Restoration of mental health is the function of clinical or psychiatric services, ranging from nonmedical services for those who are mildly or temporarily disturbed to hospital services for those with severe mental illnesses. In many cases, public hospitals in the United States have not been provided with the facilities to use modern knowledge of better ways of handling mental illnesses. Mental health associations strive to bring new treatment into use promptly. Many communities need such encouragement to provide local inpatient and outpatient services and nonmedical services, such as vocational and social rehabilitation. Many hospitals fail to follow up patients when they recover enough to leave the hospital, even though they still need psychiatric service.

The protection of mental health, *i.e.*, the prevention of mental disorder, is essentially outside the field of psychiatry, falling more within the area of public health. However, some medical treatment, not involving mental disorder, may be considered as preventive when it forestalls involvement of the brain; *e.g.*, in pellagra and syphilis. Similarly, the correction of certain social problems and life crises may prevent serious mental disorder. Mental disorders are found in 100 or more different diseases, each with its own set of causes; hence it is not possible to depend upon any general measures to treat or prevent mental disorders. Much that is done in the name of prevention is an attempt to alter adverse conditions found repeatedly in the background of the mentally ill. Though application of such measures can be thoroughly justified, it must be remembered that such preventive effort has not been tested scientifically, and it is not known how great a part adverse conditions play in the causation of mental illnesses.

The third aspect of mental health, *i.e.*, positive mental health, differs from restoration and prevention in that it is oriented toward talents and assets (positive) rather than illnesses (negative). It is concerned with facilities that identify and develop talents and capacities and, therefore, is more a matter of education, occupation and recreation.

These three aspects, of course, are not in practice separable, since all are concerned with the effective functioning of an integrated being. *See* also PSYCHIATRY; PSYCHOLOGY, APPLIED; PSYCHOTHERAPY; PUBLIC HEALTH; HOSPITAL; and articles on the various mental diseases. (G. STE.)

**MENTAL TELEPATHY** is the communication of two organisms without the use of the senses. *See* PARAPSYCHOLOGY.

**MENTAL TEST:** *see* PSYCHOLOGICAL TESTS AND MEASUREMENTS; EXAMINATIONS.

**MENTAWAI,** a group of islands off the west coast of Sumatra, administratively a part of Sumatera Barat (West Sumatra) province, Indonesia. The group includes Siberut, Sipura, North Pagai and South Pagai, the latter two also known as Nassau Islands. The population is sparse, totaling perhaps 40,000. Elevations are below 1,500 ft.

The west coasts are steep and rocky; elsewhere low ridges alternate with narrow plains. Like western Sumatra, the islands are tectonically unstable, and earthquakes are frequent. Most of the islands are covered with forest.

Coral reefs and heavy surf make approach dangerous, and the resulting isolation may explain the very primitive culture of the indigenous people. Racially they seem to belong to the early (Proto-) Malays. Linguistically they are classified as a separate branch of the Malayo-Polynesian family, and more specifically related to the Batak (Sumatra) group (*see* MALAYO-POLYNESIAN LANGUAGES; SUMATRA: *Population*). Most of the people are still animists, preoccupied with placating spirits and observing taboos, and distrustful of Christian missionary activity. Social organization is by village, usually subdivided into endogamous clan groups. Authority and inheritance are patrilineal. The villages, commonly located along river banks, are irregular groupings of small houses on stilts, although long houses are occasionally seen. In the few coastal towns are a number of Chinese and Sumatran traders.

Crops are grown on temporary clearings, chiefly tubers such as taro and yams; sago gathering is also important. Some rice is grown on dry fields, but it seems to be a late introduction. Pigs are kept, but no large livestock. Hunting with bow and poisoned arrows, gathering of forest products and fishing supplement agriculture. Coconuts are widely grown, and copra has become the chief export commodity. There are few roads, one of them along the coast of Siberut, where Muarasiberut is the main town.

(J. O. M. B.)

**MENTEITH,** a district of southwestern Perthshire, Scot., roughly comprising the Perthshire basin of the Forth west of the Ochil hills. On the northeast it extends to the Teith. The Menteith hills rise north of Aberfoyle. The village called Port of Menteith (pop. of civil parish [1961] 793) is on the northern shore of the Lake of Menteith, 4 mi. E. of Aberfoyle. On Inchmahome ("Isle of St. Colmoc or Macholmoc," also "Isle of Rest") are ruins of an Augustinian priory founded in 1238 by Walter Comyn. The island was the residence of Mary Queen of Scots, when a child of five, for a few months before her departure to France in 1548. On Inch Talla stands the ruined tower of the earls of Menteith, dating from 1428.

Formerly Menteith was a stewartry and gave the title to an earldom. The title was first held by Gilchrist, a Celtic chief ennobled by Malcolm IV, and passed successively to Walter Comyn, to a branch of the Stewarts, and finally to the Grahams, becoming extinct in 1694.

**MENTHA,** the generic name for mint plants, many of which are cultivated for the aromatic oil obtained from all parts of the plant, but a few are grown in the garden for ornament and fragrance. *See* MINT; PENNYROYAL; PEPPERMINT; SPEARMINT.

**MENTHOL:** *see* CAMPHOR.

**MENTON** (Ital. MENTONE), a town in the *département* of Alpes-Maritimes, France, at the Italian border, about 18 mi. (29 km.) E. of Nice. Pop. (1962) 17,211. The town stands below a rocky amphitheatre, along a circular bay divided by a spur. Along the shore lies the visitors' quarter, with luxurious hotels and wide boulevards; on the promontory stands the old town, with steep, narrow streets and dark passageways, nestling around the strong castle that once protected it against pirates. Facing southeast, and sheltered on the north and west by the Alpes-Maritimes, the town has a warm climate that makes it an ideal Mediterranean resort even in winter (mean winter temperature, 9° C. [49° F.]). A sandy beach ("Les Sablettes") adjoins the harbour, which has a quay for yachts and sailing boats. The Lemon festival in February and the music festival in August are well known. Behind Menton, in the hills, lie many charming villages.

Menton was probably the Lumone of the Itineraries, but no Roman remains exist. After having belonged to the counts of Ventimiglia and a noble Genoese family, it was purchased about the middle of the 14th century by the Grimaldis, lords of Monaco. During the first republic and the first empire it belonged to France, but in 1815 it reverted to the prince of Monaco, who subjected it to such exactions that in 1848 its inhabitants proclaimed the town (with Roquebrune on the west) independent, under the protection of Sardinia. In 1860 both Menton and Roquebrune were purchased by France from the prince of Monaco and added to the *département* of Alpes-Maritimes. During World War II it was occupied first by the Italians, then by the Germans. Though it was liberated in Sept. 1944, bombardment continued till April 1945, and the town suffered considerably.

**MENTOR,** in Greek legend, the son of Alcimus and friend of Odysseus (*q.v.*), who makes him guardian of his household. In Fénelon's *Télémaque* he plays a prominent part, giving the hero much good advice; hence the modern use of mentor for adviser, sage counselor.

**MENZEL, ADOLF FRIEDRICH ERDMANN VON** (1815–1905), German lithographer and painter, known in his day for picturing the times of Frederick the Great, was born on Dec. 8, 1815, at Breslau, and moved to Berlin in 1830. In 1832 he took charge of his dead father's lithographic workshop, and, self-taught, rapidly became famous in this medium. In 1839–42 he illustrated F. Kugler's *Geschichte Friedrichs der Grosse* with 400 plates, decisive in their effect on German 19th-century graphic

art; and this was followed by illustrations for similar publications such as a lavish edition of Frederick's works with 200 plates (1843–49) and E. Lange's *Die altpreussische Armee* (1852). In painting Menzel was soon famous for his glittering re-creations of such scenes as Frederick the Great's concerts at Sanssouci and "The Ball Supper" (1878) showing the court of William I vigorously refreshing itself. In later times he was most admired, however, for minor paintings and drawings dating from about 1840 onward. These interior, street and landscape scenes show an unorthodoxy of vision reminiscent of that of Menzel's contemporary Honoré Daumier. Subjects are viewed from high or low angles, there are departures from conventions of grouping and framing and excursions are made into railway and industrial subjects, the most famous of which is "The Foundry" (1875). Menzel died in Berlin, Feb. 9, 1905. (D. C. T. T.)

**MENZEL, WOLFGANG** (1798–1873), German literary critic and historian. Most of his works are forgotten, but for years he was a centre of stormy controversy and contributed much to the intellectual life of his time. He was born on June 21, 1798, at Waldenburg in Silesia and studied at Breslau, Jena and Bonn, but his liberal ideas forced him to take refuge in Switzerland from 1820 to 1824. He finally settled in Stuttgart where he edited first Cotta's *Literaturblatt* (1825–48) and subsequently (1852–69) a literary periodical of his own. He was a member of the Württemburg diet. He published some poetry, but most of his work was literary history and polemic. As a nationalist and a romantic, he bitterly opposed the influence of Goethe, and fell out with the Young Germans (*see* GERMAN LITERATURE); Ludwig Börne's savage attack *Menzel der Franzosenfresser* appeared in 1838. His main works are *Die deutsche Literatur* (1828, revised 1836) and *Deutsche Dichtung von den ältesten bis auf die neueste Zeit* (1858–59). He died in Stuttgart on April 23, 1873.

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**MENZEL-BOURGUIBA** (formerly FERRYVILLE), a commune of Tunisia in the Bizerte governorate, on the Bizerte roadstead, 10 mi. (16 km.) S.W. of Bizerte. Pop. (1956) 34,732. It owes its origin and its development, under French rule, to the naval dockyard of Sidi Abdallah, which depends on the fortress of Bizerte.

After Tunisia achieved independence the commune was renamed in honour of the first president of the republic, Habib Bourguiba, and the rural commune of Tindja was annexed to it. It is the headquarters of a *délégation* (administrative district). Its prosperity declined considerably following the French evacuation of the Bizerte naval installations in 1963. (J.-J. Ds.)

**MENZIES, SIR ROBERT GORDON** (1894– ), Australian statesman, prime minister 1939–41 and since 1949, was born in the small wheat town of Jeparit, Victoria on Dec. 20, 1894. His father owned a country store. After primary education at rural state schools, he won a series of scholarships and graduated with first class honours in law from Melbourne university. He immediately gained great success at the bar, but soon turned to politics. After six years in the Victorian state legislature, he entered the federal house of representatives in 1934 and became prime minister by April 1939. Defeated during a wartime crisis in Aug. 1941, Menzies faced political oblivion, but instead organized the so-called Liberal party which (in coalition with the Country party) swept into office in Dec. 1949. There, under his leadership, it remained for an unprecedented length of time, winning its seventh successive general election in 1963.

Menzies became the first notable politician in Australian federal history deliberately to uphold a conservative political philosophy. "Democracy's true glory," he said in 1954, "is not the achievement of a uniform mediocrity or of a spirit of dependence upon government, but the encouragement of talent and initiative, the elevation of the individual, the giving of opportunity to all who have the inherent quality to seize it." His fervent admiration of British manners and traditions, British achievements in empire and government, and the royal connection received important expression in his support for Britain's policy during the Suez conflict of 1956, in expounding which he achieved universal recognition. Such behaviour has not won unanimous approval in Australia, his Anglophilia especially being sometimes presented in a critical light. Menzies became a member of the Order of the Thistle in Feb. 1963.

Menzies' conservatism does not mean that his governments have been negative or inactive. Indeed, by maintaining large-scale immigration from Europe, attracting much overseas capital, encouraging important developmental projects, and expanding education especially at the tertiary level, they helped to make the 1950s one of the most prosperous and constructive decades in Australian history. Nor did the government fail to employ fiscal controls to maintain full employment, diminish balance of payments problems, and check inflation. In foreign policy, as Suez demonstrated, it has remained very close to traditional alliances: when British and American interests clashed, the former won out; for the rest strong support has been given to NATO and SEATO. Participation in the Colombo plan and at least titular modification of the "White Australia" immigration policy have been more novel elements.
(O. M. R.)

**MEPHISTOPHELES** (MEPHOSTOPHILES), Faust's familiar spirit. The first spelling is Goethe's, the second is the original form, and the name has undergone many other vowel shifts. Various etymologies have been suggested for the original version: Hebrew *mephis-tophel* ("destroyer-liar"), Greek *Mephos Phigein* ("not loving light"), etc.; also a faulty Greek translation of Lucifugum, a category of supernatural beings invented by the Byzantine scholar and philosopher Michael Constantine Psellus and described by Johannes Tritheim as ". . . a sort wandering in darkness, a mysterious kind of demon, dark through and through, malicious, restless, stormy." The presence of Lucifuge in the French *Grand Grimoire* (one of the chief medieval textbooks of necromancy) gives some plausibility to this theory. It is not recorded that the historical Faust ever named a familiar spirit, although he referred to the devil once or twice as his *Schwager* ("crony" or "brother-in-law"); and it seems probable that the anonymous author of the first *Faustbuch* (1587) invented the name. It is vain to seek in the many and various lists of fiends in magical manuals, except in the so-called Faustian *Höllenzwänge* ("harrowings of hell"), where it was introduced into existing ritual texts which the editors attributed to Faust in order to increase their sales value. In the interests of verisimilitude the great Faustian ritual classic *Magia Naturalis et Innaturalis* (in the Weimar Grand-Ducal library) placed Mephisto high in the infernal hierarchy, among the seven electors or planetary spirits. These derived ultimately from the *maskim* of the Akkadians, the seven adversaries of the planetary gods. *Magia* assigned Mephisto to Jupiter, gave variant spellings (Mephistophiel, Mephistophielus, Mephistophiles and Mephistophilus), brought him into prominence throughout as Faust's familiar and gave a portrait of him as a tubby little monk. But even in this manual Mephisto is completely overshadowed by the far mightier and more sinister Aciel (undoubtedly the black sun of the Akkadian cosmos); and he is chiefly conspicuous by his absence in other Faustian rituals, although he was allowed a minor part in some. A latecomer and a parvenu in the infernal hierarchy, he never became an integral part of a tradition which predated him by thousands of years. He belongs to legend and literature. Ritual magic rejected him.

In the first *Faustbuch*, Mephostophiles was represented as a formidable, remorseful, yet ruthless, fiend and realistically characterized. He gained considerably in stature in the Elizabethan prose version by P. F. Gent (1592) and attained to tragic proportions in Christopher Marlowe's drama (published 1604) as a fallen angel, torn between satanic pride and dark despair. Goethe's Mephistopheles is entirely different, perhaps a subtler but certainly a slighter creation. He is coldhearted, cynical, witty, malignant and destructive, the very spirit of denial, as he defines himself; but nevertheless

> A part of that same might
> Which wills the evil course and furthers right.

As such he is far from displeasing to the Almighty, with whom he is on easy terms; and his mission is foredoomed to failure because

(unlike his predecessors in the *Faustbücher* and Marlowe's drama) he is incapable of satisfying Faust's desires. He is finally befooled, resembling in this the comic devil or poor devil of pre-Lutheran popular literature, for Faust's soul escapes him while he is making improper advances to the angels who have come to rescue it. In his great speech against the light (*Studierzimmer I*) there are traces of a different conception based on the ancient dualism between good and evil, darkness and light which harks back to Zoroastrianism; but Goethe's Mephisto is too strongly individualized and also too protean a character to fit readily into any abstract system. *See* also FAUST. (E. M. BR.)

**MERANO** (Ger. MERAN), a city in the Trentino–Alto Adige region of Italy, Bolzano province, 29 km. (18 mi.) N.W. of the city of Bolzano by road. Pop. (1961) 37,520 (commune). It is situated at the foot of the central chain of the Alps in the high valley of the Adige, exactly at the confluence of the Adige and the Passirio. The population is predominantly German-speaking; the city was in that part of Tirol transferred from Austria to Italy by the treaty of St. Germain (1919). (*See* also TIROL.)

In the 20th century Merano was transformed from a small mountain town into a modern tourist and health resort. The settlement is first mentioned in 857. In the middle ages it lay entirely on the right bank of the Passirio and was enclosed by walls (of which some gates remain). In the centre of Merano is the Gothic parish church, built between the 14th and 15th centuries. Nearby is a small castle (Castello Principesco), built in the 15th century by the Habsburgs. In the surrounding area are about 30 other castles, the most celebrated of which is Tirolo, from which the region took its name, famed as the residence of the Ugly Duchess (Margaret of Carinthia; *q.v.*).

**MERCANTILE SYSTEM,** the name given to the economic policies and practices followed by European states for about 150 years during the 17th and 18th centuries. The adjective "mercantile" is often challenged as unsatisfactory and "system" may be used only if it does not imply a rigid body of theories and practices. The term was brought into use by Adam Smith although he used it loosely to denote either a system of commerce, the commercial system or the mercantile system. Its own practitioners never used the term. The generic term "mercantilism" covers the practices in France known as Colbertism and in Germany and Austria known as Cameralism. Some students put the beginning of mercantilism as far back as 1550 when in England a group of extremists known as "bullionists" appeared. In Italy a tract by Antonio Serra was published in 1613 setting forth many of the leading tenets of the so-called system. Sir James Steuart's *Inquiry Into the Principles of Political Economy* (1767) is the last of the mercantilistic publications. The end of the period is marked by publication of Adam Smith's *Wealth of Nations* in 1776.

As generally understood, mercantilism is associated with the growth of nationalism and the emergence of modern European states. Its writers, most of whom were pamphleteers, emphasized measures that states might employ to attain strength and power for both offensive and defensive purposes. Only a difference in the degree of the measures employed differentiates the practices of 17th and 18th century European states from those used in Greece, Rome and Carthage of the ancient world.

When European states began to take shape toward the end of the middle ages, national survival was of foremost importance. The influence of the church, which stressed the need to control industry and commercial operations in the interests of the community, was easily transferred to the government. As towns expanded and became self-regulating and finally grew into national states, the view developed that self-preservation was the first rule of the state. The formation of the states of modern Europe was a process that lasted for many centuries. England was early in its attainment of national unity. France and Spain came next, Germany and Italy somewhat later. Explorations in the 15th and 16th centuries brought distant territories under the control of European powers, and led to the introduction of mercantilist practices in their colonial regimes.

**Spain.**—Spain was pre-eminently successful in developing a colonial empire and drew from the new world great quantities of gold and silver, which made her the most powerful European state for a time. Spain could obtain precious metals directly from the mines but other nations could get them only by trade and commerce. Nations were inclined to attribute Spain's greatness to her almost limitless supply of precious metals. The desire for money was common to all nations. It had increased commerce and added to the bitter rivalries that led to wars. Money, in the form of gold and silver, provided the sinews of war for, with a full treasury, armies could be bought and a vigorous population could flourish. This led to the development in theory and practice of the idea of a favourable balance of trade that would increase the nation's supply of gold and silver money. Money circulating within the state, it was argued, added little to the wealth of the state. Therefore, policies designed to control foreign trade so that the country sold more to other countries than it bought from them were certain to increase the wealth of the state. This, in turn, would strengthen and encourage home industries as producers of goods for foreign markets. Spain, however, continued to drain precious metals from her colonies and buy freely from other states; she lost her treasure and failed to develop home industry. In the end, Spain changed from the richest to one of the most impoverished of the European states.

**English Mercantilism.**—England was by far the most successful of the European states in attaining national strength and unity. She licensed trading companies that brought home great profits both for themselves and for the crown. As noted above, the earliest English writers on the general subject of foreign trade and commerce were known as "bullionists." Their basic theory was that once the nation obtained a supply of bullion it should not be exported. They advocated regulation of foreign exchange and a prohibition of the export of bullion, even for capital purposes that might bring in greater gains through transactions. Their influence gave way to more liberal mercantilists who argued that greater gains would come from trade if the nation exported more goods than were imported. Thomas Mun (1571–1641), a London merchant and director of the East India company, set forth views that became gospel for both financial and commercial policy. His doctrines were supported by many others. However, a new and disturbing element entered the picture—the rising level of prices that wiped out gains and changed the national economic picture. Prices rose in all nations but Spain suffered the most. Locke, the English philosopher, called attention to the velocity of circulation of money as a factor affecting the level of prices. Most writers thought that an increase in the quantity of money was the sole cause of rising prices.

In the early period of mercantilism in England restrictions on trade were universal. Later in the period two writers, Sir William Petty (1623–1687) and Sir Dudley North (1641–1691), argued that trade and commerce would flourish without the state-imposed restrictions. They held that there was really no difference between domestic and foreign trade, and that all trade was beneficial both to the trader and to the public. They also maintained that the amount of money or treasure a state needed would be automatically adjusted and that money, like any other commodity, could exist in excess. North was, in reality, the first advocate of a "One World" concept. He refuted the age-old theory that a nation could grow rich only at the expense of another and argued that trade was in reality a two-way street. Adam Smith gets credit for finishing off mercantilism.

**General Principles.**—In general, all states subscribed to the belief that precious metals were the most desirable form of national wealth. Next, if a nation did not possess mines or have access to them, precious metals should be obtained by trade. Then followed the idea that trade balances must be "favourable," meaning an excess of exports over imports. Most states had colonial possessions that served as markets for exports and suppliers of raw materials to the mother country. Manufacturing was forbidden in the colonies and all commerce between the colony and the mother country was held to be a monopoly of the mother country.

Each nation wished to have a large population, for a large population would provide a supply of labour, a market and a source of soldiers. Human wants were to be minimized, especially for im-

ported luxury goods, for they drained off precious foreign exchange. Sumptuary laws were passed to make sure that wants were held low. Thrift, saving and even parsimony were regarded as virtues, for only by these means could capital be created. The rules of mercantilism were unevenly applied and enforced. Mercantilist writers disagreed among themselves as to what policies the state should follow and at no time was there a "system" in the accepted sense of the term. Many of the practices were deep-rooted in medievalism and as the Swedish scholar, Eli Heckscher, wrote (*Mercantilism*, vol. i, p. 40), they were "unintentional planlessness." However, the underlying current of nationalism, or building a strong state, was always present. That some states were more successful than others is a well-known historical fact.

Mercantilism should never be regarded as a separate thing, apart from the great sweep of economic, political, social and even religious forces that shaped the growth or the decline of nations. It was the period in which capitalism got its start. Its promise of profit was the powerful driving force behind the bold activities that characterized practices associated with mercantilism. In turn, the state provided a favourable climate for capitalistic endeavours. The state and capitalism needed each other. The medieval doctrines of poverty and self-negation gave way to a stronger policy of affluence and abundance. The price paid to accomplish the objectives was, in many instances, a high one.

**Modern Practices.**—States have never ceased to resort to commercial practices presumed to be to their benefit. No modern state has unqualifiedly accepted either mercantilistic policies or policies of free trade. Every state has developed commercial policies designed to build or to conserve its national strength as peaceful or warlike measures demanded. Trade balances are still carefully watched by every nation. Hard bargains are driven, each party expecting a greater gain in the trading. Bounties on exports and duties on imports are found today as they were under mercantilism.

The gold stock of nations is a matter of interest in international credit and financial transactions, even though the sheer possession of gold is not the goal of modern commerce. States grant special franchises as was done in the reign of Queen Elizabeth I. Quotas tend to restrict imports without quite the same purpose as protective tariffs. Pressure groups favour or oppose import or export of commodities. Strong national consciousness still prevails and indeed is responsible for many new national states, each employing in one form or another the same devices which proved productive in the past.

Nations have not freed themselves from all the "errors" of mercantilism. Nor have they adopted free trade, mainly because it cannot be done. The trend of government in modern states, together with their internal economic disorders of inflation largely induced by wars, provides an unhealthful climate for either mercantilism or *laissez faire* for either the short or the long run. The problem of sheer survival has taught nations that they must have a semblance of balanced production in their national economy. At least the old error of mercantilism, ignoring of agriculture and the overemphasis of trade and commerce, is removed. Nor can the error of *laissez faire*, free trade in commerce and industry, be perpetuated. National ego has never been especially pacifistic, yet survival in the modern day, in contrast to the mercantilistic period, calls for co-operation far beyond the imagination of Dudley North, the liberal mercantilist, who envisioned the world as an economic unit without trade barriers and each nation sharing in the bounties of nature.

*See* also references under "Mercantile System" in the Index.

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**MERCAPTANS** are organic chemical compounds similar to the alcohols in structure but containing sulfur in place of oxygen. They are thus thioalcohols, or thiols. Their generic name is derived from *mercurium captans*, which refers to the formation of characteristic crystalline mercury salts by the interaction of the thiols with mercuric oxide.

Mercaptans may be either aliphatic or aromatic. Ethyl mercaptan, $C_2H_5{\cdot}SH$, a typical aliphatic thiol, is a volatile liquid boiling at 36.2° C. and sparingly soluble in water with a disagreeable smell. It is made by warming sodium ethyl sulfate with aqueous potassium hydrogen sulfide. Ethyl mercaptan is used commercially in the production of the drugs sulfonmethane (Sulfonal) and sulfonethylmethane (Trional). *n*-Butyl mercaptan, a liquid boiling at 98° C., is a component of the scent of skunks.

Thiophenol, or phenyl mercaptan, $C_6H_5{\cdot}SH$, the simplest aromatic thiol, is a liquid boiling at 169.5° C. and is prepared by reacting benzenediazonium chloride successively with potassium ethyl xanthate and caustic alkali or by reducing benzenesulfonyl chloride with zinc dust and sulfuric acid.

**MERCATI, MICHELE** (1541–1593), Italian naturalist and physician, whose most famous work is *Metallotheca Vaticana* (1574), a description of the museum of natural history he established in the Vatican. A member of a distinguished family, Mercati was born on April 13, 1541, at San Miniato in Tuscany. He studied medicine and philosophy at the University of Pisa, where Andrea Cesalpino (*q.v.*) encouraged his interest in natural science. At the age of 20, Mercati was placed in charge of the Vatican gardens by Pope Pius V. Mercati's enthusiasm for science and his botanical and mineralogical collections brought him widespread recognition.

He tended Gregory XIII during his last illness and became physician to Clement VIII. Mercati died in Rome on June 25, 1593. His writings include *Istruzione sopra la peste* (1576) and *Degli obelischi di Roma* (1589). (J. M. WI.)

**MERCATOR, GERARDUS** (latinized form of GERHARD KREMER) (1512–1594), the greatest of the Renaissance geographers, best known for the map projection which now bears his name, was born at Rupelmonde, in East Flanders, on March 5, 1512. He matriculated at the University of Louvain in Aug. 1530. He studied mathematics, astronomy and cosmography under the celebrated Gemma Frisius; and at Louvain he first practised as a maker of scientific instruments. In the pair of large globes completed by Gemma in 1537 Mercator collaborated, probably as engraver; and he prepared a set of field instruments for the emperor Charles V. His earliest printed cartographic works, of each of which one copy only is now known, were a map of the holy land (1537); a world map (1538) on a double cordiform projection derived from that used by Oronce Finé in 1531; and a large map of Flanders completed in 1540 from a survey made in the three previous years. Mercator's terrestrial globe, 41 cm. in diameter, was published in 1541, the celestial in 1551; and in 1552 he presented them to Charles V at Brussels with an astronomical ring, or armillary sphere, and a manuscript *Declaratio* on the uses of all three instruments.

Mercator had early inclined toward Protestantism, and in 1544 he was arrested on a charge of heresy, although without serious consequences. Fear of religious persecution was doubtless the motive for his emigration in 1552, at the invitation of the duke of Jülich, Cleves and Berg, to Duisburg, in the German Rhineland, where his workshop was established for the remainder of his life. In 1564 he was appointed cosmographer to the duke, to whom some of his most important works were to be dedicated. Mercator's great map of Europe, in 15 sheets, which had been begun in Louvain, was published at Duisburg in 1554. This map illustrates Mercator's progressive emancipation from Ptolemy, whose excessive length of 62° for the Mediterranean was reduced to 58° in Mercator's globe of 1541 and to 53° in his map of Europe. On Oct. 28, 1556, he observed a solar eclipse at Duisburg; in 1563 he surveyed Lorraine for Duke Charles II, but his map was apparently never published. In 1564 Mercator published the second of his large wall maps, that of the British Isles, in eight sheets. This was engraved from materials supplied to him by an English friend, who has not been identified.

In 1569 Mercator produced his memorable world chart drawn on the projection named after him and entitled *Nova et aucta orbis*

*terrae descriptio ad usum navigantium accommodata.* Mercator was neither the inventor nor the first user of this projection (which is discussed in the article MAP); but he was the first to apply it (by an empirical method) in a nautical chart for the use of seamen, so that the pilot could lay off a compass course on the chart as a straight line making the same angle with all meridians.

In the little *Chronologia*, published at Cologne, also in 1569, Mercator described the majestic plan of the great cosmographical work which was to occupy the rest of his life, with its threefold division into modern maps, Ptolemy's maps, and maps of ancient geography. Apart from a revised edition of the Europe (1572), all Mercator's remaining output consisted wholly of atlas-size maps. His critical edition of the 27 Ptolemaic maps (with one added) was published at Cologne in 1578 under the title *Tabulae geographicae Cl. Ptolemaei ad mentem auctoris restitutae et emendatae* and reprinted in 1584, with the Latin text added. Helped by his sons and grandsons, Mercator drove forward the preparation of the modern maps for the atlas. Progress was delayed by lack of engravers; but in 1585 the first part, devoted to France, Belgium and Germany and containing 51 maps, was published, and four years later the second part, covering Italy, Slavonia and Greece in 23 maps, appeared. Mercator suffered strokes in 1590 and 1593 and died at Duisburg on Dec. 2, 1594. The third part of the atlas, devoted mainly to the British Isles, was dedicated to Queen Elizabeth I in 1595 by Rumold Mercator (Gerardus' son), who, in the same year, published the complete work, *Atlas sive Cosmographicae meditationes de fabrica mundi et fabricati figura*, with 107 maps in all.

As a geographical consultant, Mercator had an international reputation. Among his correspondents were, in England, John Dee and Richard Hakluyt; in the Netherlands, Abraham Ortelius and the scholar-printer Christophe Plantin, whose account books testify to the sale of Mercator's maps and instruments throughout Europe. In their Duisburg workshop Mercator and his family practised all the cartographic processes from compilation and drawing to the engraving of the map. He was rightly described by a panegyrist as *ingenio dexter, dexter et ipse manu* ("cunning alike of mind and of hand").

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(R. A. Sn.)

**MERCEDARIANS** (ORDO B. MARIAE DE MERCEDE REDEMPTIONIS CAPTIVORUM; O. DE M.; also called NOLASCANS), a Roman Catholic mendicant order founded in Spain early in the 13th century by St. Peter Nolasco for the purpose of ransoming Christian captives from the Moors in Spain; now engaged mostly in hospital work. They were formerly widespread in western Europe and Latin America (along with an order of nuns, founded in 1568) but have declined. The habit is all white, with a badge worn round the neck. The motherhouse is at Rome. *See* PETER NOLASCO, SAINT; ORDERS AND CONGREGATIONS, RELIGIOUS.

**MERCEDES,** the capital of Soriano, a ranching and wheat-growing department in southwest Uruguay, is on the Río Negro, about 186 mi. from Montevideo by rail. Founded in 1781, it has an active port; its beaches and river promenade attract tourists. During the summer season, regattas and a tennis tournament provide social and sporting attractions. The cathedral of Mercedes is interesting architecturally and has a fine dome. There is an airport. Mercedes has some industries in addition to tourism, but its principal function is as a departmental administrative, commercial, ranching and agricultural centre. The population of Mercedes was 50,302 (1962 est.). (M. I. V.)

**MERCENARY,** one who serves or acts solely for motives of personal gain, particularly a soldier who offers himself for service in any army that will hire him. Mercenaries are probably as old as war itself. They appeared in almost every highly organized society and played an important part in the ancient world. In European history they came to the fore in the 12th and 13th centuries. As the feudal organization of warfare decayed and capitalism emerged, mercenaries formed the nuclei of many armies. With the full development of capitalist society, however, national armies took more and more the place of professional adventurers in search of gain.

The Swiss Wars produced a famous Swiss infantry that frequently sold its service where it was profitable. Other outstanding examples were the German *Landsknechte* of the 15th and 16th centuries, who, in some cases, also served as mercenaries abroad. A particularly significant part was played by the Italian mercenaries of the later middle ages, whose commanders often gained great power. *See* CONDOTTIERE. (H. HH.)

**MERCERIZING,** a chemical treatment of cotton yarn or fabric to permanently obtain a greater affinity for dyestuffs and various chemical finishes, increased tensile strength, greater absorptive properties and, usually, a high degree of lustre, depending upon the method used. The discovery of the process is credited to John Mercer, an English calico-printer and chemist, who first observed its effects in 1844 and was granted an English patent in 1850. Mercer had been working for some time on the dyeing of textiles and was also interested in increasing the strength of the fibre. It was not until 1889 that another English chemist, H. A. Lowe, discovered that the application of tension not only controlled shrinkage but also produced a permanent lustre.

Briefly, mercerization consists of first treating the yarn or fabric with a caustic soda (sodium hydroxide) solution of controlled concentration for a definite though short period of time (usually less than 4 min.); caustic soda is the least expensive alkaline mercerizing agent and is easier to control than most other swelling agents, *e.g.*, sulfuric acid, which have mercerizing effects. The material is then treated with water to remove the caustic. If the material is under tension at this time, a high degree of lustre is obtained; if no tension is applied considerable shrinkage occurs with little or no lustre. In both cases, however, a gain in tensile strength and affinity for dyestuffs is generally noted. Mercerization without tension gives a considerably greater gain in tensile strength and also imparts elasticity to cotton yarns or fabrics; elastic conforming bandages and stretch diapers are produced by this technique, which is called slack mercerization.

Mercerization is believed to change the physical form of the cotton fibre rather than chemically modifying its structure, as in the chemically modified cottons developed later. In mercerization the untreated cotton fibre, which has a flattened, twisted, ribbonlike appearance, swells to become roughly circular in cross section; with the swelling of the cell wall the internal canal all but disappears and the fibre becomes translucent. The swelling action also removes most of the twist, giving the fibre a rodlike form which closely approximates the appearance of silk or man-made fibres. This transition from ribbon to rodlike structure, which reflects more light, is responsible for the lustre of the finished fabric.

Generally, the better quality cotton goods are mercerized, particularly those that are vat-dyed. Excellent colour fastness is obtained with goods so treated, and in addition less dye colour, often to the extent of 25% or more, is required to obtain the desired shade. Fabrics containing coloured yarns such as chambrays, ginghams and coloured yarn shirtings are frequently mercerized to improve their appearance. For the same reason the finish is especially desirable for combed yarn broadcloth, oxford and knitted jersey used in dress apparel for men, women and children. Combed twills and gabardines for work clothing and military uniforms are mercerized to produce a stronger, more durable fabric. Large quantities of mercerized yarn are used in sewing and embroidery threads and in hosiery. Special effects, such as a transparent appearance, linenlike appearance, firm crispness, and parchmentizing, can be obtained by special methods of mercerizing.

Goods dyed in solid shades are sometimes mercerized after dyeing to eliminate poor penetration or poor surface appearance by a retreatment with caustic of a higher concentration. A well-known trouble encountered in dyeing is light specks on the cloth caused by neps (immature or dead cotton in the yarn). The swell-

ing action of the mercerizing caustic changes the physical appearance of these fibres to approximate that of normal ripe cotton fibre and after dyeing they are decidedly less conspicuous.

*See* also COTTON MANUFACTURE: *Converting of Cotton Goods: Finishing.* (J. E. Ho.)

**MERCHANDISING:** *see* RETAILING; MAIL-ORDER BUSINESS.

**MERCHANT ADVENTURERS,** the name given to a company of English merchants trading with the Netherlands and later also with northwest Germany, from the early 15th century until 1806. The medieval English merchant in the overseas trade was always known as an "adventurer," and with the curtailment of English commerce in the Baltic and elsewhere in the later middle ages, the name gradually became restricted to the merchants carrying on trade with the Netherlands. Its members were drawn from all prominent English ports and its governors and other officers were elected at the mart town overseas where the members of the company all did their trading. The first charter was issued in 1407. The chief activity of the Merchant Adventurers was the export of English woolen cloth and, to a far lesser extent, of lead and tin. The remarkable growth of the English woolen industry in the 15th and early 16th centuries brought wealth and influence to the Merchant Adventurers, partly at the expense of their rivals, the Merchants of the Staple, who exported wool. It also led to the predominance of Londoners in the affairs of the company, since most cloth was exported through London.

The heyday of the Merchant Adventurers extended from the late 15th century to 1564 when trade with the Spanish Netherlands was interrupted. During this period the mart was at Antwerp and the rich cloth fleets sailed from London to the four annual fairs, two of which were kept at Antwerp and two at Bergen op Zoom. Up to three-quarters or more of the English foreign trade lay in the hands of the London Merchant Adventurers, whose great men had much influence upon Tudor finance and policy. The long search for a new mart ended in 1611 when Hamburg and one or another town in the republican Netherlands replaced Antwerp. Meanwhile, a new charter in 1564 extended its trade monopoly to northwestern Germany and also granted the privilege of incorporation. But with the expansion of English foreign trade beyond Europe, the economic importance of the Merchant Adventurers began to dwindle. The company was attacked in parliament and elsewhere as a monopoly. Its privileges were suspended for a short time in 1587 and again for a longer period in 1614–17; they were largely ignored during the Commonwealth and were finally abrogated in 1689. The company survived as a trade association at Hamburg until the French occupation of the city in 1806. *See* also CHARTERED COMPANY.

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(G. D. R.)

**MERCHANT BANKERS,** firms that were originally engaged in international trade but have now come to perform a variety of financial services. In Britain 18 of them, including all the leading ones, are members of the accepting houses committee and make the accepting of bills of exchange an important part of their business. Their acceptances are eligible for discount at the Bank of England and command the finest possible rates. Acceptance business is much less important than it was, but merchant banks had (in 1960) well over £100,000,000 of acceptances outstanding. Some are large dealers in foreign exchange and in bullion. During the 19th century, they issued many foreign loans in London; this business is much diminished, but some of the leading firms have taken to issuing stocks and shares for British industry. These firms form an important part of the new issue market and also act as trustees and investment advisers. Merchant banks accept deposits, largely from overseas, and do a small amount of ordinary banking business; most of their deposits are, however, either invested in short-dated government bonds or lent to the money market (*q.v.*). *See* also BILL OF EXCHANGE. (E. V. MN.)

**MERCHANT MARINE:** *see* SHIPPING; SHIPBUILDING (MERCHANT AND NAVAL); NAVAL ARCHITECTURE.

**MERCHANT MARINE ACADEMY, UNITED STATES:** *see* MILITARY, NAVAL AND AIR ACADEMIES.

**MERCHANT MARINE SERVICE,** the personnel of commercial ships as distinguished from the personnel of naval vessels. Merchant fleets are important economic assets for many nations, contributing to the national income, promoting trade and providing employment. In every nation with a large merchant marine an elaborate set of rules and procedures has been developed for its organization and management.

**United States.**—At the end of World War II the U.S. operated nearly half the world's ocean-going merchant marine but the strength of its merchant fleet declined during the postwar years. By the 1960s about 100,000 men were employed on approximately 1,000 privately operated deep-sea ships, 20,000 men on the Great Lakes fleets and 80,000 operating smaller craft on the vast network of inland waterways. Another 120,000 men derived employment from the construction and repair of vessels and the loading and discharge of their cargoes. With a laid-up fleet of nearly 2,000 ships and a reservoir of trained manpower, the U.S. merchant fleet was in a position that permitted rapid expansion.

Regulations pertaining to safety, licensing and certification of merchant seamen have been the responsibility of the U.S. coast guard since 1942. Formerly these functions were assigned to the bureau of marine inspection and navigation.

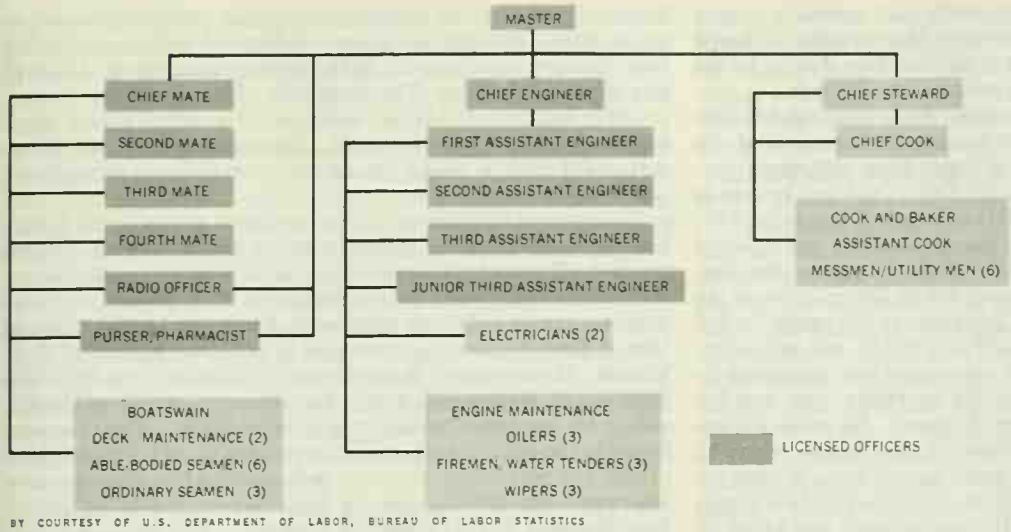
Overall responsibility for the ship and its crew rests with the master. Under the master, who is himself a deck officer, the chief mate heads the deck department and supervises cargo stowage and ship maintenance. At sea the other deck officers stand watches and in port they assist in directing cargo operations. In addition the second mate keeps navigating books and equipment while the third and fourth mates care for lifesaving and fire-fighting equipment. The boatswain is the working foreman of the deck crew. The engineering force is organized along similar lines: the chief engineer has overall charge of engineering matters and the first assistant's relationship to him is like that of the chief mate to the master. On a typical ship the first assistant is responsible for main engines, the second assistant for boilers, and the third and junior third assistants for auxiliary machinery. The steward's branch handles food preparation and care of living spaces.

The size, complexity and tempo of modern shipping requires a great deal of shore-based direction and support. Agents or branch offices in each port arrange for cargoes, fueling, tow boats and many other details of ship management. The head office of each company maintains overall responsibility for operations afloat and ashore.

Peacetime training of unlicensed mariners is primarily accomplished on the job but the New York City Maritime Trades high school prepares some youths for unlicensed maritime occupations. During World War II and for a brief period thereafter the warring nations trained men for their expanded merchant fleets and many young men learned nautical trades while in the naval service.

A seaman's document is a prerequisite to shipboard employment. Such a document is issued to an applicant who can show a commitment of employment from a steamship operator or union official, prove that he is an American citizen and obtain security clearance. Because most maritime companies have closed-shop agreements, union membership is also generally required. Crewmen are hired from among union members seeking jobs through hiring halls, with such factors as seniority and time on the beach determining precedence. Selection of the master, chief engineer, first mate and first assistant engineer is the prerogative of the shipowner.

After he has had the required experience, a seaman may take examinations and obtain a certificate as an able-bodied seaman or qualified member of the engine department. Since manning ships to comply with the law requires that most of the crew hold certificates above novice ratings, holders of such certificates have broadened job opportunities. In addition to licensing and certificating, government agencies such as the U.S. coast guard investigate reports of neglect, lack of skill or misconduct. Docu-

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COMPLEMENT OF A TYPICAL CARGO SHIP

ments of seamen found at fault are revoked or suspended. Records of seamen are maintained and shipping commissioners administer marine employment contracts, traditionally called shipping articles.

Conditions aboard ships have improved remarkably in the 20th century. Rates of pay for crew members have increased in proportion to increases in the size and speed of ships. The comfortable rooms provided for members of the crew bear slight resemblance to the crowded forecastles of the past. Food from refrigerated storerooms, cooked in modern galleys and served in clean messrooms, far exceeds the minimum standards prescribed by laws enacted when scurvy was a concern. Although amelioration of conditions has eliminated much of the need for harsh discipline the traditional authority of shipmasters is maintained. Despite improved conditions, seafaring remains subject to a rigorous and changing environment. Physical examinations and medical care for seamen are provided by national medical services, which also enforce quarantine and sanitation regulations.

A number of private organizations exist to care for the needs of merchant seamen. New York's Seaman's Church institute, seamen's branches of the Young Men's Christian association, and Seamen's Friends societies, among others, offer counseling and social service as well as modestly priced food and lodgings. Merchant Marine Library associations provide books for shipboard use. Seamen's banks for savings send representatives to ships when the men are paid so that funds can be deposited safely. While seamen now approaching retirement age can look to social security as well as company-sponsored or union-sponsored pensions, Sailor's Snug Harbor on Staten Island in New York and other organizations for many years have provided for aged seafarers. (N. L. F.)

**Great Britain.**—In the middle of the 1960s the total manpower of the British merchant navy was about 125,000. Of these about 15,000 were deck officers and 25,000 engineer officers. All training for the merchant navy in Great Britain must include both experience on the job and actual experience at sea. This is the one invariable common requirement for the award of all certificates of competency, whether as masters, deck officers, engineer officers, able-bodied seamen or ship's cooks.

Deck officers normally have some form of training before they go to sea. This may be the two- or three-year course in H.M.S. "Conway" at Anglesey, H.M.S. "Worcester" on the Thames, the Nautical college, Pangbourne, Berkshire, or some less famous but equally efficient shore establishment. Most shipping companies require their apprentices or cadets, while serving their three- or four-year training period at sea, to keep their studies up-to-date through the Merchant Navy Training board's system of correspondence courses. A few companies have special training programs on their own cadet ships. After this training period is completed a young man may take his second mate's certificate at the age of 20 and proceed, at the age of 24 or 25, to his master's certificate.

Engineer officers are required to complete a shore apprenticeship in shipbuilding or some other branch of heavy engineering before going to sea, but alternative training schemes exist providing a combination of academic training with practical experience both on shore and at sea. The majority of ratings, deck and catering, are trained at schools run by the National Sea Training schools and controlled by the industry but there are also many voluntary training establishments which train boys for a life at sea.

Conditions of employment in the merchant navy are laid down in collective agreements between shipowners and seafarers, freely negotiated through the Joint Industrial Council for Shipping of the National Maritime board, which is quite independent of the government. An important development in this field after World War II was the introduction of the Established Service scheme in 1947. It gave men of good character opportunity of permanent employment at sea under mutually agreed conditions of service. It eliminated the casual aspect of maritime employment with the result that unemployment in the merchant navy has been negligible even in times of recession. The co-operation between employers and workers of all grades in the industry has also covered such other fields as welfare: here the co-ordinating body is the Merchant Navy Welfare board which channels the work of the industry and of the voluntary bodies in such a way as to prevent overlapping and to serve seafarers best. (*See* LABOUR LAW: *England.*) (A. W. W.)

**Other Countries.**—Most other maritime countries recruit and train their seafarers on lines similar to those developed in Great Britain. In the Scandinavian countries, where much store was set on actual experience in sail training vessels, old sailing ships used to be set aside for this purpose. Training programs for officers and engineers in most European countries are generally regulated by the state although some of the larger shipowning companies operate their own training programs and provide their own facilities. Conditions of employment and wages of seafarers are generally the subject of collective agreements between the seafarers' trade unions and the shipowning employers' federations. Individuals are "signed on" at the beginning of each voyage and "signed off" at the end in the presence of a government official. Ships which are registered under flags of such nonmaritime countries as Liberia generally carry crews of British, Scandinavian, Italian, Greek or Chinese origin. In most cases terms of employment are governed by conditions applying in the countries of origin concerned. *See* also SHIPPING. (P. DE.)

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**MERCHANT NAVY:** *see* MERCHANT MARINE SERVICE; SHIPPING.

**MERCIA,** one of the kingdoms of Anglo-Saxon England. It derived its name from *Merce* (people of the marchland) because the original settlement bordered on Wales. This original area lay along the upper and middle Trent and its tributaries and comprised most of Staffordshire, Derbyshire, Nottinghamshire and North Warwickshire. In the 7th century the Mercians absorbed the

Hwicce and the people of Middle Anglia and spread also into Cheshire, Shropshire and Herefordshire. Mercia came to denote an area bounded by the frontiers of Wales and East Anglia, by the Humber estuary and, from the 9th century, the Thames.

Mercian kings claimed descent from the Anglo-Saxon god Woden through kings who reigned in the continental homeland of the Angles. One authority calls them Iclingas, from Icel, seven generations from Woden, and perhaps the first of the line to rule in England. A king called Cearl was father-in-law of Edwin (d. 632) of Northumbria, but the first king whose activities are recorded was Penda, five generations after Icel. His battle against the West Saxons in 628, before he became king, led to the transfer of the Hwicce to Mercia. He helped Cadwallon of Gwynedd to kill Edwin, to whom the Mercians were subject, in 632, and soon afterward became king. Northumbrian supremacy was reasserted by Oswald in 633, but he was killed in 641 by Penda, who soon became dominant throughout southern England. He made his son Peada subking of Middle Anglia, subjected East Anglia, where he killed three of its kings, and drove out Cenwalh from Wessex for three years. With an army from all the midlands and East Anglia he invaded Northumbria in 654. He was defeated and killed by Oswiu. Mercia became Christian after his death. Oswiu's supremacy was brief, for in 657 a Mercian revolt set Penda's son Wulfhere on the throne, and secured Lindsey. Wulfhere was a powerful king who became overlord of Surrey and of Essex, including London, and deprived the West Saxons of their lands in Oxfordshire, and of the Isle of Wight and south Hampshire, giving these to Aethelwalh of Sussex. But he lost Lindsey after a defeat in Northumbria, which he invaded between 670 and 674 with an army drawn from all the southern kingdoms. His brother Aethelred recovered Lindsey after the battle of the Trent in 678, and held the West Saxon lands north of the Thames as well as Berkshire and Wiltshire. He invaded Kent in 676, and was recognized as lord by East Saxons who reigned in parts of this kingdom. But he lost Surrey and Sussex to Ceadwalla of Wessex, and Wihtred's accession in Kent in 690 or 691 ended his influence there. He entered Bardney monastery in 704. His successor Cenred had to meet a serious invasion by the Welsh, and was succeeded when he went to Rome in 709 by a dissolute youth, Ceolred, who fought in Wessex in 715. Aethelbald, succeeding in 716, re-established the Mercian supremacy.

Though Bede excludes Mercian kings from his list of overlords of England south of the Humber, Penda and Wulfhere fell little short of this position, and Bede allows it to Aethelbald in 731. How he won his power by 731 is uncertain, but in 733 he occupied Somerton in Wessex, and his defeat by the West Saxons in 752 did not rob him of control in Berkshire and Wiltshire. He warred on Northumbria in 737 or 740, and on the Welsh in 743. St. Boniface praised his strong government, though he accused him of immorality and of violation of church privileges. He was murdered in 757, and his successor Beornred was soon expelled by the greatest of Mercian kings, Offa (*q.v.*), a descendant of Penda's brother.

Offa established even more firmly Mercian supremacy over all England, except Northumbria. Even before he conquered the province of Hastings in 771, the kings of West Sussex were his vassals. So also were the kings of East Anglia and Essex, and, for most of his reign, those of Kent, to one of whom he refers as his thegn. Yet he met with some opposition: Kent seems to have been independent for ten years after the battle of Otford in 776, and Cynewulf of Wessex recovered land in Oxfordshire and Berkshire and held them until Offa captured Bensington (Benson) in 779. Late in his reign, Offa strengthened his position by marrying one of his daughters to Beorhtric of Wessex in 789 and another to Aethelred of Northumbria in 792.

Offa brought his country into closer contact with the continent, dealing with Charlemagne almost as an equal. They exchanged letters and embassies, negotiated concerning trade, and there is a connection between their respective reforms of the coinage. The breakdown of a suggested marriage between Offa's daughter and Charlemagne's son resulted in a quarrel, during which Charlemagne threatened to exclude English traders, but it was composed, partly by the offices of Alcuin. Pope Adrian I regarded Offa as so formidable that he was alarmed by a rumour that Offa schemed to depose him. He sent two legates to England in 786, and in 787 Offa obtained papal consent to the raising of the see of Lichfield into an archbishopric. The great dike along the Welsh border, probably built after raids into Wales in 778 and 784, affords tangible proof of Offa's great resources. No further trouble with Wales is recorded until he raided it in his last year. He was remembered also as a law giver.

Offa's sense of the dignity of his position is shown by his having his son Egfrith anointed as king in 787, in imitation of Carolingian practice. But Egfrith survived his father's death in 796 by less than five months, when he was succeeded by Coenwulf, who was able to suppress a Kentish rebellion and make his brother Cuthred king of Kent. When the latter died in 807, Coenwulf ruled Kent himself. He suppressed the archbishopric of Lichfield in 802. His influence in Wessex ended with the accession of Egbert in 802, and in his last years he had trouble with Wales. This war continued in the reign of his brother Coelwulf (821–823), the last king of the old royal line, who was deposed in 823. His successor Beornwulf was defeated by the West Saxons and killed by the East Angles in 825. Before this year, Kent had obtained a king of its own. Ludeca, who followed Beornwulf, was killed by the East Angles in 827, when trying to avenge his predecessor. Mercian fortunes reached their lowest ebb in 829, when Egbert of Wessex conquered Mercia and drove out Wiglaf, but he returned in 830 and re-established Mercian independence, even being able to revive the practice of the former Mercian overlords of summoning to his councils bishops from south of the Thames. Beorhtwulf succeeded him in 840, to be followed by Burgred in 852. These reigns are marked by peaceful co-operation with Wessex. Berkshire, still Mercian in 843, was ceded to Aethelwulf of Wessex by 849, and the Thames became finally the boundary. Burgred in 853 obtained West Saxon help against the Welsh and married Aethelwulf's daughter.

The vikings raided London in 842, and again in 851, when they put Beorhtwulf to flight. In 868 Aethelred I and his brother Alfred went at Burgred's request to his help against the Danes, but these avoided battle and were bought off, an expedient which was repeated when the Danes were at London in 872 and at Torksey in 873. The Danes drove out Burgred in 874, placing on the throne a thegn, Ceolwulf (II), but in 877 they took part of Mercia from him, and settled in strength northeast of Watling street. Henceforward Mercia consisted of an English and a Danish area, with many social differences between them.

Ceolwulf, the date of whose death is unknown, was the last Mercian king. Ealdorman Aethelred was governing Mercia by 883, but never took the royal title. He acknowledged the overlordship of Alfred, who made over to him London in 886 and gave him his daughter Aethelflaed in marriage about 889. Aethelred combined with Alfred to defeat the Danes in 892–896, when Mercia was much raided. Aethelred and Aethelflaed ruled with almost royal power, and after her husband's death in 911 Aethelflaed effectively helped her brother King Edward the Elder to reconquer the Danelaw; but after her death in 918 Edward took her daughter to Wessex, to prevent the founding of a Mercian royal line. Mercia was afterward administered by ealdormen, sometimes as a single province, sometimes divided. Important ealdormen were Aelfhere (956–983), Eadric Streona (1007–17) and Leofric (*c.* 1023–57). *See* ENGLISH HISTORY; *see* also references under "Mercia" in the Index.

*See* F. M. Stenton, *Anglo-Saxon England*, 2nd ed. (1947); *English Historical Documents*, vol. i, ed. by D. Whitelock (1955), pp. 18–38, 91 ff. (D. WK.)

**MERCIER, DÉSIRÉ JOSEPH** (1851–1926), Belgian Roman Catholic philosopher and prelate, a leader in the 19th-century revival of Thomistic philosophy, was born Nov. 21, 1851, at Braine-l'Alleud, in the Walloon part of Brabant. He studied at Malines and Louvain, being ordained priest on April 4, 1874. He taught in the philosophy section of the Malines seminary (1877–82) and served as spiritual adviser. Meanwhile, Pope Leo XIII followed up his call for a revival of Christian philosophy with a letter of 1880 to Victor Auguste Cardinal Dechamps of

Malines. The pope asked that Louvain university offer a program in Thomistic philosophy, and in 1882 Mercier was appointed professor at Louvain for this purpose. After assuring the pope of his love for Aquinas, he attended J. M. Charcot's clinic in Paris for instruction in recent psychology.

Mercier's inaugural address at Louvain (1882) pledged modern Thomism to unite Christian faith with reason, empirical observation with speculation, and tradition with perpetual growth in thought. Lecturing publicly on the main parts of Thomism in relation to modern philosophy and science, he attracted lay and ecclesiastical students from many countries. Two papal briefs of 1888–89 urged the founding of an Institut Supérieur de Philosophie at Louvain, and in 1894 it started with Mercier as president. He published an influential course of philosophy and an account of contemporary psychology, while eminent colleagues worked in philosophy of science, sociology and medieval philosophy. The institute became a major centre of Thomism, published the *Revue Néoscolastique* (now *Revue Philosophique de Louvain*) and evaluated contemporary philosophies.

Mercier, who had been made a domestic prelate in 1887, was appointed archbishop of Malines in 1906 and was created a cardinal in 1907. He energetically supported priests' retreats, workers' colleges and social improvements. During World War I his courageous stand against the Germans' burning of the Louvain library and deportation of workmen made him the moral leader and international spokesman of the Belgian people. He forthrightly insisted that might cannot permanently overcome right and that God's word cannot remain bound. Asked how he could remain serene even in wartime, Cardinal Mercier replied that his secret consisted in "giving oneself confidently to the goodness of God." During the Versailles meeting, Pres. Woodrow Wilson visited him at Malines and later invited him to the United States. The cardinal's tour of the United States and Canada in 1919 resulted in civic and academic honours, as well as financial support for rebuilding the Louvain library.

Mercier was actively interested in the ecumenical work of reuniting the Christian churches. Although aware that this was a slow process, he sponsored the Malines conversations (1921–25), with Lord Halifax and other Anglicans, on interfaith problems. In the spring of 1924 Cardinal Mercier celebrated the jubilee of his ordination. He died in Brussels on Jan. 23, 1926. At the 1951 centenary, the Cardinal Mercier chair was endowed for lectures by visiting philosophers at Louvain university.

His works include *Retreats to His Priests*, Eng. trans. by J. M. O'Kavanagh (1912); *Manual of Modern Scholastic Philosophy*, by Mercier and professors of Louvain, trans. by T. L. and S. A. Parker, 2 vol. (1917–18); *Origins of Contemporary Psychology*, trans. by W. H. Mitchell (1918); *Cardinal Mercier's Own Story*, Eng. trans. (1920).

*See* John A. Gade, *The Life of Cardinal Mercier* (1934); L. de Raeymaeker, *Le Cardinal Mercier et l'Institut Supérieur de Philosophie de Louvain* (1952). (J. D. C.)

**MERCIER, HONORÉ** (1840–1894), Canadian opponent of confederation and champion of French-Canadian interests, Liberal premier of Quebec, was born at St. Athanase in Lower Canada (Quebec) on Oct. 15, 1840. Mercier was educated at the Jesuit college of St. Marie, Montreal. When he was reading law, he became the editor of the Conservative *Courrier de St. Hyacinthe*, the editorship of which he resumed in 1866, but left the Conservative party in that year and vigorously opposed the scheme of confederation on the ground that it would prove fatal to the French Canadians. In 1872, he was elected for two years a member of the house of commons and in 1879 he entered the legislative assembly of Quebec. On the retirement of Henri Joly from the leadership of the Liberal party in Quebec in 1883, Mercier was chosen as his successor. His prominent role in the Quebec agitation in behalf of the French-speaking Louis Riel, executed in 1885 as leader of the Northwest rebellion, helped him win the provincial election of Oct. 1886, and he became premier of Quebec in Jan. 1887. He succeeded in passing the Jesuit Estates act, a measure to compensate the Society of Jesus for the loss of property confiscated by the crown at the beginning of the 19th century. In 1891, while on a visit to Rome, he was created a count of the Roman empire by Leo XIII. It was alleged that subsidies voted for railways had been diverted to political use and he was dismissed by the lieutenant governor in 1891, and in 1892 his party was hopelessly defeated. He was brought to trial but acquitted. Mercier died at Montreal on Oct. 30, 1894. (J.-C. B.)

**MERCIER, (LOUIS) SÉBASTIEN** (1740–1814), French dramatist, born in Paris, June 6, 1740, was one of the first writers of *drames bourgeois*. His *Du Théâtre* (1773) emphasized the theatre's didactic function and criticized traditional French tragedy and comedy as artificial and sterile. He wrote about 60 plays, including a social comedy, *La Brouette du vinaigrier* (1775); *Jenneval* (published 1767, performed 1781), adapted from George Lillo's *London Merchant* (1731); such *drames* as *Le Faux Ami* (1772) and the antimilitarist *Le Déserteur* (published 1770, performed 1782); and two historical dramas about the French religious wars, *Jean Hennuyer, évêque de Lisieux* (1772) and *La Destruction de la Ligue* (1782), so provocatively anticlerical and antimonarchical that they were not performed until after the Revolution. Mercier was not a technical innovator; his best plays present a thesis forcefully, subordinating other dramatic considerations to the didactic end. As well as plays, he wrote *L'An 2440* (1770), a work of prophetic imagination; and *Le Tableau de Paris* (2 vol. 1781; 12 vol. 1782–89), which foreshadows Honoré de Balzac's classification of social types.

Mercier, nicknamed *le singe de Jean-Jacques*, was a humanitarian idealist, who was strongly influenced by Rousseau and shared his views of society, rejecting the *philosophes'* belief in progress. A member of the Convention, his moderate views led him to oppose the death penalty for Louis XVI. He was imprisoned during the Terror but was released after Robespierre's death. He died in Paris, April 25, 1814.

*See Théâtre complet* (1778–84); L. Béclard, *L. S. Mercier, sa vie, son oeuvre* (1903). (W. D. Hh.)

**MERCK, JOHANN HEINRICH** (1741–1791), German writer, was born at Darmstadt on April 11, 1741. He was one of the foremost art connoisseurs of his time and wrote a number of interesting articles on painters; he wrote too on the natural sciences. He is remembered for his relations with the leading writers of his time, including Friedrich Nicolai and C. M. Wieland and, above all the young "Stürmer und Dränger," Herder and Goethe. He had a rare sympathy for their poetic aims, and his criticism, though often bitingly sarcastic, was of great help to them. He helped to found the *Frankfurter Gelehrte Anzeigen* in 1772, in which some of Goethe's earliest pieces were published, and contributed regularly to Wieland's *Teutscher Merkur*. His original contributions are slight but of interest, particularly his criticism of bureaucratic absolutism. A man of wide intellectual and artistic interests, his petty duties as an official in the war department of the tiny court of Hesse-Darmstadt exacerbated his disposition to sarcasm and discontent. Family misfortunes and the failure of several business enterprises led him to commit suicide at Darmstadt on June 27, 1791. Goethe has left an appreciative memorial of him in *Dichtung und Wahrheit*, and his letters are an invaluable source for the literary life of the times.

Bibliography.—Works and letters in 3 vol., ed. by K. Wolff (1909–11); correspondence with Goethe, Herder, Wieland and others, ed. by K. Wagner (1835, 1838 and 1847). *See* also G. Zimmermann, *J. H. Merck* (1871); H. Prang, *J. H. Merck* (1949); R. Pascal, *The German Sturm und Drang* (1953). (Ro. P.)

**MERCOEUR, PHILIPPE EMMANUEL DE LORRAINE,** Duc de (1558–1602), leader of the resistance in Brittany against Henry IV of France, was born at Nomény in Lorraine on Sept. 9, 1558, the son of Nicolas de Lorraine, comte de Vaudémont. His father was created duc de Mercoeur in 1569; and in 1575 his half sister Louise was married to Henry III of France, while he himself was married to Marie de Luxembourg, duchesse de Penthièvre. He succeeded to his father's duchy in 1577. Governor of Brittany from 1582, he rebelled when Henry III, having had his cousins of the house of Guise assassinated (Dec. 1588), tried to recall him (April 1589); and when Henry III was assassinated (Aug. 1589), Mercoeur rallied most of Catholic Brittany against the Protestant Henry IV. He set up a *parlement*

of his own at Nantes and put forward his son Philippe as "prince and duke of Brittany." Spain sent 7,000 men to help Mercoeur (Oct. 1590), but England sent troops and ships against him. Mercoeur won a victory at Craon in Anjou on March 23, 1592, but lost ground in the years following Henry IV's conversion to Catholicism. Mercoeur at last submitted at Ponts-de-Cé in Anjou on March 20, 1598: he resigned Brittany, received 4,000,000 *livres* and agreed that his daughter and eventual heiress, Françoise (1592–1669), should marry Henry's natural son César, duc de Vendôme. Mercoeur then went to serve with the Holy Roman emperor Rudolf II's army against the Turks in Hungary. On his way back to France he died of fever at Nürnberg on Feb. 19, 1602. His *Correspondance* is edited by G. de Carné, two volumes (1899).

**MERCURIC CHLORIDE** (Corrosive Sublimate) has a variety of uses even though it is extremely poisonous and may cause death if swallowed or inhaled. In medicine, it is sometimes used as a topical antiseptic in a concentration of one part per 2,000 parts of water. Other uses include those of embalming, general disinfecting, preservation of wood, manufacture of other mercury compounds and the catalyzing of organic syntheses.

Mercuric chloride, whose formula is $HgCl_2$, is obtained commercially as odourless, colourless rhombic crystals or white granules by one of two methods: (1) heating mercury to its volatilization point and causing it to combine directly with dry chlorine; (2) subliming mercuric sulfate with common table salt (sodium chloride). Mercuric chloride melts at 265° C., boils at 303° C. and has a specific gravity of 5.32. The following weights of mercuric chloride are soluble in 100 ml. of the indicated solvents: 6.9 g. in water at 20° C. and 61.3 g. in water at 100° C.; 33 g. in alcohol at 25° C.; and 25 g. in ether. The pH of an aqueous solution of mercuric chloride is about 4.7.

**MERCUROCHROME,** a trade name of merbromin, the first of a series of antiseptic substances in which mercury was incorporated into an organic molecule in an attempt to obtain the bacteriostatic and bactericidal action of mercury without the irritant effects of mercuric chloride (*q.v.*). Mercurochrome contains from 24% to 26.7% of mercury. Dilute water solutions, which are brilliant red with yellow-green fluorescence, exert a weak surface anti-infective action on skin, mucous membranes and wounds. Its activity is decreased in the presence of body fluids, and it penetrates poorly except in injured tissues.

It is used commonly in the home as a first-aid measure to prevent infection in small cuts and wounds and to a lesser degree professionally as a general surface anti-infective. It has been largely replaced by more effective agents of the series (*e.g.*, nitromersol [Metaphen] and thimerosal [Merthiolate]) or by antibiotics. (V. E.)

**MERCURY** (Mercurius, Meroutius, Miroutius) the Roman god of merchandise and merchants, commonly considered identical with the Greek Hermes (*q.v.*), introduced at Rome with a name derived from a root related to merchandizing (*merx*, "merchandise," etc.; another view is given by F. Altheim in *Griechische Götter*, pp. 39 ff.). Although obviously not of primitive Italian cult, his worship was introduced rather early. His temple on the Aventine in Rome was dedicated in 495 B.C., and there he was associated with the goddess Maia (*q.v.*), identified as his mother through her association with the Greek Maia, mother of Hermes. Both Mercury and Maia were celebrated in a festival on May 15 (the month of Maia), the dedication day of the temple, a holiday of special importance for the guild of merchants (*mercatores, mercuriales*).

ROMAN STATUE OF MERCURY, CARRYING CADUCEUS, IN THE VATICAN MUSEUM, ROME

Near the Porta Capena there was a spring sacred to him, the water of which was used by merchants for a lustral rite on May 15 (Ovid, *Fasti, lege:* v, 673 ff.).

In Roman art Mercury is more purely represented as a standing, usually nude, figure holding a purse, symbolic of his business functions, but artists were free to borrow attributes of the Greek Hermes irrespective of their appropriateness to the Roman deity. Hence, he is found wearing winged sandals and winged cap and carrying the caduceus (*q.v.*).

Bibliography.—G. Wissowa, *Religion und Kultus,* 2nd ed., pp. 304–306 (1912); Steuding in W. Roscher, *Ausführliches Lexikon der griechischen und römischen Mythologie;* Platner-Ashby, *Topographical Dictionary.* (R. B. Ld.)

**MERCURY** is the smallest of the major planets and has a diameter of only about 3,000 mi. It is also the nearest to the sun, with a mean distance of 36,000,000 mi., or 0.39 of the earth's distance. But the eccentricity of its orbit, amounting to 0.206, is much greater than that of any other major planet, and its perihelion and aphelion distances (minimum and maximum distances from the sun) are, respectively, 28,500,000 and 43,350,000 mi., or approximately in the ratio of 2 to 3. Its period of revolution in its orbit is 88 days, but its synodical period, *i.e.*, the interval between, say, successive superior conjunctions with the sun, is 116 days. At its most favourable elongations it recedes only about 28° from the sun. After Pluto its orbit has a greater inclination (7°) to the ecliptic than that of any other major planet. The albedo (the percentage of sunlight reflected from the planet's surface) is low, but at a mean elongation its brightness is about equal to that of a star of zero magnitude; and although at a favourable elongation it can reach −1.2 magnitude, the planet is frequently dimmed or obscured by the haze and mists near the horizon.

As Mercury has no satellite it has been necessary to determine its mass from its attraction on another body; the minor planet Eros is the best for this measurement. On the basis of this measurement, Mercury's mass was found to be 0.054, or about one eighteenth that of the earth. The planet's density is almost six times that of water, higher than that of any other planet. Because the mass is comparatively small, the high density cannot be attributed to gravitational compression; instead, it implies a high percentage-abundance of iron, higher than that of the earth.

**Surface Features and Rotation.**—As the angular diameter of Mercury varies from about 5 to 13 sec. of arc, its phases are easily observed by even a small telescope. But under the circumstances of observation (daytime or near the horizon) it is far from easy to define the surface features with accuracy.

Between 1881 and 1889 Giovanni Schiaparelli at Milan carried out a careful study of the planet. His conclusion was that the periods of axial rotation and orbital revolution are identical and that the axis of rotation is approximately normal to the orbit plane.

It would, of course, follow from such conditions that the planet always presents approximately the same face to the sun, as the moon does to the earth, though in consequence of the large eccentricity of the orbit, the effect of libration in longitude of the surface markings as seen from the sun would cause a displacement of nearly 24° on each side of a mean position. About 37% of the surface would be permanently sunlit; the same amount in perpetual night; and the remainder exposed alternately to sunlight and darkness, with enormous changes of temperature during each revolution.

A fresh attack on the problem of Mercury's rotation was made from 1924 to 1929 by E. M. Antoniadi at Meudon with the help of the great 33-in. refractor, and the result was to establish Schiaparelli's deductions. The markings seemed to be somewhat variable in intensity, but—apart from the libration mentioned above—constant in position relative to the terminator, thus indicating the identity of the periods of rotation and revolution.

Because the markings on Mercury appeared to be of variable intensity, Antoniadi suspected the presence of a tenuous atmosphere.

*Transits of Mercury From 1677 to 2003*

| Year | Mo. and Day | Hour | Year | Mo. and Day | Hour |
|---|---|---|---|---|---|
| 1677 | Nov. 7 | 0 | 1845 | May 8 | 8 |
| 1690 | Nov. 9 | 18 | 1848 | Nov. 9 | 2 |
| 1697 | Nov. 2 | 18 | 1861 | Nov. 11 | 20 |
| 1707 | May 5 | 11 | 1868 | Nov. 4 | 19 |
| 1710 | Nov. 6 | 11 | 1878 | May 6 | 7 |
| 1723 | Nov. 9 | 5 | 1881 | Nov. 7 | 3 |
| 1736 | Nov. 10 | 22 | 1891 | May 9 | 14 |
| 1740 | May 2 | 11 | 1894 | Nov. 10 | 7 |
| 1743 | Nov. 4 | 22 | 1907 | Nov. 14 | 0 |
| 1753 | May 5 | 18 | 1914 | Nov. 7 | 0 |
| 1756 | Nov. 6 | 16 | 1924 | May 7 | 14 |
| 1769 | Nov. 9 | 10 | 1927 | Nov. 9 | 18 |
| 1776 | Nov. 2 | 10 | 1940 | Nov. 11 | 11 |
| 1782 | Nov. 12 | 3 | 1953 | Nov. 14 | 5 |
| 1786 | May 3 | 18 | 1957 | May 5 | 13 |
| 1789 | Nov. 5 | 3 | 1960 | Nov. 7 | 5 |
| 1799 | May 7 | 1 | 1970 | May 8 | 20 |
| 1802 | Nov. 8 | 21 | 1973 | Nov. 9 | 23 |
| 1815 | Nov. 11 | 15 | 1986 | Nov. 12 | 16 |
| 1822 | Nov. 4 | 14 | 1993 | Nov. 5 | 16 |
| 1832 | May 5 | 0 | 1999* | Nov. 15 | 9 |
| 1835 | Nov. 7 | 8 | 2003 | May 6 | 19 |

*Mercury grazes the sun's limb.

Lyot and Dollfus observed the planet under better conditions (at the Pic du Midi) and found no evidence of such variation. However Dollfus' polarization measurements indicated that there might be a trace of atmosphere, probably no more than 0.003 of the terrestrial atmosphere. And, in theory, this is what would be expected from a consideration of the high surface temperature on the sunlit side of the planet, about 340° C., or higher than the melting point of lead. The temperature of the dark side of the planet is probably about −253° C., which heat is obtained by conduction from the interior of the planet.

The surface of Mercury may be compared with that of the moon. Like that of the moon, Mercury's reflectivity is 7%. Similar patches, known as *maria* or seas (presumably lava fields), have been observed on the surfaces of both planets. And the microstructure of the surfaces of the two bodies (pulverized lava) is probably identical—a deduction from the fact that the polarization curves of the two bodies are indistinguishable.

Dollfus found the obliquity of the planetary equator to be 7°, about the same as the orbital inclination on the ecliptic.

**Transits.**—Since the inclination of Mercury's orbit to the ecliptic is 7°, it usually happens that at the time of inferior conjunction the planet passes north or south of the sun, but should conjunction occur when it is near one of its nodes, it crosses the sun's disk and is seen during transit projected on the sun as a small black spot. Since earth passes the line of nodes about May 7 and Nov. 9, transits can take place only near those dates. The November transits, however, which occur with Mercury in the neighbourhood of perihelion and, consequently, more remote than usual from earth, are more common than those in May, when the conditions are reversed, the limits of distance from the node within which the planet must be for a transit to take place being 4° 45′ and 2° 40′, respectively. The table gives the dates and Greenwich mean astronomical times of the middle of all the transits from 1677 (the date of the first one accurately observed) until the year 2003. The hours are in all cases reckoned from noon.

**Motion of Perihelion.**—What was for a long time a perplexing problem was presented by the motion of Mercury's perihelion, the line of apsides—or the longer axis of the orbit—showing a greater advance in the direction of the planet's motion than could be accounted for by the gravitational action of all the other planets. Urbain Leverrier in 1845 concluded that the excess of motion was 35 sec. of arc per century, but this was increased by later investigations to over 40 sec. of arc per century. It was accordingly concluded that Mercury is disturbed by some unknown masses or that Newton's law of gravitation is not rigidly true. Leverrier attributed the excess of motion to the action of a group of planets revolving inside the orbit of Mercury, and at first this explanation seemed to be confirmed by the occasional reports of dark objects seen in transit across the sun's face. But for very many years past, the sun has been photographed almost daily at some observatory or other, such as Greenwich or the Cape of Good Hope, without any such objects being detected, and photographs of the sky in the neighbourhood of the sun during total eclipses have likewise failed to disclose anything of the sort. If, then, such intra-Mercurial bodies exist, they must be extremely small. It was at one time suggested that the minute particles which produce the zodiacal light might be invoked to explain the observed motion, but the idea was shown on theoretical grounds to be untenable. Solution of the difficulty was supplied by Einstein's theory of generalized relativity, and the matter was regarded as satisfactorily explained.

*See* also references under "Mercury" in the Index. (G. P. K.)

**MERCURY,** a metallic element, is the only common metal that is liquid at ordinary temperatures. It was known to the ancient Chinese and Hindus and has been found in Egyptian tombs of 1500 B.C. The term *mercurius* was first employed about the 6th century by the alchemists, who used the symbol for the planet Mercury to represent the metal, which, because of its mobile form and its colour, was called quicksilver. Its symbol Hg derived from the Latin *hydrargyrum*, "liquid silver."

## OCCURRENCE AND PRODUCTION

Mercury occurs free in nature, but the principal ore is cinnabar, the red sulfide, HgS. Other compounds, such as selenides, tellurides and chlorides, occur but are not of economic importance. The average percentage of mercury in igneous rocks is estimated at $10^{-7}$, its abundance being less than one one-hundredth that of zinc or of lead.

The most important mercury mines in Europe are those of Almadén in Spain, Abbadia San Salvatore in Italy and Idria in Yugoslavia. In the U.S. the mines of California, Nevada, Alaska and Idaho lead the field. Among deposits in other countries are those of Turkey, Czechoslovakia, Chile, Peru, Mexico, China, Japan, the Philippine Islands and the U.S.S.R. (*See* also CINNABAR.)

The extraction of mercury from the sulfide ore is accomplished either by roasting in air: $HgS + O_2 \longrightarrow Hg + SO_2$ or by roasting with lime: $4HgS + 4CaO \longrightarrow 4Hg + 3CaS + CaSO_4$

The metal is condensed from the furnace gases, usually with little difficulty, and is not readily oxidized by air. Much of it drops from the condensers in the form of soot (mercury in wet dust), and the metal is commonly separated from this by mechanical agitation with lime.

In small-scale laboratory work, mercury can be purified by filtration, followed first by washing with nitric acid or mercurous-nitrate solution to remove the less noble metals and then by distillation to separate the mercury from the more noble metals.

The production of mercury in the United States follows the trend of demand and price and is affected by the volume of imports. After its wartime peak of 51,929 flasks (1 flask = 76½ lb. mercury) in 1943, U.S. production dropped to 4,535 in 1950. It rose to more than 38,000 flasks in 1958 for the highest peacetime production since 1883. The guaranteed-price ($225) program expired at the end of 1958. World production (all figures approximate), which reached a modern high of 275,000 flasks in 1941 and dropped to 107,000 in 1948, fluctuated between about 160,000 and 260,000 after 1950.

## PROPERTIES AND USES

**Properties.**—The physical properties of the metal, atomic number 80, atomic weight 200.59, are listed in the table along with those of cadmium, zinc and copper for comparison.

The coefficient of cubical expansion of mercury is given by the equation: $\alpha = 1.8006 \times 10^{-4} + 2 \times 10^{-8}\, t$ from 0° C. to 300° C. This linear expansion, together with the fact that mercury does not wet glass, makes the metal useful in thermometers. An alloy of mercury and thallium, 8.5% Tl has a lower melting point and can be used in thermometers down to −60° C. The high density and low vapour pressure of mercury make it useful in barometers, manometers and in vacuum gauges, such as the McLeod gauge. Its good electrical conductivity makes it exceptionally useful in electrical switches and relays of the sealed type. The value of the ohm is defined in terms of the conductivity of mercury.

**Uses.**—Mercury enjoys continued and typical use in agricultural and industrial fungicides; in mercury batteries (used as power packs for the transmission of temperature and other data from the first U.S. satellites) and other electrical apparatus and in barom-

eters, thermometers and other industrial and control instruments (as mentioned above); and in the electrolytic production of chlorine (*see* below) and caustic soda. Mercury also is used in the electrolytic purification of nuclear waste. Many of its compounds, particularly the oxide, chloride, sulfate, acetate and phosphate (see *Chemistry*, below), find extensive uses in industrial chemistry as catalysts, mercuric sulfate, for example, in making methyl styrene. Mercury also is used in pigments called mercadium reds and in a frozen-mercury casting process (*see* METALLURGY: *Precision Casting*).

Mercury is used in heat engines in three large installations in the United States. The high boiling point allows a considerable increase in theoretical efficiency of such engines over that possible when using steam.

Gaseous mercury, like all gases, does not conduct electricity unless it is ionized. The first ionization potential of mercury is 10.39 v. The property makes it useful in rectifiers for alternating current and for lighting. The light emitted by electrical discharge through mercury vapour is rich in ultraviolet rays, and lamps of this kind in fused quartz envelopes are widely used as strong sources of ultraviolet light.

High-pressure mercury-vapour lamps, besides being used for general lighting and many special applications, were widely installed for street lighting and highway lighting in the second half of the 20th century (*see* also LIGHTING: *Gaseous Vapour Lamps*).

Amalgams (*q.v.*) are alloys of mercury with other metals. The easy amalgamation of gold and silver was once employed in extracting these metals from ores. The process is now rare.

Amalgams of sodium and of potassium are employed as reducing agents. In one technical method for producing chlorine a flowing mercury cathode is used in electrolyzing the sodium chloride solution. The sodium ions discharge at the mercury surface, forming sodium amalgam, which is continuously drained away and treated with water to form sodium hydroxide and hydrogen. (For details of the process, *see* CHLORINE: *Commercial Preparation.*) Two-phase amalgams of cadmium in the Weston cell and of zinc in the Clark cell are used to give constant electromotive forces in these standard cells (*see* INSTRUMENTS, ELECTRICAL MEASURING: *Primary Electrical Standards*).

Amalgams are extensively used in dentistry for fillings.

**Pharmacology and Therapeutics.**—Elemental mercury can be absorbed through the skin. The greatest source of danger in industrial and research laboratories lies in the inhalation of mercury vapour. The relative toxicity of various compounds toward organized tissue depends on their relative ease of formation of the mercuric ion. Thus, mercuric chloride is most toxic while some nonionizable organic mercurials are safe even on intravenous administration. The ionizable salts, particularly the bichloride, benzoate, cyanide, oxycyanide, salicylate, red mercuric iodide and potassium mercuric iodide, may be used as antiseptics, with great care. The popular organic mercurial antiseptics are not destructive to tissues and are less irritating than the simpler mercury salts. Ointments of metallic mercury and of its insoluble compounds also are employed. Yellow mercuric oxide ointment consists of 1% of the yellow oxide in lanolin and petrolatum. Ammoniated mercury ointment contains 5% of $HgNH_2Cl$ in lanolin and petrolatum; it is used as a skin antiseptic. Several ointments of metallic mercury are made by triturating various amounts of metallic mercury into lanolin, white wax and petrolatum. Mercurous chloride (calomel) once was widely used as a cathartic; it also has diuretic action.

Chronic mercury poisoning results from exposure to small amounts of mercury over extended periods of time, as may occur in industries which use mercury or its salts. The symptoms are loss of appetite, salivation, gingivitis, nutritional disturbances, increasing renal damage and anemia. The treatment consists of removal of the patient from all contact with mercury or its compounds, promotion of elimination and improvement of the patient's nutritive state. Response is sometimes very slow.

Acute mercury poisoning results from ingestion of soluble mercury salts. They are irritant poisons. Mercuric chloride precipitates all proteins with which it comes in contact, thus causing an ashen-gray appearance of the mouth and pharynx. Vomiting usually occurs a few minutes after ingestion. The physician should know the length of time that elapsed before vomiting occurred and also its thoroughness. Administration of protein, in the form of milk or raw eggs, followed by evacuation by emesis and washing of the stomach by means of a gastric tube will inactivate and remove the mercuric ions not yet absorbed. This treatment must be followed by treatment to combat the systemic toxicity.

## CHEMISTRY

The element is placed in group II of the periodic table of elements, in the same family with zinc and cadmium. It has seven stable isotopes, the mass numbers and percentage abundances of which are: 196, 0.15%; 198, 10.0%; 199, 16.9%; 200, 23.1%; 201, 13.2%; 202, 29.8%; 204, 6.8%. Isotope 204 is a good heat-exchange material and is of atomic interest because of its low-absorption cross section. In natural mercury the seven isotopes each emit the same spectral lines, with very slight differences in wave length because of the isotope shift. For use as a standard the wave length of a spectral line from a single isotope is preferred. The stable mercury isotope of mass 198 has been produced by neutron bombardment of gold. The green line of wave length 5,461 Å is recommended as a wave-length standard. Radioactive isotopes having mass numbers 197 and 205 have been produced by artificial transmutations. The isotope 197 has a half life of 64 hours and decays by k-electron capture to $Au^{197}$.

Isotope 205 has a half life of 5.5 minutes and decays by emission of a beta particle to $Tl^{205}$. Other radioactive isotopes have also been reported in studies on artificial radioactivity. These are useful as tracers in the study of many chemical problems. The element has two electrons in the 6s orbitals, which accounts for its being bivalent in the higher oxidation state, forming mercuric compounds. Mercury also can exist in the univalent state, forming a second well-defined series of compounds. In this state the remaining 6s electron is used in the association of two molecules. Thus, all mercurous salts exist as double molecules not only in solution but in the solid and gaseous states; *e.g.*, $Hg_2Cl_2$.

The soluble compounds of mercury are fairly easily reduced. Thus, metallic copper or silver will replace mercury from solution slowly; the more active metals, such as zinc and tin, rapidly. The oxidation-reduction potentials for the two reactions

$$2Hg \rightarrow Hg_2^{2+} + 2e \quad -0.799 \text{ v.}$$
$$Hg \rightarrow Hg^{2+} + 2e \quad -0.854 \text{ v.}$$

are so nearly alike that reducing agents which reduce the mercuric ion to the mercurous ion will, in excess, reduce the mercurous ion to mercury. This must be considered in all the applications of mercury compounds in analytical chemistry.

The common univalent compounds of mercury are the oxide, chloride, bromide, iodide, sulfide, nitrate, sulfate, phosphate and chromate. Mercurous oxide, $Hg_2O$, results from the action of

*Physical Properties of Mercury Compared With Zinc, Cadmium and Copper*

| | Mercury | Zinc | Cadmium | Copper |
|---|---|---|---|---|
| Melting point, ° C | −38.87 | 419.4 | 320.9 | 1,083 |
| Boiling point, ° C | 356.9 | 907 | 767 | 2,595 |
| Density of liquid | 13.546[20°] | | | |
| Density of solid | 14.193[−39.4°] | 7.14[20°] | 8.65[20°] | 8.95[20°] |
| Vapour pressure | $4.1 \times 10^{-6}$ mm at −39° C<br>$1.85 \times 10^{-4}$ mm at 0° C<br>$1.85 \times 10^{-3}$ mm at 25° C<br>$7.73 \times 10^{-3}$ mm at 100° C<br>760 mm b.p. at 356.9° C | | | |
| Critical temperature | 1,450° C | | | |
| Critical pressure | 1,586 atm | | | |
| Critical density | 5 g. per c.c. | | | |
| Latent heat of vaporization at the boiling point, cal./g. | 70.62 | 475 | 240 | 1,755 |
| Resistivity, ohm cm at 20° C | $95.8 \times 10^{-6}$ | $5.89 \times 10^{-6}$ | $7.6 \times 10^{-6}$ | $1.68 \times 10^{-6}$ |
| at 0° C | $94.07 \times 10^{-6}$ | $5.75 \times 10^{-6}$ | | |

alkalies on soluble, mercurous salts. It is unstable, slowly decomposing into mercury and mercuric oxide. Mercurous chloride, $Hg_2Cl_2$, commonly known as calomel (*q.v.*), is probably the most important mercurous salt. It is prepared by subliming a mixture of mercury and mercuric chloride: $HgCl_2 + Hg \rightarrow Hg_2Cl_2$. It is formed as a white precipitate when mercuric chloride solutions are treated with reducing agents. The saturated solution of mercurous chloride in normal potassium chloride solution has a constant electromotive force against a mercury electrode. This electrode—mercury-solid mercurous chloride-chloride ion—is used as a reference electrode in electrochemical measurements.

The most common bivalent compound of mercury is mercuric chloride, bichloride of mercury or corrosive sublimate. It is extensively used as an antiseptic. Mercuric bromide and iodide are less soluble. The iodide exists in two crystalline forms, yellow and red. The red form is the stable one at ordinary temperatures and transforms to the yellow modification at 128° C. It is soluble in solutions of iodides, forming a stable complex ion $HgI_4^{2-}$. Nessler's reagent, a solution of potassium-mercuric iodide, $K_2HgI_4$, is used in the detection of small amounts of ammonia. With ammonia it becomes turbid because of the formation of a yellow precipitate, $Hg_2NI{\cdot}H_2O$. Mercuric nitrate results from the action of excess nitric acid on mercury. It is easily hydrolyzed, yielding the basic salt $Hg(NO_3)_2{\cdot}HgO$. The sulfate formed by the action of hot concentrated sulfuric acid on mercury is also stable only in the presence of excess acid. On dilution it yields the basic salt $HgSO_4{\cdot}2HgO$. Mercuric cyanide and mercuric thiocyanate, like the halides of mercury, form complex ions in the presence of alkali cyanides or thiocyanates, forming such compounds as $K_2Hg(CN)_4$ and $K_2Hg(CNS)_4$. The latter compound is used as a reagent in chemical microscopy because it gives characteristic crystalline precipitates with a number of metal ions. Mercuric thiocyanate is used in making pyrotechnic novelties called Pharaoh's serpents, serpents or serpents' eggs. It burns to form a voluminous ash so that a small pellet quickly changes to a long, fragile serpentine form. Mercuric fulminate, $Hg(OCN)_2$, is formed when alcohol is added to a hot solution of mercuric nitrate. The dry powder explodes on impact and is used in percussion caps for detonating other explosives.

Mercury sulfide exists in two forms, the red cinnabar and black metacinnabar. It is formed when hydrogen sulfide is passed into solutions of mercuric salts, the black form being usually obtained.

Mercuric ammonia compounds result from the action of ammonia or ammonium hydroxide on compounds of mercury. Thus, mercuric chloride and ammonia yield the compound $HgCl_2{\cdot}2NH_3$, containing ammonia of crystallization. From solution, ammonium hydroxide precipitates the ammono-basic chloride $HgNH_2Cl$, known as infusible white precipitate. Mercurous chloride and ammonium hydroxide yield this same compound along with metallic mercury, the finely divided metal making the material appear black. When both ammonolysis and hydrolysis occur, derivatives of Millon's base, HOHgNHHgOH, are formed. The formula is also written $Hg_2NOH{\cdot}H_2O$. The iodide $Hg_2NI{\cdot}H_2O$ is the yellow precipitate formed by the action of ammonia on Nessler's reagent, mentioned above.

**Analysis.**—The mercurous ion is recognized by the formation of a white precipitate with chloride which blackens on treatment with ammonia. The mercuric ion is recognized by the formation of the same white precipitate when stannous chloride is added to a hydrochloric acid solution of the substance being tested, $2HgCl_2 + Sn^{2+} \rightarrow Hg_2Cl_2 + Sn^{4+} + 2Cl^-$. This precipitate is reduced by excess stannous chloride to a gray precipitate of mercury, $Hg_2Cl_2 + Sn^{2+} \rightarrow 2Hg + Sn^{4+} + 2Cl^-$. The mercurous ion may be determined quantitatively by precipitating and weighing mercurous chloride. The mercuric ion may be determined by precipitating and weighing the sulfide or by titration with iodide. Mercury may be determined electrolytically, using a platinum cathode. It may also be determined by decomposing the sample with lime in a combustion tube and passing the vapours through a weighing tube containing gold foil to absorb the mercury.

*See* also references under "Mercury" in the Index.

BIBLIOGRAPHY.—For the history of mercury, *see* B. Neumann, *Die Metalle* (1904); A. Rossing, *Geschichte der Metalle* (1901). The general chemistry is given in J. W. Mellor, *A Comprehensive Treatise on Inorganic and Theoretical Chemistry*, 16 vol. (1922–37) and *Supplement*, ed. by H. V. A. Briscoe *et al.* (1956). A concise treatment is given in W. M. Latimer and J. H. Hildebrand, *Reference Book of Inorganic Chemistry*, 3rd ed. (1951). For physical data on the metal, *see* A. E. van Arkel, *Reine Metalle* (1939); on the metal and its compounds, *see* International Critical Tables; New York Academy of Sciences, *Mercury and Its Compounds* (1957). For mercury poisoning, *see* L. Goodman and A. Gilman, *The Pharmacological Basis of Therapeutics*, 2nd ed. (1955). For production and consumption *see* U.S. Bureau of Mines, *Minerals Yearbook* (annual). (I. B. J.; WM. B.)

**MERCURY FULMINATE** is an explosive once widely used in the manufacture of percussion caps. By the 1960s it had been largely replaced by lead azide in this application because of the latter's greater stability, reduced tendency to decompose in moist air and greater convenience of manufacture. Also, the fulminate requires the use of a critical raw material—mercury.

Mercury fulminate, $Hg(ONC)_2$, was discovered by E. C. Howard in 1799; J. von Liebig isolated the free fulminic acid in 1823. Other salts of this acid had been known even earlier; *e.g.*, silver fulminate was prepared by L. G. Brougnatelli in 1798. Although the use of mercury fulminate to ignite gunpowder was common considerably earlier, its use for detonation of high explosives originated with Alfred Nobel's invention of blasting caps in 1867.

Mercury fulminate is a gray, sandy, crystalline powder with a specific gravity of 4.4. When dry, it is extremely sensitive to friction, percussion and flame. Ignition instantly changes into detonation, except when the granular material has been pressed to high density ("dead pressed"). Mercury fulminate is not very stable to heat and deteriorates after protracted storage in tropical climates, particularly if not protected from humid air. Deterioration makes it less explosive and may easily result in misfires. It can be stored wet or dry at moderate temperatures and may be shipped in containers filled with water. Mercury fulminate is exceedingly toxic. *See* DETONATOR; EXPLOSIVES; PROPELLANTS.

*See* A. Marshall, *Explosives*, 3 vol., 2nd ed. rev. (1917–32); T. L. Davis, *The Chemistry of Powder and Explosives*, 2 vol. (1941–43).

(G. B. K.; X.)

**MERCY,** a noble family of Lorraine, celebrated in German history for military services in the 17th and 18th centuries.

FRANZ VON MERCY (d. 1645) is supposed to have been born at Longwy, in the duchy of Bar, in the 1590s and to have begun his military career in the service of the Holy Roman emperor Rudolf II in 1606. He emerges into history during the Thirty Years' War (*q.v.*). Wounded in the battle of Breitenfeld (1631), he made his name in 1634 by holding Rheinfelden for five months (April–August) against Bernhard of Saxe-Weimar's Swedes and was promoted major general. After the campaigns of 1635–37 in Alsace and in Franche-Comté, he entered the Bavarian army as master general of ordnance in 1638. Having frustrated the French plan for invading Bavaria in the spring of 1643, he was promoted field marshal; and he won a great victory over the French at Tüttlingen (Nov. 24, 1643), when their general Josias Rantzau was taken prisoner. Outside Freiburg, in Aug. 1644, he opposed both the duc d'Enghien (later the great Condé) and Turenne; and on May 5, 1645, he defeated Turenne at Herbsthausen, near Mergentheim. Turenne and Enghien, however, then combined their forces, and on Aug. 3, 1645, Mercy was killed at Alerheim, in the second battle of Nördlingen (*q.v.*). Enghien set the inscription *Sta viator, heroem calcas* ("Halt, traveler, you are treading on a hero") on the spot where Mercy fell. Mercy was also remarkable as a member of the Fruchtbringende Gesellschaft for the encouragement of German literature.

Franz von Mercy's son PETER, GRAF VON MERCY, fought for Charles IV and Charles V of Lorraine against the French and went to Hungary with Charles V against the Turks in 1683 but was killed in the attack on Buda (1686).

Peter's son CLAUDIUS FLORIMUND, GRAF VON MERCY (1666–1734), entered the Austrian army as a volunteer in 1682 and served in Hungary (1684–90) and with Prince Eugene of Savoy in Italy (1690–96) and in Hungary again (1697). When the War of the Spanish Succession broke out he was already a lieutenant colonel. His bravery at Cremona (Jan. 1702) won him command of a

regiment of cuirassiers, with which he operated on the Rhine front (1702–03) and in the reprisals against Bavaria (1704). The audacity of his raids against the French (1706–08) made his reputation, but his attempt at an incursion into Franche-Comté (1709) was a failure.

When war against the Turks in the Balkans was resumed, Mercy, now a general of cavalry, shared in Eugene's victory of Peterwardein (Aug. 1716), in the occupation of the Banat of Temesvár and in the capture of Belgrade (1717). After the peace of Passarowitz (1718), he was called away to fight the Spaniards in Sicily (1719–20). Returning to the newly annexed Banat as military governor, he pursued an enlightened policy, organizing a good administration, rehabilitating the economy and encouraging the settlement of immigrants from the west. Summoned to Italy again on the outbreak of the War of the Polish Succession, he was killed in the battle for Parma on June 29, 1734. The diplomat Mercy d'Argenteau was his adoptive son.

**MERCY, SISTERS OF,** a Roman Catholic religious congregation founded in Dublin, Ire., in 1831 by Catherine Elizabeth McAuley (*q.v.*). Her principal lieutenants were Mary Clare Moore, foundress in England; Mary Xavier Warde, foundress in the United States; and Mary Ursula Frayne, foundress in Australasia. The congregation is not governed centrally, although in the course of time unions have been effected among groups of convents. The diffusion of the congregation throughout the English-speaking world was rapid. By 1894, 77 independent foundations had been made in Ireland; by 1927, 45 in England; by 1922, 61 in the United States; and by 1901, 29 in Australasia. There are other scattered foundations in Scotland, Newfoundland, etc. The sisters number over 25,000, half of them in the United States. They engage in education and all kinds of social service. In the United States alone they operate a score of colleges and many high schools, grammar schools and hospitals.

See *Theological Studies*, 18:254–270 (1957). (E. A. R.)

**MERCY D'ARGENTEAU, FLORIMUND,** Graf von (1727–1794), Austrian ambassador to France and political adviser to Marie Antoinette during the French Revolution, was born at Liège, in the Low Countries, on April 20, 1727. He entered the diplomatic service in 1751, when he accompanied Kaunitz to France. Kaunitz procured his appointment as minister plenipotentiary to the Sardinian-Piedmontese court at Turin in 1754 and as ambassador to Russia in 1761. Sent as ambassador to France in 1766, he worked to consolidate the Austro-French alliance; and in 1770 the archduchess Marie Antoinette was married to the dauphin, who in 1774 became king of France as Louis XVI.

In the crises of 1787–88 Mercy used his influence to support Loménie de Brienne before advising the recall of Necker. When the Revolution began (1789) he was active on the crown's behalf: it was he who in April 1790 arranged that Mirabeau should act as secret adviser to the court. In Dec. 1790, however, he was transferred to the Austrian Netherlands. Despite urgent invitations he did not return to France. His letters to Marie Antoinette warned her against relying on foreign help if she should take refuge abroad. After the fall of the French monarchy (1792) and again after the execution of Louis XVI (1793), while France and Austria were at war, he personally appealed to the emperor Francis II for measures to save Marie Antoinette; and finally he even sent an appeal to Danton. Having been in charge of political affairs at the headquarters of the Austro-Prussian army in the Netherlands, Mercy was appointed ambassador to Great Britain in July 1794. He died in London on Aug. 25, 1794.

There are editions of Mercy's correspondence with Maria Theresa, three volumes (1874); with Graf L. Starhemberg (1884); and with the emperor Joseph II and Kaunitz, two volumes (1889–91).

**MERCY KILLING:** *see* Euthanasia.

**MERCY SEAT,** a cover of gold for the boxlike ark of the covenant which stood in the most sacred room of the Temple in Jerusalem, the holy of holies (*see* Temple Architecture; *The Jewish Temple*). The Hebrew name for it was *kapporeth*, which literally means covering. The English term derives from the Greek word used by the translators of the Septuagint, *hilasterion*, propitiatory or mercy seat. This name stresses the fact that in the priestly movement that flourished after the return from exile the cover over the ark was both a symbol of the forgiveness of God and the focal object in which, in the cultus, God's forgiveness was mediated to the people. Its role in worship is closely associated with the ceremonies of the Day of Atonement (*cf.* Lev. xvi), which in Hebrew means "day of covering" (Yom Kippur). On that day the high priest entered the room in which the ark stood, to burn incense and to sprinkle the blood of the sacrifices of repentance upon the mercy seat and before it. The smoke of the incense enveloped the mercy seat, protecting the priest from the awful presence of God, who dwelt above it. The greatest proof of the grace and mercy of God was that he accepted his people's act of repentance in this rite; and it was equaled by his gift of the mercy seat itself, as the means by which to perform the rite. In 1 Chron. xxviii, 11 the mercy seat sums up the whole meaning of the holy of holies. *See* also Ark: *Aron*. (J. C. Ry.)

**MER DE GLACE,** a spectacular glacier, covering 16 sq.mi., on the northern side of Mont Blanc (*q.v.*), near Chamonix, France. It is formed by the confluence of the Géant and the Leschaux glaciers below the Tacul massif, and is easily accessible by the railway from Chamonix to Montnevers, alongside the glacier. It has clearly developed lateral and medial moraines, and crescentic flow marks showing the more rapid movement of its centre.

(Ar. E. S.)

**MEREDITH, GEORGE** (1828–1909), who, both as poet and novelist, ranks among the outstanding writers of the Victorian age in England. As a poet of lyrical impulse, also as one able to embody the ideas of his time in his poetry, besides expressing the deep emotion arising from his personal experience, he exhibits great variety in content, manner and metre. Although he was primarily an intellectual novelist, capable of a scintillating brilliance in his criticism of society, and with a markedly individual and sometimes difficult style, some of his work is directly moving.

He was born at Portsmouth, Hampshire, on Feb. 12, 1828. He himself was protectively reticent about his birth, parentage and early years, and the facts were only revealed after his death. He made use, however, of his early experiences in his novels, and in *Evan Harrington* drew unforgettable portraits of his three Meredith aunts, and of his grandfather, Melchizedek Meredith, as "the Great Mel." Melchizedek had set up as a tailor and naval outfitter in Portsmouth in about 1784, and when he died in 1814, he left his business to his surviving son, born in 1797 and baptized Gustave Urmston, but later renamed Augustus Armstrong. In 1823, Augustus married Jane Eliza Macnamara, the daughter of a local innkeeper. George was their only child, and he used to make much of his Welsh and Irish ancestry as giving him Celtic qualities of wit and imagination. His mother died in 1833, and he was left to the care of his father, and of an adult cousin and an aunt. When he was nine he was sent to St. Paul's school, Southsea; and in 1838, when his father was declared bankrupt and moved to London, where he later set up a shop, he was sent to a boarding school. In 1840, his mother's sister died intestate, and George inherited half her estate. In 1841 he was made a ward of chancery, and his aunt's solicitor was appointed trustee of his money, which included also a small legacy from his mother. His father, in surrendering the guardianship of his son, expressed a wish that he should receive an education which should fit him to become a solicitor, and George himself chose to go to the Moravian school at Neuwied, where he remained from Aug. 1842 until the end of 1844. But he was largely self-educated, reading Goethe and Richter for himself.

On returning to England, he seems to have lived for two years with his father, who in 1839 had married his Portsmouth housekeeper and who in 1849 migrated to South Africa, where he set up as a tailor in Cape Town and whence he returned in 1863, to die at Southsea in 1876. In 1846 Meredith began to train for the law, being articled to R. S. Charnock, who, besides being a solicitor, was an antiquary leading a Bohemian life, and a member of the Arundel club. There Meredith met R. H. Horne, Lord John Manners and Dickens, and he later contributed 24 poems to *Household Words*. There also he met Edward ("Ned") Gryffydh

Peacock and Mary Ellen, the widowed Mrs. Nicolls, the children of Thomas Love Peacock (*q.v.*), and with them he produced a manuscript magazine, *The Monthly Observer*, from March 1848 to July 1849. Though very poor, he decided at this time to abandon the law for literature. His first noteworthy publication was the poem "Chillianwallah," published in *Chambers' Edinburgh Journal* in July 1849. In August he married Mrs. Nicolls, who was nearly seven years his senior, with a daughter of five, and after a short trip abroad they went to live at Weybridge, Surrey, where their son, Arthur Gryffydh, was born in 1853. But, as Meredith was to say later, "No sun warmed my roof-tree, the marriage was a blunder," and in 1858 his wife left him to live in Capri with an artist called Henry Wallis. She returned in 1859, and died at Weybridge in 1861.

While living at Weybridge, for some time with Peacock, and then near him, Meredith, besides catching sparks from Peacock's conversation, met his life-long friends Sir Alexander and Lady Duff Gordon, by whose daughter Janet, later well known as Janet Ross, he was from the first enchanted, and with whom he remained on close terms all his life. There, too, he met many prominent writers, Bulwer-Lytton and Tom Taylor among them. He also began to publish, and in June 1851 there appeared his *Poems*, which it cost him about £60 to get into print, a volume notable only for the first version of "Love in the Valley." The book was a failure, though it drew encomiums from Tennyson, W. M. Rossetti and Charles Kingsley. In 1855 he produced his first prose work, *The Shaving of Shagpat: An Arabian Entertainment*, which fell flat, though eliciting high praise from George Eliot. This was followed in 1857 by *Farina: a Legend of Cologne*, which was even less well-received. His first work to receive any popular applause was *The Ordeal of Richard Feverel*, published in 1859. This was widely read, though some vocal readers objected to it as having dangerous ideas, typified by a remark in the *Spectator* review accusing it of "a low ethical tone": thus, in spite of an adulatory three-column review in the *Times*, Mudie's library withdrew it from circulation. However, it brought him the acquaintance of Carlyle, and of Swinburne and Dante Gabriel Rossetti, with the last two of whom he lodged for a short time at Rossetti's house in Chelsea, with unhappy results. In 1858 he also met Capt. (later Rear-Admiral) Frederick Augustus Maxse, who remained a close friend, and it was partly to be near him that in 1859 he went to live at Copsham cottage, near Esher.

Although now well started on his career as a writer, with many friends in the world of letters, Meredith was forced to seek other sources of income and, as well as engaging in occasional journalism, was employed to read aloud two days a week to a Mrs. Benjamin Wood of Eltham, a lively old lady who had translated Lucian. In 1860, he became a regular contributor to the Conservative *Ipswich Journal*, earning £200 a year for eight years by writing leading articles and a weekly news column. In 1862 he was engaged to write occasional articles for another Conservative paper, the *Morning Post*, and although himself a leading spirit in a group of young philosophic radicals which included John (later Lord) Morley (who occasionally helped him in writing an article) and Frederic Harrison, he contrived to satisfy both papers by his support for Tory principles in a manner which bears out his indication that he was a journalist only by necessity, and suggests that he regarded political journalism with some cynicism. His attitude to another appointment in 1860, as reader to the publishers Chapman and Hall, which remained for 35 years his main source of income, was more responsible, although his judgments seem to have been erratic: he encouraged Thomas Hardy, Olive Schreiner and George Gissing, but rejected Mrs. Henry Wood's *East Lynne*, Samuel Butler's *Erewhon* and George Bernard Shaw's early novels.

At Copsham, in 1859, he began work on *Evan Harrington: or He Would be a Gentleman*, published serially in *Once a Week*, in a pirated edition in the United States in 1860, and in England in 1861. This was followed by *Modern Love and Poems of the English Roadside* (1862). Though he spent much time in walking, not only in England but in France, Switzerland, Austria and Italy, often with his son, Arthur, he worked steadily, and throughout 1862–63 laboured at *Emilia in England* (published 1864; renamed *Sandra Belloni*, 1886). At this time he was also spending at least a day a week in London, in connection with his work as journalist and publishers' reader.

In 1863, Meredith met Justin Theodore Vulliamy, who was living at Mickleham with three unmarried daughters, the youngest of whom, Marie, he married in Sept. 1864. It was an extremely happy marriage, and after the honeymoon and some time spent staying with the Vulliamys, and in a rented house at Esher, they settled at Kingston lodge, Norbiton, opposite Norbiton hall, where was then living William Hardman, a barrister, occasional journalist and amateur photographer, whom Meredith had met in 1861, and who had become a close friend—a man jovial and vigorous, "a fountain of our sweetest, quick to spring in fellowship abounding," as Meredith described him in an epitaph. At Kingston lodge the Merediths' son, called William Maxse after two of his father's friends, was born in July 1865.

Meanwhile, Meredith was finishing *Rhoda Fleming* (publ. 1865) and was also wrestling with *Vittoria* (publ. 1867), the sequel to *Emilia*. This was being serialized in the *Fortnightly Review* when in June 1866 he went to Italy as war correspondent to the *Morning Post*. At the end of 1867, during Morley's absence in America, he acted as editor of the *Fortnightly Review*, and in 1868 he did some work for the *Pall Mall Gazette*.

The novels written at Norbiton were not well received, and in Jan. 1868, the Merediths moved to Flint cottage, Box Hill, where the atmosphere and surroundings were more restful and more suited to creative writing. Here, in June 1871, their daughter, Marie Eveleen, was born, and here, in a chalet built later at the top of the sloping garden, Meredith wrote his greatest works. It remained his much-loved home for the rest of his life.

During 1870–71 *The Adventures of Harry Richmond* was serialized anonymously in the *Cornhill Magazine;* it was published as a book in 1871. This first-person narrative, more natural in style and romantic in incident than Meredith's earlier novels, contains much autobiographical material and feeling, especially in its description of the hero's relationship with his father, which reveals something of Meredith's own emotional experience, born from his unsympathetic relations with his own father, and from the detachment from him of his son Arthur (to whom he was devoted), possibly in resentment of Meredith's second marriage. *Harry Richmond* was followed by *Beauchamp's Career*, serialized in a shortened version in the *Fortnightly* (1874–75) and published in 1876. In January and July 1877 he published two short stories, *The House on the Beach* and *The Case of General Ople and Lady Camper*, in the *New Quarterly Magazine;* a third, *The Tale of Chloe*, appeared in July 1879. Also in 1877, on Feb. 1, he delivered at the London Institution his classic lecture "On the Idea of Comedy and the Uses of the Comic Spirit," which was printed in the *New Quarterly Magazine* in April, and published as *An Essay on Comedy and the Uses of the Comic Spirit* in 1897. A greater success than *Beauchamp's Career* was *The Egoist*, which, after serialization in the *Glasgow Weekly Herald*, which Meredith had not authorized, was published in 1879, a second edition being brought out within a year. It was greeted with almost unqualified praise, the first of Meredith's books to achieve success with both critics and public. *The Tragic Comedians* followed in Dec. 1880.

Meredith then turned to poetry, and *Poems and Lyrics of the Joy of Earth*, including "The Woods of Westermain," "The Lark Ascending," "Phoebus and Admetus" and the revised and extended "Love in a Valley," appeared in 1883. He returned to the novel with *Diana of the Crossways*, his most popular piece of fiction, published early in 1885. He suffered a crushing blow in the death of his wife in September of that year, and in his distress once more turned to poetry, with *Ballads and Poems of Tragic Life* (1887), and, more important, *A Reading of Earth* (1888). At this time also he was grieved by his increasing estrangement, which he did his best to heal, from his son Arthur, who died in 1890, as also did William Hardman. Yet other novels followed in quick succession: *One of Our Conquerors* (1891), *Lord Ormont and His Aminta* (1894) and *The Amazing Marriage* (1895). Other prose works were published after his death, notably the unfinished *Celt*

*and Saxon* (1910). In 1898 he issued *Odes in Contribution to the Song of French History* and in 1901, *A Reading of Life. Last Poems* was published posthumously in 1909.

During the last years of his life, Meredith was a public figure. As a youth handsome, exuberant, athletically active, toward the end he became almost paralyzed, though never losing his talent for brilliant conversation, and his armchair by the fireside at his home at Box Hill became, as J. M. Barrie said, "a throne of letters in this country," where he received visits from his many friends such as Leslie Stephen, R. B. (later Lord) Haldane, Morley, H. M. Hyndman and Alice Meynell, his perfect Egeria, as well as pilgrimages from younger men. Honours were increasingly accorded him. In 1892 he succeeded Tennyson as president of the Royal Society of Authors; on his 70th birthday he received a congratulatory address signed by 30 famous people; and 1905 brought him the order of merit, and the gold medal of the Royal Society of Literature. He died at his home at Box Hill on May 18, 1909. Strong representations were made for his burial in Westminster abbey, but the dean refused permission, and after cremation his ashes were buried in Dorking cemetery beside his second wife.

## HIS PHILOSOPHY AND HIS POETRY

Meredith's "philosophy," to give that name to deep intuitions which were never systematized, has rightly been described as one of affirmation. Not believing in a future existence, he felt that the solution of life's problems must be found in living. He has often been regarded as a supreme optimist; but it was, rather, a belief in humanity, that it could rise above its animal limitations, that dominated his outlook. "My aim," he wrote to his son William, "is never to take counsel of my sensations, but of my intelligence. I let the former have free play, but deny them the right to bring me to a decision." To Meredith, to live is to value, and to be judged; for, as we read in "Earth and Man," Man is Earth's "great venture." But the brain must never deny the blood. It was not a cold intellectuality that Meredith aimed at; it was a fusion of the "blood" and "brain" that made the motivating "spirit." For the whole process of evolution is from earth to mind, a process gloriously celebrated in one of his greatest poems, "The Woods of Westermain." After a reference to "hours when mind was mud," he goes on, in an exultant passage, to declare that

> Blood and brain and spirit, three
> (Say the deepest gnomes of Earth)
> Join for true felicity.

Earth must be the basis, must never be denied. In *Poems and Lyrics of the Joy of Earth*, a significant title, he writes of the lark ascending, that "'Tis love of earth that he instils" as he sings

> The song seraphically free
> Of taint of personality.

Life is to be fully lived, fully enjoyed, in spite of its pains, sorrows and frustrations; thus a certain stoicism is apparent in his verse, as when in "Foresight and Patience" we read that hard Necessity is Wisdom's mother, while "The Lesson of Grief" acknowledges the brotherhood of sorrow.

The essential Meredith is to be found in his poetry rather than in his novels, about which he tended to be impatient; and it would accord with his wishes to be regarded primarily as a poet, both his first and last publications being in verse. His *Poems* (1851) show great variety, considerable accomplishment in metre and a latent power, but contain nothing very striking except the first draft of "Love in the Valley," brought to its final form in 1878, but already a superbly musical expression of young love. His strength first showed itself in the *Modern Love* volume of 1862, the title-poem of which, at the time neglected save by the few, now, with its 50 16-line "sonnets," ranks among the great sequences. In this still "modern" and poignantly moving poem, Meredith, with painful self-examination, dramatized the tensions of his first marriage, that "union of this ever-diverse pair," resolving the misery without bitterness or reproach. Though the narrative is faint and somewhat involved, the sequence abounds with haunting phrases of which one at least has become well known:

> In tragic life, God wot,
> No villain need be! Passions spin the plot:
> We are betrayed by what is false within.
> (xliii)

Some of the "sonnets" exist as memorable poems in their own right.

It was in his middle period that Meredith achieved his most splendid poetry. The poems of this period divide themselves into pieces of sheer lyricism, such as "The Lark Ascending," and resolutions of deeply pondered intuitions, as in "Earth and Man." The two are often blended, "The Woods of Westermain" and the "Ode to the Spirit of Earth in Autumn" offering examples of penetrating power of thought combined with surging poetic impulse. Most of these poems exhibit great fertility of imagination and a genius for metaphor, while the packed thought is of an urgency that raises it to song, as in "The Day of the Daughter of Hades," "The Nuptials of Attila" and "The Night of Frost in May." Although the element of song was never absent from Meredith's verse, some of his later work, devoted largely to what might be called "political" poetry, as "Napoléon" or "France 1870," sometimes falls away. "The Empty Purse" is too thick with thought to be redeemable as poetry. Yet throughout Meredith reveals great metrical skill, even triumphantly using galliambics in "Phaeton," and he could combine various metres in one poem with great success. Many of his briefer poems are of the first rank: "A Ballad of Past Meridian," "Lucifer in Starlight" and the second of the two sonnets, "The Spirit of Shakespeare," need alone be named to establish this claim. Many other pieces make unforgettable impact, as does "The Thrush in February," which has much of the ecstatic quality of "A Lark Ascending," but ends with the balancing note, "The crocus lays her cheek to mire."

## HIS FICTION

The elements that make up the complex of a Meredithian novel are so varied, and so varyingly treated, as to rule out a general description. It can be said, however, that none is realistic in the common sense of the term, for Meredith did not relish pursuing what he contemptuously dubbed "cobwebs in a putrid corner." And although there is deep emotion in all, and sometimes passion, he refused to "fiddle harmonics on the sensual strings." Neither were there to be any "happy tales of mystery" for him; his way lay between "the unreal and the overreal," as he wrote in *Beauchamp's Career*, to go on: "My people conquer none, win none; they are actual yet uncommon. It is the clockwork of the brain that they are directed to set in motion, and . . . the conscience residing in thoughtfulness that they would appeal to." His novels, it can be said, are the application of his "philosophy" to men living in society. Thus, in a letter to Maxse, he could write: "I strive by humanity to represent it; not its morbid action. I have a tendency to do that, which I repress." What chiefly aided him in repressing it was the sense of comedy that keeps the eye clear and the mind unclouded. It is the civilizing agent.

Brilliantly stating his position is his *Essay on Comedy*. As he envisaged it, for the comic writer "a society of cultivated men and women is required, wherein ideas are current, and the perceptions quick. . . ." And again, "There will never be civilization where Comedy is not possible: and that comes of some degree of social equality of the sexes," Comedy being "an interpretation of the general mind." Further, "The life of Comedy is in the idea . . . And to love Comedy you must know the real world, and know men and women well enough not to expect too much of them." It is sharply distinguished from satire, since "You may estimate your capacity for Comic perception by being able to detect the ridicule of them you love, without loving them less." And, as we find in his novels, "The Comic spirit is not hostile to the sweetest songfully poetic."

Thus, though most of Meredith's novels are a strange commingling of comedy, romance and tragedy—the last even a little "morbidly" introduced in the unnecessary deaths of Richard Feverel, Nevil Beauchamp and Chloe—and all end tragically or in disillusion, it is the comedy that is the distinctive, saving focus, keeping the reader alert. This last appeared at the outset in *The Shaving*

*of Shagpat*, an Arabian Nights' tale outdoing William Beckford's *Vathek* in brilliance and invention; but it was *The Ordeal of Richard Feverel* which, though unevenly written, already mixed the elements and revealed the qualities that characterize all the novels. Here are to be found Meredith's ability to portray passionate youthful love; the necessary binding earthy medium; the lyrical response to nature, often in landscape paintings—woods in England at evening (*Sandra Belloni*), sunrise over Venice (*Beauchamp's Career*), for example; and, hovering over all, the Imp of Comedy, with his "silvery laughter" at pomposity, pretension and self-delusion. Here too, in Lucy Desborough, is a first sketch of the heroines that, championing the cause of women's equality, he created as such superb characters—Diana and Vittoria in the books named after them, Clara Middleton and Laetitia Dale (*The Egoist*), Cecilia Halkett and Renée (*Beauchamp's Career*).

The notorious difficulty of his novels is due to more than one cause: sometimes to the involved complexity of the plot, often combined with a multiplicity of characters, as in *Vittoria;* sometimes to its extravagance, as in *Harry Richmond* and *The Amazing Marriage;* but more often to the close-woven, aphoristic language. But, as Meredith wrote to G. P. Baker: "Concerning style, thought is tough, and dealing with thought produces toughness." His novels are not for those of lazy mind, which, as Diana said, hates metaphor. The rapidity of thought of his characters makes them leap over the usual intermediate steps. Not that all Meredith's novels are difficult in this sense, and his great scenes are free of complicated writing; yet he exacts the highest qualities of perception, mind and spirit from the reader.

His genius for comedy was allowed full scope in *Evan Harrington*, an almost farcical exposure of snobbery, in which appear, fictionally dramatized, the three of Meredith's aunts who had married "above their station in life," together with "the Great Mel" and his widow. Snobbery occupies also certain portions of *Sandra Belloni*, snobbery which leads to a sad, disillusioned ending, as, in a different form, it leads to the sad endings of *Rhoda Fleming* and *One of Our Conquerors*. *Vittoria*, a sequel to *Sandra Belloni*, with the same heroine, is concerned with Mazzini and his revolutionary struggles, but these are less important to the plot than those of Lassalle in the least comic of all Meredith's novels, *The Tragic Comedians*. *The Egoist* is his masterpiece in high comedy, and to read it is a salutary discipline from which the reader emerges both healthier and heartier. As art it is consummate, not only in its perfect dramatic construction, its closeness, its complete rounding off and its almost tragic catastrophe of disillusion, but in the exquisite points it makes again and again. It probes as deep as psychological borings need probe, and often reaches the topmost height of the sublimely ridiculous. *Beauchamp's Career*, Meredith's own favourite of his novels, is a masterpiece of a different kind, achieving a perfect balance of all his qualities, the comic, the romantic, the scenic and the socially philosophical. Almost as well balanced and not demanding so deep a response nor such mental agility from the reader, is *Diana of the Crossways*, the most immediately popular of his works.

Though the creation of character was not Meredith's main object, some of his male personages are as unforgettable as his heroines: Sir Willoughby Patterne (*The Egoist*), Richmond Roy and Squire Beltham (*Harry Richmond*) and Everard Romfrey (*Beauchamp's Career*). Some minor characters are also little creations that dwell in the memory: the Patterne aunts, Mrs. Mountstuart Jenkinson and Vernon Whitford (*The Egoist*), the Cogglesby brothers (*Evan Harrington*), the protagonists in the little comic gem *The Case of General Ople and Lady Camper*. Some of his characters are suggested by actual people, with such dramatizations as are to be expected. Among these the aunts in *Evan Harrington* have already been mentioned, and there also is a representation of the Duff Gordons as Sir Frank and Lady Jocelyn and their daughter Rose. Diana Warwick of the Crossways is supposedly drawn from Mrs. Norton (*see* NORTON, CAROLINE ELIZABETH SARAH), who was wrongly supposed to have divulged a cabinet secret to the press. In *The Egoist* Peacock is recognizable in Dr. Middleton; in *Beauchamp's Career*, Nevil Beauchamp is clearly Maxse, who fought an election as radical candidate at Southampton, and William Hardman is depicted as Blackburn Tuckham; as early as *Richard Feverel*, Meredith's friend Maurice Fitzgerald is portrayed as Adrian Harley, while Robert Louis Stevenson is recognizable as Gower Woodseer in *The Amazing Marriage*. But from whatever source his characters come, all exhibit an astounding energy that imparts itself to the reader.

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**MERENGUE,** a Caribbean dance, variously attributed to the Haitian and Dominican republics. Although there are several varieties of the dance, the Dominican merengue is probably the most popular.

In dancing the merengue a step-close is taken to the side and repeated with a slight dipping of the knee or dragging of the foot. The accent occurs on the first and third beats of a 4-4 measure. The basic step may be done from side to side, forward and backward, turning and rocking forward or backward. The dance, usually performed in closed position, occasionally is done in an open-break position. (B. WE.)

**MERES, FRANCIS** (1565–1647), English writer, author of *Palladis Tamia: Wits Treasury* (1598; edited by D. C. Allen, 1938), a commonplace book containing uninspired comments on religion, music, painting, etc., and a section on poetry. Here, among other information valuable to scholars, Meres gives a list of the plays Shakespeare had produced by 1598 and mentions the deaths of Marlowe, Peele and Greene. He also quotes what is evidently general opinion on contemporary poets, calling Shakespeare "the most excellent in both kinds" (comedy and tragedy) "for the stage"; and Chaucer, "the God of English poets." Born at Kirton, Holland, Lincolnshire, and educated at Pembroke college, Cambridge, in 1602 Meres became rector of Wing, Rutland, and died on Jan. 29, 1647.

*See* G. Gregory Smith, *Elizabethan Critical Essays* for part reprint and introduction (1904); and J. W. H. Atkins, *English Literary Criticism: the Renascence* (critical) (1947).

**MEREZHKOVSKI, DMITRI SERGEEVICH** (1865–1941), Russian poet, novelist, critic and thinker, who played a leading part in the revival of religious-philosophical interests among the Russian intelligentsia, was born in St. Petersburg on Aug. 14 (new style; 2, old style), 1865, the son of a court official. He graduated from the historical-philological faculty of St. Petersburg university, and his first volume of poetry was published in 1888. His essay *On the Causes of the Decline and on the New Trends in Contemporary Russian Literature* (1893), sometimes erroneously described as the manifesto of Russian symbolism, was nevertheless an important landmark of Russian "modernism." At the beginning of the 20th century, he and his wife, Zinaida Hippius, organized religious-philosophical colloquia and edited the magazine *Novy Put* (1903–04).

With his trilogy *Khristos i Antikhrist* ("Christ and Antichrist") Merezhkovski revived the historical novel in Russia. Its three parts—*Smert bogov: Yulian Otstupnik* (1896; Eng. trans., *The Death of the Gods*, 1901); *Voskresshie bogi: Leonardo da Vinchi* (1902; Eng. trans., *The Forerunner*, 1902); and *Antikhrist: Petr*

*i Aleksei* (1905; Eng. trans., *Peter and Alexis*, 1905)—are set in widely separated epochs and geographical areas. They reveal historical erudition and archaeological minuteness, and also serve as vehicles for Merezhkovski's historical and religious-philosophical ideas, with their underlying concept of Christianity of the "Third Testament." His three fictional works from Russian history—the play *Pavel I* (1908) and the novels *Aleksander I* (1911–12) and *14 Dekabrya* (1918; Eng. trans., *December the Fourteenth*, 1933)—also form a trilogy. Merezhkovski's favourite method is that of antithesis. He applied it, not only in his novels, but also in his critical study *Tolstoi i Dostoevski* (1901–02), a work of seminal importance and enduring value. His *Gogol i chort* (1906; "Gogol and the Devil"), is also an important critical work.

Before the Revolution of 1917 Merezhkovski was opposed to the existing regime (as can be seen from *Le Tsar et la Révolution*, written jointly with Mme Hippius and Dmitri Filosofov and published in Paris in 1907); he welcomed the February Revolution of 1917, but opposed the Bolshevik seizure of power. He emigrated in 1919, and settled eventually in Paris where he published two more historical novels under the general title *Rozhdenie bogov* (1924–25; Eng. trans., *Birth of the Gods*, 1925) and biographical studies on Napoleon, Jesus Christ, St. Paul, St. Francis of Assisi, Joan of Arc, St. Augustine, Dante and others, most of which have been translated into English. In later life he regarded Mussolini and Hitler as potential saviours of mankind from Communism. He died in Paris on Dec. 8, 1941.

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**MERGANSER,** the name for fish-eating ducks constituting the tribe Mergini of the subfamily Anatinae. Skilful divers, mergansers pursue their prey under water, propelling themselves by the powerful feet set far back on the body, and capture prey in their long, slender, toothed-edged bills. Most are crested and slender-bodied. In flight they present a distinctive long line, the bill, neck and body being held rigidly horizontal, unlike other ducks. They nest in tree or rock crevices near water.

The largest species, the common merganser, or goosander (*Mergus merganser*), measures about 25 in. long. The male has a greenish-black head with a simple crest, white wings and a white breast tinged with peach; the female has a reddish-brown head with a pronounced crest and a grayish body with white definition of the throat and neck. In both sexes the bill and feet are orange. *M. merganser* breeds in northern Europe, Asia and North America; the American subspecies (*M. m. americanus*) is the commonest cold-weather duck on northern fresh waters.

The slightly shorter red-breasted merganser (*M. serrator*) has a similar breeding range but is more maritime otherwise. It resembles the goosander except that the male has a long double crest, a white collar and a broad rust-coloured chest band above the whitish breast, while the female has brownish-gray upperparts.

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RED-BREASTED MERGANSER (MERGUS SERRATOR)

Much smaller (about 16 in. long) and shorter billed is the European smew (*M. albellus*), the male of which is white lightly marked with black and has a fluffy head crest; the female is grayish with a brown cap and bold white cheeks and white neck. About the size of the smew, the male hooded merganser (*Lophodytes cucullatus; Mergus cucullatus* of the British Ornithologists' union), of North America, has a fan-shaped white crest edged in black, black marked white wings and cinnamon sides; the female is dusky, with a dark head and buffy underparts. Other species occur in northern Asia (*M. squamatus*), southern Brazil (*M. octosetaceus*) and the Auckland Islands (*M. australis*). *See* also DUCK.

(HT. FN.)

**MERGENTHALER, OTTMAR** (1854–1899), U.S. inventor of the Linotype machine, was born May 11, 1854, at Hachtel, Ger. A precocious boy, he was ambitious to study engineering, but his father, burdened with the higher education of older sons, found the expense beyond his means. Ottmar was apprenticed to a watchmaker at the age of 14, later attended technical classes at night, and in 1872 emigrated to the United States. In 1878 he became a naturalized U.S. citizen. While employed in the Baltimore machine shop of August Hahl, a relation, he was assigned to work on an inventor's plans for a device to make type molds of papier-mâché. This device proved impracticable, but Mergenthaler became dedicated to the problem involved: the mechanization of the tedious work of typesetting. In 1886 he produced his Linotype which, by bringing copper matrices into brief contact with a molten, but fast-cooling, alloy, rapidly molded column-widths of type. The machine, by speeding the printing process and reducing its cost, fostered a dramatic expansion of all publishing fields and a rapid increase in literacy. Mergenthaler later patented other successful inventions, but the Linotype remained his life interest. He was a compulsive worker who often overtaxed his strength. At 45 he contracted tuberculosis; he died in Baltimore, Md., Oct. 28, 1899. (M. Sy.)

**MERGUI,** the southernmost district of the Union of Burma, in Tenasserim division, is bounded west by the Andaman sea and east by Thailand. Pop. (1962 est.) 227,833. Area 11,325 sq.mi. It is a long narrow strip, about 260 mi. long and 50 mi. wide, dominated by two north-south ranges, with the Tenasserim river winding between them till it turns north and flows through a narrow gorge in the western range to the sea. The whole district is densely forested with a few areas of cultivation along the coast and in the broader valleys. The forest is mainly of evergreen equatorial type with a great variety of trees, many of great size. The coast line, which has the outlying Mergui archipelago (*q.v.*), is broken, and for several miles inland the land barely rises above sea level, being drained by numerous muddy tidal creeks. South of Mergui town the land has low mangrove swamps alternating with small fertile rice plains. The four principal rivers are the Tenasserim, Lenya, Pakchan and Palauk, the first three being navigable for a considerable distance. Unexploited coal is found along the Tenasserim and its tributaries. There are tin mines at Maliwun and elsewhere, and other minerals occur but mining is less important than in the Tavoy district to the north. Rainfall is heavy, exceeding 150 in., and the dry season is short; these two factors together have led to the development of rubber planting.

From the writings of early travelers it appears that Mergui, then under Siamese rule, was a rich and densely peopled country. On occupation by the British (1824–25) it was found to be almost depopulated—the result of border warfare; the entire population numbered only 10,000.

MERGUI TOWN (1953 pop. 33,697), the district headquarters, is on an island at the mouth of the Tenasserim river. It has a rubber and tin ore exporting trade, which has eclipsed its earlier importance as the centre of the archipelago's pearling trade, and also has a considerable coastal trade with Rangoon and Malaya with exports including rattans, dried fish and edible bird nests.

(L. D. S.)

**MERGUI ARCHIPELAGO,** a cluster of more than 200 islands in the Andaman sea off the Tenasserim coast of southern Burma. They are noted for their picturesque beauty, some of them rising to 2,000 ft. and covered with tropical forests right to the water's edge. The main islands are King, Tavoy, Elphinstone, Ross, Sellore, Bentinck, Domel, Kissaraing, Lampi and St. Matthew's. They are sparsely inhabited by the Selungs, or Salons (sometimes called sea gypsies), and by Burmans who combine fishing with subsistence agriculture. There is also an old-established pearl-fishing industry. (L. D. S.)

**MERIAN, MATTHÄUS** (1593–1650), Swiss engraver and etcher, was born in Basel. In 1609 he was placed under Dietrich Meyer, a painter and engraver of Zürich, and in 1613 went to Nancy. After studying in Paris, Stuttgart (1616) and the Low Countries, he went to Frankfurt, where in 1618 he married the eldest daughter of J. T. de Bry, publisher and engraver. He worked with his father-in-law at Oppenheim, returned to Basel; but went back to Frankfurt after De Bry's death (1623) to take over his business.

Merian completed in 1624 the great record of discovery and travel *Collectiones Peregrinationum in Indiam,* which had been begun by the De Brys in 1590. De Bry's business remained in Merian's family until 1726, when a great fire destroyed it. Between 1627 and 1629 Wenceslaus Hollar was in Merian's studio in Frankfurt. Between 1625 and 1630 Merian published illustrations to the Bible; in 1635 he began the series *Theatrum Europaeum,* and in 1642 published Martin Zeiller's *Topographia,* the plates etched and engraved by himself and his sons Matthäus and Caspar. Among his last works was a "Dance of Death" (1649). He died in Frankfurt. (C. H. C. B.)

**MÉRIDA,** capital city of the state of Yucatán in Mexico. Pop. (1960) 170,834. Mérida stands at the northern end of a porous limestone plain which is ideal for growing the cactuslike agaves from which henequen or sisal hemp fibres are taken. Henequen and other products are shipped from Progreso, its Gulf of Mexico port, 23 mi. away. Most of the drinking water is obtained from underground pools, formed by rain seeping through the limestone, and is pumped to the surface by windmills. Mérida was founded in 1542 by Don Francisco Montejo (the younger) on the site of an ancient Mayan city called Tho. A famous landmark in Mérida is the House of Montejo *(La Casa Solariega* or *Adelantado),* built in 1549. Called the "white city" for its cleanliness, it is a tourist base for trips to nearby ruined Mayan cities, such as Chichén-Itzá, Uxmal, Labná and Kabah. The magnificent Mayan architecture caused the Spaniards to name Mérida after the Spanish city of the same name, which was known as the Rome of Spain. Most of the Mayas speak their own language, and the women still wear the huipil, a straight white dress with colourful embroidery at the neck and hem. For sale in Mérida's market are handsome objects of henequen, fine linen hammocks, filigree gold jewelry, tropical fruits, and venison the year round. Yucatán's locally developed railway system from Campeche to Progreso is connected to trunk lines of the National railways of Mexico, linking the peninsula with the rest of Mexico. Mérida has a 16th-century cathedral, an archaeological museum and is the seat of a university (Universidad Nacional del Sureste de Mexico). (H. R. Hy.)

**MÉRIDA** (anc. AUGUSTA EMERITA, capital of Lusitania), a town of western Spain, in the region of Estremadura and province of Badajoz, is situated on the right bank of the Guadiana river, 61 km. (38 mi.) E. of Badajoz by road. Pop. (1960) 34,297. Mérida is an important railway junction where the Madrid-Badajoz railway meets the lines from Seville, Huelva and Cáceres. Augusta Emerita was founded in 25 B.C. As the capital of Lusitania it soon became one of the most splendid cities in Iberia, and was large enough to contain a garrison of 90,000 men. Chief among the Roman remains is the bridge, constructed of granite under Trajan, or Augustus, and restored by the Visigoths in 686 and by Philip III in 1610. It comprised 81 arches, 17 of which were destroyed during the siege of Badajoz (1812), and measured 2,575 ft. in length. There are a few remnants of Roman temples and of the colossal wall which encircled the city, besides a Roman triumphal arch, commonly called the Arco de Santiago, and a second Roman bridge, by which the road to Salamanca was carried across a small river, Arroyo de la Albarrega (Alba Regia). Early in the 8th century Mérida was occupied by the Moors who enlarged the *alcázar* or citadel which was originally the chief Roman fort. From the Lago de Prosérpina, also called Charca de la Albuera, a large Roman reservoir, 3 mi. N., water was conveyed to Mérida by an aqueduct, of which there are extensive remains. The Roman theatre is in good preservation; there are also vestiges of an amphitheatre and of a circus, 485 yd. by 120.

*See* Martin Almagro, *Mérida, guia de la ciudad y de sus monumentos* (1957).

**MÉRIDA,** capital of Mérida state in western Venezuela, lies on a terrace near the Chama river. It is on the trans-Andean highway (not to be confused with the Pan-American highway, which follows a far more direct and a shorter route between Caracas and the Venezuela-Colombia border) at the north foot of the Sierra Nevada de Mérida, the country's only mountain chain to have permanent snow at the higher elevations. Mérida, founded in 1558, long suffered because of its inaccessibility; it was not until coffee became commercially important that the people of Mérida found a product of sufficient value per unit of bulk to support the high cost of transportation. In the second half of the 20th century the Sierra Nevada de Mérida was the principal coffee-producing area of Venezuela. The city is 300 mi. S.W. of Caracas and 145 mi. S.E. of Maracaibo. Mérida enjoys one of the pleasantest climates in the country; it has two distinct rainy seasons. Mérida resembles a town of Castile with its narrow cobbled streets, flowers, convents, shuttered houses and neat plaza. It was destroyed by earthquakes in 1812 and again in 1894. It is a small manufacturing centre, making textiles, cordage goods, tobacco products, vegetable oil and furniture. The cathedral, convents and university serve to make it the religious and academic centre of the region. Pop. (1961) 40,404. (L. We.)

**MERIDEN,** a city in Connecticut, U.S., midway between New Haven and Hartford. It was named in a deed in 1664 from "Meriden Farms" in Dorking, Surrey, Eng.; the word means "pleasant valley." The town was incorporated in 1806; the city was chartered in 1867 and the town and city were consolidated in 1922.

Meriden is a highly industrialized community. Its principal industries are the manufacture of sterling silver, gold, silver- and nickel-plated ware, britannia ware, ball bearings, cut glass, cabinet hardware, casters, lighting fixtures, electrical accessories, cutlery, hardware and household utensils. The pewter and silverware industry is an old one. Samuel Yale began the manufacture of pewter in 1794. The famous trade mark "1847 Rogers Brothers" indicates the year in which Rogers brothers began the manufacture of silverware there.

The city is the site of a state school for delinquent boys and a state tuberculosis hospital. It occupies an area traversed by the Quinnipiac river and Harbor brook. The countryside is dominated by the Hanging hills of which West Peak, Mt. Lamentation and Mt. Higby are the most prominent. A state park has been established in the hills in the northwest part of the city.

Meriden lies on the perimeter of the great urbanized belt that extends across Connecticut from New York city to Boston. Travelers who cross the area are likely to have difficulty in distinguishing the city (which is also a standard metropolitan statistical area) as an independent community. Pop. (1960) 51,850. For comparative population figures *see* table in CONNECTICUT: *Population.* (E. E. Sr.)

**MERIDIAN,** a city of eastern Mississippi, U.S., 136 mi. N. of Mobile and 247 mi. S.W. of Memphis; the seat of Lauderdale county. Meridian sprouted in 1854 at the planned junction site of two rail lines 20 mi. from the Alabama boundary, the name having been chosen by a pioneer railroad man who thought the word meant the same thing as "junction." As other railroads moved in, the village developed as a railroad town. Meridian was incorporated in 1860. In 1948 it adopted a council-manager government, the first city in the state to do so.

As the city's population grew its economy became diversified. Manufactures include garments, metal window frames, dump truck

bodies, furniture, sewer tile, brick and cement, hosiery, lumber, fertilizer, roofing and insulation board. Stockyards, cotton and cottonseed-oil mills and compresses are a part of the industrial pattern. A naval auxiliary air station is located 12 mi. north.

Excellent recreational facilities are available in the city and surrounding area. A public junior college was opened in 1956.

For comparative population figures *see* table in MISSISSIPPI: *Population*. (E. H. Hs.)

**MERIDIAN,** any north-south line drawn directly from pole to pole on the surface of a sphere or spheroid, as on the surface of the earth globe or a celestial globe. Any number of meridians may be drawn, but for practical purposes the number must be limited, so as not to cover or obscure data to be shown on the globe. Meridians are used as markers, or marking lines, to help indicate longitude (*see* LATITUDE AND LONGITUDE). On the earth globe, or on a world map, the prime meridian is the specially designated zero meridian that passes through Greenwich, Eng. By international agreement, in 1884, it is used as the primary, or base, meridian for the indication of longitude east and longitude west, as, for example, the meridian of 30 degrees east longitude or the meridian of 60 degrees west longitude. In another meaning, meridian refers to noon (midday), in the sense of the highest (noon) position of the sun as it crosses the meridian of a particular place. From this meaning come the time designations A.M. (Latin *ante meridiem*, before noon, that is, before such crossing), and P.M. (Latin *post meridiem*, after noon). (R. M. GL.)

**MERIKANTO, FRANS OSKARI** (1868–1924), Finnish composer known for his national operas and popular songs. Born at Helsinki, Aug. 5, 1868, he studied there and in Germany and from 1911 to 1922 was conductor of the Helsinki opera. At Viipuri in 1908 he produced *Pohjan neite* ("The Maid of Bothnia"), the first opera to Finnish words, based on a libretto from the Finnish national epic, the *Kalevala*. It was followed by two other Finnish operas, produced at Helsinki in 1910 and 1920. He was also known as an organist. He died at Hausjärvi-Oiti, Feb. 17, 1924. His son, Aarre Merikanto (b. 1893), wrote symphonies, concertos and other works, largely under German influences.

**MÉRIMÉE, PROSPER** (1803–1870), one of the greatest writers of short stories in French literature, and also a dramatist, essayist, historian and archaeologist, was born in Paris on Sept. 28, 1803, of parents of good Norman middle-class stock, both of whom were cultured and artistic. He was an assiduous pupil at the Lycée Impérial (later the Lycée Henri IV) and in the law faculty of Paris. His private reading, during this formative period, was in 18th-century literature: Rousseau and, above all, Voltaire. He made a thorough study of English and Spanish, learned Greek, and even acquired some familiarity with the occult sciences. Many English, as well as French, painters came to his father's house and perhaps this was the origin of his lifelong admiration for English taste and imperturbability. He frequented a society which loved mystification, irony and excess, and hovered between the two intellectual tendencies of his time: one which sought to prolong the 18th century in an art that was neoclassical, impersonal and cold; the other which hailed the new century as a summons to rejuvenate art. Sincere and loyal friends such as Stendhal helped him to find his way and directed him toward his true vocation—literature.

As early as 1822 he wrote *Cromwell*, a play that was never published and of which the manuscript has been lost. In 1825 he published the *Théâtre de Clara Gazul*, a collection of plays derived from the Spanish poetic dramatists. He indulged his taste for mystification by leading his readers to believe that these pieces were translated by a certain Joseph l'Estrange from the works of a Spanish actress, of whom he provided a biography. In the following year he again misled his readers by publishing a collection of ballads purporting to be a translation from the Serbian; he gave it the title of *La Guzla*, an anagram, in fact, of Gazul. Many French and foreign scholars were deceived, notably the well-known Slavonic scholar Sir John Bowring (*q.v.*); even Pushkin was taken in. A renaissance of the historical drama and novel, under the influence of Sir Walter Scott's novels, was taking place in France at this period, and Mérimée, following the taste of the time, next published a group of dramatic sketches, *La Jacquerie* (1828), and the novel *La Chronique du règne de Charles IX* (1829).

The young author was still seeking his path. In 1829, with the publication of "Mateo Falcone" in the *Revue de Paris*, he found his vocation as a writer of short stories. In this year, as well as writing his comedies *L'Occasion* and *Le Carrosse du Saint Sacrement* (the latter is still successfully produced), he contributed a series of short stories to various reviews, among them "L'Enlèvement de la redoute" and "Tamango." In 1833 he collected these stories, together with "Le Vase étrusque" (1830) and others, in one volume, *Mosaïque*. More stories followed: "La Double Méprise" (1833), "Les Âmes du Purgatoire" (1834), "La Vénus d'Ille" (1837), "Colomba" (1840), "Arsène Guillot" (1844), "Carmen" (1845) and "L'Abbé Aubain" (1846). He returned to imaginative works toward the end of his life with "Lokis" (1869), "La Chambre bleue" (1871) and "Djoûmane" (1873).

During the reign of Louis Philippe (1830–48) Mérimée decided to become a civil servant and obtained a post as head of a department at the Ministère de la Marine (the admiralty). In 1831 he met Jenny Dacquin, a young girl who became his devoted friend. They corresponded for 40 years and his letters to her were published in 1873 as *Lettres à une inconnue*. In 1834 he was appointed inspector general of historical monuments and for more than 25 years he carried out this work with untiring zeal. He worked diligently also at his historical studies: *Essai sur la guerre sociale* (1841), *Études sur l'histoire romaine* (two volumes, 1844), *Histoire de Don Pèdre Ier, roi de Castille* (1848). He was elected to the Académie des Inscriptions et Belles Lettres in 1843 and to the Académie Française in 1844.

While in Spain in 1830 he had made the acquaintance of the countess of Montijo, and when her daughter Eugénie became empress of the French (Jan. 23, 1853) Mérimée was made a senator. He was admitted into the royal circle on terms of intimacy but he felt no real sympathy for Napoleon III, though the *Histoire de César*, which the emperor was writing, was something of a bond between them. On the other hand he had an almost paternal affection for the empress, mingled with respectful admiration for her character and beauty. His obligations as a courtier were not allowed to interfere with his work and he wrote a number of articles on historical and literary subjects. He traveled a great deal during his last years, going frequently to London to see Sir Anthony Panizzi (*q.v.*), director of the British museum, the closest friend of his old age; his long series of letters to Panizzi have been described as "Mérimée's history of the Second Empire" (*Lettres à M. Panizzi: 1850–70*, 1881). After 1857 illness compelled him to pass each winter at Cannes; there he had the company of friends and the society of the English colony: two of his mother's friends, Miss Fanny Lagden and Mrs. Ewers, lavished affectionate care upon him. The outbreak of the Franco-German War filled him with distress and he foresaw defeat. He was in Paris when he learned that the empress Eugénie had sought refuge in England and that a republic had been proclaimed, and he returned to Cannes with despair in his heart. He died there on Sept. 23, 1870, and was buried in the English cemetery.

**Works, Style and Personality.**—Mérimée's literary output was more substantial than is often supposed, and includes, as well as plays and short stories, numerous books and articles on history, archaeology and literary criticism. His historical studies on Roman and Spanish history still remain of interest both for their sound scholarship and for their style. His *Histoire de Don Pèdre Ier, roi de Castille*, can, in this respect, be considered a masterpiece. Nor should Mérimée's position as inspector general of historical monuments be forgotten; he had this work much at heart and devoted himself to the study of archaeology. At a period when the roads were often impassable he traveled over almost the whole of France and his numerous and exact observations were published in a series of *Notes de voyage* (five volumes, 1835–40). Between 1845 and 1849 he published an important study on the unusual frescoes in a church in Poitou: *L'Église de St. Savin et ses peintures murales*. There are few French historical monuments which were not saved from ruin or unintelligent restoration by his efforts.

He had a lively enthusiasm for the history and literature of Russia. He started to learn Russian in 1848 and in 1849 began to translate various works of Pushkin, a storyteller whose concise technique seemed to him to have similarities with his own. He wrote two articles and a long study on the false Dimitri (1853) and translated Gogol's *Revizor* (*The Government Inspector*, 1836). The reading of Gogol's *Taras Bulba* initiated him into the life of the Cossacks and gave him the idea of writing several essays about them between 1854 and 1863 (collected in *Cosaques d'autrefois*, 1865). Russian literature was, if not unknown, little understood in France, and Mérimée was its first and principal interpreter.

But it is to his short stories that Mérimée owes his fame and he can be considered as one of the great masters of this particular literary kind. Unlike many of the romantic writers, he never permitted local colour and the picturesque, however appropriate or discreetly employed, to take precedence over the psychological delineation of character. He portrayed love in all its fatal and cruel effects and he admired those passionate and forceful natures that have something inhuman about them and rise above the common run of men. "Mateo Falcone" is the story of a father who kills his son because he has betrayed family honour; "Colomba" portrays a young Corsican girl who forces her brother to commit murder for the sake of vengeance; "Carmen" (upon which the opera by Bizet is based) describes a gypsy girl with whom a young soldier is in love; because of her he becomes a deserter, a murderer and a thief, and finally, driven to despair by her unfaithfulness, he kills her. One of the essential traits of Mérimée's genius was his interest in the exceptional character. He also possesses the power of disconcerting the reader by the art with which, using realistic detail and precise delineation, he establishes the presence of the supernatural and the fantastic, as in "Les Âmes du Purgatoire" and "Vénus d'Ille." Whatever his subject, Mérimée treats it with an extraordinary strength of expression; in a few lines he can construct a full and living portrait. His style has the classic simplicity of Voltaire; he knows how to pick out the significant details, and find the right words to present them.

Mérimée's *Correspondance générale* shows to the full his remarkable talent as a letter-writer. Written with penetration and wit, his letters give a remarkably living picture of the events and manners of his period. They are a revelation too, of his inmost character. He was considered by many to be skeptical and unfeeling but in these letters he reveals himself as a loyal and constant friend, sensitive, kind, sometimes tender, behind a façade of irony, skepticism and detachment. In his letters, as in his work as a whole, Mérimée remains, among the French writers of his age, the one least affected by the passing of time, and this is due to the sobriety and restraint he brought to the shaping of his stories. His work was a renewal of classicism in a romantic age.

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**MERINA,** the name applied to the inhabitants, sometimes called Hova, of the central part (Imerina) of the interior plateau of Madagascar. Strictly speaking, the term Hova designates the Merina caste of freemen, as distinct from the castes of former nobles (Andriana), serfs (Mainty) and slaves (Andevo). The Andriana are thought to have migrated from Indonesia more recently than other Indonesian elements of the population, being lighter in skin colour and more Malayan in appearance, differences preserved through caste endogamy. Originally organized in a group of small independent kingdoms, each ruled from a hilltop fortress, and often at war among themselves, the Merina achieved lasting political unity under the ruler Andrianampoinimerina (1787–1810), and in the reign of Radama I (1810–28) subjugated over two-thirds of the island. Later rulers claimed the whole of Madagascar as their domain, a claim not generally recognized by foreign powers. Antananarivo (*q.v.*), the present capital of the Malagasy Republic, was first established by Merina rulers as their seat of government. This royalty was abolished by Gen. J. S. Galliéni in the French conquest of Imerina, the last queen, Ranavalona III, being exiled in 1897. Merina population in the 1960s was about 1,200,000.

*See* also MALAGASY REPUBLIC.

*See* A. Dandousu and G. S. Chapus, *Histoire des Populations de Madagascar* (1952); D. Attenborough, *Bridge to the Past: Animals and Peoples of Madagascar* (1962). (R. F. G.)

**MERING, JOSEPH VON,** BARON (1849–1908), German physician, physiologist, pharmacologist and experimental pathologist who did important pioneer work in the control of diabetes and the development of barbiturates, was born in Cologne, Feb. 28, 1849, the son of Baron Friedrich Everhard von Mering. His early medical career was spent in Strasbourg, where he engaged in private medical practice, laboratory research, teaching clinical medicine, forensic medicine and laryngology. In 1890 he moved to Halle, where in 1900 he became director of the medical clinic. He served in that position with distinction until his death on Jan. 5, 1908.

Von Mering was a pioneer investigator in many fields. He was noted for the discovery of phlorizin diabetes, the experimental production of diabetes by removal of the pancreas, his studies on gastrointestinal physiology and the introduction of new sedative and hypnotic drugs; among the latter was barbital, developed in collaboration with Emil Fischer.

The experimental production of pancreatic diabetes (shared with Oskar Minkowski) must be ranked among his greatest achievements since it became a landmark in the modern investigation of diabetes mellitus leading, in 1921, to the discovery of an extract of pancreas, insulin, as a remedy for the condition. (F. N. A.)

**MERINO:** *see* SHEEP; WOOL.

**MERIONETH** (SIR FEIRIONYDD), a county of north Wales bounded north by Caernarvonshire and Denbighshire, east by Denbighshire and Montgomeryshire, southeast by Montgomeryshire, south by the Dovey estuary, dividing it from Cardigan, and west by Cardigan bay. It is nearly triangular, its greatest length from northeast to southwest being about 45 mi. and its greatest breadth about 30 mi. Area 660.2 sq.mi. Merioneth is situated in the Snowdonia National park (64% of the park being in the county) and has been described as a paradise for botanists and geologists. In the mid-1960s there were more than 2,500 ac. owned by the National trust or under its protection. There were four national nature reserves including the area round Cader Idris.

**Physical Features.**—The outstanding geological feature is the Harlech dome, a mountain tract about 15 mi. from north to south by 10 mi. from east to west from the coast inland. It is roughly oval, with Barmouth and Dolgellau, Harlech and Maentwrog around its edges. It is of Cambrian age and composed of grits, quartzites and slates, forming a large anticline. Its central portion is occupied mainly by Harlech grits and Menevian beds.

Round the dome on the north, east and south, from Towyn to Caernarvonshire, great volcanic masses, mostly greenstone, stand out in a sweeping curve. This belt of high ground surrounding the dome includes Rhobell Fawr (2,408 ft.), composed of andesitic rock, while in the Arenig beds are the rugged heights of Cader Idris (*q.v.*), Aran Fawddwy (2,970 ft.) and Arenig Fawr (2,800 ft.). The rough grits of the Harlech dome are separated from the grits and lavas farther east by the valley of the Eden and Mawddach. South of Rhobell Fawr the great ring of volcanic mountains is broken across by the deep, straight Bala cleft—one of the sharpest geological fault lines in Britain. The great fault line has many branches; the Mawddach estuary line, with its fine sands, represents a section which has sunk seaward. Here and there along the eastern boundary of the county, Llandovery and Wenlock strata are included. In the Berwyn mountains the Ordovician rocks again appear with associated andesitic and felsitic lavas and tuffs. West of Llangar, near Corwen, is a small patch of Carboniferous Limestone. Glacial drift with boulder clay is prominent in the valleys and on the mountainsides, while a good deal of blown sand fringes the coast north and south of Harlech. The southern section of the county is bordered in some parts by the river Dyfi (Dovey), which rises in a small lake near Aran Fawddwy, passes Machynlleth and expands into an estuary on Cardigan bay, the origin of which is probably associated with the Llyfnant fault zone of northern Cardiganshire and southern Montgomeryshire.

**History.**—The Ardudwy coast between Barmouth and Harlech seems to have been important in Megalithic times, while finds of flat axes of bronze to the northeast of Bala lake indicate early attempts to reach the coast from what is now known as England by way of the Bala cleft. The finds of gold and Late Bronze Age hoards on the northwest coast near Harlech indicate contact with Ireland. The upper Dee valley as well as other strategic sites in the county have hilltop camps of Romano-British age. A Roman trackway ran from the military site at Pennal, in the south of the county, northward to Tomen y Mur and thence to Segontium (at Caernarvon) and Kanovium (Caerhun) in the north. Somewhere to the east of Dolgellau this trackway was met by another following the Bala cleft from Caergai. Meirionydd is one of the oldest regional names in Wales. Merioneth is its Anglicized form. It represents the territory of Meirion or Meriaun, grandson of Cunedda who conquered northern and western Wales in the 5th century A.D. In the post-Roman centuries, shut off by hills on all sides, Merioneth experienced little Saxon, Scandinavian or early Norman influence. In this respect it bears a striking contrast with the neighbouring county of Montgomery, which had easier connections with England. In Saxon times the county was under the princes of Gwynedd, although some parts of what later became Merioneth were under the princes of Powys. A Norman attempt to enter the county was repulsed in 1096. During the next 300 years there were many battles in the neighbourhood of Corwen, which commanded the entrance to the county via the Bala cleft. There Owain Gwynedd was posted to repel Henry II and Owain Glyndwr (Owen Glendower; *q.v.*) retreated from Corwen before Henry IV. The remoteness of the region made it a gathering ground of the Welsh resistance to the English, and in the county and over its borders, at Dolgellau and Machynlleth, there are traditions of Glyndwr's parliaments. In this sheep-rearing county the Cistercian abbey of Cymmer (Y Fanner), near Dolgellau, was founded about 1200. It was dissolved by Henry VIII, though some interesting ruins remain. The county was still inaccessible in Elizabethan times and its remoteness was mentioned by the Elizabethan writer and poet, Thomas Churchyard (1587). About that time may be traced the beginnings of the slate industry, though it did not come into prominence until the 18th century.

There were quarries in the 19th century at Ffestiniog, Corris, Aberllefenni, Pennal, Abergynolwyn and Arthog, though the depression in the slate industry after 1914 seriously diminished the output. There are records of gold mines in the Mawddach valley from early times, and copper has been mined in the Ardudwy and lead in the Dyfi valleys. The flannel and woolen industries were formerly important in the county. In the 18th century Dolgellau was famous for its production of a Welsh tweed cloth, and at Bala stockings and woolen caps were made.

**Population and Administration.**—The population of the county in 1961 was 39,007. There are no municipal boroughs. The urban districts are: Bala (pop. [1961] 1,603), Barmouth (2,348), Dolgellau (2,267), Ffestiniog (6,677) and Towyn (4,466). There are four rural districts. The shire is in the Wales and Chester circuit and assizes are held at Dolgellau, the county town; the court of quarter sessions is held alternately at Bala and Dolgellau. The county returns one member to parliament and is in the dioceses of St. Asaph and Bangor.

**The Economy.**—The climate varies much with the elevation. The county is mainly a region of pastoral farming, and grain crops cover a small area only; oats and mixed corn are the most important cereal crops. Potatoes and turnips are also grown, but more than half the land area of the county is in rough grazings. While the soil is generally thin, there are fertile tracts in the valleys, and there is some reclaimed land. The chief features of the farming are beef-cattle rearing and sheep farming, and there is some milk production. The county is noted for its hardy Welsh Mountain sheep, and the Welsh Mountain ram from Merioneth is in great demand in other counties. The Welsh Black cattle are noted and are exported to midland pastures. The Forestry commission acquired large areas of rough land for the planting of coniferous trees, and forestry is one of the major industries of the county.

A vast pumped storage hydroelectric plan, the first in the United Kingdom, began operating at Tanygrisiau near Blaenau Ffestiniog in 1961. A nuclear power station began operation at Trawsfynydd in 1963 and the construction of a large reservoir at Tryweryn near Bala was authorized by the Liverpool corporation in 1957.

The railway (Western Region) skirts the coast from Portmadoc to Aberdovey. The coast is almost unnavigable, because of sandbanks; the only havens are Barmouth and Aberdovey.

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**MERKSEM,** a town of Antwerp province, northern Belgium, is separated from the city of Antwerp by the Albert canal and stands on the highway to the western Netherlands. Pop. (1961) 36,098. A simple village with no significant history, Merksem lay between the heathy Campine to the east and the polderland to the west, and was covered at high tide before the Scheldt was dammed. The church of St. Bartholomew (*c.* 1200) was destroyed by a German flying bomb in 1944, but was later rebuilt. There are flour mills, glass factories, foundries, margarine- and other food-processing plants. Merksem was much damaged at the end of World War II. (R. M. An.)

**MERKYS, ANTANAS** (1887–1955), the last prime minister of independent Lithuania, was born at Bajorai, near Skapiskis, in the northeastern part of his country, then part of the Russian empire. After graduating from a secondary school in Riga he studied law at Tartu (Dorpat) and at Kiev. He served in the Russian army and, after 1919, in the Lithuanian army. Having been defense minister four times during the period 1919–27 and governor of Klaipeda (Memel) from 1927 to 1932, he became prime minister of Lithuania on Nov. 21, 1939. After a visit to Moscow on the eve of the occupation of his country by the Soviet forces (June 15, 1940), he was arrested and deported to the U.S.S.R., were he died in 1955. (Ma. G.)

**MERLE D'AUBIGNÉ, JEAN HENRI** (1794–1872), Swiss Protestant minister and historian of the Reformation, was born on Aug. 16, 1794, at Eaux Vives, near Geneva, of parents who were Protestant refugees from France. He studied theology at Geneva where he was influenced by the evangelicalism of Robert Haldane, and was ordained in 1817. He then visited Germany for the celebration at the Wartburg of the German Reformation

and decided to write a history of Luther and his times. He studied in Berlin, being influenced there by the church historian J. A. W. Neander. From 1818 to 1823 he was minister of the French church in Hamburg. In 1824 he became minister of the French church in Brussels and preached at court. After the revolution of 1830 he departed for Geneva and in 1832 was appointed professor of church history in the newly formed theological college there which was supported by the Evangelical alliance. He shared also in the ministry of the Free Evangelical church at Geneva. In 1846 he received, on Neander's recommendation, the degree of doctor of theology of Berlin. He died in Geneva on Oct. 21, 1872.

Merle d'Aubigné wrote several volumes on the history of the Reformation and also shorter books supporting Evangelical Free Church principles. His major work, in two parts, was *Histoire de la Réformation au XVI^e siècle* (1835–53) and *Histoire de la Réformation en Europe au temps de Calvin* (1863–78). This work was translated into English and other languages and renewed interest in the Reformation at a time when this was needed. It shows the influence of Neander by its emphasis on spiritual life, but certain errors, a partisan use of sources and a rhetorical style blur the picture of the period.

*See* J. Bonnet in *Société de l'histoire du protestantisme français*, vol. xxiii (1874). (B. H.)

**MERLIN, ANTOINE CHRISTOPHE** (MERLIN DE THIONVILLE) (1762–1833), an extremist of the French Revolution who tempered his opinions as he grew older, was born in Thionville, in Lorraine, on Sept. 13, 1762. He first studied theology, but eventually became a lawyer (1788). Elected to represent Moselle in the Legislative Assembly (1791), he spoke with great effect against the *émigrés* and was one of the three deputies to join the Cordeliers, then the most radical of the political clubs in Paris. Elected to the Convention in Sept. 1792, he was sent in December *en mission* to Mainz, where the French garrison was expecting to be besieged by the Austro-Prussian forces. With his colleagues there, J. F. Reubell and Nicolas Haussmann, he signed a joint letter to the Convention during Louis XVI's trial: "We are surrounded by the dead and wounded; it is in Louis Capet's name that the tyrants are slaughtering our brothers and we learn that he is still alive!"

When the siege of Mainz began, Merlin showed great courage, notably in servicing a gun on the ramparts. After the garrison was forced to capitulate (July 1793), he went with it to fight the rebels of the Vendée in September. In 1794, however, he joined the opposition against Robespierre and played an important part in the Thermidorian reaction.

Merlin sat in the council of the five hundred from 1795 to 1798 and in the latter year was appointed administrator general of posts. He took no part in public affairs during the consulate. Under the Restoration he was not exiled in 1816 as other regicides were, because he had not formally voted for Louis XVI's death. His comment to J. P. G. Viennet on the July revolution of 1830 shows how his sentiments had changed since 1791: "You have unleashed the tiger, have better luck than we did—find how to muzzle it." Merlin died in Paris on Sept. 14, 1833.

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**MERLIN, PHILIPPE ANTOINE,** COMTE (MERLIN DE DOUAI) (1754–1838), one of the foremost jurists of the French Revolutionary and Napoleonic periods, was born at Arleux, between Douai and Cambrai, on Oct. 30, 1754. An advocate in the *parlement* of Flanders from 1775, he soon became very well informed on matters of law. Deputy for Douai in the Constituent Assembly from 1789, he carried important legislation abolishing feudal and seigniorial rights. In 1791 he became president of the criminal tribunal at Douai. Elected to the Convention by the *département* of Nord in Sept. 1792, he voted for the death sentence at Louis XVI's trial in Jan. 1793. On Sept. 17, 1793, Merlin, as a member of the committee of legislation, presented to the Convention the law for the detention of suspects. After Robespierre's fall (July 1794) he was almost continuously a member of the committee of public safety. He supported the reaction against the Jacobins, but also concerned himself with legislative work. The code of crimes and penalties enacted on Oct. 25, 1795, was largely drafted by Merlin and was sponsored by him in the Convention.

On the inauguration of the Directory (Nov. 1795) Merlin was appointed minister of justice. Two days after the *coup d'état* of 18 Fructidor, he became himself one of the five directors (Sept. 6, 1797). On June 18, 1799, however, he resigned when the legislative chambers were threatening to impeach him.

Merlin returned from Douai to become deputy government commissioner at the supreme court in 1800, commissioner there in 1802 and *procureur général* in 1804. He did more than any other lawyer to fix the interpretation of the Code Napoléon. He was appointed a councilor of state in 1806 and created comte in 1810.

At the first Restoration (1814) Merlin immediately went over to Louis XVIII. He was removed from office, however, in Jan. 1815. During the Hundred Days he resumed his functions, was elected to the chamber of representatives and was appointed minister of state. On the second Restoration he was banished. In exile in the Netherlands or in Belgium he devoted himself to his *Répertoire de jurisprudence* (5th ed., 18 vol., 1827–28) and to his *Recueil alphabétique des questions de droit* (4th ed., 8 vol., 1827–30). Having returned to France on the July revolution of 1830, Merlin died in Paris on Dec. 26, 1838.

*See* L. Gruffy, *La Vie et l'oeuvre juridique de Merlin de Douai* (1934). (C. E. DU.)

**MERLIN,** in Arthurian legend, an enchanter and counselor to Uther Pendragon and his son King Arthur (*q.v.*). Merlin, to whom many political prophecies were ascribed throughout the middle ages, is a fascinating, often enigmatic figure with a strange ancestry, half man, half demon. The name appears as Myrddin in Welsh tradition. With Myrddin there came to be associated a northern legend of Lailoken, a wild man of the woods, gifted with powers of divination. There is an Irish form of the legend, attached to the name Suibne Geilt. There was also a story in the *Historia Britonum* of Nennius (*q.v.*) of a boy Ambrosius, a child without a father, who revealed to the British legendary king, Vortigern, the cause of the nightly disintegration of the fortress he was building against the Saxons. In Geoffrey of Monmouth (*q.v.*), from whose work the Merlin of romance derives, these traditions are combined. In the *Historia regum Britanniae* Ambrosius becomes Merlin-Ambrosius and Geoffrey explains that his father was an incubus. Merlin is adviser to Uther and Arthur, brings Stonehenge over from Ireland and prophesies events to come. In the *Vita Merlini* Geoffrey tells the story of Merlin's madness in the woods and of his divinations. Giraldus Cambrensis (*q.v.*) in his *Itinerarium Cambriae* distinguishes two Merlins: the first, Ambrosius, prophet for Vortigern; the second, Celidonius or Silvester, who lived in a Scottish forest.

Merlin is a somewhat ambiguous figure in Geoffrey and in Wace (*q.v.*), who wrote a free Old French version of Geoffrey's *Historia*, but Robert de Borron transforms him into a character worthy to be a prophet of the Holy Grail in his *Merlin*, of which only the beginning has survived in its original form in verse. He does this by giving an account of his birth which integrates Merlin into the Christian system. According to this the devils had planned to produce an antichrist with a devil as father and a virgin as mother, but their designs were thwarted by the virtue of the mother, and when Merlin was born he was virtuous and endowed by God with the gift of prophecy. In the first part of the 13th-century French prose *Lancelot*, the third branch of the Vulgate cycle of Arthurian romances, Merlin reverts to the Merlin of Wace and an account of his birth is given in which the demonic side of his nature predominates. A tendency toward rationalization lies behind this change for the worse. The author uses Merlin to explain the Lady of the Lake's knowledge of magic; she learns it from him and then imprisons him without losing her own virtue.

Merlin thus becomes the ultimate source for much of the magic in the early part of the prose *Lancelot*. He resumes his role of

prophet of the Grail in the later branches of the Vulgate cycle into which is incorporated an *Estoire Merlin*, containing a prose rendering of Robert de Borron's *Merlin* and a pseudochronicle account of the beginning of Arthur's reign. In this continuation Merlin advises Uther to establish the Round Table and suggests that his true heir will be revealed by the sword-in-the-stone test. It also expands Merlin's role as Arthur's counselor and includes the story of the wizard's infatuation with Nivene which brings about his death when he is imprisoned under a rock. The same legend occurs in the *Huth Merlin* continuation, the form of the Merlin story used by Sir Thomas Malory (*q.v.*) as the basis of his *Morte Darthur* (1485).

Such inconsistencies and fluctuations in the character of Merlin are determined by the requirements of the narrative; they tend to reflect varying attitudes toward magic and represent different stages in the development of Arthurian romance. *See* also ARTHURIAN LEGEND; GRAIL, THE HOLY; LANCELOT.

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(E. M. K.)

**MERLIN** (*Falco columbarius*), a small falcon (*q.v.*) of both old and new worlds, usually called pigeon hawk in America. Its range includes most of Eurasia, Africa, most of North America and some islands. It is migratory over much of its range, in the new world going south as far as Peru.

The merlin is about 10–13 in. long, varying somewhat over its range, the female being larger than the male. The male has slaty upper parts with a wide black band on the distal part of the tail; under parts are buffy, streaked with dark brownish; there are no dark facial stripes; wings are long and pointed. The female is nearer dark brownish above, whitish or creamy below with very heavy streaks of dusky brownish, and the tail has alternating whitish and dark bands (whitish ones narrower). The young during the first summer and winter closely resemble the female. Colours are pale or dilute in populations dwelling in dry areas (as in deserts), darker in humid areas (as in British Columbia).

In forests it uses old nests of other birds, such as crows, or even squirrel nests; in much of its range it lays its eggs on the ground or in a niche in a cliff. A small depression is lined with bits of plant material and there the three to seven (usually four) eggs are laid. Incubation, mostly by the female, requires 28–32 days. The male brings food to a nearby place and the female comes for it, later he feeds both mate and brood till the latter are nearly ready to depart. The young attain flight in 28 days. One brood is reared yearly.

A dashing bird with buoyant flight, the merlin usually flies near the ground or among trees. Most of its food consists of birds up to about starling size (rarely to the size of plover), some insects and numerous small mammals. There are known instances of its capturing the young of several game-bird species. The merlin was once much used in English falconry (*q.v.*). (R. S. PR.)

**MERMAIDS AND MERMEN** were members of a mythical race, half-human, half-fish, who were supposed to inhabit the sea and some inland waters, though they could also live on land. The earliest form of the legend shows them as divine or semi-divine beings, such as the Chaldean sea-god Ea (or Oannes), who had a fish's body and a man's head and feet. The Phoenician god Dagon was also fish-tailed and human-headed, as were the Tritons and Sirens of Greek mythology. A similar conception appears in an Amerindian legend concerning a man-fish by whom the tribal ancestors were led from Asia to America.

In later European folklore, mermaids and mermen were thought to belong to the natural order, though they had certain characteristics suggesting kinship with fairies. Like the latter, they had magical powers and could foretell the future. They loved music and were often heard singing. They had no souls and, though very long-lived, were not immortal. Their bodies were believed to be human above the waist, with a fish's tail below. They could, however, assume complete human shape occasionally, and in some forms of the tradition, they were without tails.

Numerous folktales record marriages between men and mermaids. In most, the man first steals the mermaid's cap or belt, her comb or mirror, and thus gains power over her. As long as these objects remain hidden she lives with him, but if she finds them she returns at once to the sea. In some variants, the marriage lasts while certain agreed conditions are fulfilled and ends when they are broken. The well-known stories of *Mélusine* (*q.v.*) and *The Lady of Llyn y Fan Fach* are examples of this type.

Though sometimes kindly, mermaids and mermen were usually dangerous to man. Their gifts brought misfortune in their train. If offended, they caused floods and other disasters. One seen by sailors on a voyage was a sure omen of shipwreck. They sometimes lured mortals to death by drowning, or enticed young people to live with them underwater, as did the Mermaid of Zennor, Cornwall, whose story is commemorated by a carved bench end in the church.

Belief in the existence of these hybrid beings was widespread and curiously persistent. Claims to have seen them, or heard them singing, have been made in comparatively recent times. In some cases, but not all, faulty observation of seals, dugongs or manatees seen at a distance may account for such claims. The strength of the tradition can also be seen in the frequent appearance of mermaids in church carvings and coats of arms, and in the numerous "mermaid" place names attached to pools, rocks and coves in England and elsewhere.

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(C. S. HE.)

**MERMILLOD, GASPARD** (1824–1892), Swiss bishop of Lausanne and Geneva, cardinal, preacher and formulator of Roman Catholic social doctrine, was born at Carouge, near Geneva, on Sept. 22, 1824. He was ordained in 1847 and worked in Geneva for ten years before establishing the first Roman Catholic parish there since Calvin's time; in the same year, 1857, he was made the vicar-general of the bishop of Lausanne for the canton of Geneva. He was made titular bishop of Hebron and auxiliary for the canton in 1864 and administrator in 1871; the canton protested, and what is known as the Swiss *Kulturkampf* ensued (*see* SWITZERLAND: *History*). Mermillod was forbidden to exercise first his episcopal and then his priestly functions. In 1873 on his appointment as vicar apostolic he was at once expelled from Switzerland. He then administered his vicariate from Ferney, on the French side of the border, until in 1883 he returned as bishop of Lausanne and Geneva, though the latter city only withdrew its objections to him in 1890, when he was made a curial cardinal.

In 1882 Pope Leo XIII made him chairman of a commission of theologians appointed to elaborate Catholic social doctrine; in 1885 he founded the Union Catholique d'Études Sociales et Économiques, and these bodies exercised a major influence on *Rerum Novarum* (1891), the classic encyclical on social questions. Cardinal Mermillod died in Rome on Feb. 23, 1892. His works were published in a three-volume edition in 1893–94.

*See* L. Jeantet, *Le Cardinal Mermillod* (1906).
(M. DR.)

**MERODACH-BALADAN,** the biblical rendering of the name of MARDUK-APLA-IDDINA II (d. 694 B.C.), who became king of Babylonia (721–710; 703–702 B.C.). He was ruler of the Chaldean district of Bit-Yakin, on the shores of the Persian gulf. On the accession of Sargon II of Assyria in 722 B.C. Marduk-apla-iddina entered Babylon and claimed the throne there by taking "the hands of the god Bel." Although Sargon retaliated in the following year by attacking Marduk-apla-iddina's Elamite

allies at Der, the outcome of the battle was indecisive and Marduk-apla-iddina retained his position in Babylon until 710 B.C. His rule was not popular and when Sargon approached, having previously neutralized the Elamites, the leading citizens went out to bring him unopposed into the city. Marduk-apla-iddina fled to Bit-Yakin where the Assyrians left him in control.

It was probably after Sargon's death in 705 B.C., that Marduk-apla-iddina sent an embassy to Hezekiah of Judah (II Kings xx, 12–19; Isa. xxxix) as part of a campaign to raise opposition to Assyria while he worked to regain the throne in Babylon. Help was not given but Marduk-apla-iddina marched on Babylon, deposed a local nominee and established his rule from nearby Borsippa, which was a city better disposed toward him.

Sennacherib marched south late in 702 B.C. and defeated the Babylonians, with their Elamite and Arab allies, in battles at Cuthah and Kish. After Bit-Yakin had been raided again, Marduk-apla-iddina fled to southern Elam where he died in 694 B.C.

See *Cambridge Ancient History*, vol. iii, pp. 45–63 (1925); C. J. Gadd, "An Inscribed Barrel-Cylinder of Marduk-apla-iddina II" in *Iraq*, vol. xv, pp. 123–134 (1953). (D. J. Wi.)

**MEROE,** a ruined city on the east bank of the Nile about 4 mi. N. of Kabushiyah in the Northern province of the Republic of the Sudan. It was the southern administrative centre of the kingdom of Cush, sometimes called Ethiopia (*see* Ethiopia, Ancient), in Nubia, from *c.* 750 B.C. and became the capital of that kingdom *c.* 590 B.C. early in the reign of Aspelta, after the sack of Napata (*q.v.*) by Psamtik II. It was surveyed by Karl Lepsius in 1844. The town site through which the railway passes and the famous sun temple in the plain beyond (described by Herodotus) were excavated by J. Garstang (1909–14) but the results were never fully published. The distant cemeteries and the three groups of pyramids were excavated by G. A. Reisner in 1921–23. The chief features in the town are a riverbank quay, with palaces nearby, the earliest of which was built by Aspelta; and, backing on the east face of the palace enclosure, the great temple of Amon. Nearby are remains of other important buildings. To the north of the later palace is a degenerate copy of a Roman bath (protected by a temporary building); most of the other remains are in a highly ruinous condition owing to the decayed state of the sandstone from which they are built. The quarries from which the stone came are in the hills north and east of the town. On either side of the railway lie a dozen heaps of iron slag, showing that Meroe was once a great ironworking centre. Indeed it is probable that the knowledge of ironworking gradually spread into Africa from Meroe.

A fine bronze head of Augustus now in the British museum and probably raided from Aswan *c.* 24 B.C., in the period of Gaius Petronius' governorship of Egypt, was found under the palace floor, and two great stelae from a temple at Hamdab about 2 mi. S. mention the struggle with the Romans. The best stela is now in the British museum and the other is erected in Meroe itself. Having existed as a town for over 1,000 years, and having been the capital of Cush for about 900 years, Meroe was finally sacked by the Aksumites between A.D. 320 and 350. *See* also Nubia.

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**MEROITIC LANGUAGE AND WRITING.** The Ethiopian kings of Napata, and afterward of Meroe, employed the Egyptian language in hieroglyphic writing for their formal inscriptions and presumably for other records. In Nubia, however, there are monumental records, tombstones, funerary altars, and graffiti, dating from the first century B.C. to near the end of the third century A.D. inscribed in a native language and in a special script which is called Meroitic, since Nubia was then ruled from Meroe.

The same writing is found also on potsherds, and the use of it on prepared skins and writing tablets of wood can be certified from small fragments. For the decoration of temples and other objects the original hieroglyphic (pictorial) forms of the Meroitic writing symbols were employed, but modified hieroglyphic Egyptian was also used for the same purpose.

The symbols of Meroitic writing were modeled on Egyptian, but were employed on an entirely different system. Like Egyptian, the Meroitic writing was from right to left; the signs, unlike Egyptian, face backward. The elaborate Egyptian writing does not express vowels, whereas the simple Meroitic system aimed at recording syllables each consisting of a consonant followed by a vowel.

The Meroitic alphabet consisted of 17 consonantal signs and four rather vague vowel signs together with two syllabics *te* and *tē* or *tō*, making 23 characters in all.

Besides the alphabet there were special symbols for numerals, and perhaps in rare cases resort could be had to special picture signs to symbolize special words. The words were usually separated by double points so that the writing was admirably clear except in regard to the distinction of vowel sounds and the probability that a certain kind of vowel (*a*?) was not marked and had to be surmised from the context.

Meroitic writing was deciphered in 1910 after the discovery of a large number of new inscriptions in lower Nubia and at Meroe; the language, however, is still almost entirely a sealed book, though names of persons, deities and places, also certain titles borrowed from Egyptian and Meroitic titles which occur in Egyptian demotic, are readily found.

It can only be stated as yet that the Meroitic language shows agglutinative formation, absence of gender and some degree of connection with Nubian. *See* also Nubia.

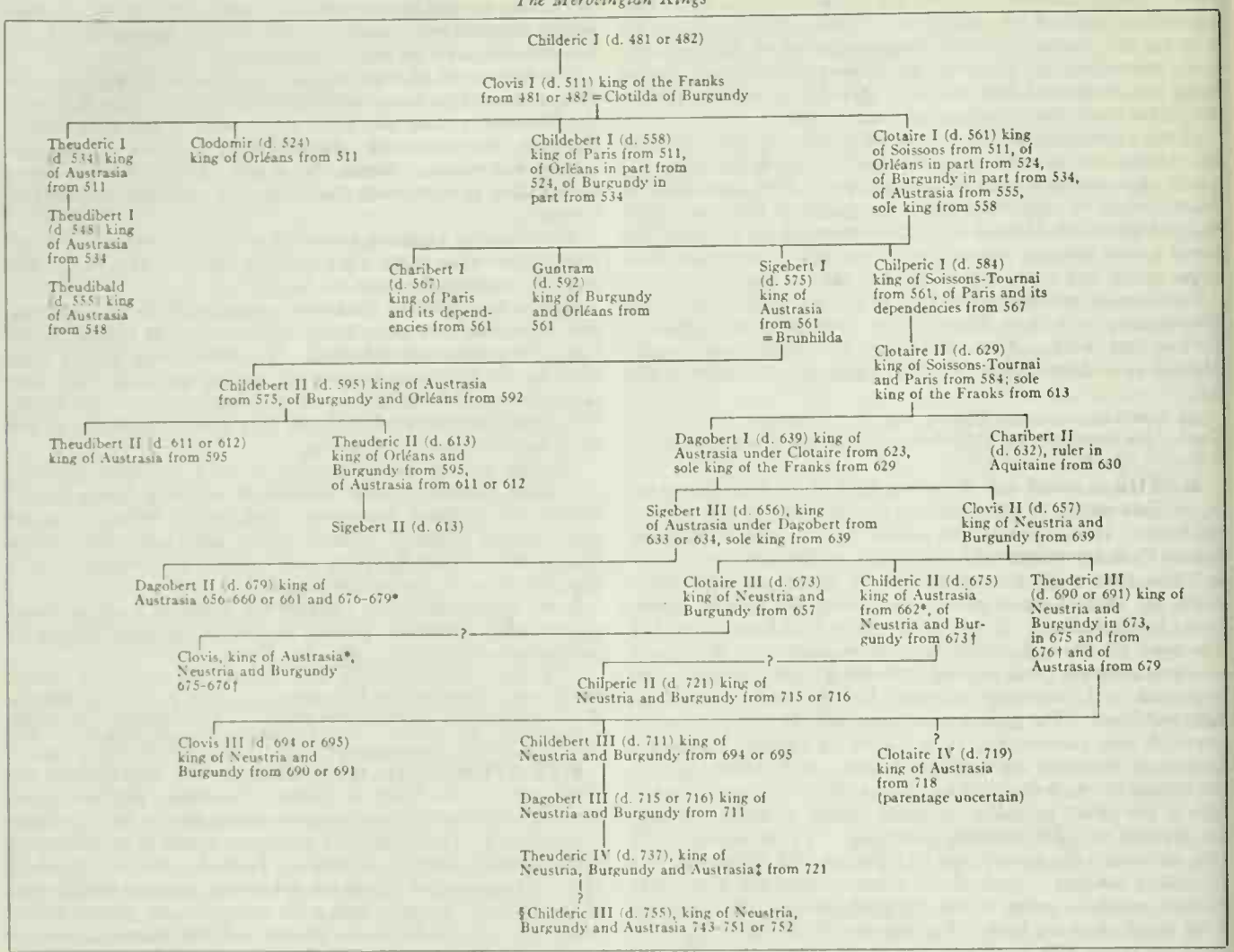
*See* F. Ll. Griffith, *Karanòg, The Meroitic Inscriptions of Shablûl and Karanòg* (University of Pennsylvania, Eckley B. Coxe, Jr., Expedition to Nubia, vol. vi, 1911) and articles in *The Journal of Egyptian Archaeology;* E. Zylharz, "Das meroïtische Sprachproblem" in *Anthropos*, xxv, with bibliography (1930). (F. Ll. G.; C. T. He.)

**MEROVINGIANS,** the Frankish dynasty reckoned as the "first race" of the kings of France. It derives its name from Merovech, of whom nothing is known except that he was the father of Childeric I. This Childeric I ruled over a tribe of Salian Franks (*see* Franks) with his capital at Tournai. His son Clovis I (*q.v.*), who succeeded him in A.D. 481 or 482, founded the fortunes of the dynasty, bringing under his rule not only all the Salian tribes but also the Ripuarian Franks and the Alamanni and extending his dominions to the Loire river by his victory over Syagrius and to the Pyrenees by his victory over the Visigothic king Alaric II (507). Clovis' conversion from paganism to Catholic Christianity served to promote a fusion between the Franks and the Gallo-Roman population of the conquered territory and so assured the survival of his achievement (the Visigoths had been Arians ruling over Catholic Gaul).

Though the dominions of Clovis were partitioned among his sons at his death (511) Frankish expansion went on with the conquest of Burgundy (534). Temporarily reunited under Clotaire I from 558, the *regnum Francorum*—that is, the Merovingian territory in its entirety—was partitioned again in 561. There followed half a century of rivalry and bloodshed fomented by the queens Fredegund and Brunhilda (*qq.v.*) till unity was restored under Clotaire II in 613. For the principal kingdoms into which France was divided under the Merovingians *see* Austrasia; Burgundy; Neustria. Dagobert I, who became sole king in 629, restored the prestige of the kingship by subduing the magnates and by withstanding the pressure of the Slavs in Germany.

On Dagobert's death (639) the *regnum Francorum* was again divided (by arrangements made in 633 or 634), and in the period following his death the Carolingians (*q.v.*), whose ancestor Pepin of Landen had previously been mayor of the palace in Austrasia, came to assert their control over the Austrasian kings (*see* Mayor of the Palace). The Carolingian Pepin II (of Herstal) defeated the Neustrians at Tertry in 687, and thenceforward the Merovingian kings were merely puppets of the Carolingian mayors, who appointed or deposed them as they thought fit. Finally, in the winter of 751–752, the last Merovingian king, Childeric III, was deposed and the Carolingian Pepin the Short had himself elected king of the Franks in his place.

*The Merovingian Kings*




*Dagobert II was deposed in 660 or 661 by the Carolingian Grimoald, who set up as king of Austrasia his own son Childebert, whom Sigebert III had adopted before Dagobert's birth, but this Childebert reigned for a few months only; then, after an interval during which Clotaire III may have claimed the kingdom, Austrasia passed in 662 to Childeric II, who was succeeded for a very short time (675–676) by Clovis, the supposed son of Clotaire III, before Dagobert II's restoration. †Theuderic III succeeded Clotaire III in Neustria-Burgundy in 673, was deposed in favour of Childeric II, was restored in 675, then was momentarily replaced by Clovis the supposed son of Clotaire III but finally recovered Neustria-Burgundy in 676. ‡Between Theuderic III's death (690 or 691) and 721 there were no kings of Austrasia, except briefly Clotaire IV, but only Carolingian mayors. §Childeric III may have been a son of Chilperic II; from Theuderic IV's death (737) to Childeric III's accession (743) there was no king of the Franks.

The table shows the genealogy of the Merovingian kings. Numerous princes who never came to the throne are omitted.

(C.-E. P.)

**MERRIAM, CLINTON HART** (1855–1942), U.S. biologist, who first described many genera and species of North American mammals and plants, was born in New York on Dec. 5, 1855, and was educated at Yale and Columbia universities. In 1872 he accompanied the Hayden geological surveys in Utah, Idaho, Montana and Wyoming as naturalist; in 1875 he was assistant to the U.S. fish commission at Woods Hole, Mass.; in 1876 he collected marine invertebrates in the Bay of Fundy; in 1881 he visited the Bermudas; in 1881 and 1882 he studied the life of the St. Lawrence river; and in 1883 he sailed to the arctic seal fisheries as surgeon on the ship "Proteus." In 1885 he took charge of the newly established division of ornithology and mammalogy in the U.S. department of agriculture, later called the U.S. biological survey, in 1896. He had charge of the Death valley expedition in 1890–91 and served as Bering sea commissioner to investigate seal fisheries off the Pribilof Islands in 1891.

In 1910 he became a research associate of the Smithsonian institution and conducted biological and ethnological investigations under the E. H. Harriman trust fund until 1939. He was also chairman of the U.S. geographic board, 1917–25. In later years he devoted himself to the distribution, linguistics and mythology of Pacific coast Indians. Merriam published a number of books and some 400 scientific papers. He died March 19, 1942.

**MERRILL, ELMER DREW** (1876–1956), U.S. botanist, authority on the classification of Asiatic and Philippine plants, was born in East Auburn, Me., Oct. 15, 1876. His principal positions were, successively, director of the Philippine bureau of science (1919–23); dean of the college of agriculture of the University of California (1923–29); director of the New York Botanical garden (1930–35); and, finally, Arnold professor of botany (1935–48) and director of the Arnold arboretum (1935–46) of Harvard university. He published numerous articles in the field of systematic botany, mostly concerned with plants of southeastern Asia and the western Pacific islands. Merrill's larger works are: *A Flora of Manila; Enumeration of Philippine Flowering Plants; Index Rafinesquianus; Plant Life of the Pacific World; The Botany of Cook's Voyages;* and *Bibliography of Eastern Asiatic Botany* (with E. H. Walker).

(R. C. R.)

**MERRILL, FRANK DOW** (1903–1955), U.S. army officer, leader of the specially trained jungle fighters known as "Merrill's Marauders" in Burma during World War II, was born at Hopkinton, Mass., on Dec. 4, 1903. He enlisted in the regular army and graduated from the U.S. military academy in 1929. Assigned to the U.S. embassy in Tokyo in 1938 and to the China-Burma-India theatre in 1941, he eventually became operations officer for Gen. Joseph W. Stilwell (*q.v.*). To retake north Burma from the Japanese, Merrill organized and led a regimental-sized group of Ameri-

can volunteers brought to India for training in guerrilla tactics. The Marauders in Feb. 1944 left Ledo, in Assam, and marched several hundred miles through mountainous Burmese jungle to outflank the enemy, harass his lines of communication and defeat him in a series of sharp engagements. Undernourished, fever-ridden and near exhaustion, the Marauders climaxed their campaign in May by capturing, with the aid of Chinese reinforcements, the Myitkyina airfield. The city fell in August, making possible the extension of the Ledo road from India to a juncture with the Burma road into China and thereby providing an overland supply route to supplement the air route over the so-called Hump.

After duty as deputy commander of U.S. forces in the India-Burma theatre, Merrill in 1945 served as chief of staff of the 10th army, Okinawa. In 1947 he was with the U.S. military advisory group to the Republic of the Philippines. He retired from the army in 1948 as a major general and died on Dec. 11, 1955, at Fernandina Beach, Fla. (MN. BN.)

**MERRIMACK,** a river formed in the White mountains of central New Hampshire, U.S., by the confluence of the Pemigewasset river, which originates in Profile lake in Franconia Notch State reservation, and the Winnipesaukee, which flows from Lake Winnepesaukee, New Hampshire's largest lake. The Merrimack flows south through the cities of Concord, Manchester and Nashua in New Hampshire before crossing the state line into Massachusetts where it turns northeast at Lowell and continues past Haverhill to its mouth on the Atlantic ocean near Newburyport. Of its total length of 110 mi., the lower 22 mi. of the Merrimack are tidal.

The cities along its banks used the water power of the Merrimack to produce a large portion of the cotton and woolen textiles and hosiery of New England from about 1850 to the 1930s. These industries were still active in the second half of the 20th century, but the boot and shoe industry, plus miscellaneous industries characteristic of New England, employed a majority of the workers. The Merrimack valley is the central artery for tourist travel to many vacation centres in New Hampshire. (A. S. CN.)

**MERRIMAN, HENRY SETON** (pen name of HUGH STOWELL SCOTT) (1862–1903), English novelist, known for his adventure stories, was born on May 9, 1862, at Newcastle upon Tyne, and educated at Loretto school, Musselburgh, and in Vevey, Switz., and Wiesbaden, Ger. His literary career began in 1888 with *Young Mistley*, and he made his first decided hit with his Russian story, *The Sowers* (1896), which was followed by many other well-constructed novels about other nationalities. He was an enthusiastic traveler, many of his journeys being undertaken with his friend Stanley Weyman. He died at Melton, near Ipswich, on Nov. 19, 1903.

Among his most successful books were *Flotsam* (1896), *In Kedar's Tents* (1897), *Roden's Corner* (1898), *The Velvet Glove* (1901), *The Vultures* (1902), *Barlasch of the Guard* (1903) and *The Last Hope* (1904). (R. L. GR.)

**MERRIMAN, JOHN XAVIER** (1841–1926), South African statesman who played a major part in creating the Union of South Africa, was born in England on March 15, 1841, at Street, Somerset, the son of a clergyman who afterward became bishop of Grahamstown, Cape Colony. His family moved to South Africa in 1849 and he was educated at the Diocesan college, Rondebosch, and Radley college, England, returning to the Cape in 1861. He was at various times a land surveyor, a diamond dealer, a wine merchant, a mine estate manager and a farmer; but from 1869 until 1910 he was a member of the Cape house of assembly and primarily a politician. He quickly made his mark in parliament and served in the ministries of Sir John Molteno (1875–78) and Sir Thomas Scanlen (1881–84). In 1890 he joined Cecil Rhodes's first ministry, believing in its policy of Anglo-Boer co-operation, but three years later he resigned; and after the Jameson raid he became a bitter opponent of Rhodes, of the diamond and gold-mining corporations, and of British imperialism. He joined W. P. Schreiner's ministry in 1898, but resigned in 1900 rather than acquiesce in a treason bill aimed at the Cape rebels. He then spoke on pro-Boer platforms in England and in 1902 thundered against Sir Alfred Milner's attempt to suspend the Cape constitution.

From its foundation in 1903, Merriman was the natural leader of the South African party, which included both the Afrikaner Bondsmen and English-speaking anti-imperialists like himself; and he became prime minister of the Cape Colony when the South African party defeated Jameson's Unionist (Conservative) party at the polls in 1908. Taking the treasury portfolio himself, he devoted much of his energy to stabilizing the colonial finances by an unpopular policy of retrenchment and new taxation. It was largely due to him that the constitution of the Union became unitary and for the most part flexible. He was disappointed when the premiership of the Union went to Louis Botha and declined to serve in his cabinet. But he supported the governments of Botha and J. C. Smuts as a member of the Union parliament until 1924, and during World War I his sympathies were alienated from Afrikaner nationalism. He died at his farm, Schoongezicht, near Stellenbosch, on Aug. 1, 1926. A stirring orator and strict Gladstonian financier, Merriman was also a man of strong convictions and great political courage.

*See* also SOUTH AFRICA, REPUBLIC OF: *History*. (L. M. T.)

**MERSEBURG,** a town of Germany in the *Bezirk* (district) of Halle, which following the partition of the nation after World War II became part of the German Democratic Republic. It lies about 12 mi. S. of Halle city and 19 mi. W. of Leipzig on the left bank of the Saale river and is linked to Magdeburg and Erfurt by rail. Pop. (1961 est.) 49,153. It was founded about 800 as a frontier fortress against the Slavs, and was a favourite residence of Henry I the "Fowler" (d. 936), Otto I and Henry II. From 968 until the Reformation it was the seat of a bishop and it received its municipal charter in 1188. Merseburg passed to the electorate of Saxony in 1561 and was captured by the Swedes during the Thirty Years' War. From 1657 to 1738 it was the residence of the dukes of Saxony-Merseburg. There is an imposing castle (dating from the 15th century) and a 13th-century cathedral (restored 1883–86).

Industries include tanning, brewing and the manufacture of cellulose; there are also various engineering plants in the town. Adjoining Merseburg to the north is its industrial satellite Schkopau, with a large chemical works (producing mainly carbide and synthetic rubber) and a large power plant. On the southern edge of Merseburg is Leuna, with the country's largest enterprise, a nationally owned chemical complex in which a wide variety of synthetic products are produced from locally mined lignite. There is a technical college of chemistry in Merseburg. The town and its satellites were severely damaged in World War II.

**MERSEN, TREATY OF,** the treaty signed in Aug. 870, at Mersen or Meerssen, 4 mi. N.E. of Maastricht in the Netherlands, between the West Frankish king Charles the Bald and his half brother the East Frankish king Louis the German for the partition of Lotharingia (*see* CAROLINGIANS; LORRAINE). It first reduced the Frankish dominions north of the Alps and the Rhône from a tripartite division to that bipartite division, namely between France and Germany, which was to last for more than 1,000 years, though the detail of the treaty's arbitrary provisions was soon superseded. The treaty's frontier assigned Frisia to Louis, then ran southward, giving Liège, Verdun and Toul to Charles, and Aachen, Cologne, Trier and Metz to Louis; swung westward south of Toul, then eastward, to give Besançon to Charles; then turned sharply westward again before crossing the Jura to the borders of the disputed kingdom of Provence.

**MERSENNE, MARIN** (1588–1648), French mathematician and theologian, the closest friend of Descartes and the savant in whom, according to Thomas Hobbes, "there was more than in all the universities together," was born near Oizé in Maine on Sept. 8, 1588. He was a fellow pupil of Descartes at La Flèche. Having joined the Minim friars (1611), he settled in 1620 at the convent of L'Annonciade in Paris.

For many years Mersenne acted as intermediary between Descartes and other philosophers. It was he who collected the various "objections" appended, with Descartes' "replies" to them, to the 2nd edition of the *Meditations* (1642); and he also secured criticisms of the *Dioptric*. His own *Quaestiones in Genesim* (1623) included an attack on Robert Fludd (*q.v.*); when Fludd retorted,

Mersenne was supported by Pierre Gassendi. Further books were *L'Impiété des déistes* (1624); *La Vérité dans les sciences* (1625); *Harmonie universelle* (1636–37), on music and musical instruments; and a number of works on mathematics and on the physical sciences. For "Mersenne numbers" *see* NUMBERS, THEORY OF. In geometry his name is particularly associated with research on cycloid curves. He died in Paris on Sept. 1, 1648.

*See* his *Correspondence*, ed. by Mme Paul Tannery, Cornélis de Waard and R. Pintard (1932 *et seq.*). (S. V. K.)

**MERSEY,** a river formed at Stockport, Eng., by the junction of the Goyt and Tame, which rise near Buxton and northeast of Oldham, at 1,600 and 1,700 ft. respectively. They and their tributaries thus drain a considerable area of the western side of the Derbyshire Pennines, but the Mersey itself lies entirely below 150 ft. and traverses the Lancashire-Cheshire plain. It rounds the southern side of Manchester, between Cheadle, Gatley and Sale on the south and Didsbury, Stretford and Urmston on the north. At Flixton and Irlam the modified course of the river has been used to form part of the Manchester Ship canal, so that from this point to 5 mi. E. of Warrington it is entirely artificial. When the river Bollin joins the canal north of Lymm, surplus water is allowed to flow by the old course as a meandering river. It passes through Warrington, below which it becomes tidal and rapidly widens. The inner Mersey estuary forms a great cistern of about 30 sq.mi. between Widnes and Liverpool. This fills and empties twice a day with the flow and ebb of the tide, and so produces a rapid current of water in the narrows between Liverpool and Birkenhead, thus obviating the necessity for dredging, except near one or two dock entrances and near the entrance of the ship canal. After a course of about 70 mi. (taken from the confluence of the Goyt and Tame to the seaward end of the Bootle docks and including the meanders and the artificial portion which forms part of the ship canal) the river debouches into the southeastern corner of the Irish sea, which is occupied by large areas of sand banks, covered at high water, and through which the shipping channel is maintained to a sufficient depth by the same tidal stream.

The principal tributary of the Mersey on the north side is the Irwell (passing through Bury) with its tributaries the Croal (through Bolton) and the Roch (through Rochdale). The Weaver, draining most of mid-Cheshire, enters the inner estuary just below Runcorn.

Queensway, the road tunnel under the Mersey that connects Liverpool and Birkenhead, was begun in 1925 and opened to traffic in 1934; the railway tunnel was completed in 1886 (*see* BIRKENHEAD; TUNNEL). For Mersey docks and harbour *see* LIVERPOOL. (R. K. GR.)

**MERSIN,** a Turkish Mediterranean seaport and capital of Içel *il* (province), situated at the extreme western end of the Cilician plain, 16 mi. W.S.W. of Tarsus and 40 mi. W.S.W. of Adana. Pop. (1960) 68,485. The modern port, constructed in the 1960s, is an outlet for the agricultural produce and minerals of Cilicia.

Mersin itself is of no great antiquity, having replaced the Roman harbour town of Soli-Pompeiopolis, the ruins of which lie immediately to the west. British excavations undertaken after 1937 in a mound called Yümük Tepe on the western outskirts of Mersin indicate primitive settlements in the remote Neolithic period; a village was fortified as early as 3600 B.C. and again at the time of the Hittite empire in the Late Bronze Age, when it must have fallen within the territory of Kizzuwatna (*see* CILICIA). The settlement deteriorated during the Greek period and ceased to be occupied after the foundation of Pompeiopolis.

*See* J. Garstang, *Prehistoric Mersin* (1953). (S. H. LL.)

**MERTHYR TYDFIL** (MERTHYR TUDFUL), a county and parliamentary borough of Glamorgan, Wales, situated on the Taff river, 24 mi. N.N.W. of Cardiff by road. Pop. (1961) 59,039. It was named after St. Tydfil, a 5th-century Christian princess slain by raiding Picts. At Penydarren park are remains of a Roman fort. The borough stretches about 10 mi. down Taff vale, the main centres of population being Merthyr, Penydarren and Dowlais (north) and Treharris (south). Situated on the northern edge of the south Wales coalfield, Merthyr Tydfil is a product of the industrial revolution with narrow, irregular streets interspersed with spoil-tips and slag-heaps. There are no buildings of architectural interest. Iron resources in the area led to four ironworks (Dowlais, Cyfarthfa, Penydarren and Pentrebach) being established between 1757 and 1783. A furnace for smelting iron ore, started in 1759, later provided the Guest family with their first introduction to ironmastership. Export of iron to America began about 1780. By 1845 the ironworks, with 18 blast furnaces, were the largest in the world. The first steel rails made by the Bessemer process were rolled there in 1856. The production of iron led to the mining of local coal for smelting.

In the late 18th century the Glamorganshire canal was built to transport iron from Merthyr to Cardiff. The first steam locomotive, built by Richard Trevithick, hauled a load of iron from Merthyr to Abercynon. I. K. Brunel built the railway from Merthyr to Cardiff in 1841.

The trade depression of the 1920s–1930s caused the huge Dowlais steel works to close in 1930 (though the foundry and other parts continued operating). Many collieries also stopped work and by 1932 more than 50% of the working population was unemployed. The area became dependent mainly on the collieries of Treharris which, together with those at Merthyr Vale, were the only deep mines being worked in the mid-1960s. Before World War II the introduction of new light industries was begun; these eventually included engineering, joinery and the manufacture of chemicals, stockings (on the site of the old Dowlais ironworks) and washing machines. Cyfarthfa castle (1825), which has a fine park (160 ac.), houses the museum, art gallery and a grammar school. The town has a technical institute and a college of further education. Merthyr Tydfil became a county borough in 1908.

**MERTON,** one of the 32 London boroughs that came into existence on April 1, 1965, under the provisions of the London Government Act 1963 which reorganized local government in the metropolis and the area around it. These 32 London boroughs constitute Greater London (*see* LONDON). Merton, in the south, is composed of areas that were previously in Surrey: the former municipal boroughs of Wimbledon and Mitcham, and the former urban district of Merton and Morden. *See* MERTON AND MORDEN; MITCHAM; WIMBLEDON.

**MERTON AND MORDEN,** an urban district of Surrey, Eng., which under the London Government Act 1963 was amalgamated on April 1, 1965, with the Surrey boroughs of Mitcham and Wimbledon to form the new London borough of Merton (*see* LONDON). The urban district (1911) is a residential area with some light industries 10 mi. S.S.W. of Charing Cross. Pop. (1961) 68,011. Area 5.1 sq.mi. Merton and Morden is a parliamentary constituency. Merton parish church (12th century) contains a seat used by Lord Nelson when he lived at Merton place (now demolished). At Merton priory, once a rich Augustinian house, Thomas Becket and Walter de Merton, founder of Merton college, Oxford, were educated. The John Innes Horticultural institution was moved from Merton to Bayfordbury, Hertfordshire, in 1949. Morden hall, with the deer park crossed by the river Wandle and the bird sanctuary, was left to the National trust in 1942.

**MERULO, CLAUDIO** (1533–1604), Italian composer, organist and music publisher, was born at Correggio in 1533. In his early 20s he was organist of Brescia cathedral; he became second organist of St. Mark's, Venice, in 1557 and first organist in 1566. In 1584 he left Venice and two years later was appointed court organist at Parma, where he remained until his death in 1604.

Merulo's most important compositions, all written for the organ, include three books each of *ricercari* and canzonas and two books of toccatas. The toccatas present an alternation of florid improvisatory sections and slow-moving fugal passages. Merulo developed a brilliant style of organ playing and was the outstanding keyboard virtuoso of the generation preceding G. Frescobaldi.

(H. J. DN.)

**MERV,** an ancient city of central Asia, situated in the oasis formed by the branches of the Murgab river, about 17 mi. E. of the modern town of Mary (*q.v.*) in the Turkmen Soviet Socialist Republic of the Soviet Union. As Mouru it is mentioned

in the *Avesta;* and in cuneiform inscriptions it appears as Margu, the seat of a satrapy of the Achaemenid empire, whence the name Margiana was passed on to the province of the successive Seleucid, Parthian and Sassanid kingdoms (*see* IRAN). It was in Margiana that the Parthians settled many of their Roman prisoners after the battle of Carrhae (53 B.C.). Under the later Sassanids, Merv was the residence of the *marzuban* or "warden of the marches," as well as the seat of a Christian archbishop.

The Arabs conquered the oasis in A.D. 651, rebuilt the city slightly to the west of the original site and made it the capital of Khurasan. Using Merv as his base, Qutaiba ibn Muslim, early in the 8th century, conquered Balkh, Bukhara, Ferghana and Kashgaria; and later Muslim leaders penetrated into China. The Abbasid movement began in Merv in the 8th century (*see* CALIPHATE).

Under the Abbasid caliphs Merv was one of the great centres of Islamic learning. In the 11th century the Seljuk Turks took the oasis, and Sultan Sanjar (1118–57) made Merv his capital. Under the able rulers of this dynasty Merv attained the zenith of its glory, though a temporary setback occurred in 1153, when the Ghuzz Turks overran the oasis.

In 1221 the Mongols conquered the oasis, destroyed the town and demolished the dam on which all the irrigation depended. In 1409 the Timurid ruler Shahrukh repaired the dam and built a new city immediately south of the ruins of the old town, but it never prospered as its predecessor had. Shah Ismail, the first Safavid ruler of Persia, annexed Merv in 1510, but neither he nor his successors could prevent raids by the Uzbeks from beyond the Oxus (Amu Darya). In 1787 Shah Murad of Bukhara conquered the oasis, destroyed the dam again and dispersed the inhabitants. Early in the 19th century Merv came under the rule of Khiva, but the Tekke Turkmens drove the Khivans out in 1856 and remained supreme until the Russians occupied the oasis in 1884.

The principal monuments are the mausoleums of Sultan Sanjar and of Mohammed Khanapeh (1112); medieval walls and castles; and the mosque and mausoleum of Talkhatan Baba (*c.* 11th century).

BIBLIOGRAPHY.—E. O'Donovan, *The Merv Oasis* (1882); V. A. Zhukovski, *Razvaliny starogo Merva* (1894); G. Le Strange, *Lands of the Eastern Caliphate* (1930). (L. LO.; G. E. WR.)

**MÉRYON, CHARLES** (1821–1868), French etcher, one of the first of the great French artists to use the life of a modern city as the material of expression, was born in Paris on Nov. 24, 1821. His father was an English physician, his mother a French dancer. Méryon's childhood was spent with his mother, but she died when he was still young. He entered the French navy, and in the corvette "Le Rhin" made a voyage around the world. On the coast of New Zealand he made drawings which he employed years afterward as studies for etchings of those regions. Méryon left the navy as a lieutenant. He entered the studio of Bléry, who taught him the technique of etching. Although very poor, Méryon would not ask for assistance from his relatives and earned his living by hack work. For practice he made studies after Dutch etchers, such as Zeeman and Adriaen van de Velde. He then began the series "Eaux-fortes sur Paris," executed from 1850 to 1854, and although Méryon always considered these plates as a set, they were never published as such. Besides these 22 etchings, Méryon produced about 70 others, including all the work of apprenticeship and decline.

Although Méryon was a great master of his medium, he was appreciated by only a few artists and critics. His prints sold for almost nothing. His life was one of great disappointments and terrible hardships; he became subject to hallucinations and shortly after the completion of the Paris series, he was committed to the mental institution at Charenton. A partial cure was effected, but he was returned to the asylum in 1867 and died there in 1868.

The etchings of Méryon complement the poems of Baudelaire, in their similar subject matter and in that both made use of traditional forms, with no innovation other than personal genius, to produce works that remain striking for their originality and modernity. It is evident that architecture must enter largely into any representation of a city, however visionary the representation. Generally speaking, Méryon's figures are incidental, like those of a landscape painter, but sometimes, as in his "La Morgue," they tell the story of the picture, or, as in "La Rue des Mauvais Garçons," with the two women secretly conversing, at least suggest it. In "L'Abside de Notre-Dame," by many considered to be Méryon's masterpiece, how empty would have been the scene, even with its miraculous effects of light and atmosphere, without the few human figures. Perhaps the lesson was learned from Giambattista Piranesi, who brought to life the ruins of Rome and Paestum with a few beggars and vagabonds, but in Méryon's work it is extended into the poetry of a later time.

*See* Loÿs Delteil, *Catalogue raisonné of the Etchings of Charles Méryon,* ed. by H. J. L. Wright (1925); G. Geffroy, *Méryon* (1926), the best and most comprehensive biography of the artist. (H. Es.)

**MERZIFON,** a town in Amasya *il* (province), Turkey, situated 25 mi. N.W. of Amasya town at the foot of the Tavsan Dagi overlooking a plain which is largely devoted to sugar beets, fruit orchards and vineyards. Pop. (1960) 22,096. Protected from the cold northern winds by the mountain ranges of northern Anatolia, the climate is milder than that of the interior. Merzifon, an important handweaving and spinning centre, is famous for its cotton textiles. There is a 15th-century mosque built by Murad II, and the Kara Mustafa Pasa Camii (1666–67) in the centre of the town is a typical example of Ottoman-style provincial architecture. (N. TU.; S. ER.; E. TU.)

**MESA,** a flat-topped tableland with steep sides, common in the Colorado regions of the United States; a butte is similar, but smaller. Both are formed by erosion; during denudation areas of harder rock in a plateau act as flat protective caps for portions of land situated between such places as stream valleys, where erosion is especially active. This results in table mountains or fortress hills. The term is borrowed from Spanish and derives from the Latin *mensa,* "table."

**MESA VERDE NATIONAL PARK,** covering 52,073.62 ac. in the southwestern corner of Colorado, contains the most notable prehistoric cliff dwellings in the United States and also provides some of the most striking scenery to be found in the national parks. From the north end there is a sweeping view of mountains, mesas and river valleys in Colorado, Utah, Arizona and New Mexico. Hundreds of prehistoric pueblo (village) ruins are to be seen on the high tableland and in the rugged canyons that dissect it. The visitor may view there the development of Pueblo culture from subterranean lodges of the 7th and 8th centuries A.D. to the adobe and stone surface pueblos and cliff dwellings which were occupied from the 9th to the 13th centuries, when they were deserted for some unknown reason.

The most striking ruins are the multistoried apartments built under overhanging cliffs. The largest of these is Cliff palace (excavated in 1909) in which 223 rooms can still be counted, including numerous kivas, the circular ceremonial chambers of the Pueblo Indians.

Although early Spanish explorers gave the great mesa its name (meaning "green table"), there is no evidence that they discovered the large cliff dwellings hidden in the many canyons. Small cliff houses in the lower reaches of the canyons were discovered by W. H. Jackson and W. H. Holmes of the Hayden survey in the 1870s. On Dec. 18, 1888, two cowboys, Richard Wetherill and Charles Mason, discovered Cliff palace. In 1891, Gustav Nordenskiöld excavated in the major ruins on the mesa and published a report which is one of the outstanding books on North American archaeology. The national park, which has a museum, camping facilities and overnight accommodations, was established in 1906. *See* also CLIFF DWELLERS; PUEBLO INDIANS; INDIAN, NORTH AMERICAN: *Culture Provinces: The Southwest.* (J. O. BW.)

**MESCAL,** a Mexican brandy distilled from the fermented mash of the roasted crown of any of several cultivated or wild species of large magueys or agaves. (*See* AGAVE.) The crown, cabbagelike in form, consists of a short thick stem with fleshy leaf bases, some root tissue and often the young flower shoot. After this is roasted in stone-lined pits it becomes dark brown and sweet. The roasted material is pounded, water is added, fermentation takes place in this mash and from it the brandy is distilled.

The term mescal is also applied to some large agave plants; the roasted crowns, an important pre-Columbian food (this may be the earliest use of the term); a drink prepared as is the brandy but not distilled; the peyote cactus, *Lophophora williamsii*; and the (mescal) bean of the tree *Sophora secundiflora*. The peyote and the *Sophora* bean are sometimes added to the brandy.

(L. KA.)

**MESDAG, HENDRIK WILLEM** (1831–1915), Dutch marine painter, was born at Groningen on Feb. 23, 1831. He entered the family banking firm of Mesdag, but about 1866, owing to the influence of Jozef Israëls, took up the study of art. His sea pieces became famous and earned him the gold medal of the Paris Salon, among them being "Effet du soir à Scheveningen" (1872); "Après l'Orage" (1895); "Rentrée des bateaux de pêche" (1900); and "Une Soirée sur la plage de Scheveningen" (1911). He presented his fine collection of pictures and *objets d'art* to the nation, and they are housed in the Mesdag museum at The Hague. Mesdag died at The Hague on July 7, 1915.

**MESETA** (Spanish *mesa*, "table") is the tectonic block constituting the main structure of the Iberian peninsula. It extends over 81,000 sq.mi., with an average elevation of 2,300 ft. or more, and comprises the oldest and most complex geological rocks of the peninsula—granites, gneisses and crystalline slates and quartz. Its western slope is gently inclined and forms the regional dip, attracting the major drainage of the peninsula with the river basins of the Douro (Duero), Tagus and Guadiana. The other borders rise abruptly in the folded ranges of the Cantabrians to the north and the Levante mountains to the east. A certain symmetry is provided by the tectonic troughs of the Ebro in the northeast and of the Guadalquivir in the south, overlooked by the ranges of the Iberian cordillera (Sistema Ibérico) and the Sierra Morena respectively. The Meseta is divided by the block mountains of the central cordillera (Sierras of Guadarrama, Gredos, Peña de Francia) into the northern high basin of Old Castile and the lower plateaus to the south of New Castile and Extremadura. There is also contrast in vegetation and economy between the western outcrops of crystalline rocks with poor soils and the eastern plains of Tertiary limestones and marls which form the major agricultural zones. *See* SPAIN: *Physiography*.

(J. M. HO.)

**MESHED** (MASHHAD, "the place of martyrdom"), the capital of Khurasan *ostan* (province) in northeastern Iran, lies at 3,197 ft. in the valley of the Kashaf Rud, a tributary of the Hari Rud, 440 mi. E. of Teheran. Pop. (1956) 241,989. It is a market and trading centre for Khurasan and has large khans (inns) and bazaars. It is also an important political and religious centre, lying on the ancient trade route to Seistan, Afghanistan and central Asia. It is visited annually by more than 100,000 pilgrims. The climate is pleasant and healthful with a maximum winter rainfall. Water is piped to the town from Lake Gilas. The town has modern roads, hospitals, schools, cinemas, libraries and a museum, as well as extensive public parks. It is linked by rail with Teheran and has an airport to the south.

Meshed lies in the centre of one of the richest agricultural regions in Iran; crops produced and marketed include wheat, barley, fruit and sugar beet. The town is the centre of the northern wool trade and manufactures carpets which are exported.

**History.**—The modern town is an offshoot of the ancient city of Tus and owes its importance to the burial place and shrine of the imam Ali Reza, the eighth of the Shi'a imams. Caliph Harun al-Rashid, on his way through Khurasan to suppress a revolt in Transoxania, died suddenly at Sanabad, near Tus, in A.D. 809 and was buried in the garden of the house where he died. In A.D. 819 his son, Caliph al-Ma'mun, visited his father's grave accompanied by his son-in-law, the imam Ali Reza, who died suddenly after eating grapes. He was buried next to Harun, and a mausoleum was raised by Ma'mun over the two graves. The Shi'a (the party of Ali) believe that Ali Reza was poisoned, and they come to worship at his shrine and to execrate that of Harun, who was a Sunni Muslim and not a Shi'a. The influx of pilgrims led to Meshed's replacing Tus (famous as the birthplace of Al-Ghazzali and the poet Firdausi) which never recovered from its destruction by Meram Shah (Miranshah), one of Timur's sons, in 1390.

The greater part of the shrine and other buildings were destroyed in the 9th century, but a new building was re-erected by the sultan Mohammed in 1009. Although severely damaged in the Mongol attack and sack of 1220, part of the sacred buildings escaped and traces of the earlier structure remain. Shahrukh, the son of Timur, did much to beautify the town, and his wife, Queen Gowhar (Gauhar) Shad Khatum, erected the mosque that goes by her name. This building is one of the finest architectural achievements of Iran and is noted for the splendour and colour of its decoration. The 16th and 17th centuries were times of trouble for Meshed and it was sacked by the Turkmen and the Uzbeks. It was restored by Abbas I (1571–1629), who encouraged the pilgrimage and beautified the city. Nadir Shah (1736–47) made it his capital, and added to its buildings a spectacular golden gateway to the shrine and a vast mausoleum for himself. After Nadir's death, Meshed became the capital of a small state controlled by his grandson. In the 19th century Fath Ali Shah, the second Qajar ruler, built the law courts and made further additions to the shrine of Ali Reza. The town has been modernized and improved by the Pahlavi dynasty, with the result that it is one of the largest and most important cities in the country.

*See* A. Upham Pope, *A Survey of Persian Art From Prehistoric Times to the Present* (1938); P. M. Sykes, *History of Persia*, 2 vol. (1939).

(M. V. S.-W.)

**MESMER, FRANZ** (FRIEDRICH) **ANTON** (1734–1815), Austrian mystic and physician, inventor of the method of treatment called after him mesmerism, forerunner of the modern hypnosis (*q.v.*), was born on May 23, 1734, at Iznang, a village near Lake Constance. He studied theology and medicine at the universities of Ingolstadt (Germany) and Vienna. His interest in the teachings of Paracelsus caused Mesmer to believe that the stars influence the health and general condition of human beings by way of a subtle and invisible fluid. He became convinced that there was a healing and magnetic power in his own hands, and in 1775 he first called this force emanating from his body "animal magnetism" which, he believed, permeated the universe.

Mesmer had striking successes especially with hysterical patients, but he consistently believed and emphasized that his remarkable cures were entirely natural phenomena. Conventional medical men in Vienna, however, accused him of practising magic, and in 1778 he was finally ordered to leave Austria. He then settled in Paris. His popularity continued for several years, but doctors called Mesmer an impostor and a charlatan, and in 1784 the French government appointed a commission of physicians and scientists to investigate his activities. Benjamin Franklin was a member of this commission, which reported that Mesmer had indeed effected many cures but attributed them not to animal magnetism but to some as yet unknown physiological causes. The report as a whole was unsympathetic to Mesmer; he lost his flourishing practice and retired to private life in Versailles.

He lived for a time in Switzerland, but early in 1814 he moved to a village near his native Iznang. He died in 1815.

Mesmer's faith in his own cures was undoubtedly sincere. He himself never grasped the psychological and physiological implications of his treatment by animal magnetism and could not foresee the therapeutic benefits to be derived by later generations from suggestion or hypnosis.

(M. GO.)

**MESOLITHIC.** The concept of a Mesolithic period in European prehistory was first proposed by archaeologists to fill the gap between the Paleolithic, with its chipped stone tools, and the Neolithic, which had polished stone tools. The varied tool kits assigned to the Mesolithic are based on chipped stone, often including characteristic microlithic elements which occurred only rarely in Upper (late) Paleolithic contexts. In some Mesolithic assemblages, however, pecked or polished stone tools also occur. In addition a variety of antler, bone and wooden equipment such as harpoons, hafts, fish spears, dug-out canoes, bows, arrows and other implements for hunting, fowling and fishing are found.

In northwestern Europe, the type locality, the Mesolithic began with the retreat of the fourth European glacier about 8000 B.C.

and lasted until about 2700 B.C. As the continent gradually warmed, the big-game animals disappeared and the people began to exploit new sources of food in the postglacial environment. Although culturally and technologically they were continuations of the earlier Paleolithic inhabitants, Mesolithic peoples developed diverse local adaptations to special environments. There was greater isolation of people because they were more settled and progress seems less spectacular than in the Upper Paleolithic, but the increasing efficiency in obtaining food from a restricted environment was of importance in cultural evolution. By 3000 B.C. the Mesolithic peoples were rapidly being absorbed by cultivators moving into Europe from the south and east.

Outside northwestern Europe there is no direct counterpart to the Mesolithic. Even in northwestern Europe there is a clearer difference between Mesolithic and Neolithic than between Upper Paleolithic and Mesolithic. Thus the term is not, as once was thought, a reflection of a world-wide sequence of events in man's past.

*See* also ARCHAEOLOGY: *Prehistory: The Old World of the Recent Period;* and references under "Mesolithic" in the Index.

(F. A. HE.)

**MESOLONGION** (MISSOLONGHI, MESOLONGHI), seat of a metropolitan and capital of Aetolia and Acarnania *nomos* (department), is situated on the north side of the Gulf of Patras (Patraikos Kolpos), about 7 mi. from the coast, on the northern shore of a large, shallow lagoon. Pop. (1961) 11,266. Its chief trade is in fish and wine. The town is famous for its part in the Greek War of Independence, notably for the siege which Prince Alexandros Mavrokordatos and Markos Botsaris sustained in 1822–23 against a vastly superior Turkish army, for its heroic but unsuccessful defense against Reshid Pasha and Ibrahim Pasha in 1825–26, and for its association with Lord Byron who died of fever there in 1824. The poet is commemorated by a statue and a monument in the *Heroon* (a mass grave or garden of remembrance). *See* GREEK INDEPENDENCE, WAR OF. (D. M. N.)

**MESON:** *see* PARTICLES, ELEMENTARY.

**MESOPOTAMIA,** "the land between the rivers," namely the Euphrates and the Tigris in western Asia. The upper courses of the two rivers, which lie in the mountains of eastern Turkey, are not included. From the foot of the mountains to the Persian gulf the term Mesopotamia is sometimes used in a wide sense to include the plain of southeastern Turkey and all of Iraq (*q.v.*); sometimes it is used in a narrow sense for the northern part only. The region of Baghdad, where the two rivers come closest to each other, marks the border between the northern part, called Mesopotamia by the Romans and Al Jazirah ("the Island") by the Arabs; and the southern alluvial plain, called Babylonia by the Romans and Iraq Arabi by the Arabs. Mesopotamia in the wider sense is bordered in the north by the Turkish mountains, in the southeast by the Persian gulf, extending eastward beyond the Tigris to the Zagros range on the border of Iran and westward beyond the Euphrates to the escarpment of the Syrian desert. Mesopotamia in the narrow, or Roman, sense is "the island" between the rivers from the foot of the mountains to Baghdad only. In this article the term is used in the wide sense in the sections dealing with medieval and recent history; especially for the last periods of Ottoman rule, no other term offers itself for the territory that later became Iraq. In the sections dealing with ancient history, however, the term is used in the narrow sense, while the history of the alluvial plain is treated in the article BABYLONIA AND ASSYRIA.

For a description of the geographical features of the country and of its structure and the changes that have taken place in it, reference should be made to the article IRAQ, where these matters are fully discussed. *See* also EUPHRATES; TIGRIS.

## PRECLASSICAL TIMES

The great political powers that determined the history of Mesopotamia were Babylonia in the south and Assyria in the north (*see* BABYLONIA AND ASSYRIA: *History*). Therefore most of the sources for the history of Mesopotamia (in the narrow sense) come from Babylonian and Assyrian centres.

**Prehistoric Periods.**—In the 4th millennium B.C. the village cultures of the Hassuna and Tell Halaf periods extended over all of northern Mesopotamia (*see* ARCHAEOLOGY: *Prehistory; Egypt and Western Asia: Mesopotamia*). The culture named after the type site of Samarra, on the Tigris north of Baghdad, which overlaps in time with the Hassuna and Tell Halaf periods, was restricted to the middle Tigris and middle Euphrates regions. Both the Samarra and the Tell Halaf cultures excelled in their elaborately painted pottery. In the period following Tell Halaf—*i.e.*, in the latter part of the 4th millennium B.C.—Mesopotamia shared with Babylonia the culture known as Ubaid, though local differences between northern and southern Ubaid existed. Northern Ubaid furnished the first example of the type of temple that remained dominant through the ages: a temple excavated at Tepe Gawra, northeast of Mosul, is the oldest known building whose walls were decorated with pilasters and recesses.

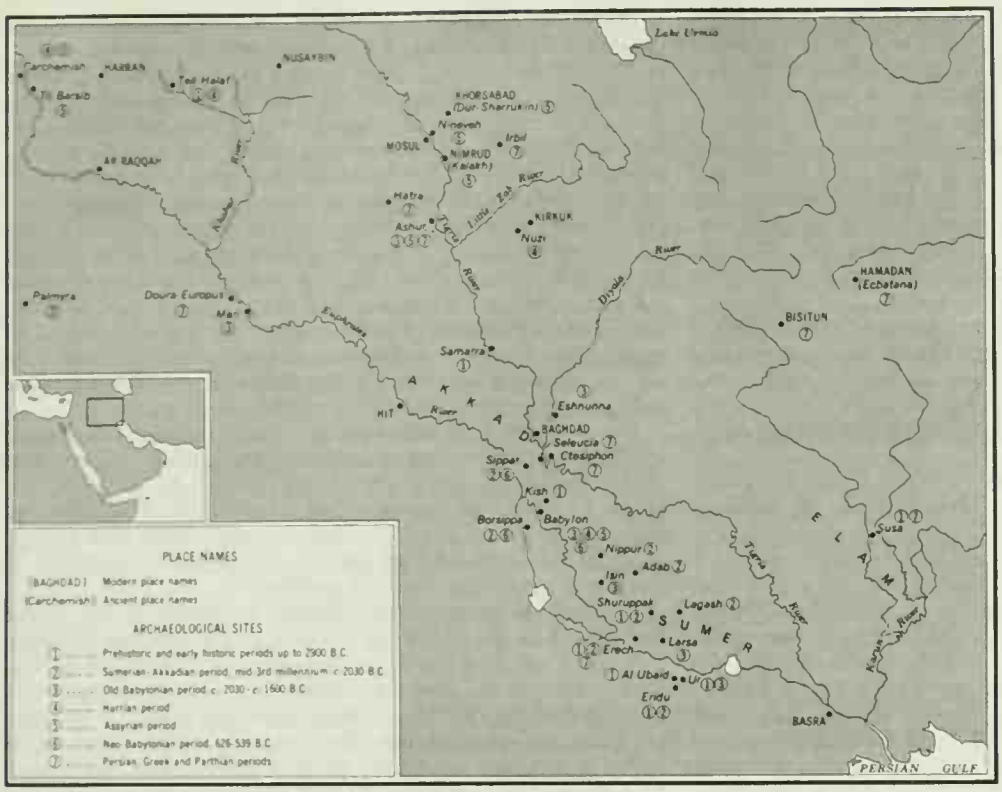
The great step from village culture to high civilization was made in Babylonia in the period called Protoliterate, when the Sumerians arrived toward the end of the 4th millennium. In north Mesopotamia, however, the culture called Gawran, which in time corresponds to the southern Protoliterate period, shows little change, although the so-called Eye temple of Tell Brak (northwest of Mosul) is similar to southern buildings.

**Ancient Ethnography.**—Nothing is known of the ethnic background of the prehistoric cultures of the Hassuna, Samarra, Tell Halaf and Ubaid periods. Whether the Eye temple of Tell Brak testifies to the presence of Sumerians that far north, or may be explained by cultural influence from the south, is an open question. In historical times Mesopotamia, which is open to the Syrian desert, saw a constant influx of Semitic-speaking nomads from the Arabian peninsula: the earliest inscriptions in the Semitic Akkadian language found at Mari (Tell el Hariri on the middle Euphrates) belong to the Early Dynastic period (middle of 3rd millennium B.C.). About the same time Semites were also present in Babylonia, where they soon (about 2350 B.C.) established the dynasty of Akkad. During the early part of the 2nd millennium a new group of tribes, speaking a language of the western Semitic type known as Canaanite, was found all over Mesopotamia. In the 12th century it was the Aramaeans who constituted a new Semitic element, and beginning with the 9th century Arabs appeared on the scene.

The Assyrians, who centred around the Mosul region, spoke a dialect of Akkadian and shared in the high civilization of Babylonia. How early they settled in Assyria and adopted a sedentary way of life is unknown; from before 2000 to 600 B.C. the Assyrians were clearly distinct from the above-mentioned Semitic nomads, although their Akkadian language belongs to the Semitic family of languages.

Apart from these Semites, a non-Semitic people was found in Mesopotamia from the late 3rd to the middle of the 2nd millennium B.C., the Hurrians. Their language is not related to any known linguistic group. Around 1500, Hurrians under Aryan dynasties established kingdoms in north Mesopotamia, the most important of which was the kingdom of Mitanni. After 1200 the Hurrians were either absorbed by the Aramaeans or retreated into the Armenian mountains, where a language akin to Hurrian was then spoken in the kingdom of Urartu.

**Early History.**—After the Sumerian king Lugalzaggesi, who founded the first empire including Mesopotamia by marching along the Tigris and Euphrates to the "upper sea" (the Mediterranean), it was Sargon of Akkad (about 2350 B.C.) who extended his own empire over the same area. Sargon's grandson, Naramsin, built a palace at Tell Brak, and a stele of his was found near Diyarbakir. The empire of the 3rd dynasty of Ur (about 2130–2030) included Assyria, where governors of the kings of Ur were installed. When the kingdom of Ur collapsed, Ashur seems to have become independent. The earliest historical kings of Assyria fall roughly into the middle of the period of the dynasties of Isin and Larsa (about 1900). When in the 19th century B.C. Assyrian trade colonies flourished in Anatolia, the trade routes from Ashur along the upper Tigris and across Mesopotamia to the upper Euphrates must have been safe.




FROM "GROSSER HISTORISCHER WELTATLAS," 1958, BAYERISCHER SCHULBUCH VERLAG, MUNICH

HISTORICAL CULTURES IN MESOPOTAMIA

**Western Semites.**—Before 1800 B.C. Assyria suffered a setback, and the Anatolian trade came to an end. About that time speakers of a west Semitic language were established on the middle Euphrates. Most information comes from Mari. There ruled a dynasty of local kings with west Semitic names such as Yagit-Lim and Yakhdun-Lim. The records were written in Akkadian, but many west Semitic idioms in the texts, as well as the proper names of individuals, show that the majority of the people belonged to the newcomers. People of the same stock entered Babylonia somewhat earlier (about 1900), where they seized power in Isin and Larsa and founded the new kingdom of Babylon.

Around 1820 B.C. Shamshi-Adad, a man of west Semitic origin, was able to build up a large kingdom in Mesopotamia. Early in his career he spent some time in Babylon. He then turned north, conquered Ashur, where he made himself king, and Mari, where he installed his second son, Yasmakh-Adad, as viceroy. Although Shamshi-Adad ruled over Ashur and erected some buildings there, he had other residences as well; one of them, called Shubat-Enlil, was situated in the Khabur region of northern Mesopotamia. The last ten years of Shamshi-Adad coincide with the first ten of the great Hammurabi of Babylon, who began his northward expansion immediately after Shamshi-Adad's death. In Mari, Yasmakh-Adad was driven out and replaced by Zimri-Lim, an offspring of the old local dynasty. Hammurabi used Zimri-Lim as a figure in his political game which ended by the conquest of Mari (about 1770). The bulk of the Mari archives belongs to the reign of Zimri-Lim. In these documents various small kingdoms of Mesopotamia are mentioned in connection with campaigns of Hammurabi of Babylon, Ishme-Dagan of Ashur and others. Not enough is known to give a detailed historical account. It seems clear, however, that Ishme-Dagan himself finally came under the overlordship of Hammurabi, so that toward the end of the latter's reign the kingdom of Babel held not only all of Babylonia proper but also the middle Euphrates valley and Assyria.

From the Mari documents something is learned also about the nomadic tribes with which Zimri-Lim and his officials had to deal. Repeated inroads of nomads upon the cultivated land occurred. Some tribes were already sedentary at the time, others were leading a nomadic life, and the king of Mari tried various methods of pacifying them and, occasionally, of securing their military help. Several tribal names appear. The Hanaeans seem to have been settled around the town of Hana upstream from Mari. The names Amorites and Sutaeans (*Amurrû, Sutû*) seem to be more general designations for nomads, but there is no clear evidence that *Amurrû* was a general term for all western Semites, as the name "Amorites," introduced for them by some writers, would imply (*see* AMORITES). A large nomadic tribe, divided into several subtribes, is called "the sons of the south," written with the word sign for "sons" followed by the Canaanite word *yamina* for "south." If the sign for "sons" is also read in Canaanite, the name is *Banu-yamina*, and the similarity of this name with that of the Israelite tribe of Benjamin has been much discussed. The question as to whether the biblical Benjaminites are part of the same tribe as the *Banu-yamina* of Mari, or whether different tribes were only called "southerners" by their neighbours, is still unsolved, though caution would argue in favour of the second alternative. Parts of the large tribe of the "sons of the south" actually appeared in the south; *i.e.*, in Babylonia; the majority of the tribe, however, must have kept the name "southerners" as a tribal name in spite of wide wanderings, since the king of Mari had to deal with them not only around his capital but also in the northern part of Mesopotamia.

**Kassites.**—During the reigns of Hammurabi's successors the Babylonian kingdom lost its power and many of its territories. Assyria became an independent kingdom again, and a new people, the Kassites (*q.v.*; *Kashshû*), appeared on the scene. Several of the Babylonian kings after Hammurabi had to fight the Kassites in Mesopotamia. Toward the end of the Babylonian dynasty the Kassites ruled over Hana on the middle Euphrates. In Babylonia proper, the Kassites seized power after the downfall of the Babylonian dynasty (about 1600 B.C. according to the chronology adopted here; *see* BABYLONIA AND ASSYRIA; *History: Middle Period: Chronology*).

**Hurrians and Aryans.**—Already in the latter part of the Akkad period (about 2200 B.C.) a Hurrian ruler, Tish-Adal of Urkish, is known from north Mesopotamia (*see* HURRIANS). In the Mari archives some Hurrian texts were found, which show that this language was spoken there in the Hammurabi period. About two generations before the fall of Babylon (about 1650) Hurrians lived in the plain of Antioch and other parts of north Syria. After the dark period following the fall of Babylon, they had spread all over Syria and Mesopotamia. At this time, about 1500, a small number of Aryans were associated with them. These Aryans, speaking the language known from India and venerating some Vedic gods (Indra, Varuna, Mitra and the Nasatyas), must be regarded as members of those Aryan tribes that later settled in India, but they must have left the main tribes on the way and settled in Mesopotamia instead. They soon became the ruling class among the Hurrians, individual Aryans became kings of small states in Syria, and in Mesopotamia they founded several kingdoms, one of which was called Hurri, while another was known as Mitanni.

The Mitanni kingdom, which existed from about 1500 to about 1360 B.C., had its centre in the Khabur region of north Mesopo-

tamia. It extended westward to the Mediterranean sea, where Mukish with its capital Alalakh (Atshana) in the plain of Antioch was one of its vassals. Eastward it reached as far as Kirkuk near the Persian border; Kirkuk itself, called Arrapkha in antiquity, was the centre of a vassal kingdom which included Nuzi (Yorghan Tepe). Assyria, which lay between the Khabur and Kirkuk, must also have been part of the Mitanni empire, and there are some indications that it was under Mitannian suzerainty indeed, although the Assyrians themselves only kept the memory of an unbroken sequence of Assyrian kings. The Mitanni kingdom was organized on the basis of feudalism. Under the Aryan dynasty there existed vassals and a class of noblemen, called *Mariannu*, who were chariot warriors. According to their proper names, both Aryans and Hurrians belonged to this nobility.

Since Washshukanni, the capital of the Mitanni kingdom, had not been found by the early 1960s, the sources for the history of that kingdom come either from such peripheral sites as Alalakh and Nuzi or from neighbouring countries, mainly Egypt and the Hittite kingdom. Several generations of Mitanni kings are known. The most outstanding ruler was Saushatar (or Shaushshatar; about 1480 B.C.), who was the overlord of both Nuzi and Alalakh and is said to have looted the palace in Ashur. The Syrian campaigns of the Egyptian king Thutmose III, who crossed the Euphrates and conquered part of Naharina, "(the land of) the two rivers," should be dated after the reign of Saushatar. Thereafter, however, the two countries were on friendly terms, as is shown by the fact that several Mitanni princesses were married to Egyptian kings: a daughter of Saushatar's successor, Artatama, to Thutmose IV; Gilu-Khepa, the daughter of the next king, Shuttarna II, to Amenhotep III; and Tadu-khepa, daughter of Tushratta, became the wife first of the same Pharaoh and later of his son, Amenhotep IV (Ikhnaton), from whose archive, the so-called Tell el-Amarna letters, this information comes.

Tushratta was the last independent king of Mitanni. In the north, the Hittite king Suppiluliumas (or Suppiluliuma), who led his country to new power after a period of weakness, became his most formidable enemy (*see* HITTITES). Suppiluliumas took advantage of the rivalry between Tushratta of Mitanni and Artatama of Hurri by allying himself with the latter. A first campaign against Tushratta was unsuccessful. In a second campaign, Suppiluliumas descended to the Khabur region from the north, looted Washshukanni, while Tushratta avoided a battle, and conquered most of Syria as far as Damascus and the Lebanon. When Tushratta was killed by one of his sons, dynastic struggles broke out between Hurri and Mitanni and went on for some time.

In the year (1353) of the death of Tutankhamen of Egypt, Suppiluliumas conquered Carchemish on the Euphrates and installed his son Piyassilis (or Piyassili) as viceroy of that country. Thereafter he was approached by Mattiwaza, a son of Tushratta, to help him against Shuttarna of Hurri, who had driven him from his country. Suppiluliumas sent Piyassilis of Carchemish to lead him back to his capital, and after a victory over Shuttarna, Mattiwaza was married to Suppiluliumas' daughter and made a Hittite vassal as ruler of Mitanni. From then on the region which had been Mitanni was part of the Hittite empire and was mostly called Hanigalbat.

Soon, however, Assyria rose to power and became a dangerous neighbour of the Hittites. Adad-nirari I of Assyria (1308–1275 B.C.) twice conquered Hanigalbat: at first he made the local ruler, Shatuara I, tributary. Shatuara's son, Wasashata, revolted and turned to the Hittites, but lost his life when Adad-nirari reconquered his country and laid it waste. After the death of Adad-nirari, Hanigalbat was lost to the Assyrians once more, so that Shalmaneser I (about 1275–45) had to reconquer it. He defeated not only Shatuara II of Hanigalbat but also the Hittites who helped the latter; he turned the whole territory east of the Euphrates into an Assyrian province. Also under his son, Tukulti-Ninurta I (1245–08), Mesopotamia remained part of the Assyrian empire.

**Aramaeans.**—Under Tukulti-Ninurta's successors, Assyria suffered a setback, while in Mesopotamia, Aramaeans (*q.v.*) appeared for the first time. Tiglath-pileser I (1116–1076 B.C.), who restored Assyria to its old power, defeated some Aramaean tribes in Mesopotamia and extended his campaigns into southeastern Turkey and to the Mediterranean coast. After him, however, Assyria declined again, and during this period the Aramaeans must have established themselves firmly in Mesopotamia and parts of Syria. During the 10th century B.C. they occupied many of the formerly Hittite small states of Syria, and when, around 900, Assyrian kings began a new expansion, they had to fight Aramaeans on the western border of Assyria and on the middle Euphrates, where they conquered the Aramaean kingdom of Laqe. The site of Tell Halaf, near the sources of the Khabur, then called Guzana (Gozan), was the seat of another Aramaean kingdom, one of whose rulers, Kapara, decorated his palace with elaborate reliefs and statues (10th or 9th century B.C.). Afterward Guzana became an Assyrian province. Still another Aramaean state, Bit-Adini with the capital Til Barsip (Tell Ahmar) on the Euphrates south of Carchemish, was conquered and turned into an Assyrian province by Shalmaneser III in 856.

**Assyrian and Neo-Babylonian Periods.**—Mesopotamia remained part of the Assyrian empire until its end. The policy of deporting the entire population of conquered territories must have affected Mesopotamia as well as other parts of the near east. An Aramaean element also entered Assyria proper, where Aramaean writing appeared during the period of the Assyrian empire. The rise to power of the Chaldeans, an Aramaean tribe that had settled in southern Babylonia and in 626 established the Neo-Babylonian dynasty, contributed to the downfall of Assyria. When Nineveh was conquered in 612 by Nabopolassar of Babylon and Cyaxares of Media, the last Assyrian king tried to hold out in Harran in Mesopotamia but was defeated there too, despite the help he got from Egypt. The battle of Carchemish (605 B.C.), in which the Babylonian crown prince, Nebuchadrezzar, defeated Pharaoh Necho, put an end to the Egyptian attempt at controlling Mesopotamia. The Assyrian empire was divided between Media and Babylonia, but the exact frontier between the two kingdoms in Mesopotamia is not known. Harran was held by the Medes at first. When Cyrus the Great by his victory over Astyages put an end to the Median kingdom, Nabonidus of Babylon was able to seize Harran, where he built a new temple to the moon-god. The cult of this god flourished in Harran from at least the 9th century B.C. into the Christian era. With the conquest of Babylon in 539 Cyrus gained all of the Neo-Babylonian kingdom, and Mesopotamia became part of the Persian empire. Little is known about Mesopotamia under Achaemenid rule, not even to which of the satrapies of the kingdom it belonged. It remained in the Persian empire until the time of Alexander the Great. Alexander occupied the country after his victory over Darius III at Gaugamela in 331 B.C. He died at Babylon in 323 B.C., having returned there after his conquests in the east. (H. G. Gk.)

## SELEUCIDS, PARTHIANS AND ROMANS

**Under the Seleucids.**—Macedonian colonization in Mesopotamia probably began during Alexander's lifetime; a military settlement at Carrhae was in existence before 312 B.C. Under the Seleucid kings a large number of new cities were founded on the Euphrates, on the Tigris and in the country between the rivers. To encourage hellenization in Mesopotamia was undoubtedly a main object of policy for the Seleucids; with Syria it represented the heart of their empire and through it alone lay the connection, so important for trade, with the provinces to the east of the Tigris. The most important of the new cities were Seleucia (*q.v.*) on the Tigris, which became the Seleucids' eastern capital; Nicephorium (modern Ar Raqqah); Edessa (later renamed Antioch); Antioch in Mygdonia (Nisibis; modern Nusaybin); and Europus (Doura, originally founded as a military colony by Nicanor, governor of the upper satrapies under Antigonus I Monophthalmus; *see* DOURA-EUROPUS); but many other names might be added. It is especially significant that certain districts and cities were given names taken from the Macedonian homeland (Mygdonia, Europus, Edessa, Amphipolis, etc.). By far the greater number of the new foundations were in Mesopotamia proper, since the southern region (Babylonia) was already thickly settled with native towns before the Macedonian conquest. Babylon itself had suffered

great destruction in the fighting between Seleucus I Nicator and Antigonus in the years between 312 and 302 B.C. and Seleucia on the Tigris took its place as administrative capital and commercial centre.

In 141 or 140 B.C. the Parthians under their king Mithradates I overran Babylonia and most of Mesopotamia. Only northern Mesopotamia was left to the Seleucids. From this, their foothold on the east bank of the Euphrates, Demetrius II Nicator and Antiochus VII Sidetes launched the invasions which recovered lower Mesopotamia and Babylonia for their kingdom; but the reconquest was in both cases (*c.* 140 and 130 B.C.) of the briefest duration. Thereafter the Seleucid kings were too weak to contest Parthian rule, which then embraced the whole of Mesopotamia. While the Greek cities came to terms with their Parthian overlords, increasing numbers of Arabs moved from the desert fringe into the settled zone, mixing with the Greek and native town dwellers. In some places, as at Edessa (*q.v.*), the newcomers became strong enough to establish themselves as the dominant race. Nevertheless, most of the Greek cities succeeded in preserving their identity into the Christian era. (*See* also SELEUCID DYNASTY.)

(R. H. SI.)

**Parthian Period.**—Under Mithradates II (*c.* 124–*c.* 87 B.C.) Mesopotamia was a definite part of the Parthian empire, of which the Euphrates became the western boundary; but in 92 B.C. on that river Mithradates' ambassador met Sulla, though the long duel between Parthia and Rome did not begin immediately.

Before long Mesopotamia (especially the district of Nisibis) was attached to the growing dominions of Armenia under its ambitious king Tigranes (*c.* 94–*c.* 56 B.C.), perhaps with the consent of the Parthian king Sinatruces (Sanatruces). The lost territory, however, was recovered by Phraates III (king of Parthia *c.* 70–*c.* 57 B.C.), and Rome guaranteed Mesopotamia to Parthia by the treaties of Lucullus and Pompey (66 B.C.). It was traversed, however, several times by Roman troops crossing from Armenia to Syria, and Parthia's declaration of war against Armenia involved it with Rome. Gabinius crossed the Euphrates (54); but the command was assumed by Crassus, who, though he seized Ichnae, Nicephorium and other cities, fell near Carrhae (53), and the Parthian dominion was confirmed. The tragedy of the ides of March saved Mesopotamia and the east from a great campaign by Julius Caesar. It was at the hands of Publius Ventidius, and west of the Euphrates, at Gindarus (northeast of Antioch), that the Parthians received the check that put an end to any real rivalry with Rome (38 B.C.). Mesopotamia narrowly escaped being the scene of the struggle when Marcus Antonius in 36 finally decided to make his disastrous attempt against Phraates IV by way of Armenia. Tiridates III found support in his attempt to secure the throne of Artabanus III in Mesopotamia (*c.* A.D. 36), and it was there that he saw his army melt away. The expedition against Rome of Vologaeses I (*q.v.*) of A.D. 62 reached no farther westward than Nisibis (Nisibin), and in 63 a peaceable arrangement was made.

Of the half-century that preceded Trajan's great oriental undertaking not much is known. When in 115 Trajan entered Mesopotamia from the north no serious resistance was offered, and it became a province as far as Singara. The woods at Nisibis, the headquarters, provided material for the boats with which in 116 he crossed the Tigris. Hatra, an interesting fortress which seems to have been Aramaean, fell, and the army advanced to Hit, where it found the fleet that was subsequently transferred to the Tigris. For the revolt that occurred while Trajan was on the Persian gulf, in which the Jews had an important hand, Nisibis and Edessa suffered capture and destruction. Hatra successfully withstood siege, however, and Hadrian abandoned Mesopotamia, setting the boundary at the Euphrates. Again for half a century there is not much to relate. Then, when Vologaeses III, yielding to his growing discontent, took advantage of the death of Antoninus Pius to invade Armenia, the Romans were victorious (165), and after the storming of places such as Nicephorium, Edessa and Nisibis, western Mesopotamia was once more Roman as far as the Khabur, Carrhae becoming a free city and Osroene a dependency.

By this time Christianity had secured a foothold, perhaps first among the Jews, and we enter upon the earliest period from which documents in the Edessan dialect of Aramaic, known as Syriac, have been preserved. Unfortunately they contain practically nothing that is not of Christian origin. On the death of L. Aelius Aurelius Commodus, Hatra aided Niger against L. Septimius Severus in 194; Osroene rose against Rome; and Nisibis was besieged and other Roman places taken. But Septimius Severus appeared in person (195), and from Nisibis as headquarters subdued the whole country, of which he made Nisibis metropolis, raising it to the rank of a colony, incorporating the Sinjar district, where Arabs from Yemen had settled. On his retiring, everything was undone, only Nisibis holding out, but on his reappearance in 198 the Parthians withdrew. Again the Euphrates bore a Roman fleet. Hatra, however, was besieged twice in vain. Peace then prevailed till Caracalla's unprovoked attack on Parthia in 216, after he had reduced Osroene to a province. On Caracalla's assassination near Carrhae (217), his successor, Macrinus, was defeated at Nisibis and had to purchase peace, though he retained Roman Mesopotamia, reinstating the princely house in Osroene.

### SASANIAN PERIOD

Ardashir's power was rising when the Parthian Artabanus died in 224, and Ardashir proposed to prove himself the successor of the Achaemenids. Hatra resisted the first Persian attack as it had resisted Rome, but Mesopotamia was overrun, Nisibis and Carrhae being taken (233). It was immediately, indeed, recovered by Alexander Severus, and retained, whatever was the precise success of the war; but Nisibis and Carrhae were retaken by the Persians in the reign of Maximin (Maximinus). Under Gordian III in 243 Mesopotamia was entered by a great Roman army which recovered Carrhae and Nisibis and defeated the Persians at Resaena; but after Gordian had been killed in battle at Massice on the Euphrates Philip the Arabian (244) made the best terms he could with Shapur I. Whatever they were, the Roman garrisons seem not to have been really withdrawn. A rest for Mesopotamia seems to have followed; but in 258 Shapur, tempted by the troubles in the Roman empire, overran the country, taking Nisibis and Carrhae and investing Edessa, and when Valerian invaded Mesopotamia he was eventually made prisoner near Edessa (260). After Shapur's cruel victories in Syria, however, he was defeated by Odaenathus, who relieved Edessa, and Mesopotamia became for ten years practically part of an Arabian empire (*see* PALMYRA), as it was to be four centuries later. In consequence of the revolt of Zenobia, Mesopotamia was lost to Rome and the Euphrates became the frontier. Aurelian overthrew the Palmyrene rule, but he was assassinated before he could carry out his intended expedition against Persia; M. Aurelius Probus was assassinated before he was able to do anything, and although Carus easily overran Mesopotamia, which became Roman again, and even took Ctesiphon, the Romans retreated on his death (283). The next incident is the defeat of Galerius, between Carrhae and Callinicum, where he had entered Mesopotamia (about 296), in the war provoked by Narses in consequence of his relations with Armenia. When it was retrieved by a signal victory, Diocletian advanced to Nisibis and thence dictated terms of peace by which Mesopotamia to the Tigris was definitely ceded to Rome (298).

After about 40 years' peace the struggle was resumed by Shapur II. Nisibis thrice endured unsuccessful siege (338, 346, 350), although meanwhile Constantius had suffered defeat at Singara (345). Then Mesopotamia enjoyed two short rests (separated by a sharp struggle) while the rivals were engaged elsewhere. In 363 Julian (*q.v.*) made his disastrous attempt, and Jovian bought peace at the price, among other things, of Singara and Nisibis; *i.e.*, practically all eastern Mesopotamia.

The surrender of Nisibis, which had been in the possession of Rome for so many generations, caused consternation among the Christians, and Ephraem Syrus (*q.v.*) moved to Edessa, where his "school of the Persians" soon became famous. In the war of 421–422, in which the northeast of Mesopotamia was chiefly concerned, the Romans failed to take Nisibis, and it became a natural rallying point for the Nestorians after the condemnation of Nestorius at the Council of Ephesus (431). Matters were still more

complicated when the western Christians of Edessa found themselves unable to accept the ruling of Chalcedon against Monophysitism in 451 (*see* MONOPHYSITES), and there came to be three parties: Nestorians (*q.v.*), Jacobites (*see* ANTIOCH, SYRIAN ORTHODOX PATRIARCHATE OF) and Melchites (*q.v.*).

In the beginning of the 6th century there was another severe struggle in Mesopotamia, which was recorded by an anonymous Syriac historian, and in infringement of agreement the Romans strongly fortified Dar'a against Nisibis. The Persian invasion of Syria under Kavadh I (*q.v.*) was driven back by Belisarius, but the latter was defeated in his pursuit at Callinicum (531). The peace begun by Khosrau I (532) was not long kept, and Roman Mesopotamia, except the pagan Harran, suffered severely (540), Edessa undergoing a trying siege (543). The 50 years' peace also (561) was short-lived; the Romans again failed in an attempt to recover Nisibis (573), while Khosrau's siege of Dar'a was successful. Mesopotamia naturally suffered during the time of confusion that preceded and followed the accession of Khosrau II, and the Romans recovered their old frontier (591).

With the accession of the emperor Phocas (602) began the great war that shook the two kingdoms. The loss of Edessa, where Narses revolted, was temporary, but the Roman fortress of Dar'a fell after nine months' siege (*c.* 605); Harran, Ras al'Ain and Edessa followed in 608, many of the Christian inhabitants being transported to the far east, and Khosrau II carried the victorious arms of Persia far into the Roman empire. Finally Heraclius turned the tide, and Kavadh II gave up the conquests of his predecessor. The Syrian Christians, however, found that they had only exchanged the domination of a Zoroastrian monarch for an unsympathetic ecclesiastical despotism. In the confusion that followed, when men of letters had to live and work in exile, Nisibis set up for a time (631–632) a grandson of Khosrau II. Finally all agreed on Yazdegerd III, but while Khosrau II and Heraclius had been at death grips with each other a great invasion had been preparing in Arabia. (X.)

## MEDIEVAL AND MODERN PERIODS

**The Arab Conquest and the Caliphate.**—Mesopotamia, already in part Arabized before the days of the Prophet Mohammed (d. A.D. 632), assumed, after its occupation by conquering Arab bands and armies in A.D. 634 and the years following, a permanent and indeed outstanding place in the Islamic empire and society. The loot-rewarded battles which achieved the Muslim conquest, the permanent eviction of the Persian power, the installation of Arabs from the Hejaz as a ruling aristocracy, the rapid conversion of most (though never all) of the Mesopotamian population to the new faith, the foundation of important new cities, the rebellions, feuds and schisms, the early and developing administration of the country as a group of Muslim provinces precariously obedient to the government of Mecca and later of Damascus, all belong to the general history of early Islam and to that of the caliphate (*q.v.*). The century A.D. 650–750 was for Mesopotamia a period of profound cultural and social change, marked by the foundation of great cities, but an era also of endless intrigue, violence and disorder. The foundation of the Abbasid caliphate (750), centred later on Baghdad, marked the beginning of Mesopotamia's greatest days, and the unbroken line of the Abbasid caliphs, varying as these did from great and famous rulers to powerless puppets, enjoyed thereafter for five centuries a unique semireligious prestige, and contributed great services to learning, literature and the cultural life remembered as "Arab civilization." Political and military power in Mesopotamia, exercised habitually in the name of the caliph (but in practice often ignoring him), was in these centuries wielded over varying regions of the territory by local dynasties, such as the Hamdanids of Aleppo-Mosul in the 10th century; their successors the Uqaylids in the 11th; and the tribal Mazyadids of central Iraq in the first half of the 12th. From time to time power was seized by invading captains or potentates from outside, of Turkish or Persian origin, such as the Buyids (*q.v.*) in the 10th–11th centuries; the (predominantly Kurdish) Marwanids of the northern Jazirah in the 11th; branches of the Turkish Seljuks or their Atabeg successors in the 11th–13th centuries (such as the Zangids in Mosul, Sinjar and the northern Jazirah); and the Ayyubids (*q.v.*; the dynasty of Saladin) in the 12th–13th. Brief and violent, these dynasties bequeathed great names and they were remembered for grandiose public works, high cultural standards and a level of material development, urban and rural alike, never since achieved in the territory.

**Mongol, Turkmen and Persian Invasions.**—The destruction of Baghdad and the wonderful lower-Mesopotamian irrigation system by the Mongol hordes of Hulagu in 1258 ushered in a long period of darkness and obscurity throughout the area. Everything that was valuable, or internationally of interest, vanished quickly or gradually from the Mesopotamian scene, with the ruin of its cities, the decay of agriculture, large-scale immigration of destructive desert folk and aggression from the hills to the east. The three centuries of Mesopotamian history from 1258 to 1534 offer the most drab and disheartening of spectacles.

This span of time falls into four periods, not one of which is marked by any significant material or cultural advance. For the first 80 years the country was ruled by governors sent from the Mongol (but now Persian and Muslim) court of the Il-khans (*q.v.*), themselves subordinate to the supreme khakhan in far-off China: governors (among whom Ghazan Khan is the least forgotten) inept in administration, jealous and disorderly, equally incapable of controlling the countryside or restoring the half-deserted cities. Finally, years of civil war (1336–39) among competitors for the viceregal throne made possible the intervention of another ex-Mongol Persian prince, Hasan Jelair. He occupied Baghdad in 1340 and ruled Mesopotamia as a province of his northwest Persian empire, with its capital at Tabriz. The Jelair administration, not without pretensions to culture and good will, stood undisputed for more than half a century, but in 1401 the country was to suffer another blow of typically Mongol atrocity. The destruction wrought by Timur (*q.v.*) was little less than that of Hulagu. The territory, weakened and humiliated anew, fell after the Mongol withdrawal to the rule of a newly arisen Turkmen dynasty of northern Persia, itself initially an offshoot or vassal of the paramount Timurids. This was the Kara-Koyunlu, or Black Sheep, dynasty, which succeeded in maintaining itself, and indeed adding to its dominions, with Mesopotamia as one of its principal provinces, for some 60 years from 1410 to 1469. Its fall was at the hands of a second Turkmen power, similar in origin and development. The founder of the White Sheep, or Ak-Koyunlu, state was an officer of the Timurids. Neither he nor his warlike but quarrelsome and ambitious descendants and captains could give, or seriously attempt to give, peace or progress to the distracted territory; and after scarcely more than a generation (1469 to 1508) of White Sheep government it passed into the possession of the rapidly rising, pious and aggressive ruler of Persia, founder of the great Safavid (Safawid) dynasty and empire, Shah Ismail, who after years of intrigue and frontier bloodshed entered Baghdad in 1508, to make Iraq a province of the newborn, hopeful, civilized Safavid empire.

**Under Turkish Rule.**—Some immediate improvement in urban tranquillity and peaceful traffic did not include the still wild tribal and foothill areas, and the 26 years of Persian rule were restless and unhappy. The eastward advance of the Ottoman power, under an ambitious sultan, easily seduced the loyalty of frontier Kurds and the Jazirah cities; Persian viceroys in Baghdad itself were apprehensive and unsure when the strong hand of Ismail Shah Safavi was withdrawn; and the final advance of Sultan Suleiman I (*q.v.*) the Magnificent from the Bosporus to the undefended walls of Baghdad, almost unopposed, transferred the city and all Mesopotamia from Persian to Ottoman allegiance in a day (1534). Nearly four centuries of rule as a Turkish province followed: three of these under the oppressive, stagnant regime of the unreformed Ottoman empire, and nearly one, dating from 1831, under the half-modernized Turkey of the reforms.

The first 90 years of Ottoman rule, semimilitary in type, capricious, obscurantist, disorderly, effective only in urban and suburban areas, ended with the reoccupation of Baghdad and most of the country in 1623, after years of frontier warfare, by the outstanding Persian ruler Shah Abbas I. The Persian restoration

lasted for 15 years. It was ended by an impressive reconquest by the armies of Sultan Murad IV (1638) and an infusion of fresh (but scarcely more beneficent) life into the administration. The ever-changing governors of the three vilayets (Mosul, Baghdad and Basra), themselves servants of a state already hopelessly corrupt and weakened, attempted little beyond the imposition of order in the more accessible areas, occasional public works—mosques, bridges, flood-banks or barracks—tax collection through the sheikhs, aghas or urban tax-farmers, and the remission of minimal sums to Istanbul. But at least for nearly a century foreign invasion was kept at bay, and, despite the ungoverned independence of outlying desert or mountain chieftains, and the complete secession of the Basra district for three generations under a local dynasty (1620–70), some semblance of order was preserved in the central regions.

The 18th century witnessed the continuance of these conditions, together with new features: an increase in the civilian and semi-specialized (though not modernized) character of the government, with the general use of educated former slaves in high office; the increasing power of the janizaries and the decreasing power of the sultan to influence events; the first entry of European traders, consuls and missions on the scene; the emergence and persistence of local principalities in the inaccessible northeastern, Kurdish districts, where Turkish troops rarely penetrated and also in the city of Mosul where a local family (the Jalilis) held the pashalik irremovably for many years. But the century was best remembered for the great wars with Persia, once again aggressive under Nadir Shah, the gallant resistance and counterattacks by the pashas of Baghdad—Ahmed and Hassan Pasha—and the sieges of Baghdad and Mosul (1720 and 1743). The last phase of the pre-reformed Turkish regime (1749–1831) was one of constant strife between pretenders to power, who included some striking personalities, and increased attempts to discipline the tribes, obtain obedience from outlying vassals and keep open communications. The contrast was never greater between the rich courts and almost royal pretensions of the greater pashas of Baghdad and the stagnant backwardness and oppressed poverty of the countryside. The last ruler of the old regime, Daud Pasha, ended his tenure of office after a crisis of plague and river floods; he was superseded in 1831, after the destruction of the janizaries, by a new-type governor sent from Istanbul.

The last near-century of Turkish rule in Mesopotamia (1831–1914) was a period in which half-understood, ill-drafted and largely inapplicable reforms in the Ottoman empire were brought, at last, to these most remote and backward of its provinces, while at the same time the region, as a land gateway to India and itself a territory of fascinating archaeological and biblical interest, became better known to the states and publics of Europe, whose representatives and travelers lived or toured there. The future Iraq emerged into the full light of day with all its interest and potentialities, of which the British were, among European nations, the most conscious, their consuls being by far the most influential and privileged. Indeed, central and lower Mesopotamia, in and after the mid-19th century, became something approaching a British sphere of influence, as Mosul was, vaguely, a French. (Russian and German ambitions in which the country could play a part had no present significance to the inhabitants.) The opening of communications—telegraphs, a postal service (British), river boats, passable roads, tolerable bridges, rumours (and one practical example) of railway building—did much to change the atmosphere of the country. The same is true of the few but important works of irrigation (culminating in the British-built Hindiyah barrage of 1912), of numerous pretentious but inferior government buildings and of a number of new townships founded as military or staging posts.

Externally, the country was free from any more serious threat than Persian frontier restlessness (the result in part of an international boundary never defined until 1912), or the raids of tribesmen from inner Arabia, which area the Turks had for a time, though no more than nominally, succeeded in adding to their dominions. A largely modernized army, however ragged, starved and ill-equipped, supported the line of pashas of Mosul, Baghdad and Basra vilayets, which now assumed their final form and organization; and these often-changing governors (no longer appointed, however, by bribery, nor removed by imperial caprice) included some men of vigour, integrity and realistic intelligence. Such were Ali Ridha Pasha (1831–42), immediate successor of Daud; Najib Pasha and Mohammed Rashid "the spectacled" (1842–52 and 1853–58); Namiq Pasha, vigorous but obtuse (1853–60); Midhat Pasha (*q.v.*; 1869–72), by far the most able and best remembered, and the most modern-minded and enlightened ruler seen in the country for many generations; and Nadhim Pasha (1911–12), terror of the turbulent tribes and outstanding Turkish statesman. For all of these the paramount tasks, never satisfactorily achieved, were the settlement and orderly administration of the recalcitrant tribes, the enforcing of obedience on Kurdish hill-chiefs till lately disloyal and ungovernable, the provision of some approach to acceptable public services and the installation of a workable machinery of day-by-day government. Toward success in these tasks, as in the application of modernized law codes, with the inauguration (from 1870 onward) of a less chaotic land-tenure system and a less burdensome plan of revenue collection, the widely varying, baffled and half-educated Turkish governors did what they could, or what a resentful and backward Arab population made possible. In these decades were gradually evolved the standard of government and the government-to-public, the tribal-to-urban and the religion-to-society relationships which were the inheritance of the future Iraqi kingdom. The 19th century in Mesopotamia, inglorious in almost every way, was nevertheless a highly formative period in which later hindsight can see elements of progress, and which prepared many of the essential conditions for the successor government of King Faisal I (1921–33).

The Turkish government, aided by the immense prestige of the sultan-caliph, was accepted by the vast majority of the people as inevitable and irremovable. Nevertheless, change and reform were in the air and toward the end of the period, from 1900 onward, the Arab nationalism already in evidence in the Levant and Egypt as the vigorous, half-cultural, half-political movement of a small clique of the intelligentsia, made its entry, unobserved by the rulers, into Iraq also. It was a movement based on reviving Arab self-consciousness, on a slowly and almost timidly growing ambition for self-rule and on resentment at chronic misgovernment by foreigners, for such were the Turks in language, culture, character and interest. Without unanimity or any agreed formulation of aims, and without effective means of action, ideas of Arab —in some minds, possibly, of Iraqi—nationalism began in secret to find expression in the early years of the 20th century in the greater Mesopotamian cities, among civilian would-be politicians and army officers; and by 1914 the movement had already attracted to it some of the future statesmen of the post-1920 Iraqi monarchy.

*See* also PERSIAN HISTORY; TURKEY; *History*. For history after 1914 *see* IRAQ. *See* also references under "Mesopotamia" in the Index. (S. H. Lo.)

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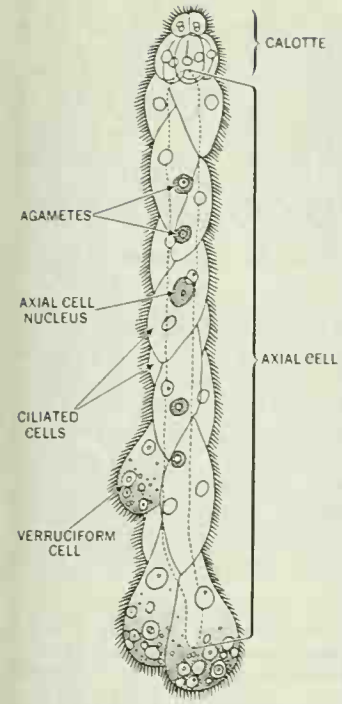
**MESOZOA,** a small group of minute wormlike organisms parasitic in marine invertebrates. They are chiefly of academic interest, being perhaps the simplest structured multicellular animals. The body consists of a single layer of ciliated cells, usually rather constant in number and arrangement for any given species, enclosing one or more reproductive cells. The life cycles involve both sexual and asexual generations.

Their relationships are uncertain. They are commonly treated as a small phylum of doubtful position or as a class of, or appendix




FROM "THE ENCYCLOPEDIA OF THE BIOLOGICAL SCIENCES," ED. PETER GRAY, 1961; REINHOLD PUBLISHING CORP.

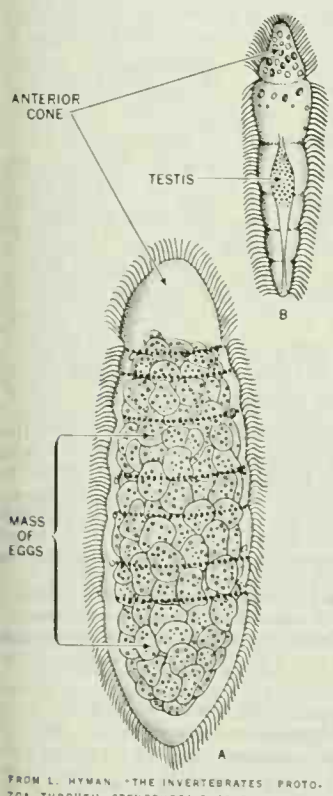
FIG. 1.—EARLY RHOMBOGEN PHASE OF A DICYEMID MESOZOAN

to, the flatworms. Mesozoa comprises two orders: the Dicyemida and the Orthonectida.

Dicyemids are found in the renal organs of cephalopods (squids and octopuses). A typical member consists of a single long axial cell containing the reproductive cells and developing young, surrounded by a single layer of large ciliated cells, those at the anterior end forming a "head" or polar calotte by which the dicyemid clings to its host's tissue. There are two reproductive phases. During the nematogen phase cells called agametes give rise to vermiform larvae, similar to the parents but smaller, that escape into and increase the infection in the host. The rhombogen phase then ensues. A few germ cells give rise to infusorigens (reduced hermaphroditic individuals) that remain in the axial cell, giving rise to sperm and egg cells. The fertilized eggs develop into infusoriforms or swarm larvae, which when fully developed leave the axial cell and the host. Their fate is unknown.

In some species the first nematogens parasitizing very young cephalopods have three (or two) axial cells in a line. These forms are termed stem nematogens; they give rise to and are replaced by ordinary nematogens.

Orthonectids parasitize various marine invertebrates as multinucleate amoeboid masses (syncytia). These syncytia multiply by fragmentation and eventually give rise to sexual adults from agametes. In most species the adults are free living and of separate sexes, the female being larger than the male. The fertilized eggs develop in the female into ciliated larvae that infect new hosts, within which they fragment, their germinal cells giving rise to new syncytia.




FROM L. HYMAN, "THE INVERTEBRATES: PROTOZOA THROUGH CTENOPHORA," 1940; MCGRAW-HILL BOOK CO.

FIG. 2.—SEXUALLY ADULT ORTHONECTID (RHOPALURA GRANOSA) FROM A CLAM: (A) FEMALE; (B) MALE

*See* L. H. Hyman, *The Invertebrates: Protozoa Through Ctenophora,* vol. 1 (1940); H. W. Stunkard, "The Life-History and Systematic Relations of the Mesozoa," *Quart. Rev. Biol.,* 29:230–244 (1954). (B. H. McC.)

**MESOZOIC ERA,** the major division of geologic time that began about 200,000,000 years ago, following the Paleozoic era (*q.v.*), and ended about 70,000,000 years ago with the start of the Cenozoic era (*q.v.*). Rocks that record Mesozoic history, widespread on continents in both hemispheres, originated chiefly as sedimentary deposits on lowlands and on subsiding sea floors. These rocks, laid down in three geologic periods represented by the Triassic, Jurassic and Cretaceous systems, have been much deformed and are exposed in high parts of the Alps, Himalayas, American cordilleras and other uplifted areas. The rock formations record not only great changes in physical geography, but also major developments in organisms. Reptiles, which had a lowly beginning late in the Paleozoic era, evolved rapidly in Triassic time when forms known as phytosaurs, resembling the crocodilian gavial (*q.v.*) of northern India, attained a length of 25 ft. The quadrupedal dinosaurs, with lengths of 10 to 15 ft. in the Triassic period, developed into Jurassic monsters up to 70 ft. long and had large representatives until their extinction late in the Cretaceous period.

*Geologic Time Chart*

| System and Period | Series and Epoch | Distinctive Records of Life | 1,000 Years |
|---|---|---|---|
| | CENOZOIC ERA | | |
| Quaternary | Recent | Modern man | 11 |
| | Pleistocene | Early man | 1,000 |
| Tertiary | Pliocene | Large carnivores | |
| | Miocene | Whales, apes, grazing forms | |
| | Oligocene | Large browsing mammals | |
| | Eocene | Rise of flowering plants | |
| | Paleocene | First placental mammals | 70,000 |
| | MESOZOIC ERA | | |
| Cretaceous | | Extinction of dinosaurs | 130,000 |
| Jurassic | | Dinosaurs' zenith, primitive birds, first small mammals | 160,000 |
| Triassic | | Appearance of dinosaurs | 200,000 |
| | PALEOZOIC ERA | | |
| Permian | | Reptiles developed, conifers abundant | 235,000 |
| Carboniferous | | | |
| Upper (Pennsylvanian) | | First reptiles, coal forests | 260,000 |
| Lower (Mississippian) | | Sharks abundant | 285,000 |
| Devonian | | Amphibians appeared, fishes abundant | 320,000 |
| Silurian | | Earliest land plants and animals | 350,000 |
| Ordovician | | First primitive fishes | 400,000 |
| Cambrian | | Marine invertebrates | 500,000 |
| | PRE-CAMBRIAN TIME | | |
| | | Few fossils | 3,500,000–4,000,000 |

Marine reptiles were abundant and diverse through the era, attaining lengths of 30 ft. or more. Birds, feathered but with anatomical features suggestive of reptiles, appeared during the Jurassic period, as did the flying reptiles (pterosaurs) and small, primitive mammals. Radical changes in living forms near the close of the era may be related to physical developments, such as the closing of seaways and the rise of mountain belts, with attendant climatic changes.

For detailed information *see* CRETACEOUS SYSTEM; JURASSIC SYSTEM; TRIASSIC SYSTEM. *See* also GEOLOGY; PALEOBOTANY; PALEONTOLOGY; and references under "Mesozoic Era" in the Index. (C. R. L.)

**MESQUITE** is a common name for spiny shrubs or small trees of the genus *Prosopis* in the pea family (Leguminosae), ranging from South America into the southwestern U.S. Two races occur, one low—called running mesquite—and the other often growing into trees 50 ft. tall. Roots penetrate depths of as much as 70 ft. Trunks may be 18 in. in diameter, but more commonly are smaller or shrublike. In warmer parts of the U.S. the mesquite is considered a pest and is eradicated. The leaf is divided into numerous narrow, olive green leaflets about one-eighth inch wide and an inch long. The lacy canopy gives light shade. The flowers occur in dense, cream-coloured catkins about three inches long, followed by clusters of long beans. The beans are pale yellow, flecked with purple or red, about three-eighths of an inch wide, as much as six to eight inches long, filled with a sweet pulp. The seeds are lens shaped with a hard cover and may lie dormant in the ground for more than 40 years, or may germinate the next season. A gummy sap, resembling gum arabic, exuded from the stem is commercially valueless. The wood of the mesquite, formerly used in railroad ties, is without economic value other than for unusual furniture and trinkets.

A related species, the screw bean mesquite, *Strombocarpa odorata,* bears a tightly spiraled bean and occurs from Texas to California and southward into Mexico. The term mesquite is also applied to certain unrelated grasses of the genus *Muhlenbergia.* The present range of the mesquite in the U.S. is believed to have resulted from seeds scattering during the early cattle

WESTERN WAYS FEATURES

MESQUITE TREE (PROSOPIS), WITH SEEDLINGS SPRINGING UP UNDER CANOPY

drives. The northern range of the mesquite is limited by cold and the eastern range by excessive soil water. (EN. R. B.)

**MESROP, SAINT** (*c.* 362–440), also called MASHTOTZ, the inventor of the Armenian alphabet, was born in Hatzekatz in Taraun, Armenia. After holding the office of secretary at the court of Khosrov III (386–392, 414–415) he became a monk. His pupil and biographer Koriun shows him to have been throughout his life a zealous missionary to "barbarous regions," and his first task was to destroy the paganism still subsisting in the canton of Goghthn in Siuniq. Having as "reader and interpreter" in Armenian churches experienced the inconvenience of Syriac as the ecclesiastical language, he composed, with the encouragement of King Vramshapuh (392–414) and the patriarch St. Sahak (387–428, d. 439), an alphabet of 36 characters for his native tongue and began the work of translating the Scriptures (*see* ARMENIAN LITERATURE). He was himself the author of the first translation of the New Testament and Proverbs. He is said to have visited Theodosius II and the patriarch Atticus in Constantinople (in 422 according to P. Peeters) for permission to teach in Byzantine Armenia. Koriun, followed by Moses (*q.v.*) of Khoren and others, credit him with the invention also of alphabets for the Georgians and the Aghuanq (Caucasian Albanians); characters purporting to be the Aghuan alphabet were published in 1938 in Titlis (Tbilisi) from an Echmiadzin manuscript, but in the absence of texts their authenticity is doubtful.

Mesrop founded many schools and monasteries; he is said to have composed a number of homilies, but none can be confidently attributed to him. He died early in 440 in Vagharshapat. His feast day is celebrated on Feb. 19 in the Armenian Church, and the invention of the alphabet on Nov. 28; the Holy Translators are together commemorated on Sept. 17.

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**MESSAGER, ANDRÉ CHARLES PROSPER** (1853–1929), French conductor and composer of operettas who achieved fame both in France and England. Born at Montluçon, Dec. 30, 1853, he was a pupil of Saint-Saëns. After composing a symphony (1876) and a cantata, he completed Firmin Bernicat's comic opera *François les Bas-bleus* (1883). His reputation became established with his operetta, *La Béarnaise* (Paris, 1885; London, 1886). He married the Irish composer, Hope Temple (Dotie Davies; 1859–1938), and between 1890 and 1926 he produced 14 operettas, including *Madame Chrysanthème*, based on the novel by Pierre Loti (Paris, 1893), *Mirette* (London, 1894), *Véronique* (Paris, 1898), *Fortunio*, based on Alfred de Musset's *Le Chandelier* (Paris, 1907), and *Monsieur Beaucaire*, based on the novel by Booth Tarkington (Birmingham, Eng., 1919). Messager wrote in a light style, but he brought to the operetta a melodic elegance which made it acceptable to the more serious-minded musical public. He wrote three ballets of which the best known was *Les Deux Pigeons* (1886). In 1898 he was appointed director of the Paris Opéra-Comique where, in 1902, he conducted the first performance of Debussy's *Pelléas et Mélisande*. He was artistic director of Covent Garden (1901–06) and later associate director of the Paris Opéra, where he conducted Wagner's *Der Ring des Nibelungen*. He died in Paris, Feb. 24, 1929.

*See* H. Février, *André Messager* (1948); M. Auge-Laribe, *Messager, musicien de théâtre* (1951). (E. LR.)

**MESSAGE STICK,** a piece of wood carried by messengers among primitive peoples. Notably observed among Australian aborigines (*q.v.*), the flat or round sticks vary up to about a foot in length and commonly bear carved or burned designs. As distinctive credentials message sticks can serve to verify the authenticity of the recited communication; the curved or straight notches also can be used to help the speaker remember what to say by associating parts of the message with specific markings. The same stick may be used over and over for different messages arranging such intertribal affairs as religious ceremonies, initiations, marriages and commercial exchange. Knotted cords have served similar functions in other cultures (*see* QUIPU).

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**MESSALLA CORVINUS, MARCUS VALERIUS** (64 B.C.–A.D. 8), Roman general and patron of literature. He received part of his education at Athens, together with Horace and the younger Cicero. In 43 B.C. he was proscribed, but escaped to the camp of Brutus and Cassius. After the battle of Philippi (42) he went over to Antony, and later supported Octavian. He campaigned against Sextus Pompeius (36), the Illyrians (35–34) and the Alpine Salassi (34–33). He was elected, with Octavian, as consul for 31 in place of Antony, and took part in the battle of Actium. He subsequently held commands in the east, and as proconsul suppressed the Aquitanians; for this he celebrated a triumph in 27. Appointed *praefectus urbi* in 26, he resigned after a few days; in 11 he became *curator aquarum*. He restored the Via Latina between Tusculum and Alba, and other public buildings. He was a patron of letters after the model of Maecenas, and his immediate circle included Tibullus and the poetess Sulpicia; he was a patron of Ovid. Two panegyrics by unknown authors (one printed among the poems of Tibullus as iv, i, the other included in the *Catalepton* attributed to Virgil) indicate the esteem in which he was held. Messalla's own works are lost. They included *Memoirs* of the civil wars after the death of Caesar, used by Suetonius and Plutarch; pastoral poems in Greek; translations of Greek speeches; occasional satirical and erotic verses; essays on the minutiae of grammar. As an orator, he followed Cicero instead of the Atticizing school, but his style was affected and artificial. Later critics considered him superior to Cicero, and Tiberius adopted him as a model. Late in life he (or possibly the Messalla Rufus mentioned below) wrote a work on the great Roman families, wrongly identified with an extant poem *De progenie Augusti Caesaris* bearing the name of Messalla but really a 15th-century production.

BIBLIOGRAPHY.—Fragments of Messalla's speeches are collected in H. Malcovati, *Oratorum Romanorum fragmenta*, 2nd ed. (1955); historical works in H. Peter, *Historicorum Romanorum reliquiae*, ii (1906); grammatical works in H. Funaioli, *Grammaticae Romanae fragmenta*, i (1907). *See* also J. Hammer, *Prolegomena to an Edition of the Panegyricus Messalae* (1925); R. Syme, *The Roman Revolution*, index (1939).

Two other members of this family of the *gens* Valeria were:

MANIUS VALERIUS MAXIMUS MESSALLA, consul 263 B.C. during the First Punic War, who with his colleague Manius Otacilius reduced the area around Mt. Etna, forced back King Hieron II, and received the submission of Syracuse; he celebrated a triumph over the Carthaginians and Hieron. His relief of Messana (Messina) obtained for him the cognomen *Messalla*. To commemorate his Sicilian victory he had it pictorially represented on the wall of the Curia Hostilia, the first example of a historical fresco at Rome.

He is said also to have brought the first sundial from Catania to Rome, where it was set up in the forum. He was censor in 252 B.C.

MARCUS VALERIUS MESSALLA RUFUS, consul in 53 B.C. He was twice accused of illegal practices in connection with the elections; on both occasions he was acquitted, in spite of his obvious guilt, the second time (51) through the eloquence of his uncle Hortensius. He took the side of Caesar in the civil war. He was augur for 55 years and wrote a work *De auspiciis*. (H. H. SD.)

**MESSALLINA, VALERIA** (sometimes spelled MESSALINA) (d. A.D. 48), third wife of the emperor Claudius; she bore him first Octavia, later Nero's wife, and then (Feb. A.D. 41) Britannicus (*q.v.*). The daughter of Valerius Messala Barbatus, she was born of a patrician family. According to the sources, whom some modern scholars disbelieve, she exercised a dominant influence over Claudius in concert with the freedmen secretaries, and used it to gratify her lust and avarice. There is no good reason to reject this testimony; by procuring in A.D. 42 the unjust death of Appius Silanus, who had slighted her advances, she greatly contributed to the mutual suspicion between Claudius and the senate and to what may almost be called a reign of terror. Her later victims were numerous, but by encompassing the death of the freedman, Polybius, she alienated the others, and Narcissus (*q.v.*) proved to Claudius that she had even gone through a form of marriage with Gaius Silius, her paramour, and thus secured her execution in A.D. 48. She was only 26 years old.

*See* works listed under CLAUDIUS I; *see* also H. Dessau, *Geschichte der römischen Kaiserzeit*, vol. ii (1926). (P. A. BR.)

**MESSAPIC** is the name given to the language of the Messapii. Iapyges and Calabri who occupied the southeastern part of Italy (Calabria and Apulia) in ancient times. These tribes appear to have invaded Italy about 1000 B.C. from the opposite coast of the Adriatic (Illyricum), bringing their language with them. With the foundation of Greek colonies about 500 years later, they adopted the Greek alphabet, the Tarentine-Ionic variety, having previously been illiterate.

Over 250 brief inscriptions, and three longer ones, are known and (since J. Whatmough's edition of 1934) interpreted with reasonable certainty. The longer texts are public documents, the rest votive and funerary. In addition there are about 12 ancient glosses (words quoted and explained in authors), and a large number of proper names, local, ethnic, divine and personal, that must have been Messapic.

The more important features of the dialect are: *ā* from Indo-European *ŏ*, *b* from *bh*, *d* from *dh*, *-n* from *-m*, consonant gemination before *i*, a genitive singular ending in *-ī* (written *-ihi*), a system of personal names similar to the Italic (praenomen, nomen, cognomen), local names ending in *-oa* (pronounced *-ua*, and comparable to names like *Capua* elsewhere in Italy), the preservation of the Indo-European subjunctive and optative moods, and a sigmatic aorist.

An example of continuous text is the following inscription from Ceglie Messapico, *c.* 250 B.C., on a small square stone pillar:

anaaproditalahonaθeotoriddahipakaθi
θeotoriddaθaotoraskeoχorrihibiliva
("To the lady Aphrodita, goddess of birth, Tutoridia
gave [this], Tutoridia daughter of Tutor Cucorius.")

Here the first three words (*aprodita* being borrowed from Greek) have *-ā*, dat. sing. fem. (older *-āi*); *θeotorridda* is nom. sing. fem., a patronymic, with *-idda* from older *-idia*; *θaotoras* and *keoχorrihi* are gen. sing. masc., *-ās* from *-ôs*, and *-ihi* written for *-ī*, *-rr-* from *-ri-*; *biliva* (*cf.* Albanian *bil'ë*, "daughter"), nom. sing. fem.; *hipakaθi* is a verb, 3rd sing., with *-θi* written for *-ti*, and *v* is *u*.

BIBLIOGRAPHY.—J. Whatmough, *Prae-Italic Dialects of Italy* (1934); vol. ii, pp. 258–430 and 501–610 with vol. iii (Glossary) gives the texts, grammar and glossary; his *Foundations of Roman Italy* (1937), pp. 307–324, discusses the archaeology and ethnography of the Messapii and Iapyges. On the linguistic affiliation (Illyrian) *see* H. Krahe, *Die Sprache der Illyrier* (1955) and E. Pulgram (ed.), *Studies Presented to Joshua Whatmough on His Sixtieth Birthday*, pp. 72–89 (1957); O. Parlangèli, *Studi Messapici* (1960). (J. WH.)

**MESSENE,** an ancient Greek city, capital of Messenia (*q.v.*), founded probably in 369 B.C., after the battle of Leuctra and the first Theban invasion of the Peloponnese, by the combined Theban and Argive armies and exiled Messenians, invited to found a state independent of Sparta. The site, chosen by the Theban leader Epaminondas, lay on the western slope of the mountain which dominates the Messenian plain. The peak Ithome (mod. Ithomi; 2,618 ft.) served as acropolis. Messene remained important under the Romans, but nothing is heard of it in medieval times. The hamlet of Mavrommati occupies a small part of the site; ancient Messene should not be confused with the modern town of Messini about 10 mi. S.S.E. of Mavrommati.

Pausanias describes the city and is particularly impressed by its fortifications, which excelled all others of the Greek world. Of the wall, about 5½ mi. in extent, considerable portions remain. It is flanked by towers about 31 ft. high; these have two stories and are entered by doors on a level with the top of the wall reached by flights of steps. The theatre, the stadium, the council chamber or *bouleuterion*, and the propylaeum (entrance gate) of the agora also remain, while on the shoulder of the mountain are the foundations of a small temple, probably that of Artemis Laphria.

*See* J. G. Frazer, *Pausanias's Description of Greece*, vol. iii, pp. 429 ff. (1898).

**MESSENIA** (MESSINIA), a modern Greek *nomos* (department) and ancient district of the southwestern Peloponnese, bounded on the east by the Taygetus mountains (Taiyetos Oros), on the north by the Nedha river and the Arcadian mountains and on the south and west by the sea. Area 1,131 sq.mi.; pop. (1961) 211,970. Historically and economically important is the great plain, watered by the Pamisus river (modern Pamisos), the most fertile tract in Greece, producing oranges, citrons, almonds, figs, grapes and olives. The plain is bounded on the north by Mt. Nomia (modern Tetrasi; 4,554 ft.); on the west and southwest by the range which attains 2,618 ft. in Mt. Ithome (Ithomi) and 3,146 ft. in Mt. Mathia (Oros Likodhimos). Off the south coast of the southwestern peninsula lie the three Oenussae (Oinousai) islands and the islet of Theganussa (Venetiko). Kalamata (Kalamai) is the departmental capital.

Neolithic and Bronze Age settlements have been discovered, the most noteworthy being the magnificent Mycenaean "Palace of Nestor," the Neleid, at Pylos (Pilos), excavation of which was begun in 1939 and resumed in 1952. According to Homer eastern Messenia was under the rule of Menelaus at Sparta, while the western area formed the kingdom of the Neleidae. Dorians, traditionally led by Cresphontes, invaded the country after 1200 B.C. and intermingled with the inhabitants to form a single Messenian race. The centre of their power seems to have been in the upper Pamisus valley by Mt. Ithome. About 735 B.C. the land-hungry Spartans invaded and after a long war annexed at least the central plain (*c.* 715). Two generations later the Messenians revolted (*see* ARISTOMENES) but eventually they and the whole of their territory were subdued; some of the population fled abroad, but most were reduced to the status of helots (*q.v.*). Only a few coastal cities retained a precarious and modified independence as perioeci (*q.v.*).

Revolt broke out again *c.* 490 and yet again in 465/464; the insurgents defended themselves for some years on the rock-citadel of Ithome, but *c.* 460 they had to leave the Peloponnese and were settled by the Athenians at Naupactus (Navpaktos, at the entrance to the Gulf of Corinth). After the battle of Leuctra (*q.v.*) in 371 the Theban leader Epaminondas invited the exiled Messenians to return to their country. The city of Messene (*q.v.*) was founded *c.* 369 to be the capital of the country and, like Megalopolis in Arcadia, a check on Sparta. A great part of the land remained sparsely peopled, and Messenia never again became really powerful. After the fall of the Theban power it became an ally of Philip II of Macedonia. Subsequently it joined the Achaean league, and Messenian troops fought on the league's side in 222 at Sellasia. The Spartan tyrant, Nabis, succeeded in taking the city but was forced to retire by the Achaean leader Philopoemen and the Megalopolitans. Messenia again joined the Achaean league, though weakened by the loss of Abia, Thuria and Pherae, which entered the league as independent members. In 146 B.C. the Messenians were brought under Roman sway as part of the province of Achaea.

In the middle ages Messenia shared the fortunes of the rest of the Peloponnese. It was overrun by Slavic hordes, and was one

of the battlefields of Byzantines, Franks, Venetians and Turks, who struggled for the possession of the Morea, as recalled by the ruins of the medieval strongholds of Kalamata, Coron (anc. Asine, modern Koroni), Modon (anc. Methone) and Navarino (Pylos). Pylos (*q.v.*) was the scene of two famous battles, in 425 B.C. between the Spartans and Athenians (*see* PELOPONNESIAN WAR) and in 1827 between the combined British, French and Russian fleets and the Turks (*see* NAVARINO, BATTLE OF).

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**MESSERSCHMITT, WILLY** (1898– ), German aircraft designer and businessman, was born at Frankfurt am Main on June 26, 1898, and educated at the Munich Institute of Technology. He designed gliders and sailplanes from 1912 to 1923, then turned his attention to sport and transport aircraft, which he built in his factory at Bamberg. The outstanding characteristic of his aircraft was the single wing spar. In 1927 he became chief designer to the Bayerische Flugzeugwerke at Augsburg, later renamed Messerschmitt-Aktien-Gesellschaft, and remained head of this firm until the end of World War II. A large proportion of German fighter aircraft during the war were of Messerschmitt design, including the Me-109 (flown for the first time in 1934) and the jet-propelled Me-262, which, early in 1944, became the first jet plane to be flown in combat. In 1939 the Me-109 won the absolute world speed record with a 435-m.p.h. flight. Messerschmitt's Me-163, called the Komet, was the first airplane specifically designed for a liquid-fuel rocket motor. After World War II, he again set up an engineering works at Munich for design and production in various engineering fields. (D. CR.)

**MESSIAEN, OLIVIER EUGÈNE PROSPER CHARLES** (1908– ), French composer, organist and teacher, the son of Pierre Messiaen, a scholar of English literature who was of Flemish descent, and of the poetess Cécile Sauvage, was born at Avignon on Dec. 10, 1908. As a child he studied music at Grenoble and Nantes and in 1919 entered the Paris conservatoire, where his teachers included Marcel Dupré, Maurice Emmanuel and Paul Dukas. In 1931 he was appointed organist of the church of La Trinité, Paris, and about this time he began to study medieval music and many aspects of exotic music including the Greek and Hindu modes and the rhythms and music of China, Japan, Peru, Bolivia and Bali. Later he turned to the study of bird song. In 1936 he founded, with the forward-looking composers André Jolivet, Daniel Lesur and Yves Baudrier, the group Jeune France and in the same year began teaching at the Schola Cantorum and the École Normale in Paris. As a soldier in the army at the outbreak of World War II he was taken prisoner and interned at Görlitz, Ger., where he wrote *Quatuor pour la fin du temps*, performed at the prison camp in 1941. Repatriated the following year, he was appointed professor of harmony at the Paris conservatoire and soon became an influential figure both as composer and teacher.

The key to his method of composition is given in his treatise *Technique de mon langage musical* (1944) containing his theories on rhythm, modes, harmony and structure problems. Among other pedagogical works are his *Traité de rythme*, begun in 1948, and *Mode de valeurs et d'intensité*, forming part of *Quatre études de rythme* (1949–50) which, in opposition to the theories of Schoenberg, propounds the theory of rhythmic modes not only for orthodox compositions but also as a guide for composing electronic music. Much of his music is inspired by Catholic theology, interpreted in a quasi-mystical manner, notably in *Trois petites liturgies de la présence divine*, for orchestra (1944), *Vingt Regards sur l'Enfant Jésus* (1944), *Visions de l'amen* (1943), for piano, and *Apparitions de l'église éternelle* (1932) and *Messe de la Pentecôte* (1950), for organ. His most important orchestral work is the *Turangalila* ("Love Song") symphony (1948), in ten movements containing a prominent solo piano part and in which percussion instruments used in the manner of the gamelan of the Sunda Islands are combined with the *ondes martenot*. His later works, *Le Réveil des oiseaux* (1952), *Oiseaux exotiques* (1954) and *Catalogue d'oiseaux* (1959), incorporate meticulous notations of bird song.

*See* Claude Rostand, *Olivier Messiaen* (1957). (R. H. My.)

**MESSIAH** (MESSIAS; from Heb. *mashiah*), a term meaning in the Hebrew Bible the "anointed one" in general, and in later Judaism "the anointed one" par excellence; *i.e.*, the ultimate redeemer, the expected king of the Davidic line who would deliver Israel from foreign bondage and restore the glories of its golden age. The Greek (New Testament) translation of the term, *Christos*, has become the accepted Christian designation and title of Jesus of Nazareth, indicative of the principal character and function of his ministry (*see* JESUS CHRIST). More loosely, the term is applied to any redeemer figure, and the adjective messianic is used in a broad sense to refer to beliefs or theories about an eschatological improvement of the state of man or the world. (*See* ESCHATOLOGY.) Even secular movements with a markedly "eschatological" message of judgment and ultimate salvation (*e.g.*, Marxism) are thus occasionally described as "messianic."

In biblical Hebrew the adjective or noun *mashiah* is used of material objects (*e.g.*, the shield of Saul in II Sam. i, 21) as well as of consecrated persons such as high priests (*e.g.*, Lev. iv, 3) and kings (Saul, in I Sam. x, 1; David, in I Sam. xvi, 13 and II Sam. v, 3; Solomon, in I Kings i, 39, etc.). The latter are also called "the Lord's anointed" (*e.g.*, II Sam. i, 14; Lam. iv, 20), the title expressing the charismatic character and divine sanction of their office as well as the unique inviolability of their status (see, *e.g.*, I Sam. xxvi, 8–11 and II Sam. i, 14). In exilic and postexilic usage, the term "anointed" could denote anyone with a special mission from God: prophets (*cf.* Isa. lxi, 1), patriarchs and even gentile kings (*e.g.*, Cyrus the Mede, Isa. xlv, 1). The Old Testament never speaks of an eschatological Messiah, and even the "messianic" passages containing prophecies of a future golden age under an ideal king never use this term. Nevertheless, many modern scholars believe Israelite messianism to have grown out of beliefs connected with kingship. Comparison with the forms of divine or sacral kingship current among near-eastern peoples (Egypt in particular) suggests that in Israel, too, kingship had a definitely sacral character. Though not in any sense divine, the anointed king would be called the "son of God," and messianic hopes and functions would be ascribed to him. Many prophecies and Psalms (*e.g.*, Ps. ii) have been interpreted in this sense, and this alleged kingship ideology has been connected with the messianic doctrines of early Christianity. When actual reality and the careers of particular historic kings proved more and more disappointing, the "messianic" kingship ideology was projected on the future. With the declining national fortunes of Israel the notion developed of the eschatological Messiah-king.

After the Babylonian exile, the prophetic vision of a future restoration and of the universal establishment of God's kingdom became firmly associated with the ingathering of Israel under a scion of David's house who would be "the Lord's anointed." In the period of Roman rule and oppression, the expectation of a personal Messiah acquired increasing prominence and became the centre of a number of other eschatological concepts held by different groups in different combinations and with varying emphases. The Qumran sect (*see* DEAD SEA SCROLLS) seem to have held a doctrine (found also in later Jewish sects) of a messianic pair: a priestly Messiah of the house of Aaron and a royal Messiah of the house of David. With other groups the "son of David" messianism, with its political implications, was overshadowed by apocalyptic notions of a more mystical and mythological character. Thus it was believed that a heavenly being called the "Son of Man" (the term is derived from the Book of Daniel) would descend to save his people (as, for example, in the apocryphal Books of Enoch). The messianic ferment of the period, attested by contemporary Jewish-Hellenistic literature, is also vividly reflected in the New Testament. With the adoption of the Greek word "Christ" by the church of the gentiles, the nationalist implications of the term "Messiah" (which Jesus had explicitly rejected) vanished altogether, and the "Son of David" and "Son of Man" motifs, to which subsequently that of the Suffering Servant (Isa. lii–liii) was added, could merge in a politically neutral and religiously highly original

messianic conception. (*See* also ENOCH, BOOKS OF: *I Enoch;* ISAIAH, BOOK OF: *Themes;* SON OF MAN.)

The destruction of the Temple, exile, persecution and suffering only intensified Jewish messianism, which continued to develop theologically and to express itself in messianic movements. In popular apocalyptic a second messianic figure, the warrior-Messiah of the house of Joseph (or of Ephraim) who would precede the triumphant Messiah of the house of David but would himself fall in the battle against Gog and Magog, gained some prominence. The notion seems to have developed toward the end of the 2nd century, after the failure of the last revolt against the Romans. Messianic faith tended, in times of crisis, to develop into mass enthusiasm, frequently fed by calculations based on the Book of Daniel and other biblical passages. Almost every generation had its messianic precursors and pretenders, the most famous case being that of the 17th-century pseudo-Messiah Sabbatai Zebi (*q.v.*). Belief in and fervent expectation of the Messiah became firmly established tenets of Judaism and are included among Maimonides' 13 articles of faith. There was much variety in the elaboration of the doctrine—from the apocalyptic visionaries and (later) cabalist mystics at one end of the scale to the rationalist theologians on the other. The latter (*e.g.*, Maimonides) emphasized the unmiraculous nature of the messianic age. Modernist movements in Judaism have attempted to maintain the traditional faith in an ultimately redeemed world and a messianic future without insisting on a personal Messiah figure.

Islam too, though it has no room for a saviour-Messiah, yet developed the idea of an eschatological restorer of the faith, identified as a descendant of the Prophet or as the returning Isa (*i.e.*, Jesus) and usually called the Mahdi; *i.e.*, "the guided one." The doctrine of the Mahdi is an essential part of the Shi'ite creed, the expected Mahdi being the hidden 12th imam of the Twelver Shi'ites (*see* MAHDI; SHI'ISM). Among Sunnites the whole subject is one of folklore rather than of dogmatic theology, though all believe in the coming of a final restorer of the faith.

Eschatological figures of a messianic character are known also in religions that are uninfluenced by biblical traditions. Even as unmessianic a religion as Buddhism has produced the belief, among Mahayana groups, in the future Buddha Maitreya who would descend from his abode in the Tushita heaven and bring the faithful to paradise (*see* MAITREYA). Zoroastrianism, with its thoroughly eschatological orientation, knows of a saviour, the Soshyans (a posthumous son of Zoroaster), to whom God would entrust the task of the final rehabilitation of the world and the resurrection of the dead. Many modern movements of a millenarian character (*see* MILLENNIUM), particularly among primitive peoples (*e.g.*, the cargo cults of Melanesia) have been called messianic; but as the expectation of a personal saviour sent or "anointed" by God is not always central to them, other designations (millenarian, prophetic, nativistic, etc.) may be more appropriate (*see* CARGO CULTS; NATIVISTIC MOVEMENTS). *See* also KINGDOM OF GOD; SON OF MAN; and references under "Messiah" in the Index.

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(R. J. Z. W.)

**MESSIER, CHARLES** (1730–1817), French astronomer, regarded in his day as the foremost astronomical observer in France, after N. L. de Lacaille, was born at Badonviller, Lorraine, on June 26, 1730. While at Paris in 1751, he was hired by the astronomer J. N. Delisle as a draftsman and recorder of astronomical observations. Becoming adept at handling astronomical instruments, he was appointed clerk at the Marine observatory in 1754. He was the first in France to observe the anticipated return of Halley's comet in 1758–59 and from that time on searched for new comets and nebulae. Called the "comet ferret" by Louis XV, Messier independently discovered 15 of them. He was elected a foreign member of the Royal society in 1764 and obtained a seat in the Paris Academy of Sciences in 1770. He published a catalogue of nebulae in 1771 and another in 1781. These nebulae, which include many of the most prominent, are still known by his name. He died on April 12, 1817. (O. J. E.)

**MESSINA,** one of the principal cities in Sicily, Italy, and chief town of the province of the same name, is situated on the strait named after it, about 11 km. (7 mi.) S.S.W. of Cape Faro. Pop. (1961): city 257,288; province 671,866. Destroyed in the earthquake of Dec. 28, 1908, and subsequently rebuilt, Messina is modern in appearance, with wide streets and buildings of reinforced concrete. Of the ancient city, which was also severely damaged by an earthquake in 1783, only a few edifices remain, largely restored: SS. Annunziata dei Catalani, a Byzantine basilican church, rebuilt between 1150 and 1200 on the remains of an ancient temple of Neptune; the temple of the Teutonic knights (12th century); the church of S. Giovanni di Malta (16th century); the church of Sta. Maria della Valle, called the Badiazza (12th century). The cathedral, a very old building, possibly of the Byzantine period, was rebuilt by the Normans in the 12th century and was restored after the earthquake of 1908. Noteworthy modern buildings include the Palazzo Municipale (1924), the Palazzo di Giustizia (1928), the Palazzo del Banco di Sicilia (1936), the Palazzo della Camera di Commercio (1929), the Palazzo del Governo (1920) and the church of Christ the King (1937). The university, founded in the 16th century, is now a state university.

Messina is connected with the Italian mainland by ferry service (including train ferry and hydrofoil boats) across the strait to Reggio di Calabria and Villa San Giovanni. There is also rail service to Palermo and Syracuse and there are roads to various points in Sicily. The nearest airports are at Reggio di Calabria and Catania.

Principal occupations are trade, citrus fruit industries, the manufacture of chemicals, pharmaceutical products, foodstuffs and preserves, and the operation of the port and dockyards. Exports include agricultural and food products, chemical and pharmaceutical products, medicinal articles and building materials. Principal imports are grain, cereals, dried and salted fish, sugar, vegetable fibre, timber, pit coal, chemical products and fertilizers.

It has been established that the site of Messina was a settlement of the Siculi, an ancient tribe of Sicily, but its first historical mention was about 730 B.C. when a colony from Chalcis settled there. They named it Zancle ("sickle"), from the shape of the natural harbour. In the beginning of the 5th century it was occupied by fugitives from Miletus and Samos, which had fallen into Persian hands. The fugitives were assisted by Anaxilas, tyrant of Regium (mod. Reggio di Calabria), who then ruled over Regium and Zancle, the name of which he changed to Messene in memory of Messenia in the Peloponnese, his native region. Subsequently Messene regained its independence. Destroyed in 397 B.C. by the Carthaginian Himilco, it was reconquered by Dionysius I, tyrant of Syracuse. The city often found itself involved in the war between Agathocles, tyrant of Syracuse, and the Carthaginians.

Later, the Mamertini, mercenaries in the service of Agathocles, took Messene by force and made it the centre for their domination of Sicily (289–264 B.C.). However, they antagonized Syracuse as well as the Carthaginians and were obliged to seek help from the Romans, who had already conquered the Italic peninsula. This intervention led to the First Punic War, at the end of which Messene, which the Romans called Messana, was a free city and an ally of Rome. During the civil wars it came to be the principal military centre of Sextus Pompeius and was sacked when he was defeated by Octavian. When the western empire fell Messana was conquered by the Goths, from whom it was taken by the Byzantine general Belisarius in A.D. 535. It remained under Byzantine rule till the 9th century, when it was conquered by the Arabs.

In the Byzantine attempts to reconquer it the city suffered severe damage. Liberation came in 1061 with the landing of the Normans, led by Roger of Hauteville (afterward Roger I, count of Sicily). In 1190–91 Richard I the Lion-Heart of England with his crusaders passed several months there. In 1194 the Holy Roman emperor Henry VI held the whole of Sicily as well as Messina, where he

died in 1197. After the battle of Benevento (1266), when the Swabian dynasty ended with the death of Manfred, the city passed to the Angevins. With the whole of Sicily Messina rose against the Angevins in 1282 in the revolt called the Sicilian Vespers (*see* VESPERS, SICILIAN) and then endured a long and cruel siege by Charles I, king of Naples and Sicily. Emerging victorious, the Sicilians entrusted their crown to the Aragonese, who held it for many centuries. Having come under the rule of the house of Savoy in 1713, together with the whole of Sicily, Messina became in 1735 a dominion of the Bourbon dynasty. A plague raged in the city in 1743; the earthquake of 1783, mentioned earlier, destroyed nearly all the houses. Messina participated in the Risorgimento risings in 1821, 1847 and 1848. In 1860 Garibaldi liberated Messina, which by a plebiscite accepted union with Italy. Its history thereafter is merged with that of Italy; during World War II it suffered disastrous bombardments by both British and U.S. forces.

Among the distinguished citizens of Messina were the painter Antonello da Messina and the architect Filippo Juvara.

The province covers an area of 3,247 sq.km. (1,254 sq.mi.) and extends from the Ionian to the Tyrrhenian sea. The most important communes, besides Messina, are Milazzo, Taormina (*qq.v.*), the last-named being the principal tourist centre in Sicily, and Barcellona Pozzo di Gotto. The Aeolian Islands (the Lipari Islands, *q.v.*) are also a part of the province of Messina. (P. BR.)

**MESSINA, STRAIT OF,** between Sicily and Italy, is about 3 km. (2 mi.) wide at the northern extremity and 16 km. (10 mi.) wide at the southern; the line taken by the train ferry between Reggio di Calabria–Villa San Giovanni and Messina is 5 mi. long. At the northern end the depth is only about 300 ft. and the separation of Sicily and Italy may be post-Paleolithic. The strait was greatly feared by sailors in antiquity, especially because of the rocks and whirlpools known as Scylla and Charybdis (*q.v.*); and the currents do, in fact, present considerable difficulties, especially in a strong wind. The main current runs from south to north, and the subsidiary current in the reverse direction. They generally alternate every six hours, and are affected by the sun, the moon and the winds. When the current runs from south to north, the level of the water in the strait falls from 6 to 8 in., rising again with the other current. When the currents are especially strong, they tear seaweed from the bottom and sometimes throw up fish with atrophied or abnormal eyes and with organs for the production of phosphorescence. The strait is rich in fish and plankton and there is an institute of marine biology at Messina. Much damage was done on both sides of the strait by the sea movement produced by the earthquake of Dec. 28, 1908. (G. KH.)

**MESTIZO** in Hispanic countries has an original connotation of a person with mixed ancestry. In some localities the word may specifically indicate a mixture of European and American Indian genetic traits (*see* COLOMBIA: *The People*). However, those of strict Indian ancestry who have become culturally europeanized may also be called mestizo (or cholo) in such countries as Ecuador. In Mexico the term has been found so variable in meaning that it has been abandoned in census reports. Adding to the confusion is the variously interpreted word Ladino. *See* CENTRAL AMERICA: *Anthropology;* GUATEMALA: *The People.*

**MESTROVIC, IVAN** (IVAN MEŠTROVIĆ) (1883–1962), Yugoslav-U.S. sculptor, whose works are characterized by bold cutting and great powers of design, was born on Aug. 15, 1883, at Vrpolje in Slavonia, the son of Croatian peasants. The rudiments of his art were taught him by his father. At the age of 13 he was apprenticed to a marble cutter at Split (Spalato), and three years later entered the Vienna academy, where he studied under Edmund von Hellmer until 1904. He exhibited at the Vienna Secession exhibitions, at the Austrian exhibition at Earl's Court, London (1906), at Munich, Venice and Paris, where he attracted the notice of Auguste Rodin. Mestrovic was largely responsible for a nationalist artistic movement that included the sculptors Rosandith and Dujan Penitch, the painter Racki and the architect Plecnik, and that culminated in the exhibition at Zagreb in 1910. Mestrovic was appointed rector of the academy at Zagreb in 1922. He moved to the United States in Jan. 1947 and joined the faculty of Syracuse (N.Y.) university, becoming a U.S. citizen in 1954. In 1955 he became professor of fine arts at Notre Dame university. He died on Jan. 16, 1962, in South Bend, Ind.

Mestrovic's works include a large number of religious reliefs and figures in walnut; the Pieta relief in the National Gallery of British Art is typical. His portraits include those of his mother (1908), Madame Banac (1913 and 1915), his wife (1915), Sir Thomas Beecham (1915, in the National Gallery of British Art) and Lady Cunard (1915). Among later works are figures of St. Francis of Assisi and "The Artist's Mother in Prayer" (1925); portraits of Herbert Hoover and Pope Pius XI; and two equestrian bronze statues of American Indians set up in Grant park in Chicago, Ill. At a one-man exhibition in 1947 at the Metropolitan Museum of Art, New York city, Mestrovic's works included a Pieta figure weighing more than five tons and the symbolic figures "Job" and "Despair."

**META,** a western tributary of the Orinoco (*q.v.*). It rises in the eastern cordillera of the Andes and empties into the Orinoco at Puerto Carreño (Puerto Páez, Venez.). It flows approximately southwest-northeast and forms part of the Colombia-Venezuela boundary for about 150 mi. in the lower course. The Meta is about 621 mi. long and at its junction with the Orinoco is about 1 mi. wide. Its main headwaters rise in the high Andes east and south of Bogotá and meet to form the main river about 60 mi. out in the llanos (*q.v.*). In its course across the vast plains it receives a number of small tributaries from the northwest, chief of which is the Casanare. During the rainy season from May to October the whole river system overflows and large areas of that terrain are inundated. The drainage basin covers an area of approximately 35,000 sq.mi. almost entirely in eastern Colombia.

The river is navigable by shallow-draft boats throughout most of its course. It is little used, however, because the region through which it flows is sparsely populated, largely undeveloped and a great distance from markets. The largest towns are Villavicencio (elevation, 1,490 ft.) near the base of the Andes, 75 mi. southeast of Bogotá, and Puerto Carreño (elevation, 298 ft.) at the mouth of the Meta. (D. R. D.)

**METABOLISM,** a term that encompasses all the chemical reactions occurring in the living organism. Included are all the molecular processes by which the organism acquires and utilizes the energy it needs for growth, the maintenance of life and the performance of biological functions. The science that deals with the study of metabolism is biochemistry. As biochemists have developed a detailed understanding of the metabolic mechanisms of plants, microorganisms and various forms of animal life, the science has had an enormous impact on fundamental biology, medicine, nutrition and agriculture.

The study of metabolism has as its goal the complete, detailed description of the reactions by which the constituents of the cell are built up and broken down (intermediary metabolism) and of the mechanisms by which the chemical energy derived from the degradative reactions is conserved to be utilized in synthetic processes (energy metabolism or bioenergetics).

This article is devoted chiefly to a discussion of cellular intermediary metabolism; that is, the degradative and synthetic processes that occur within the living cells of humans and many other types of organisms. Other major portions of the article discuss general metabolism, bioenergetics and the control of metabolism.

For related information about metabolism in general the reader should *see* BACTERIOLOGY; BIOCHEMISTRY; CYTOLOGY: *Cytoplasm; Nature of Protoplasm;* PHYSIOLOGY; *Metabolism;* BIOLOGY: *The Living Organism as a Natural Body: Definition;* ENZYMES; GROWTH: *Biological Growth;* ENDOCRINOLOGY; INSECT: *Nutrition and Metabolism;* NUTRITION; PLANTS AND PLANT SCIENCE: *Metabolism;* PHOTOSYNTHESIS; METABOLISM, DISEASES OF. For additional information the reader should consult the references under "Metabolism" in the Index.

## INTRODUCTION

The origins of the study of metabolism are traceable to the work of Antoine Lavoisier (1743–94), who first clearly recognized the essential chemical similarity between combustion and the use of foodstuffs by animal organisms. Despite this recognition, however,

a more detailed understanding of metabolism in terms of its component chemical reactions did not follow for more than 100 years. Indispensable prerequisites of such an understanding were several scientific events of the 19th century, including the clarification by Theodor Schwann (1810–82) and Louis Pasteur (1822–95) of the catalytic role of microorganisms in many natural chemical transformations, the development of the organic chemistry of natural products by Emil Fischer (1852–1919) and many others, and the demonstration in 1897 by Hans and Eduard Buchner that the biological catalysts called enzymes could be extracted from yeast and made to function in the absence of living cells. (*See* FERMENTATION: *Buchner: Cell-Free Fermentation.*) Beginning early in the 20th century there was an explosive growth of detailed knowledge of metabolism, characterized by the emergence of biochemistry as a separate discipline at the crossroads of the physical and biological sciences.

Intensive study of the active yeast extracts of the Buchners and similar extracts of other living cells soon revealed the remarkable similarity of the enzyme-catalyzed metabolic sequences in cells from widely different sources. Thus it became permissible to refer to a given metabolic pathway as an entity in itself without reference to the cellular source of the enzymes involved. By the late 1930s the glycolytic pathway, by which simple hexose sugars (*i.e.*, those with six carbon atoms) are broken down to pyruvate (pyruvic acid ion) in the absence of oxygen, was elucidated through the efforts of many pioneer investigators, including Sir Arthur Harden, W. J. Young, Gustav Embden, Otto Meyerhof, John Robison, Carl Neuberg, Otto Warburg and Carl and Gerty Cori. The reactions of pyruvate oxidation were the subject of investigations by Albert Szent-Györgyi and others and were first fit into the meaningful sequence of the tricarboxylic acid cycle by Sir Hans Krebs in 1937. The basis of the energy relationships in metabolism has been clear since Fritz Lipmann in 1941 pointed out the role of the energy-rich bonds of adenosine triphosphate (ATP) as a kind of currency of metabolic energy. The biosynthetic pathways of most of the amino acids, of which proteins are composed, were elucidated by work in a great many laboratories in the 1940s and early 1950s. The decade of the 1950s brought striking advances in many areas of metabolism. The discovery of coenzyme A (CoA) by Lipmann and of acetyl-coenzyme A by Feodor Lynen provided the basis for the detailed elucidation of the degradative reactions of the fatty acids, which proved to be in accord with Franz Knoop's much earlier suggestion of a scheme of beta oxidation (see *Fats* below). The synthetic reactions of the fatty acids and of more complex lipids were also worked out, as well as the synthetic origins of the porphyrins, which include the chlorophyll of green plants and the heme of blood hemoglobin. The elucidation of the hexose monophosphate shunt pathway of glucose oxidation was another important development of the 1950s.

Following the important theoretical contributions of Linus Pauling, James D. Watson, F. H. C. Crick and M. H. F. Wilkins to the structural chemistry of the nucleic acids and proteins, the biosynthetic mechanisms of these macromolecules were clarified in the late 1950s and early 1960s. The late 1950s and early 1960s also yielded much detailed information concerning photosynthesis, although research on this topic has proceeded over many decades.

In practically all of the metabolic processes many details remain to be discovered, especially at the finer levels of molecular mechanism. In addition the entire basic mechanisms of energy transfer in oxidative metabolism and photosynthesis remain to be clarified. Finally, biochemical research in the third quarter of the 20th century centred increasingly on metabolic control and regulation, which are of the greatest importance in developing an understanding of the mechanisms by which the beautifully co-ordinated metabolic pattern of the living cell emerges from the potential chaos of hundreds of simultaneous reactions.

## GENERAL METABOLISM

**Organic.**—The sun is the source of energy that supports all life on the earth. The use of solar radiation by green plants, and a few specialized bacteria, to form carbohydrates from carbon dioxide and water is the basic metabolic mechanism by which radiant energy is converted to chemical energy. In this form solar energy becomes available to support the other metabolic activities of the plants and all the metabolic activities of other living things, all of which depend directly or indirectly on plants for food. With the carbohydrates formed by photosynthesis, the cells of green plants and of many common microorganisms can catalyze the reactions necessary to make all of the substances required to replicate themselves. Animal organisms also can commonly carry out most of these necessary degradative and synthetic reactions but generally they require a dietary source of at least a few preformed organic components, which are then called essential nutrients; included in the dietary essentials are the vitamins and some of the amino acids.

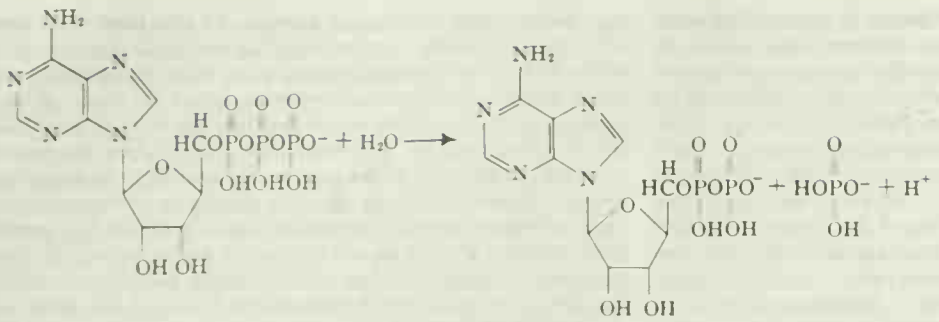
An index of the over-all metabolism of an organism can be secured by measuring its heat production under specified conditions. For studies of metabolism in humans, a reference point is the basal metabolic rate (BMR), which is measured as heat production per unit time in the resting-waking condition, 12 to 14 hours after eating.

**Inorganic.**—In addition to the organic compounds broken down and built up by the metabolic processes of the cell, a considerable number of inorganic ions are indispensably involved in metabolism. As will be evident in the discussions of individual metabolic pathways, inorganic orthophosphate ion ($H_2PO_4^-$) and pyrophosphate ion ($H_3P_2O_7^-$) are direct participants in a great many reactions. In addition certain metal ions are required for the function of the enzymes that catalyze the individual reactions of which the metabolic pathways are composed. The presence of magnesium ion, for example, is required by the enzymes that catalyze reactions involving the organic phosphate compounds. Many of the oxidative enzymes contain zinc, copper, iron or molybdenum ions. Moreover, hemoglobin, the oxygen-carrying pigment of blood, contains iron as a critical part of its structure and chlorophyll, the photosynthetic pigment of green leaves, contains magnesium ion in a very similar type of combination. All of the inorganic materials required by the organism are essential nutrients. Their ultimate source is the minerals of the earth.

## BIOENERGETICS

With the sole exception of photosynthesis, the activities of the living cell proceed by the use of energy derived from the breakdown of food or stored materials. When these materials are oxidized by the living cell, only a part of the potential chemical energy is released as heat energy, in contrast to the results of oxidation by combustion, which releases most of the energy as heat. The remainder of that potential energy is transferred to other molecules in the cell, where it can then be used to drive the necessary functions of the organism. Typically, the metabolic degradation of food and storage compounds occurs in a series of steps, in some of which the molecular change is such that one product of the reaction is markedly unstable; that is, the cleavage of that product proceeds with the release of a large amount of energy. While the unstable product remains whole, however, the energy to be released in cleavage is in a sense stored in the unstable bond, which is therefore known to biochemists as an energy-rich bond. When the energy-rich compound splits by reacting with cellular water, the chemical energy is released as heat energy. If, however, the splitting is accomplished by transfer of a part of the energy-rich molecule with its energy-rich bond to a suitable acceptor compound, a large part of the energy can be conserved and subsequently utilized to drive processes that require the input of energy.

The mechanism by which these events occur is referred to as coupling; it may be illustrated by the synthesis and cleavage of adenosine triphosphate (ATP). Many different metabolic sequences contain key steps in which one product is an organic phosphate compound with a marked tendency to transfer its phosphoryl ($—PO_3H^-$) group. In the presence of the phosphoryl acceptor compound adenosine diphosphate (ADP) and the appropriate enzyme to catalyze the transfer, energy-rich ATP is formed. In this way the synthesis of ATP is coupled to the reactions that produce energy-rich organic phosphate compounds. Furthermore, cleavage of the energy-rich terminal phosphate bond of ATP is itself a reaction that may proceed with the release of a large amount




Adenosine triphosphate (ATP) Adenosine diphosphate (ADP)

FIG. 1.—ATP HYDROLYSIS. (IN THIS AND SUBSEQUENT DIAGRAMS, UNLABELED INTERSECTIONS OF BOND LINES SIGNIFY CARBON ATOMS BEARING, IN ADDITION TO THE INDICATED GROUPS, SUFFICIENT HYDROGEN ATOMS TO MAKE UP THE NORMAL CARBON BONDING VALENCY OF FOUR)

of energy (fig. 1). Accordingly, the cleavage of ATP can be coupled to a great variety of energy-requiring processes in the cell. Thus by the use of ATP as a kind of energy currency, *i.e.*, as a common form through which energy-yielding and energy-requiring reactions are coupled, the cell can conserve and utilize much of the potential chemical energy that resides in the bonds of the food and storage materials metabolized.

There are a number of variations of this mechanism in metabolism. In some synthetic reactions it is not the terminal phosphate bond of ATP that is cleaved but the adjacent one, which is also an energy-rich bond. In other reactions the driving force is the cleavage of an energy-rich phosphate bond of a compound other than ATP. These compounds are closely related to ATP structurally and are synthesized at the expense of ATP. Furthermore, energy-rich bonds can be formed in compounds that make large quantities of energy instantly available. The creatine phosphate of mammalian muscle is such a compound. It is made at the expense of ATP and yields its energy, when needed, in the form of ATP resynthesis. All of these processes, no matter how they vary in detail, proceed by coupled reactions operating through the alternate synthesis and cleavage of ATP, which is thus accurately termed the fundamental mechanism of bioenergetics.

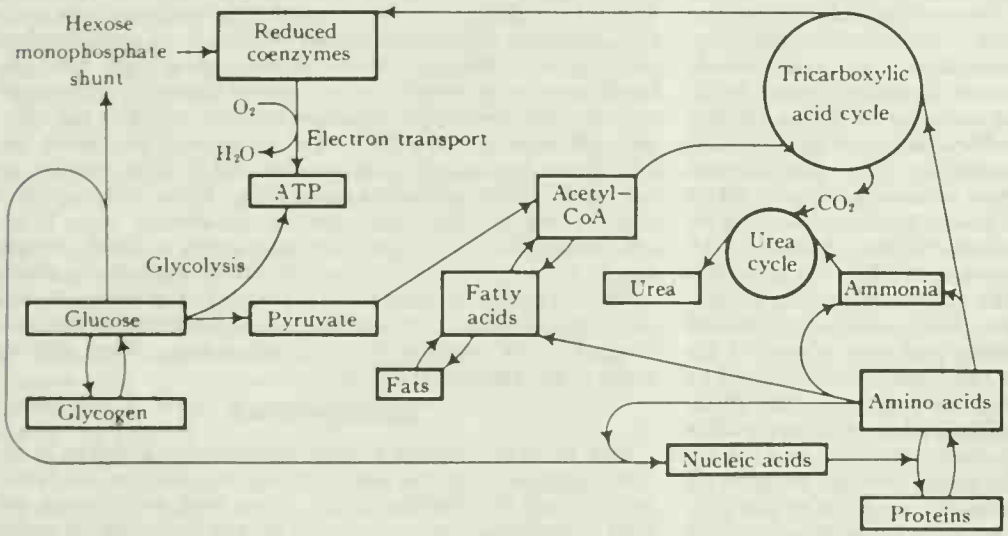



FIG. 2.—SCHEMATIC DIAGRAM OF THE MAJOR FEATURES OF ANIMAL METABOLISM. DOUBLE ARROWS INDICATE SEPARATE SYNTHETIC AND DEGRADATIVE PATHWAYS. THE CHEMICAL ENERGY REQUIRED FOR THE SYNTHETIC REACTIONS IN THE LOWER RIGHT PORTION IS PROVIDED IN THE FORM OF ATP MADE BY THE REACTION PATHWAYS ON THE LEFT

## INTERMEDIARY METABOLISM

The part of biochemistry that seeks a complete description of both the energy-yielding and synthetic reactions of living cells in terms of a network of interrelated chemical reactions is the study of intermediary metabolism. The energy-yielding reactions in which compounds from food or storage are broken down are referred to collectively as catabolism. It is customary, for purposes of discussion, to consider separately the catabolic reactions of each of the three major classes of foodstuffs; *i.e.*, carbohydrates, fats and proteins, the first two of which are also the major storage forms. The biosynthetic, or anabolic, reactions also may be considered separately but with some enlargement in scope in order to include the anabolic pathways of the complex substances that are present in only trace amounts but nevertheless rank equal in importance to the major components. The main pathways of intermediary metabolism are indicated in fig. 2. Most of the remainder of this article consists of an account of the knowledge of some of these pathways.

### CATABOLISM

**Carbohydrates.**—The principal food and storage forms of carbohydrate in animals and plants respectively are glycogen and starch, which are polysaccharides; *i.e.*, they are composed of molecules of the simple sugar glucose linked together in long chains. (*See* also CARBOHYDRATES; STARCH.) The starches and glycogen of food are hydrolyzed by digestive enzymes to glucose, which may be utilized directly or built again into a carbohydrate storage form

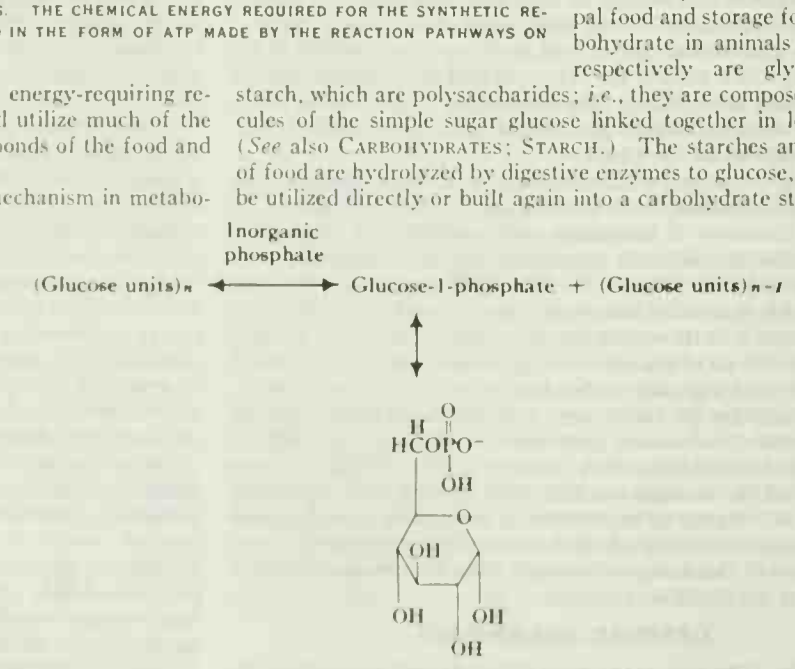



FIG. 3.—FORMATION OF GLUCOSE-6-PHOSPHATE. ARROWS WITH HEADS AT BOTH ENDS INDICATE FREELY REVERSIBLE REACTIONS

located where it is readily available when needed. In man and other animals carbohydrate storage occurs as glycogen in skeletal muscle and in the liver. The withdrawal of glycogen from storage is accomplished by the action of the enzyme phosphorylase, which converts glycogen to glucose-1-phosphate; glucose-1-phosphate, in turn, is converted to glucose-6-phosphate in a reaction catalyzed by the enzyme phosphoglucomutase (fig. 3). Alternatively, if free glucose is used directly, rather than first being made into glycogen, it is converted directly to glucose-6-phosphate by the enzyme hexokinase, with the expenditure of energy in the form of one molecule of ATP. As glucose-6-phosphate, carbohydrate is in a form that can be used in glycolysis, fermentation and the hexose monophosphate shunt, the major pathways for energy production.

FIG. 4.—FORMATION OF FRUCTOSE-1,6-DIPHOSPHATE

*Glycolysis and Fermentation.*—The main pathway of glucose-6-phosphate catabolism in the absence of an abundant supply of oxygen is called glycolysis when it occurs in muscle and fermentation when it occurs in cultures of microorganisms. The two processes differ only in their final reactions.

Glucose-6-phosphate is converted to fructose-6-phosphate (fig. 4) by an isomerase enzyme and this compound is then phosphorylated to give fructose-1,6-diphosphate at the expense of one molecule of ATP. Each of these reactions, as well as each of the succeeding ones, is catalyzed by a separate, specific enzyme. As fructose-1,6-diphosphate the sugar is ready to be split by the enzyme aldolase into molecules of two phosphorylated triose (*i.e.*, three-carbon) sugars, D-glyceraldehyde-3-phosphate and dihydroxyacetone phosphate (fig. 5). The triose phosphates generated in the aldolase reaction are freely interconverted in a separate reaction catalyzed by an isomerase. This is an important step since only the glyceraldehyde-3-phosphate is involved in further metabolism. The next reaction in the glycolytic sequence is a complex one involving both the oxidation of the glyceraldehyde phosphate to an acid and the generation of an energy-rich compound. Inorganic orthophosphate is taken up, phosphorylating the new acid group to make 1,3-diphosphoglycerate.

The compound abbreviated $NAD^+$ (nicotinamide-adenine dinucleotide), a derivative of the vitamin nicotinic acid (niacin), is a common reactant in biochemical oxidation-reduction reactions. (NAD is also called DPN, an abbreviation for diphosphopyridine nucleotide; other alternative names are cozymase and coenzyme I.)

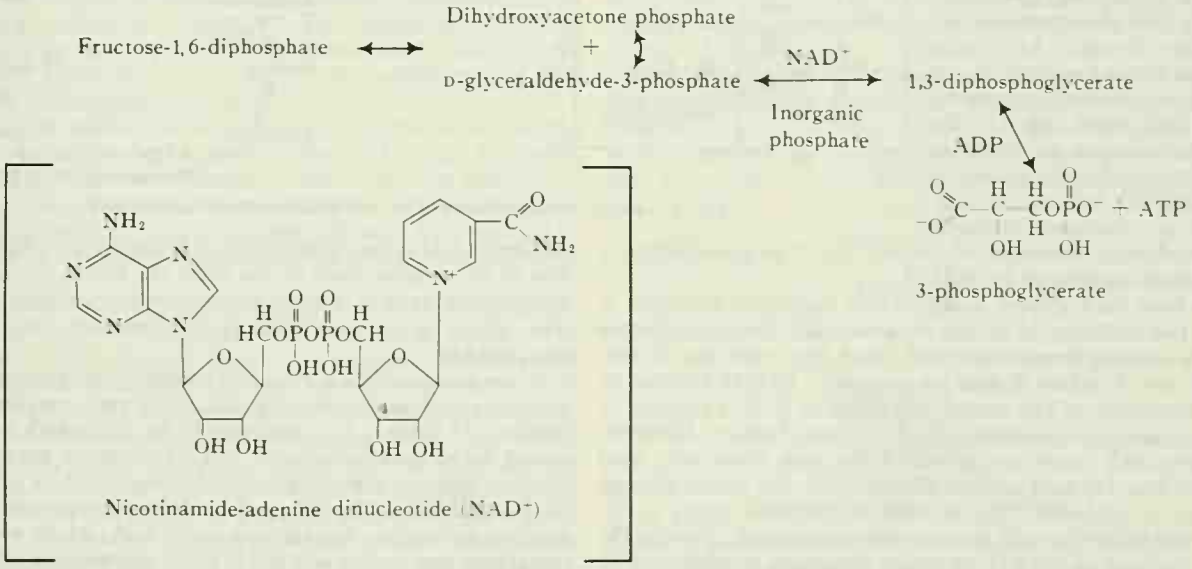



FIG. 5.—FORMATION OF 3-PHOSPHOGLYCERATE

By participating first as an oxidizing agent ($NAD^+$), then in other reactions as a reducing agent (NADH), it is cyclically regenerated instead of being permanently used up. The $NAD^+$, ATP and other compounds with this cyclic type of function are called coenzymes in recognition of the fact that the activity of many enzymes depends on the presence of one of this group of substances.

Diphosphoglycerate, in common with other acyl phosphates and anhydrides in general, is an energy-rich compound. (Acyl compounds are derivatives of acids; glycerates, for example, can be

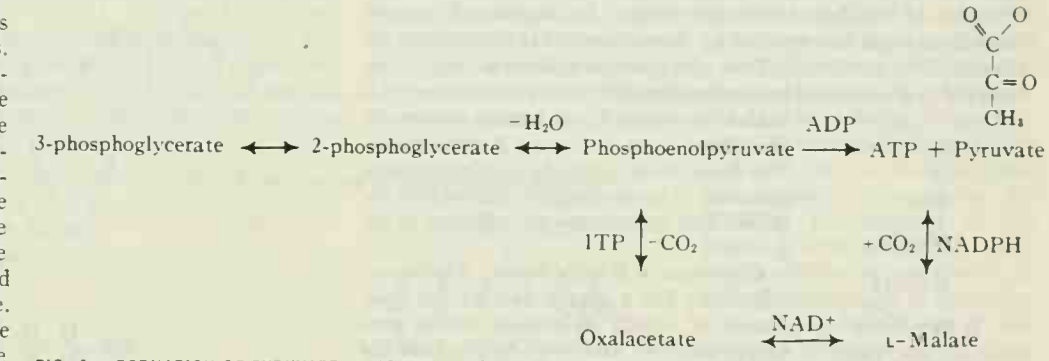



FIG. 6.—FORMATION OF PYRUVATE. $NADP^+$ IS A COENZYME THAT DIFFERS FROM $NAD^+$ BY HAVING AN ADDITIONAL PHOSPHATE GROUP. ITP (INOSINE TRIPHOSPHATE) IS AN ENERGY-RICH COMPOUND CLOSELY RELATED TO ATP. THE REACTIONS IN THE LOWER PORTION OF THE DIAGRAM ARE INVOLVED IN THE REVERSAL OF GLYCOLYSIS

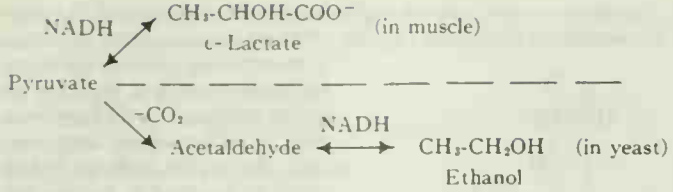
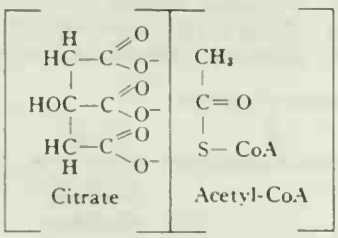



FIG. 7.—FURTHER ANAEROBIC REACTIONS OF PYRUVATE

classified as derivatives of propionic acid.) Part of the energy released in the oxidation of the aldehyde group to an acid has been conserved by the synthesis of the energy-rich phosphate bond. Not unexpectedly, then, diphosphoglycerate can react directly with ADP to synthesize ATP. This is the first reaction of glycolysis that results in ATP synthesis.

The further metabolism of 3-phosphoglycerate involves first its conversion to a 2-phosphoglycerate and then a dehydration to yield another energy-rich compound, phosphoenolpyruvate (fig. 6). As in other reactions where energy-rich phosphate bonds are formed, there is a subsequent transfer of a phosphoryl group to ADP to form another molecule of ATP.

It is in the further reactions of pyruvate that glycolysis and fermentation diverge. In muscle the glycolytic pathway terminates with the reduction of pyruvate to lactate by NADH (fig. 7). In yeast fermentation, on the other hand, pyruvate is split to acetaldehyde and $CO_2$ in a reaction that requires as a coenzyme thiamine pyrophosphate, a derivative of vitamin $B_1$. The acetaldehyde is then reduced to ethanol by NADH.




Thus from each glucose molecule that undergoes glycolysis in muscle, two molecules of lactate are generated; from each glucose molecule entering fermentation with yeast, two molecules of ethanol and two of carbon dioxide are obtained. In both systems an initial investment of two energy-rich bonds of ATP is required to make fructose-1,6-diphosphate, which can react further. However, two energy-rich bonds are generated for each triose unit (and therefore four for each original glucose unit) that passes through glycolysis to pyruvate. The net yield of chemical energy is two energy-rich bonds for each glucose unit metabolized. Finally, the $NAD^+$ reduced to NADH by triose phosphate is reoxidized to $NAD^+$ in the reduction of pyruvate to lactate in muscle or of acetaldehyde to ethanol in yeast. Thus there is no net oxidation or reduction of coenzyme in glycolysis or fermentation.

*Reversal of Glycolysis.*—Three reactions in glycolysis are essentially irreversible under physiological conditions: (1) the phosphorylation of glucose to glucose-6-phosphate, (2) the phosphorylation of fructose-6-phosphate to fructose-1,6-diphosphate and (3) the formation of ATP from ADP and phosphoenolpyruvate. Yet it is clear that pyruvate can be resynthesized physiologically into glycogen, which is the effective reversal of glycolysis over-all. This synthesis is accomplished by the glycolytic enzymes with the exception of the three irreversible steps. In the over-all reversal these three steps are replaced by detour steps that circumvent the irreversibility problem. Thus glucose-6-phosphate is simply hydrolyzed to glucose and inorganic phosphate by a phosphatase; this is also the means for obtaining fructose-1-phosphate from fructose-1,6-diphosphate. The route from pyruvate to phosphoenolpyruvate is more complex, proceeding via malate and oxalacetate, as indicated in fig. 6.

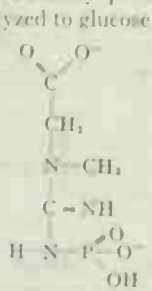


FIG. 8.—CREATINE PHOSPHATE

*Glycolysis in Muscle During Exercise.*—Glycolysis has a special role as the main source of energy in muscle during prolonged vigorous exercise. At this time the restricted supply of oxygen severely limits ATP production by other pathways, yet the repeated contraction of muscle fibres results in the hydrolysis of substantial amounts of ATP. The ATP supply is maintained for a time by transfer of phosphate from creatine phosphate (fig. 8), the energy-rich storage form in muscle. In a short time, however, the local supplies of both ATP and creatine phosphate would be drastically depleted were it not for glycolysis, which can proceed at a maximum rate in the absence of oxygen. The result is that lactate, which is the end product of glycolysis, accumulates in the muscle. When the exercise is slowed or is terminated and an abundant supply of oxygen again becomes available, only a part of the lactate is resynthesized to glycogen by the reversal of glycolysis with its detour steps, as indicated above. The remainder of the accumulated lactate is oxidized to carbon dioxide and water by the tricarboxylic acid cycle, to be described in the next section. This oxidation provides the energy required for the resynthesis of glycogen and the replenishment of the creatine phosphate supply.

*Oxidative Metabolism of Pyruvate.*—Pyruvate formed in glycolysis or by other catabolic reactions is oxidized metabolically to carbon dioxide and water in a reaction sequence known as the tricarboxylic acid cycle, citrate cycle or Krebs cycle. (For a discussion of the original form of the cycle *see* KREBS CYCLE.) This nine-reaction cycle is a ubiquitous source of metabolic energy in cells, where its reactions occur in the organized particles called mitochondria.

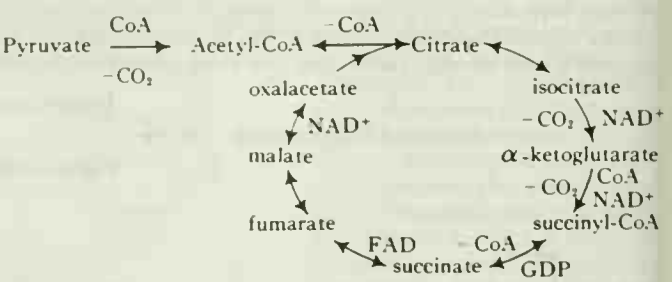



FIG. 9.—OXIDATION OF PYRUVATE BY THE TRICARBOXYLIC ACID CYCLE

In the presence of an abundant supply of oxygen, pyruvate is decarboxylated oxidatively (fig. 9). This very complex reaction requires (1) $NAD^+$, (2) coenzyme A (fig. 10), which is a derivative of the vitamin pantothenic acid, (3) thiamine pyrophosphate (another vitamin derivative) and (4) lipoic acid (a vitamin for some organisms). The net products from the pyruvate and CoA reaction are carbon dioxide and acetyl-CoA, which contains an energy-rich two-carbon unit and is a key intermediate occurring at the three-way junction of the metabolic pathways of carbohydrates, fats and proteins.

Acetyl-CoA (also known as active acetate) from the pyruvic oxidase reaction, along with that derived from the oxidation of fatty acids and certain of the amino acids, enters the tricarboxylic acid cycle by condensation with oxalacetate to form citrate. The citrate is isomerized to isocitrate, and isocitrate is oxidatively decarboxylated to $\alpha$-ketoglutarate by $NAD^+$. In a complex reaction whose mechanism is very similar to that of the pyruvic oxidase reaction, $\alpha$-ketoglutarate is oxidatively decarboxylated in

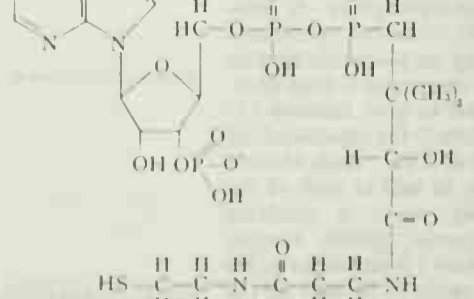


FIG. 10.—COENZYME A

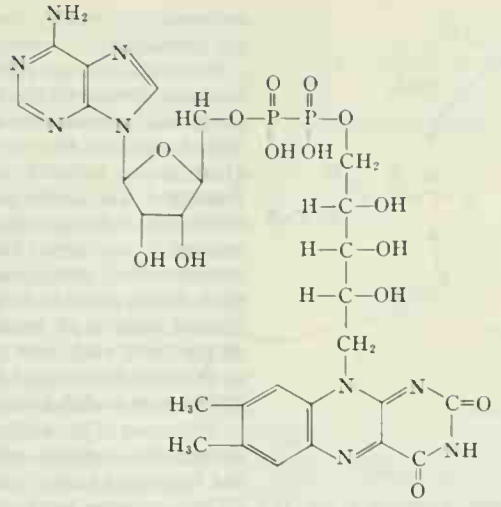


FIG. 11.—FLAVIN-ADENINE DINUCLEOTIDE (FAD)

the presence of thiamine pyrophosphate, lipoate, $NAD^+$ and coenzyme A to give succinyl-CoA. The energy-rich bond in succinyl-CoA is utilized to make ATP. The immediate energy-rich product of this reaction is guanosine triphosphate (GTP), a coenzyme very similar to ATP, but GTP is in equilibrium with ATP so that the effect is to produce ATP.

Succinate is oxidized to fumarate by the action of an enzyme that contains flavin-adenine dinucleotide (FAD) (fig. 11), a derivative of the vitamin riboflavin. FAD, unlike the other coenzymes thus far encountered, is firmly attached to the enzyme itself. Fumarate is hydrated to L-malate and malate is then oxidized to oxalacetate in a reaction mentioned above in the section *Reversal of Glycolysis*.

The cycle is complete with the formation of oxalacetate, as this product can then condense with another acetyl-CoA unit. The net result of one turn of the cycle is the oxidation of both acetyl carbon atoms of the acetyl-CoA to carbon dioxide and water, with the production of one energy-rich phosphate bond and the reduction of three molecules of $NAD^+$ and one of FAD. The carbon dioxide and water are the final products of metabolism and are excreted as such. The reduced coenzymes are reoxidized, ultimately by molecular oxygen in a process (discussed below under *Electron Transport and Oxidative Phosphorylation*) that results in the synthesis of 11 more energy-rich bonds for each acetyl-CoA oxidized in the tricarboxylic acid cycle. Before examining the oxidation of reduced coenzymes, however, we shall consider the other metabolic processes that produce reduced coenzymes and also those that are additional sources of acetyl-CoA.

*The Hexose Monophosphate Shunt.*—In many tissues glycolysis followed by the oxidation of pyruvate is not the only pathway of carbohydrate metabolism. A second important route is the hexose monophosphate shunt pathway occurring in adrenal, mammary and other mammalian tissues, higher plants and many microorganisms. The first three steps in this metabolic sequence are concerned with conversion of six-carbon sugar phosphate to a five-carbon sugar (pentose) phosphate (fig. 12). Glucose-6-phosphate is oxidized by $NADP^+$ to 6-phosphogluconate-delta-lactone. This unstable compound is hydrolyzed enzymatically to 6-phosphogluconate in a reaction that is practically irreversible. In another irreversible step the 6-phosphogluconate is then oxidized by another molecule of $NADP^+$ and at the same time decarboxylated to yield ribulose-5-phosphate and carbon dioxide.

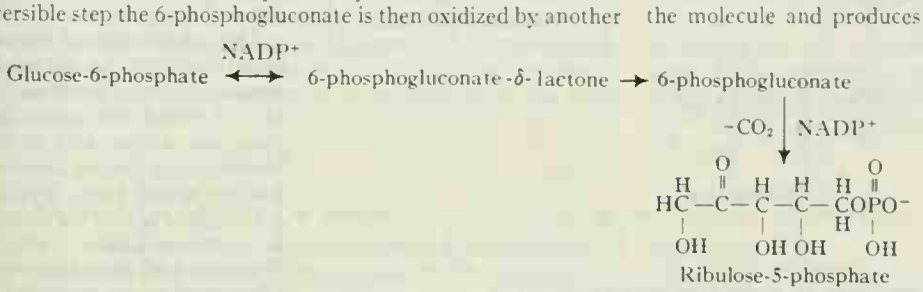


FIG. 12.—CONVERSION OF GLUCOSE-6-PHOSPHATE TO A PENTOSE-5-PHOSPHATE

This part of the hexose monophosphate shunt pathway results in the reduction of two molecules of $NADP^+$. The reoxidation of the resulting NADPH may be coupled to the production of six molecules of ATP from ADP or to any of many synthetic reactions in the cell. The NADPH generated may also be used in the effective reversal of glycolysis to make glucose or glycogen from pyruvate, as NADPH is required in the detour pathway for formation of phosphoenolpyruvate from pyruvate (fig. 6).

The five-carbon sugar phosphate ribulose-5-phosphate is in equilibrium with two other pentose phosphates, ribose phosphate and xylulose phosphate. These pentose phosphates are in turn in equilibrium with three- and seven-carbon sugar phosphates and these in turn with four- and six-carbon sugar phosphates. The hexose and triose phosphates appearing here also occur in the glycolytic pathway discussed previously. This portion of the hexose monophosphate shunt functions as a means of interconverting all the sugars whose chains are three to seven carbon atoms long. Both parts of the shunt pathway also provide means for obtaining pentose phosphate, which is an important intermediate in a number of biosynthetic processes. Moreover, the reactions of this pathway are involved in the photosynthetic process by which carbohydrate is synthesized from carbon dioxide and water in green plants.

**Fats.**—By far the most important storage form of metabolic fuel quantitatively is neutral fat. The fat molecule consists of a molecule of glycerol triply esterified with fatty acids. In metabolism neutral fat is hydrolyzed to glycerol and free fatty acids (fig. 13). The glycerol may be phosphorylated and enter the glycolytic pathway of carbohydrate metabolism by $NAD^+$ oxidation to dihydroxyacetone phosphate. The fatty acids, each of which consists of a straight chain containing an even number of carbon atoms, are metabolized by the mechanism called beta oxidation, in which the second, or beta, carbon atom from the end of the chain is oxidized; this mechanism is catalyzed by an enzyme system that is present in the mitochondria of the cell. Since the end product of fatty acid oxidation is acetyl-CoA, the presence of both the fatty acid oxidizing system and the tricarboxylic acid cycle in the same subcellular particles is clearly an efficient arrangement.

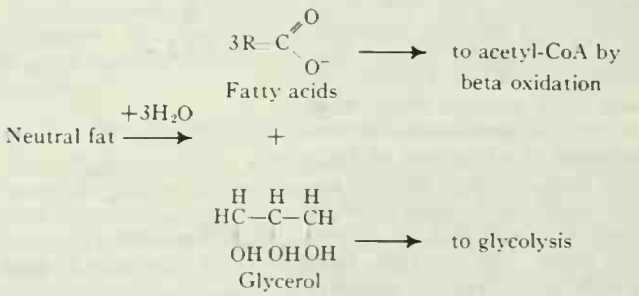


FIG. 13.—METABOLISM OF NEUTRAL FAT

To initiate the metabolism of the fatty acid molecule it is necessary to make an investment of energy in the form of ATP to synthesize the energy-rich bond of the fatty acyl-CoA (fig. 14). Beyond this initial reaction, however, the fatty acid is always handled as its CoA derivative and requires no further investment of ATP. The second reaction in this sequence introduces a double bond into the molecule and produces one molecule of reduced flavin coenzyme. The double bond is then hydrated and the resulting alcohol oxidized to a ketone by $NAD^+$. The cleavage of this ketone is accomplished by a second molecule of coenzyme A, with the production of one molecule of acetyl-CoA and a new acyl-CoA having a carbon chain two atoms shorter than the original fatty acid. This new acyl-

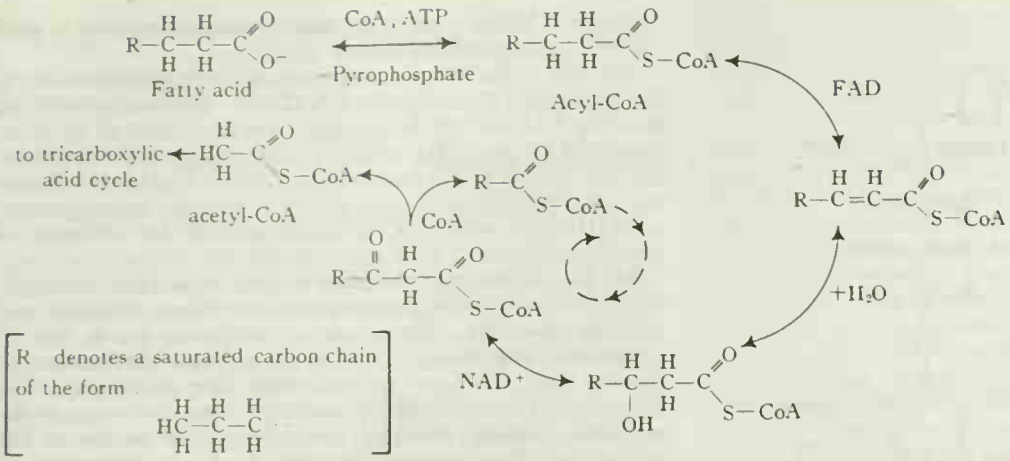



FIG. 14.—BETA OXIDATION OF FATTY ACIDS

CoA can then undergo the same set of reactions, with the removal of a second two-carbon unit, and so on.

For each two-carbon unit of fatty acid undergoing beta oxidation, the cell obtains one molecule each of the reduced coenzymes $FADH_2$ and NADH plus one molecule of acetyl-CoA. The reoxidation of the coenzymes and further metabolism of acetyl-CoA in the tricarboxylic acid cycle can yield a total of 17 energy-rich bonds for each turn of beta oxidation, neglecting the initial investment of ATP that must be made for each original fatty acid molecule. It is evident from these considerations that fats are a much more effective metabolic fuel than carbohydrates. Beta oxidation and the tricarboxylic acid cycle produce many more energy-rich bonds from the metabolism of six carbons of fatty acid than glycolysis and the tricarboxylic acid cycle produce from the metabolism of six-carbon sugar. *See* also OILS, FATS AND WAXES: *Synthesis and Metabolism in Living Organisms.*

**Proteins.**—Proteins ingested as food are hydrolyzed to their constituent amino acids by the various proteolytic digestive enzymes. These amino acids, unless utilized as such for synthesis of the specific proteins of the ingesting organism, are metabolized to yield intermediates that may be used in other syntheses or for entry into the energy-yielding reaction sequences. Protein is not used as a storage form of metabolic energy, but tissue proteins may be metabolized as a major energy source in conditions of starvation or disease, such as untreated diabetes, in which the normal pathways of energy production are blocked.

The metabolic conversions and interconversions of the 20 amino acids that commonly occur in proteins have been the subject of a great many detailed investigations and one might easily cite more than 100 specific enzyme-catalyzed reactions that have been described in this area. However, amino acids undergo only a limited number of general types of reactions and these can serve as the basis for a broad outline of amino acid metabolism.

By means of the amino acid decarboxylase enzymes, amino acids are converted to the corresponding amines (reaction 1, fig. 15). The coenzyme required is pyridoxal-5-phosphate, a derivative of vitamin $B_6$. Although this pathway may have only minor significance as a means for metabolizing proteins in energy-yielding reactions, the amine products of amino acid decarboxylation are important physiological agents. Among these amines occur a large number of compounds having high potency in hormonal roles in relation to nervous function. From histidine comes histamine, which dilates blood capillaries and stimulates gastric secretion; from tryptophan comes an intermediate in the formation of serotonin (5-hydroxytryptamine), which apparently has a function in psychic phenomena; from tyrosine comes tyramine, which is an intermediate in adrenaline (epinephrine) formation; from glutamate comes γ-aminobutyrate, which has a special function in brain tissue.

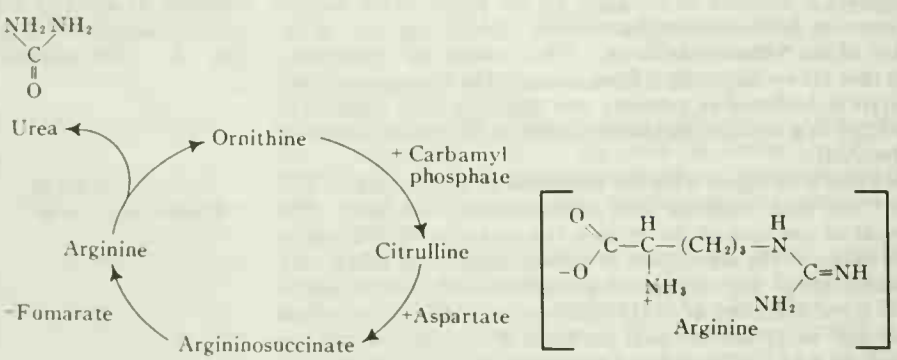
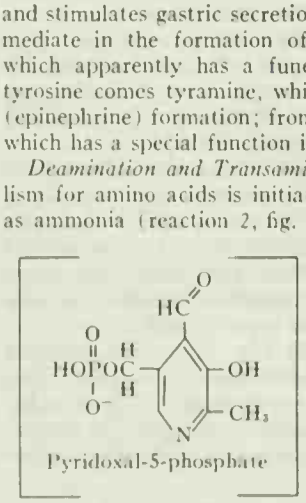



FIG. 16.—THE UREA CYCLE

*Deamination and Transamination.*—A major route of metabolism for amino acids is initiated by removal of the amino group as ammonia (reaction 2, fig. 15), which then can be excreted as urea (see *The Urea Cycle* below). The carbon skeleton of the amino acid becomes either an α-keto acid or an unsaturated acid. Those reactions resulting in keto acid formation require the presence of either $NAD^+$ or FAD and result in the production of reduced coenzyme.




The α-keto acids of the amino acids also may be obtained by transamination (reaction 3, fig. 15), in which the amino group from one amino acid is transferred to the carbon skeleton of another amino acid. Pyridoxal-5-phosphate is also the coenzyme in transamination reactions. When the keto acids are pyruvate (from alanine), oxalacetate (from

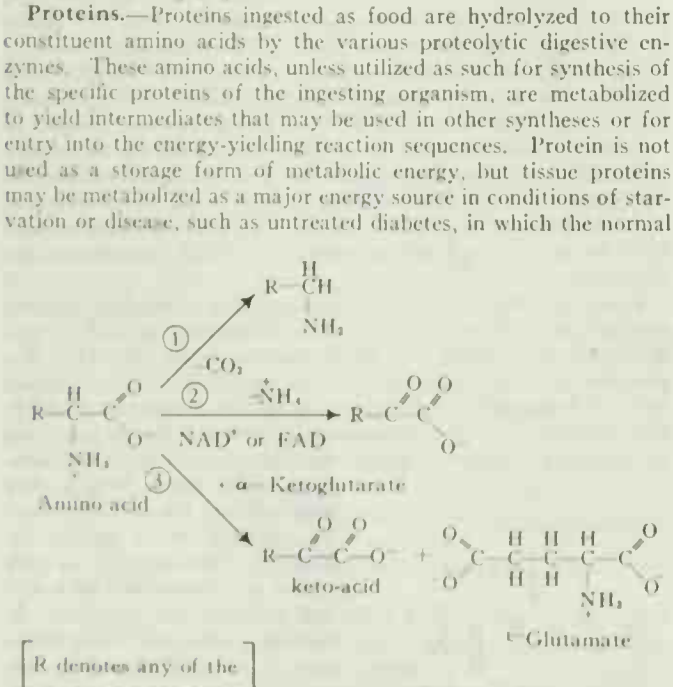



FIG. 15.—SOME REACTIONS OF AMINO ACID METABOLISM

aspartate) or α-ketoglutarate from glutamate), the further metabolism of these compounds is via the pathways outlined above for the same intermediates in carbohydrate metabolism. Decarboxylation of other keto acids, by a mechanism like that in the pyruvic oxidase reaction, gives rise to acyl-CoA derivatives that are metabolized generally by the beta oxidation pathway of fatty acid metabolism. Thus the metabolic pathways of the various amino acids lead directly into those of either the carbohydrates or the lipids.

*The Urea Cycle.*—The ammonium ions from amino acid metabolism may be excreted directly as a means of maintaining the neutrality of the body fluids or they may be made into special excretion products. In mammals the principal excretion form of nitrogen is urea. Several liver enzymes are involved in its formation (fig. 16). The amino acid arginine is hydrolyzed by arginase to yield urea and ornithine. Ornithine reacts with carbamyl phosphate (formed from ammonium ion, carbon dioxide and phosphate from ATP) to form citrulline. Citrulline in turn reacts with aspartate and ATP to give argininosuccinate, which then breaks down to arginine and fumarate. The result is a cyclic process that synthesizes urea from ammonia and carbon dioxide. *See* also PROTEINS: *Metabolism of Protein;* UREA.

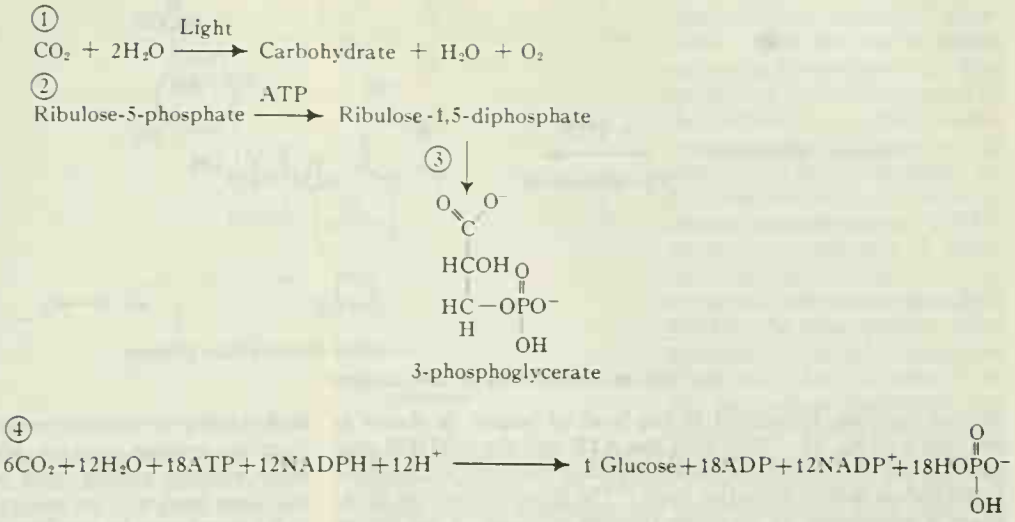



FIG. 18.—SOME KEY REACTIONS IN PHOTOSYNTHESIS

### ELECTRON TRANSPORT AND OXIDATIVE PHOSPHORYLATION

In all of the oxidative pathways described in the foregoing sections, a principal metabolic result has been the reduction of a quantity of $NAD^+$ and FAD to NADH and $FADH_2$, respectively. The necessary regeneration of these coenzymes is accomplished by reoxidation of their reduced forms. These reactions, in which electrons from the reduced coenzymes are used ultimately to reduce molecular oxygen, are called electron transport (fig. 17). Coupled to electron transport is a mechanism for formation of ATP called oxidative phosphorylation. As oxidative phosphorylation is not understood in detail, it is not known whether these reactions in which ATP is formed are basically similar to or different from those for ATP formation in glycolysis.

The cell constituents that mediate electron transport are the cytochromes. Chemically, a cytochrome is a protein bearing an iron-porphyrin active centre like that in hemoglobin. The reduced coenzyme $FADH_2$ can be reoxidized by cytochrome b, which is in turn reoxidized by cytochrome c. Cytochrome c is reoxidized by cytochrome a, which, in the final reaction of electron transport, is oxidized by molecular oxygen with the formation of water. For NADH to enter this pathway, it is first oxidized by a flavoprotein having FAD as coenzyme; the $FADH_2$ then reacts with the cytochrome series in the above way.

The oxidation of the reduced coenzymes by oxygen is a process involving a large quantity of metabolic energy. In fact most of the energy to be obtained by oxidation of the food and storage materials becomes available at this stage in metabolism. At three different reactions in electron transport there is an energy differential great enough to allow the synthesis of ATP. Thus the flow of electrons from the higher energy level of NADH to the lower energy level of $FADH_2$ results in an energy change sufficient for synthesis of one ATP; when $FADH_2$ is oxidized by the cytochromes, an oxidative phosphorylation is again possible; and finally in the oxidation of the cytochromes by oxygen, a third phosphorylation to form ATP can take place. For each reduced nicotinamide-adenine dinucleotide (NADH) entering electron transport, three energy-rich bonds are synthesized. For each $FADH_2$ entering this pathway, only two ATP molecules are synthesized.

The energy-rich phosphate bonds of ATP thus have three metabolic sources: (1) glycolysis, (2) one reaction of the tricarboxylic acid cycle and (3) oxidative phosphorylation coupled to electron transport.

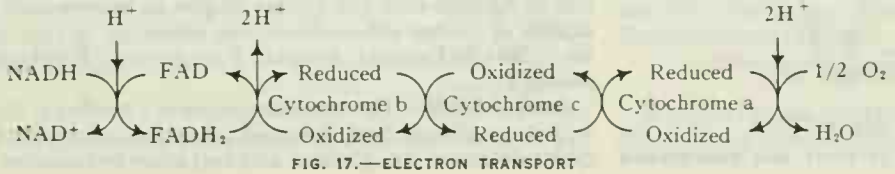



FIG. 17.—ELECTRON TRANSPORT

### BIOSYNTHETIC PATHWAYS (ANABOLISM)

The following sections will discuss some examples of the use of metabolic energy and appropriate intermediates in the formation of cell constituents. As a rule the biosynthetic pathways of compounds in the cell are different from their degradative routes.

**Carbohydrates.**—*Photosynthesis.*—The fundamental sequence on which the biosynthesis of carbohydrates, and ultimately of all other compounds, rests is photosynthesis, by which light is absorbed and converted in green plants to chemical energy.

The details of the primary photochemical reactions are not clearly understood. The pigments that absorb the light are the chlorophylls *a* and *b*. It is clear that a result of this absorption of energy is the splitting of (*i.e.*, the donation of hydrogen by) water. The oxygen of water is released by the plant as molecular oxygen. Coupled to this oxidation of water are reactions that cause the reduction of gaseous carbon dioxide and its incorporation into carbohydrate material (reaction 1, fig. 18). Considered in more detail, the direct results of the absorption of radiant energy by chlorophyll within the plant cell are the release of oxygen, the reduction of $NADP^+$ and the conversion of ADP to ATP. Production of ATP in the light reaction is called photophosphorylation. The mechanism of photophosphorylation, like that of oxidative phosphorylation, is not known. (*See* also CHLOROPHYLL, CHEMISTRY OF.)

The pathway by which carbon dioxide is reduced and incorporated has been elucidated in more detail. The ribulose-5-phosphate present in the cell is further phosphorylated by a kinase reaction using ATP (reaction 2, fig. 18). Carbon dioxide is then added in the carboxydismutase reaction and the molecule is hydrolyzed to two molecules of 3-phosphoglycerate (reaction 3, fig. 18). Reversal of glycolytic reactions in the manner indicated above in *Glycolysis and Fermentation* can then account for the synthesis of glucose. The net result of the carbon dioxide fixation and re-

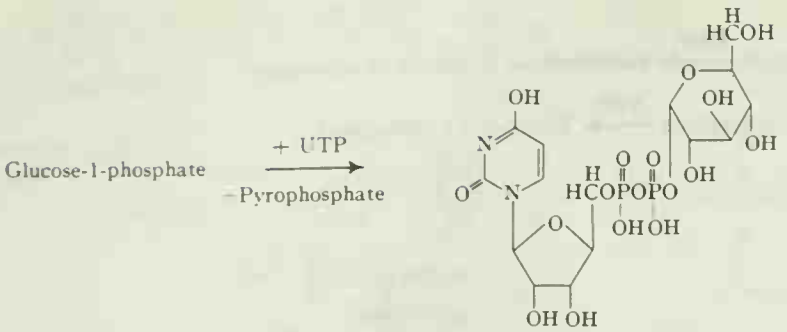



FIG. 19.—FORMATION OF UDP-GLUCOSE

duction reaction, considered at the level of hexose, is shown in reaction 4 of fig. 18. Note that the ATP and the NADPH produced in the photosynthetic phosphorylation reactions are required in the carbon dioxide reduction cycle. The supply of pentose phosphate is maintained by recycling through reactions of the hexose monophosphate shunt some of the glyceraldehyde-3-phosphate and fructose-6-phosphate being produced.

*Disaccharides and Polysaccharides.*—For the formation of the chemical bonds linking sugar molecules to one another in disaccharides (*e.g.*, lactose [milk sugar] or sucrose [common cane or beet sugar]), or the polysaccharides (*e.g.*, starch or glycogen), the input of chemical energy is required. This investment of energy is accomplished by a process referred to as activation, which occurs at the expense of ATP. Glucose is activated in a two-stage process. The first stage is the formation of glucose-1-phosphate as shown in fig. 3. The glucose-1-phosphate can then react with the energy-rich compound uridine triphosphate (UTP) to form uridine diphosphate glucose (fig. 19). The enzyme is glucose-1-phosphate uridyl transferase. UDP-glucose is an activated (energy-rich) form of glucose that can then react with a second simple sugar to give a disaccharide phosphate or with a polysaccharide chain to lengthen it by one unit. As an energy-rich compound has been used in the synthesis of a compound that has no energy-rich bond, the equilibrium is displaced far in the direction of the synthesis. Thus, large concentrations of the products can be built up.

**Lipids.**—Although only the neutral fats are considered to be of major importance as a storage form of potential chemical energy, there are in the tissues a great many lipid materials of widely varying structures. The biosynthetic pathways of a number of types of lipids are well understood. This discussion will take as examples the synthetic reactions of fatty acids, neutral fats and steroids.

*Fatty Acids.*—The formation of fatty acids for the synthesis of neutral fats does not proceed by reversal of beta oxidation, although the individual reactions of that pathway are reversible. Moreover, the synthetic process, unlike beta oxidation, does not occur within the mitochondria. The enzymes involved apparently exist bound together as a separate complex in solution in the cell.

The key reactant in fatty acid synthesis is malonyl-CoA, a compound formed from acetyl-CoA by a carboxylation reaction at the expense of ATP (fig. 20). The vitamin biotin is involved as a coenzyme. The malonyl group is then transferred from CoA to the enzyme complex and the malonyl-enzyme combination serves as an activated intermediate for the chain-lengthening reaction of fatty acid synthesis. Reaction of the malonyl-enzyme unit with a molecule of acetyl-CoA results in the formation of a $\beta$-keto acid and the release of carbon dioxide. The $\beta$-keto acid is reduced in succeeding steps by NADPH and $FMNH_2$, a reduced coenzyme (flavin mononucleotide) related to $FADH_2$, to form a fatty acyl-CoA having a four-carbon chain. This compound is released from the enzyme complex, which is then available to accept another malonyl residue from malonyl-CoA. The fatty acyl-CoA may then react with the malonyl-CoA and complete the cycle again to be lengthened by another two-carbon unit. Repetition of this process results in the buildup of the long-chain saturated fatty acids characteristic of animal tissues.

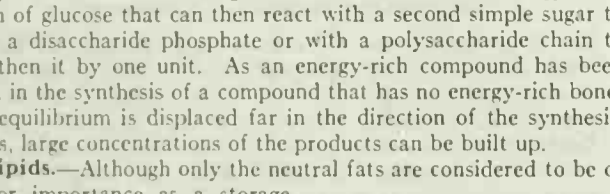



FIG. 20.—FORMATION OF A KEY REACTANT IN FATTY ACID BIOSYNTHESIS

*Neutral Fats.*—Fatty acid biosynthesis as outlined above concludes with the production of long-chain fatty acyl-CoA compounds. The storage form of fatty acids, however, is neutral fat, which is synthesized from fatty acids in three stages (fig. 21). A molecule of L-$\alpha$-glycerol phosphate derived from the phosphorylation of glycerol or from the reduction of the dihydroxyacetone phosphate of glycolysis reacts with two molecules of fatty acyl-CoA to form a phosphatidic acid. This compound is hydrolyzed by a phosphatase to yield an $\alpha,\beta$-diglyceride, which may then react with a third acyl-CoA molecule to form neutral fat.

*Steroids.*—The steroids (*q.v.*) are lipids whose structure and function are very different from those of the neutral fats. Their structure involves a system of five fused rings. Functionally, the steroids include the parent compound cholesterol, vitamin D and the adrenal cortical and sex hormones, derived from cholesterol. In the biosynthesis of cholesterol (fig. 22), acetyl-CoA is the source of all of the carbon atoms. Through a series of condensations, reductions and rearrangements the 30-carbon branched-chain hydrocarbon squalene is formed and squalene can cyclize to form the steroid ring system. In a series of several further steps, the cholesterol structure is created. Cholesterol then serves as the precursor of the steroid hormones.

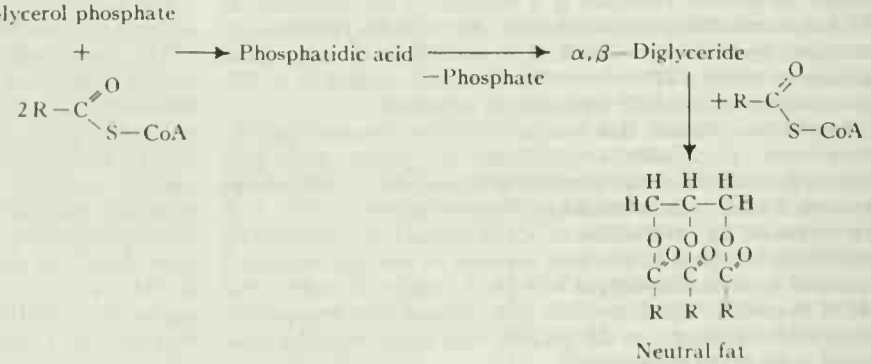



FIG. 21.—BIOSYNTHESIS OF NEUTRAL FAT

**Porphyrins.**—The porphyrin ring system occurs in the cytochromes, hemoglobin and the chlorophylls. The synthesis of this structure occurs through the condensation of units derived from succinate and the amino acid glycine. There is a direct condensation of succinyl-CoA and glycine to give an intermediate that is capable of further self-condensations, ultimately to form porphyrin. (*See* also PIGMENT, ANIMAL: *Tetrapyrroles: Porphyrin Compounds.*)

**Amino Acids.**—The metabolic origins of a number of the amino acids have already been indicated. Arginine occurs in the urea cycle; glutamate (*i.e.*, glutamic acid ion) arises by reductive amina-

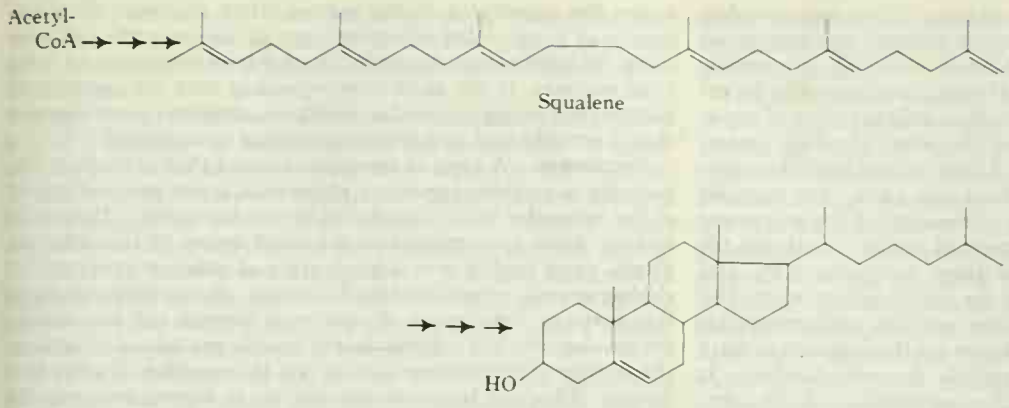



FIG. 22.—FORMATION OF CHOLESTEROL

tion of α-ketoglutarate from the tricarboxylic acid cycle; and serine, alanine and aspartate (aspartic acid ion) are the products of transamination of hydroxypyruvate, pyruvate and oxalacetate, respectively. In addition, serine is converted to glycine in a reaction involving a coenzyme form of the vitamin folic acid and to cysteine in a reaction involving another amino acid, methionine. Histidine is evidently synthesized from pentose phosphate and proline from glutamate.

A considerable number (eight in man) of the amino acids cannot be synthesized by mammals; these are the so-called essential amino acids. Although they must be supplied in the diets of higher animals, they can be synthesized by many lower organisms, and a great deal is known about their pathways of biosynthesis in microorganisms.

**Nucleotides.**—The nucleotides (*i.e.*, compounds composed of a heterocyclic base attached to the phosphoric ester of a pentose sugar) are of the utmost importance to the organism since many indispensable coenzymes are of this form (*e.g.*, ATP, $NAD^+$, FAD). Both the genetic material of the cell and important components in the mechanism of protein synthesis are nucleic acids (*q.v.*), which are polymers of the nucleotides. The nucleic acids are composed of two types of units, purine and pyrimidine nucleotides, which have largely separate biosynthetic pathways.

The purine nucleotides are synthesized in the cell by a complex series of reactions involving the incorporation of atoms from a variety of sources: (1) ribose-5-phosphate, (2) ATP, (3) glycine, (4) formyl groups from a folic acid derivative, (5) carbon dioxide and (6) nitrogen atoms from glutamine and aspartate. The product of this synthetic sequence is inosine monophosphate (fig. 23). From this compound are made the purine nucleotides of the ribonucleic acids (RNA), adenosine monophosphate (AMP) and guanosine monophosphate (GMP), which function in protein synthesis. From these nucleotides can be made the corresponding deoxyribose nucleotides that are components of the deoxyribonucleic acids (DNA), which constitute the genetic material of the cell. Vitamin $B_{12}$ is involved in the reduction of the ribosyl residue to the deoxyribosyl form.

The pyrimidine nucleotides are formed by incorporation of atoms from ribose-5-phosphate, ATP, aspartate and carbamyl phosphate. As in the case of purine nucleotide biosynthesis, the first pyrimidine nucleotide formed in the pathway, orotidine monophosphate (fig. 23), is not one of those found in nucleic acid. By decarboxylation it is converted to uridine monophosphate (UMP), which is a constituent of RNA, and UMP in turn may be converted to cytidine monophosphate (CMP), the other pyridine ribonucleotide. For DNA synthesis, CMP and UMP are reduced to the deoxyribose compounds but deoxy-UMP is methylated to thymidine monophosphate (TMP) before incorporation into DNA.

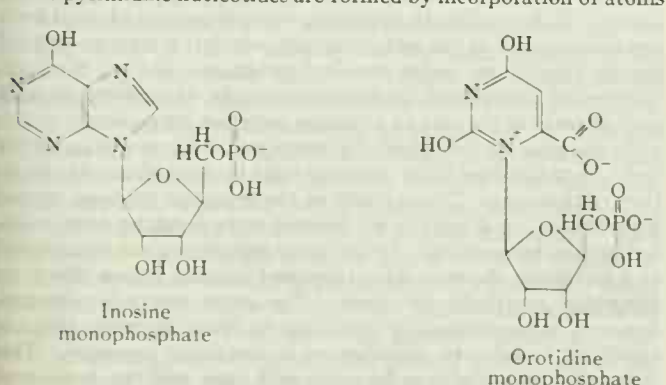



FIG. 23.—PRECURSORS OF THE PURINE AND PYRIMIDINE NUCLEOTIDES

**Nucleic Acids.**—The enzyme DNA polymerase catalyzes the synthesis of the macromolecule deoxyribonucleic acid from the triphosphates—deoxy-ATP, deoxy-GTP, deoxy-CTP and TTP, which is also a deoxyribonucleotide. A further requirement is that a primer DNA must be present in the mixture. The product DNA evidently has the same sequence of nucleotides along the chain as does the primer DNA. Clearly, the primer molecules direct the synthesis of the product and the product is a replica of the primer. Such a system is ideal for the transmission of the genetic information from cell generation to generation. There is good evidence that the nucleotide sequence in the DNA of the genes constitutes coded instructions for the synthesis of all the proteins, including the enzymes, that the cell makes.

There is a similar system for the synthesis of the RNA macromolecule. Ribonucleic acid polymerase requires ATP, GTP, CTP and UTP and a primer polymer. It is interesting, however, that the primer must be DNA rather than RNA. The product RNA faithfully mirrors the primer DNA in sequence. This system, too, is an ideal one for its function. RNA is the form in which the DNA code is read for the translation into protein structure. Thus RNA is synthesized in the nucleus of the cell as a replica of the genetic material that exists there and then emerges from the nucleus to take part in protein synthesis. This type of RNA is appropriately called messenger RNA and it attaches to the ribosomes, the ribonucleoprotein particles in the cell that are the sites of protein synthesis.

**Proteins.**—The proteins are macromolecules consisting of hundreds to thousands of L-amino acid residues linked together in a precisely determined sequence. For synthesis into protein each amino acid must be activated by its specific activating enzyme, which links the amino acid to an adenosine monophosphate moiety from ATP. The very reactive amino acid adenylates are not released into solution by the activating enzymes but are transferred to a type of RNA of relatively low molecular weight called transfer RNA. Each amino acid has its specific transfer RNA. The transfer RNA carries the amino acid, still in activated form, to the ribosome, which is the site of protein synthesis. There, each transfer RNA molecule, laden with its activated amino acid, interacts with the messenger RNA that bears the transcribed genetic code. The interaction is such that the activated amino acids become aligned in a specific sequence predetermined by the genetic code. Then, starting at one end of the array, the amino acids are linked together by the characteristic peptide bonds and the protein peels off the ribosome, assuming its specific three-dimensional configuration as it does so. Each of the many proteins that a cell synthesizes is formed in this way, according to a definite structural sequence specified in the genes inherited by the cell from its ancestors. *See* also NUCLEIC ACIDS: *Biochemical Functions of Nucleic Acids: Determination of Protein.*

## THE CONTROL OF METABOLISM

It should be clear from the foregoing discussion that cell metabolism is a very complex process that must demand a carefully regu-

lated interplay of many reaction systems. When one considers further the necessary additional controls required by complex organisms made up of many different kinds of cells built into various organ systems, the whole problem of regulation is seen to be extremely complicated. In fact, the modern understanding of metabolic controls is very incomplete but the points at which control can be exerted are becoming clear. At the cellular level the architecture of the cell is one factor that must play a role. For example, the enzymes catalyzing the synthesis of messenger RNA are present in the nucleus, where the genetic material resides. Both the tricarboxylic acid cycle enzymes and those catalyzing fatty acid oxidation are present exclusively in the mitochondria, which also contain the electron transport system and the mechanisms for oxidative phosphorylation. The enzymes for the synthesis of fatty acids, on the other hand, occur outside the mitochondria. It seems probable that both the selective permeability of the membranes surrounding these intracellular structures and the relatively fixed spatial organization of their component parts with respect to one another must be important factors in the regulation of metabolism.

**Enzyme Inhibition and Metabolic Antagonism.**—One type of mechanism clearly capable of exerting control on a rapid, short-term basis is inhibition. Enzymes isolated by the biochemist may be inhibited by a variety of agents. In some instances it is clear that the basis for the inhibition is the structural similarity of the inhibitor and the compound on which the enzyme normally acts (the substrate). The similarity may be sufficient for the inhibitor to combine with the enzyme in the same manner as the substrate but insufficient to allow splitting and subsequent release of the inhibitor. Such metabolic antagonists, which inactivate enzymes by combining with them, have been useful in chemotherapy. The classic example is the sulfa drugs, the structure of which mimics that of para-aminobenzoic acid, a component utilized by microorganisms in the synthesis of folic acid. (*See* also ANTIMETABOLITES.)

Some enzymes are known to be inhibited specifically by compounds that occur normally in cells. Such inhibition may have physiological significance as a control mechanism for biosynthetic processes since the end product of a synthetic pathway may inhibit its own synthesis. Thus, for example, in bacteria the amino acid histidine has been shown to be a specific inhibitor for an enzyme concerned with the synthesis of a histidine precursor. Such a mechanism is referred to as a feedback control. The information that an ample supply of histidine is present in the cell is by this means fed back into the synthetic system to turn it off. When the histidine concentration drops to levels requiring further synthesis, the inhibition is automatically relieved and synthesis resumes.

**Repression.**—There is a second biosynthetic control mechanism that has much the same appearance as the feedback control except that it responds much more slowly. Histidine biosynthesis in bacteria again may be taken as an example. If the bacteria are grown with an ample supply of histidine in the growth medium, the enzyme referred to in the preceding section is found to be almost completely absent from the cells. Upon removal of histidine from the growth medium, a considerable period of time must elapse before the culture can resume growth. This so-called repression effect is an inhibition of the synthesis of the enzyme from amino acids, presumably at the point of messenger RNA formation. The coded information for synthesis of that particular enzyme is simply not present at the sites of enzyme synthesis. Upon removal of the repressor histidine, time is required for the synthesis of the messenger RNA, its incorporation into the ribosomes and synthesis of the enzyme itself.

**Induction.**—Induction is a phenomenon related to repression although it operates in the formation of enzymes involved in the catabolic rather than the synthetic reaction sequences. It appears that in induction the sites for formation of the messenger RNA molecules for the synthesis of some enzymes are normally repressed. By relieving this repression, a specific substrate induces the formation of a specific enzyme involved in its metabolism. Thus addition of the substrate to the growth medium of the cell causes the appearance of the enzyme, after the usual delay encountered in the relief of repression. In this way the cell may carry the information for synthesis of a large repertoire of catabolic enzymes, at the same time expending only the amounts of material and energy required to maintain a supply of those enzymes that it actually uses in a given biochemical environment.

**Hormones.**—A type of metabolic control that is of great importance in complex organisms, although it is not well understood at the molecular level, is mediated by the hormones. These substances, which are secreted into the blood stream by the endocrine glands, exert control over a great array of different processes including growth, general metabolic activity, the secretion of digestive enzymes, the passage of substrates through cell membranes, the development and maintenance of specific anatomical structures, the activity of involuntary muscles and the secretion of other hormones. All of the hormones are effective in minute amounts. In contrast to other trace substances such as vitamins, they are elaborated by the tissues of the organism in which they operate and are also inactivated by processes in that organism.

Since the hormones differ chemically, their anabolic and catabolic pathways also differ. The steroid hormones (adrenocortical and sex hormones) are synthesized from cholesterol. They are inactivated by a variety of chemical changes and excreted with the steroid ring system intact. The hormones derived from amino acids (*e.g.*, thyroxin, adrenaline) are metabolized much as the amino acids. The peptide hormones (*e.g.*, parathormone, insulin and the several pituitary hormones) are probably synthesized and metabolized by the anabolic and catabolic pathways of protein. *See* HORMONES, VERTEBRATE; *see* also references under "Metabolism" in the Index.

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**METABOLISM, DISEASES OF.** Metabolism (*q.v.*) is an inclusive term that applies to virtually all the active processes in living organisms. It thus encompasses the chemical reactions and physical phenomena involved in the organization, maintenance and growth of living matter. Cellular metabolism defines these activities in the single-celled organism or in a cell of a multicellular plant or animal. Tissue and organ metabolism refer to the physiological activities of the highly organized conglomerates of cells in an organ or tissue of animals or man; *e.g.*, brain, liver or connective tissue.

The metabolism of tissues involves nutrition, tissue synthesis (anabolism), tissue breakdown (catabolism), respiration and energy exchange and the functional activity or work, such as muscular contraction or glandular secretion, performed by the cells or organ. In the intact man or animal metabolism obviously includes the sum of the metabolic activities of all the organs and tissues. It is possible to determine various aspects of total body metabolism such as the metabolic rate, which is a measure of total energy expenditure under standard conditions, and by more discriminating procedures to secure estimates of activity in such limited areas as the rate of hormone secretion by a gland.

In the healthy individual the many metabolic activities of the body are maintained in an optimum state by a multitude of regulatory mechanisms. This stability of the organism has been termed homeostasis. A disease is the morbid state resulting from a disturbance in homeostasis. In this sense any disease can be regarded as a metabolic disease. Infections and injuries induce illness by disturbing metabolic processes. The term metabolic diseases, however, is conventionally restricted to those disorders that are ascribable to primary disturbances in metabolic processes. This distinction cannot always be made with ease, and the decision to include or exclude certain diseases may be arbitrary. In this

article a broad inclusive definition of metabolic disease has been accepted. The number of diseases involved is so great as to prohibit much more than tabulations and definitions. Many are extremely rare.

**Nutritional Deficiency Diseases.**—Undernutrition is the result of a deficiency in calories and/or dietary protein. A severe chronic restriction in calories ultimately results in the depletion of vital structural protein. Inanition is readily detected and may be complicated by evidences of malnutrition. Extreme undernutrition in infants and children due primarily to a dietary protein deficiency has been termed *kwashiorkor*. It is also important to appreciate that protein deficiency may develop acutely from the extreme protein wasting that is a portion of the body's normal response to severe acute illnesses or injuries.

A chronic deficiency of any of the vital chemical substances (vitamins) that the body is incapable of synthesizing may lead to one or a combination of any of the several malnutrition syndromes. Deficiencies in thiamine, niacin and ascorbic acid, which are water-soluble vitamins, will induce beriberi, pellagra and scurvy respectively. The fat-soluble vitamins A and D in adequate amounts prevent the development of night blindness and rickets or osteomalacia. Malnutrition as well as undernutrition may also develop as a result of defects in gastrointestinal absorption such as that which is seen in sprue. In a sense pernicious anemia may also be regarded as a deficiency disease. The basic defect here is the absence of gastric intrinsic factor, without which vitamin $B_{12}$ cannot be absorbed.

**Inborn Errors of Metabolism.**—Inborn errors of metabolism is a term generally applied to a group of diseases characterized by the fact that their basic etiology is a highly specific, genetically determined, biochemical or metabolic abnormality. At the present time most of the diseases in this category are rare; more are continually being discovered. As a matter of fact it is already difficult to draw a sharp line between those metabolic disturbances that are inherited and those that are acquired.

Gout is probably the most common disease in this classification. It is characterized by acute recurrent attacks of arthritis that are apparently due to the accumulation of urates in body fluids and in local deposits. The hereditary factor responsible for the inherent susceptibility to gout seems to be transmitted by a single autosomal dominant gene.

A number of defects in the body's ability to handle carbohydrates can be diagnosed. In glycogen storage disease (von Gierke's disease) gross excesses of this polysaccharide are stored in tissues, especially the liver and kidneys, and normal blood glucose levels are not maintained. In galactosemia the milk sugars, lactose and galactose, are not converted to glucose because of an enzymatic defect. Infants with this disease develop mental retardation, liver disease and cataracts, but all these manifestations can be prevented if the baby is not fed galactose during the first three years of life.

Renal glycosuria is a harmless "laboratory disease" in which small amounts of glucose escape in the urine at normal blood sugar (glucose) concentrations. Fructose and some pentoses in rare instances appear in the urine in other inborn metabolic disturbances of little medical consequence.

The defective handling of various amino acids, which are the building blocks of tissue protein, has also been defined as the cause of some metabolic disorders. Cystinuria results in the formation of cystine stones in the urinary excretory tract. Excessive urinary wasting of other amino acids may not be medically important but such cases have been detected. On the other hand the hereditary inability of the kidneys to conserve amino acids may be associated with a parallel wasting of inorganic phosphate, potassium and even glucose in the urine (Fanconi's syndrome). This often results in a relative acidosis and a form of rickets or osteomalacia that is resistant to treatment with vitamin D. Renal acidosis is a rare condition in which the kidneys are incapable of excreting acid urine. There occurs an excessive excretion of calcium, phosphate and potassium. The clinical manifestations are frequent renal stone formation, osteomalacia and muscular weakness. Phenylpyruvic oligophrenia is a condition in which the amino acid phenylalanine cannot be converted to tyrosine with the result that phenylpyruvic acid accumulates. Mental deficiency is uniformly present.

Familial periodic paralysis is characterized by periodic attacks of flaccid paralysis or extreme weakness of most of the voluntary muscles of the body, but particularly those of the limbs. The paralytic condition may last from a few hours to a few days, and between attacks the patient is usually normal. It is apparently due to a deficiency in the potassium content of the muscle cells. Porphyria is a constitutional disease in which the metabolism of porphyrins, which are blood pigments, is disturbed and unusual porphyrin compounds can be detected in the urine. In one form there is extreme photosensitivity of the skin. In the more common form, the symptoms and signs are often bizarre and in the early stages simulate severe neurotic states. Severe colic abdominal pains suggesting acute surgical emergencies and profound neurological manifestations such as paralyses and convulsions are seen in some cases.

Xanthomatosis is a condition in which there occur unusual deposits of fatty material in various tissues of the body and associated elevated levels of lipids in circulating plasma. Cholesterol and/or neutral fats are the lipids involved. Arteriosclerotic vascular disease occurs early in the life of persons with familial hypercholesteremia. As a matter of fact it is appropriate to include arteriosclerosis, which is the deposition of these fatty plaques in arteries, among the very important metabolic diseases.

**Endocrine Disturbances.**—The hormones are among the most important regulators of metabolic processes. Pathologic alterations in the rate of their secretion by the endocrine glands will produce significant metabolic disturbances. Hypersecretory states may be due to functioning tumours or hyperplasic glands that have somehow escaped from their usual controlling systems. Destructive tumours, infections or vascular occlusions may lead to endocrine deficiency states; the glands may also atrophy as a result of genetic or other unknown factors. Deficiency and hypersecretory states of the anterior pituitary, thyroid, adrenal cortex, pancreatic islets, parathyroids, ovaries and testes have been described. With respect to the posterior pituitary gland only a deficiency disease has been described—*diabetes insipidus*, which is characterized by the failure of the kidneys to conserve body water in a normal fashion. No disease due to a deficiency of adrenal medullary secretions, epinephrine and norepinephrine, has been described, but secretory tumours of the adrenal medulla induce a syndrome that includes hypertension and *diabetes mellitus*.

*Diabetes mellitus* is the most common and probably the most complex of the endocrine diseases. It is a syndrome characterized essentially by pathologically high blood glucose concentrations and the spillage of glucose in the urine. The syndrome may be the result of any of several basic disturbances; more often than not the true cause is not ascertainable. Whatever the etiology, however, it may be looked upon from the practical viewpoint as a disease in which the endogenous insulin available is insufficient to meet the demands of the body. In addition to the dominating metabolic defect, which is the inability to utilize carbohydrates in an effective manner, there are abnormalities in fat and protein metabolism and more subtle disturbances that predispose the patient to the development of arteriosclerotic and other special types of vascular, renal and ocular disturbances.

**Liver and Renal Disease.**—Normal renal function is the key to the maintenance of optimum extracellular and intracellular fluid and electrolyte concentrations and is vitally concerned with the elimination of metabolites of all sorts. In renal insufficiency, from whatever cause, profound metabolic disturbances develop. Clinical signs and the biochemical changes differ somewhat from case to case depending upon the type of renal lesion, the severity of the defect and the duration of the disease. In general, it can be said that the syndrome that results can be ascribed at least in part to the retention of inorganic and organic compounds, some of which are metabolic end products normally excreted in the urine. In some instances, however, electrolytes that should be sparingly excreted for the maintenance of homeostasis cannot be retained when the need dictates, as in the sodium wasting form of

nephritis. In the nephrotic syndrome plasma protein is lost in the urine, and hypoproteinemia with attendant edema and other complications develops.

The liver is probably actively involved in the performance of more functions than any other organ in the body. It has a vital role in carbohydrate, protein and fat metabolism and is active in the conjugation and excretion of bile and other pigments, steroids, etc. Disturbances in liver function such as cirrhosis thus result in widespread metabolic derangements.

**Miscellaneous Metabolic Diseases.**—Obesity is probably the most common metabolic abnormality in the U.S. and other portions of the world where there is an abundance of food. It is of considerable medical importance in that its presence subjects the patient to significantly greater health hazards. *Diabetes mellitus*, hypertensive vascular disease and cardiac disease either occur with greater frequency or are adversely influenced by obesity. It is always due to overeating; appetite regulation is impaired. The basic etiology of most cases is obscure. The most frequently suggested causes are an occult metabolic disturbance, chronic anxiety or merely bad eating habits. True endocrine obesity is rare.

Hemochromatosis is a chronic disease in which iron is deposited in the various tissues of the body. The iron deposits induce fibrosis, impaired function and pigmentation of the skin. The liver, pancreas and heart are the most severely involved organs. The apparent cause of the disease is the excessive absorption of iron from the gastrointestinal tract or its parenteral introduction in huge amounts through multiple transfusions.

Hepatolenticular degeneration (Wilson's disease) is characterized by degenerative lesions in the basal ganglia of the brain with resulting rigidity, dysarthria and tremor, and by cirrhosis of the liver and a brownish pigmentation of the outer margins of the cornea (Kayser-Fleischer rings). Pathologic processes have been attributed to the accumulation of excesses of copper in the body. Treatment designed to enhance copper excretion in the urine has led to considerable clinical improvement.

*Myasthenia gravis* is characterized by weakness of voluntary muscles, especially after exercise. It is often associated with enlargement of the thymus gland. Present evidence indicates that the weakness is due to blockage of the acetylcholine activating mechanism at the neuromuscular junctions.

*See* ARTERIES, DISEASES OF; ENDOCRINOLOGY; GENETICS, HUMAN; LIVER; MALNUTRITION; OBESITY; URINARY SYSTEM.

*See* P. B. Beeson and W. McDermott (eds.), *Cecil-Loeb Textbook of Medicine*, 11th ed. (1963). (R. L. L.)

**METABUS,** in Roman mythology, the father of Camilla, a legendary Volscian maiden who became a warrior and was a favourite of the goddess Diana. According to Virgil in the *Aeneid*, Metabus, pursued by his enemies, was fleeing from his city with the infant Camilla when he encountered the Amisenus (Amazenus) river, which was at a high level. Fastening the child to a javelin with bark, he declared that he was dedicating her to the goddess of the woods and hurled her across the river. He then escaped from his enemies by swimming to the other bank, where he found Camilla.

Living among shepherds and in the woods, Metabus taught Camilla the rustic arts, and she became a skilled hunter and resolute warrior. She mastered the techniques of war and handled the two-edged ax, javelin and bow with facility. It was said that she could run so fast that the plants in a cornfield or the surface of a body of water would not be disturbed when she passed over them.

Camilla never married. She became the leader of a band of warriors, including a number of maidens, and fought with Turnus in a battle against Aeneas. She was killed in battle by Arruns, an Etruscan, as she was chasing a retreating soldier. Arruns in turn was killed by an arrow dispatched by one of Diana's nymphs.

**METAL.** Metals are usually distinguished from nonmetallic substances by their high conductivity for electricity and heat, their electrical conductivity decreasing with increasing temperature, and by their high reflectivity for light—their metallic lustre. Their widespread use is due not only to these properties but to the fact that the common metals can be shaped by deformation and by casting into molds, and to the fact that their properties can be controlled to a large extent by alloying with other metals, so as to increase their strength or improve other properties. Not only alloying, but also deformation and heat-treatment (*q.v.*) are used to control their mechanical properties such as hardness, strength, ability to resist repeated stressing (fatigue strength), ability to be drawn into wires (ductility) and ability to be forged into desired shapes (malleability). (*See* also METALLURGY.)

Metals occur with a great range of characteristics (these are given in detail under the names of each metal, some of which are listed in the accompanying table. The metals differ from the nonmetals in their chemical characteristics since the hydroxides of the metals (at least those of lower valence) are bases rather than acids.

There are several important groupings of the metals, and of the alloys of which they form the major constituent. The common metals (iron, aluminum, magnesium, copper, zinc, nickel, lead and tin) are produced in tremendous quantities, particularly those used in the building of large structures (iron in the form of steel, aluminum and its alloys and magnesium and its alloys). The so-called precious metals include the coinage metals, silver and gold, together with platinum, palladium and iridium which are used for jewelry. The light metals (aluminum, beryllium, magnesium and titanium) are important in the transportation industry, particularly in airplane construction. The platinum metals (ruthenium, rhodium, palladium, osmium, iridium and platinum) are in group VIII of the periodic table. The noble metals are those most resistant to high temperature oxidation; the commonest of these are gold, silver, palladium, platinum and rhodium. Contrasting with these are the chemically reactive base metals. The alkali metals are those of group Ia of the periodic table (lithium, sodium, potassium, rubidium and cesium) and are soft, low melting and rapidly oxidizing. The alkaline earth metals are those of group IIa of the periodic table (calcium, strontium, barium and radium); these elements are employed principally in the form of compounds. Some of the rare-earth metals, refined in very small quantities before 1945, have become commercially available; the rare-earth metals are the elements from atomic number 58, cerium, to 71, lutetium, (cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium). The transition metals are those in which an inner shell of electrons is only partially filled despite the presence of one or more electrons in an outer shell of higher quantum number. These are the metals from atomic number 21 (scandium) to 28 (nickel), from 39 (yttrium) to 46 (palladium), from 57 (lanthanum) to 78 (platinum) and from 89 (actinium) on. The refractory metals, possessing high melting points, have received increasing attention with the coming of high temperature applications such as turbines, jets and high-speed aircraft (tungsten, molybdenum, rhenium, tantalum, niobium, osmium, iridium and rubidium). Their melting points range from 3,410° C. for tungsten down to about 2,500° C. for iridium and ruthenium (*see* table). At the other extreme the low-melting metals (rubidium, cesium and gallium) melt just above room temperature and mercury melts at −38.87° C., so is normally a liquid and most commonly seen in thermometers and manometers.

Many elements are classed as semimetals (arsenic, antimony and bismuth of group Va, for example) because they possess much poorer conductivities than the true metals, and may be classed with the semiconductors, which differ from metals in that their conductivity increases with increasing temperature. The semiconductors are boron, carbon, silicon, germanium, tin (gray form), phosphorus, arsenic, antimony, bismuth, sulfur, selenium, tellurium and iodine.

With regard to crystal structure, the most common metallic types are (1) the face-centred cubic, such as copper, silver, gold, nickel, iron above 910° C. and lead which have a structure in which atoms are in cubic close-packing in positions at the corners of the unit cubes of the lattice and at the centres of the cube faces (these are very ductile metals); (2) hexagonal close-packed metals such as magnesium and most of the rare-earth metals with a different kind of close-packing normally described by using hexagonal axes (*see* CRYSTALLOGRAPHY); and (3) body-centred

*The Metals and Semimetals, With Some of Their Properties**

| Name | Chemical symbol | Atomic number | Density at 20°C. in g. per c.c. | Melting point °C. | Electrical resistivity at 20°C in $10^{-6}$ ohm-cm. | Coefficient of expansion† | Crystal structure‡ |
|---|---|---|---|---|---|---|---|
| Actinium | Ac | 89 | 10.07 | 1,050 | — | — | FCC |
| Silver | Ag | 47 | 10.49 | 960.5 | 1.59 | 19.1 | FCC |
| Aluminum | Al | 13 | 2.70 | 660 | 2.83 | 23.86 | FCC |
| Americium | Am | 95 | — | — | — | — | — |
| Arsenic | As | 33 | 5.73 | 817 | 33.3 | 5.59 | Rhomb. |
| Astatine | At | 85 | — | — | — | — | — |
| Gold | Au | 79 | 19.3 | 1,063 | 2.44 | 13.9 | FCC |
| Barium | Ba | 56 | 3.5 | 710 | 50 | 18 | BCC |
| Beryllium | Be | 4 | 1.84 | 1,284 | 5.88 | 9.9 | HCP |
| Bismuth | Bi | 83 | 9.8 | 271.3 | 106.8(0°) | 13.45 | Rhomb. |
| Calcium | Ca | 20 | 1.55 | 850 | 4.24 | 22.5 | FCC‡ |
| Cadmium | Cd | 48 | 8.65 | 321 | 6.83 | 29.8 | HCP |
| Cerium | Ce | 58 | 6.78 | 793 | 60 to 89 | 8.5 | FCC‡ |
| Cobalt | Co | 27 | 8.92 | 1,493 | 5.68(0°) | 13.8 | HCP‡ |
| Chromium | Cr | 24 | 7.14 | 1,550 | 13.0 | 8.2 | BCC‡ |
| Cesium | Cs | 55 | 1.90 | 28.45 | 21 | 97 | BCC |
| Copper | Cu | 29 | 8.96 | 1,083 | 1.72 | 16.5 | FCC |
| Dysprosium | Dy | 66 | 8.764 | 1,407 | 91 | 8.6 | HCP |
| Erbium | Er | 68 | 9.16 | 1,497 | 86 | 9.2 | HCP |
| Europium | Eu | 63 | 5.24 | 826 | 81 | 32 | BCC |
| Iron | Fe | 26 | 7.87 | 1,540 | 10 | 11.7 | BCC‡ |
| Francium | Fr | 87 | — | — | — | — | — |
| Gallium | Ga | 31 | 5.97 | 29.75 | 56.8 | 18.3 | Orth. |
| Gadolinium | Gd | 64 | 7.95 | 1,312 | 134 | 6.4 | HCP |
| Germanium | Ge | 32 | 5.32 | 958 | 60x10⁶ | 5.92 | DC |
| Hafnium | Hf | 72 | 13.09 | 2,130 | 32.4 | 6 | HCP‡ |
| Mercury | Hg | 80 | 13.55 | −38.9 | 95.8 | 61 | Rhomb. |
| Holmium | Ho | 67 | 8.799 | 1,461 | 94 | 9.5 | HCP |
| Indium | In | 49 | 7.31 | 156.4 | 8.8(22°) | 33 | FCT |
| Iridium | Ir | 77 | 22.42 | 2,454 | 4.9(0°) | 618 | FCC |
| Potassium | K | 19 | 0.862 | 63.5 | 7 | 83 | BCC |
| Lanthanum | La | 57 | 6.19 | 920 | 56.8 | 4.9 | HCP‡ |
| Lithium | Li | 3 | 0.53 | 186 | 11.7 | 45 | BCC |
| Lutetium | Lu | 71 | 9.7‡ | 1,652 | 68 | 12.5 | — |
| Magnesium | Mg | 12 | 1.74 | 650 | 4.6 | 27.3 | HCP |
| Manganese | Mn | 25 | 7.44 | 1,245 | 185 | 23 | Cubic‡ |
| Molybdenum | Mo | 42 | 10.2 | 2,622 | 5.78 | 5.2 | BCC |
| Sodium | Na | 11 | 0.97 | 97.5 | 4.2 | 71 | BCC |
| Niobium (Columbium) | Nb | 41 | 8.57 | 2,468 | 13.2 | 7.2 | BCC |
| Neodymium | Nd | 60 | 7.05 | 1,024 | 64.3 | 6.7 | HCP |
| Nickel | Ni | 28 | 8.9 | 1,455 | 7.8 | 12.9 | FCC |
| Osmium | Os | 76 | 22.48 | 2,700 | 9.5(0°) | 4.8 | HCP |
| Protactinium | Pa | 91 | 15.37 | — | — | — | BCT |
| Lead | Pb | 82 | 11.34 | 327 | 22 | 29.3 | FCC |
| Palladium | Pd | 46 | 12.02 | 1,554 | 10.8 | 11.6 | FCC |
| Promethium | Pm | 61 | — | — | — | — | — |
| Polonium | Po | 84 | 9.4 | 246 | — | — | SC‡ |
| Praseodymium | Pr | 59 | 6.8 | 935 | 68 | 4.8 | HCP‡ |
| Platinum | Pt | 78 | 21.45 | 1,773 | 10.6 | 9.0 | FCC |
| Plutonium | Pu | 94 | 19.737 | 639.5 | 145 | 50.8 | Monocl.‡ |
| Radium | Ra | 88 | 5 | 700 | — | — | — |
| Rubidium | Rb | 37 | 1.53 | 38.5 | 12.5 | 66 | BCC |
| Rhenium | Re | 75 | 21.0 | 3,180 | 21 | 6.6 | HCP |
| Rhodium | Rh | 45 | 12.44 | 1,966 | 4.5(0°) | 8.4 | FCC |
| Ruthenium | Ru | 44 | 12.2 | 2,400 | 7.16 to 7.6(0°) | 9.6 | HCP |
| Antimony | Sb | 51 | 6.68 | 630.5 | 41.7 | 10.9 | Rhomb. |
| Scandium | Sc | 21 | 3.016 | 1,539 | 26 | 11.4 | HCP‡ |
| Selenium | Se | 34 | 4.81 | 217 | 12(0°) | 48 | Rhomb.‡ |
| Silicon | Si | 14 | 2.32 | 1,410 | 15x10⁸ (300°) | 7.6 | DC |
| Samarium | Sm | 62 | 6.93 | 1,072 | 92 | — | Rhomb. |
| Tin | Sn | 50 | 7.3 | 232 | 11.5 | 23.5 | BCT‡ |
| Strontium | Sr | 38 | 2.6 | 770 | 23 | — | FCC‡ |
| Tantalum | Ta | 73 | 16.6 | 2,996 | 12.4(18°) | 6.55 | BCC |
| Terbium | Tb | 65 | 8.253 | 1,356 | 116 | 7.0 | HCP |
| Technetium | Tc | 43 | 11.49 | — | — | — | HCP |
| Tellurium | Te | 52 | 6.24 | 452 | 200,000 | — | Hex. |
| Thorium | Th | 90 | 11.7 | 1,842 | 18.6 | 11.2 | FCC‡ |
| Titanium | Ti | 22 | 4.5 | 1,690 | 55 | 8.24 | HCP‡ |
| Thallium | Tl | 81 | 11.85 | 303 | 18(0°) | 29.4 | HCP‡ |
| Thulium | Tm | 69 | 9.372 | 1,545 | 90 | 11.6 | HCP |
| Uranium | U | 92 | 19.05 | 1,133 | 29(0°) | 13 | Orth.‡ |
| Vanadium | V | 23 | 6.11 | 1,900 | 24.8 | 7.79 | BCC |
| Tungsten | W | 74 | 19.3 | 3,410 | 5.48(0°) | 4.4 | BCC |
| Yttrium | Y | 39 | 4.34 | 1,509 | 53 | 10.8 | HCP |
| Ytterbium | Yb | 70 | 6.959 | 824 | 28 | 25.0 | FCC |
| Zinc | Zn | 30 | 7.14 | 419.5 | 5.8 | 31 | HCP |
| Zirconium | Zr | 40 | 6.5 | 1,830 | 45 | 7.2 | HCP‡ |

*The properties of metals and semimetals are affected by the nature of impurities that may be present, variations in crystal structure and orientation and the thermal and mechanical history of the samples used to determine values; therefore the values for any two or more different samples may vary.

†Average linear coefficient of expansion near 20° C. per degree C. times $10^{-6}$.

‡Crystal structure normally found at 20° C.; ‡ indicates that other forms are known; abbreviations: FCC = face-centred cubic cubic close-packing); BCC = body-centred cubic; HCP = hexagonal close-packed, DC = diamond cubic, like the diamond structure; SC = simple cubic; Rhomb = rhombohedral (trigonal); BCT = body-centred tetragonal; Orth. = orthorhombic; Hex. = hexagonal; Tetrag = tetragonal; Monocl. = monoclinic.

cubic such as tungsten, molybdenum, sodium and iron below 910° C. with atoms at the corners and at the centres of the unit cubes. Other types are also found, as well as examples of polymorphism (*see* table).

A piece of metal consisting of a single crystal will show a dependence of properties on direction in the crystal that reflects the symmetry of the atomic arrangement within the crystal. In metals with non-cubic structures there may be a wide variation of certain properties with crystallographic direction. The accompanying table gives average values that are encountered in the common polycrystalline form in which each piece of metal is composed of many individual crystals in more or less random orientation with respect to its neighbours.

The presence of "conduction" electrons that are free to move about within a metal, not being bound to specific atoms, accounts for many of the metallic properties; the presence of defects in the crystal structure accounts for some of the mechanical properties (*see* CRYSTALS, DISLOCATIONS OF).

*See* ELEMENTS, CHEMICAL; METALLOGRAPHY; NATURAL RESOURCES; *see* also references under "Metal" in the Index.

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**METALLOGRAPHY,** the study of the structural characteristics or constitution of a metal or an alloy in relation to its physical and mechanical properties. In a broad sense, this includes: (1) the examination and interpretation of gross structural details of a metallurgical specimen, generally with the unaided eye; (2) the study of metallographic structures with the optical and electronic microscopes; (3) experimental derivation of the equilibria of alloy systems (see *Metals and Alloy Structure*, below); and (4) X-ray metallography—the study of the atomic arrangements in metals and alloys. To a large extent, the major difference between the observation techniques is a matter of resolution, or the separation of detail for observation.

## MACROSCOPIC EXAMINATION

Valuable information can be secured through examination of metal fractures and metal surfaces, either before or after appropriate surface preparation. Such observations are usually conducted with the unaided eye, with a magnifying glass, or with a metallurgical or binocular microscope at image magnifications less than about ten diameters. In macroscopic examination the interest is generally confined to the gross structural details and defects arising from fabrication, etc., of the metal, and in consequence relatively large areas of the piece may be involved.

Depending upon the nature of the specimen, preparation prior to examination may or may not be required or desirable. When preparation is necessary, it is accomplished by first sectioning the object, and grinding or machining the exposed surface of interest to achieve reasonable smoothness. In the "as smoothed" condition, a variety of defects may be visible if present, such as cracks, porosity, rolling seams, and others that are associated with the presence of voids or local separation of the piece. However, by subjecting the prepared surface to macroetching, additional details, if present, may be revealed, particularly details pertaining to crystalline, chemical and mechanical heterogeneities. Reagents for macroetching have been formulated for a variety of metals and alloys, a solution containing hydrochloric acid and water, for example, often being used to etch iron and steel (*see* also IRON AND STEEL INDUSTRY: *Metallography and Heat Treatment*).

Crystalline heterogeneity refers to the macroscopic appearance and arrangement of the crystals, known metallographically as

BY COURTESY OF G. L. KEHL

FIG. 1.—TRANSVERSE CROSS SECTION OF CAST-COPPER INGOT AFTER SURFACE PREPARATION AND MACROETCHING. MAGNIFIED ½ TIME

grains, of a cast metal as related to the manner of solidification and attendant growth of the grains. As illustrated in fig. 1, macroetching has revealed the presence of long columnar-shaped grains that originated at the side walls of the mold at the onset of solidification and which, during the solidification process, grew predominantly toward the centre of the ingot, perpendicular to the surfaces of the mold walls.

Chemical heterogeneity arises from the presence of impurities and nonmetallic inclusions, and from segregation of chemical elements. As illustrated in fig. 2, macroetching has revealed the location of segregated nonmetallic inclusions in a steel bar. The inclusions have been dissolved by the macroetching reagent, leaving voids which define the locations.

Mechanical heterogeneity arises from cold fabrication processes that plastically deform a metal. Such heterogeneity may be manifested by local deformation of the structure and attendant elongation or distortion of nonmetallic inclusions and regions of persistent chemical segregation in the direction of working.

BY COURTESY OF G. L. KEHL

FIG. 2.—TRANSVERSE SECTION OF STEEL BAR MACROETCHED TO REVEAL SEGREGATION OF NONMETALLIC INCLUSIONS NEAR THE CENTRE. NO MAGNIFICATION

## OPTICAL METALLOGRAPHY

Compared to macroscopic examination, a greater abundance of structural knowledge of a metal may be secured through microscopic examination of prepared surfaces at magnification ranging from about 100 to 1,500 diameters. In particular, optical metallography will reveal such pertinent information as size and shape of grains (*see* fig. 3), the size, shape, and distribution of structural phases and nonmetallic inclusions, microsegregation and other structural conditions of interest.

**Specimen Preparation.**—Inasmuch as microscopic examination of metals cannot be made on thin sections as in tissue microscopy, it is made on a prepared surface of a small specimen. In principle, the purpose of specimen preparation is to achieve a flat, scratch-free, mirror-polished surface having a minimum of surface distortion attending the preparational operations. In general, the procedure consists of grinding the specimen surface on a series of emery papers of decreasing grit size, either by hand manipulations or on a series of horizontally mounted rotating laps. Later the grinding scratches are removed by polishing on one or more cloth-covered laps onto which is charged an appropriately sized abrasive, such as levigated alumina or chromic oxide.

FROM GEORGE L. KEHL "PRINCIPLES OF METALLOGRAPHIC LABORATORY PRACTICE" (1949), BY PERMISSION OF MCGRAW-HILL BOOK CO., INC.

FIG. 3.—METALLOGRAPHIC APPEARANCE OF NOMINALLY PURE IRON. MAGNIFIED 100 TIMES

Electrolytic polishing is often advantageous, particularly in the case of metals that readily work-harden and those that are relatively soft. Electrolytic polishing consists of making the specimen the anode in an electrolytic cell, and some inert material, such as platinum or stainless steel, the cathode. Using a suitable electrolyte and with current flowing through the cell, metal comprising the hills of the grinding scratches will be preferentially dissolved with respect to the valleys, finally producing a nearly plane and scratch-free surface.

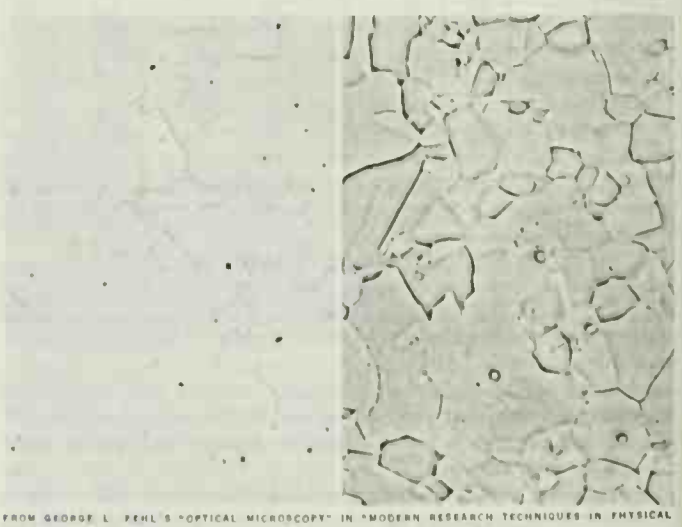
**Metallographic Etching.**—When a specimen in the "as polished" condition is examined microscopically it will usually appear homogeneous except for inclusions, voids, and surface defects, with no suggestion of the existence of a complex internal structure. However, by subjecting the polished surface to the action of a selected etching reagent, the structure is revealed by a selective and controlled solution, or unbuilding, of the structure inwardly from the polished surface.

In principle the selective attack of the etching reagent is attendant upon structural heterogeneities which differ in their rates of dissolution. Such heterogeneities may be associated with the presence of more than one phase in the structure, strained regions, or other discrete parts of the structure having higher energy than the surrounding material. The latter circumstance is illustrated in fig. 3, wherein the regions of the grain boundaries (the thin, dark lines) have been selectively attacked by the etching reagent owing to their higher energy compared to that of the grains proper which the boundaries surround. This selective attack gives rise to steep sloping valleys in the grain boundary regions, which appear dark (see *Metallurgical Optical Microscope*, below).

Metallographic etching reagents are generally composed of aqueous or alcoholic solutions of acids or mixtures thereof, alkalis, or other corrosive reagents. The reagents are applied to the polished surface by immersion or swabbing techniques, and the times of etching are usually in the order of seconds.

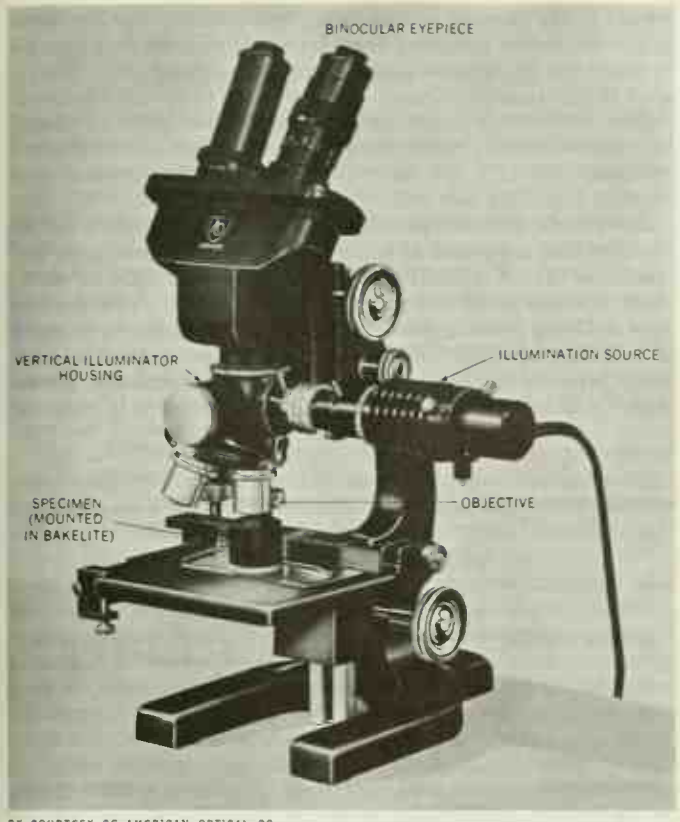
Some metals and alloys, particularly corrosion-resistant alloys, are difficult if not impossible to etch satisfactorily by immersion etching. In such cases, electrolytic etching is advantageous, and is readily carried out in the electrolytic cell arrangement for polishing. Specific electrolytes for this purpose, and appropriate cell conditions, have been formulated for a variety of metals and alloys.

Cathodic vacuum etching is ideally suited to the revelation of structure in bimetallic couples, and may also be used for etching of regular metallographic specimens and macrosections. It is, however, a specialized method and more troublesome to carry out than is immersion or electrolytic etching. The process consists of bombarding the polished specimen surface (cathode) with ions of a heavy gas at low pressure, accelerated to high velocities by a potential of 1,000 to 5,000 volts D.C. The metal atoms on



FROM GEORGE L. KEHL'S "OPTICAL MICROSCOPY" IN "MODERN RESEARCH TECHNIQUES IN PHYSICAL METALLURGY", REPRODUCED BY PERMISSION OF AMERICAN SOCIETY FOR METALS

FIG. 4.—NOMINALLY PURE NICKEL, CATHODICALLY ETCHED IN AN ARGON ATMOSPHERE (MAGNIFIED 250 TIMES)
(Left) metallographic appearance under bright-field illumination; (right) structural appearance under phase contrast




BY COURTESY OF AMERICAN OPTICAL CO.

FIG. 5.—BENCH TYPE OF METALLURGICAL MICROSCOPE

the surface are ejected selectively, depending upon the microstructure and the comparative ease (sputtering rate) by which atoms can be removed from the various components of the structure. Pure nickel, as cathodically vacuum etched, is shown in fig. 4, and is similar in appearance to the structure revealed by more conventional etching methods.

**Metallurgical Optical Microscope.**—The metallurgical microscope, illustrated in fig. 5, differs from the more familiar biological type in several respects. The microscope objectives, and the optical system in general, are designed for use without a specimen cover glass, and the optical errors are minimized when used with green-yellow illumination of an approximate mean wave length of 5,700Å (1Å = 0.1mμ = $10^{-4}$ μ = $10^{-8}$ cm.). Owing to the optical opacity of metal specimens, illumination is accomplished by means of a vertical illuminator, shown schematically in fig. 6. A beam of light from an external source is directed into the microscope body tube and is deflected vertically downward by means of a thin plane glass reflector (fig. 6[A]) or less preferably by a mirror or total reflecting prism so positioned to cover about one-half the aperture of the objective system (fig. 6[B]). The illumination upon passing downward through the objective is focused upon a small area of the specimen surface. Much of the light upon reflection from the surface again passes through the objective and plane glass reflector (or through the unobstructed portion of the aperture in the case of the mirror or prism), to form the primary real image of enlarged proportions in the vicinity of the eyepiece. The eyepiece lens system, in conjunction with the cornea lens of the human eye, then forms a virtual image which, to a normal-sighted observer, will appear to exist in space at about ten inches from the eye.

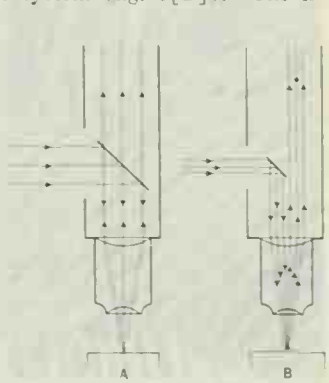
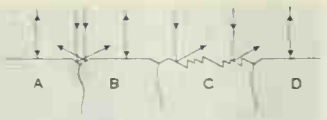



FIG. 6.—PRINCIPLE OF VERTICAL ILLUMINATION: (A) WITH PLANE GLASS REFLECTOR; (B) MIRROR OR PRISM REFLECTOR

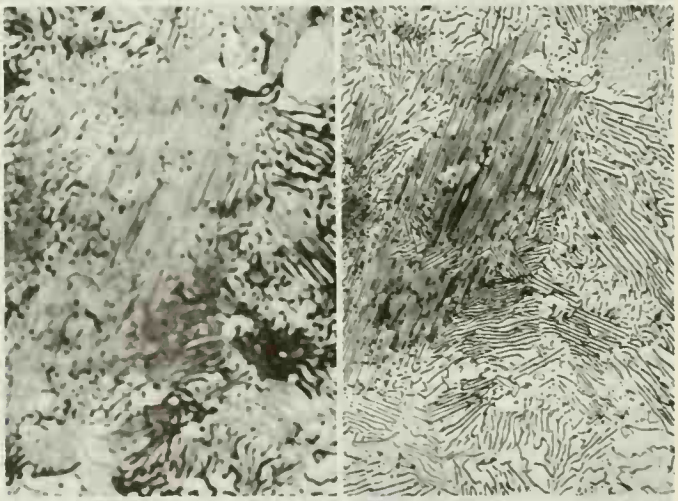



BY COURTESY OF G. L. KEHL

FIG. 7.—LIGHT SCATTER AT GRAIN BOUNDARIES AND GRAIN PROPER

Owing to the method of illuminating a metallographic specimen, a surface perfectly plane and smooth will reflect all of the incident light into the microscope objective. However, if the surface is selectively made irregular by etching, the illumination incident upon discrete elements of structure (as between [A] and [B], fig. 7) may be reflected at low angles and thus be lost to the microscope objective system. Similarly, light losses may occur by multiple reflections within local surface depressions. In consequence, grain boundaries and interfaces, cavities, surface porosity, etc., will appear dark in the final image, as seen in fig. 3 for the case of grain boundaries. After appropriate etching the metallographic appearance of the grains proper in a pure metal or in solid solution alloys may vary in tone value from dark to light. This is known as oriented grain lustre and is illustrated macroscopically in fig. 1. The phenomenon is simply a manifestation of varying degrees of reflected light losses to the objective system as related to the orientation of minute facets produced on grain sections during etching. On any one grain section the facets are similarly oriented, but differ in orientation from those on adjacent grain sections. The principle is illustrated in fig. 7, and from the direction of the reflected light from grain (C), it will appear dark in the final image.

The purpose of microscopic examination is to resolve or separate fine detail of the structure. Total magnification is secondary provided the image is sufficiently enlarged for the observation of details. Resolution of fine detail in the object is directly dependent upon the numerical aperture (light-gathering ability) of the objective system and inversely dependent upon the wave length

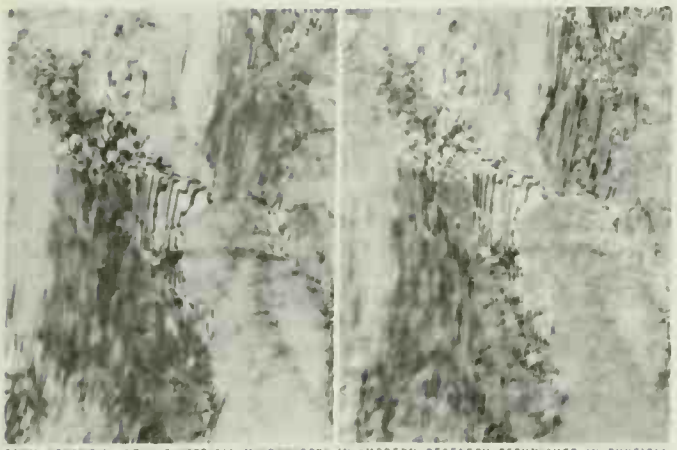


FROM GEORGE L. KEHL, "PRINCIPLES OF METALLOGRAPHIC LABORATORY PRACTICE" (1949); REPRODUCED BY PERMISSION OF MCGRAW-HILL BOOK CO., INC.

FIG. 8.—LAMELLAR STRUCTURE (PEARLITE) PHOTOGRAPHED WITH AN OBJECTIVE OF (LEFT) 0.25 NUMERICAL APERTURE AND (RIGHT) 0.95 NUMERICAL APERTURE. BOTH MAGNIFIED 600 TIMES

of light employed to illuminate the specimen. As illustrated in fig. 8, the resolution of structural detail at the same total magnification and wave length of illumination (5,700Å) is considerably improved through the use of a higher numerical objective. However, an increase in magnification of the image of fig. 8 (left) would in no way be accompanied by improved resolution. Similarly, although not as striking, fig. 9 shows the influence of wave length of radiation on resolution at the same total magnification and with the same numerical aperture objective.

**Phase Contrast.**—With regard to a metallographic specimen, alteration in the phase of the reflected light may originate locally from vertical displacements of an element of structure with respect to the surroundings, from phases of different composition and attending surface optical activity, and from the normal consequence of metallographic etching and the selective formation of surface reaction films differing in thickness and perhaps re-



FROM GEORGE L. KEHL'S "OPTICAL METALLOGRAPHY" IN "MODERN RESEARCH TECHNIQUES IN PHYSICAL METALLURGY"; REPRODUCED BY PERMISSION OF AMERICAN SOCIETY FOR METALS

FIG. 9.—LAMELLAR STRUCTURE (PEARLITE) PHOTOGRAPHED WITH (LEFT) GREEN-YELLOW ILLUMINATION OF 5,700A AND (RIGHT) ULTRAVIOLET RADIATION OF 3,650A. BOTH MAGNIFIED 500 TIMES

fractive index. The differences existing in phase of the reflective light will in no way contribute to image contrast, and will in fact incite no response by the human eye. However, in phase-contrast metallography, through the use of auxiliary optical parts, differences in phase of the reflected light are transformed into corresponding differences in light intensity in the image plane, thus producing optical contrast in the image to which the eye is sensitive. A comparison between fig. 4 (left) and 4 (right) clearly illustrates the improvement in image contrast attending phase-contrast observations.

**Polarized Light.**—Polarized light metallography is useful for revealing grain structure, detection of preferred orientation, examination of oxide surface films, identification of phases in multiple-phase structures, and others. In simple form, a metallurgical microscope can be converted for use with polarized light by insertion of a Polaroid screen in the path of the illumination beam (known as the polarizer) to produce plane-polarized light incident on the specimen surface. A second component, consisting of a Polaroid screen fitted into a cap (known as the analyzer) is placed loosely over the eyepiece of the microscope to permit rotation. As related to the crystallographic structure of the specimen, metals may be classified as being optically anisotropic wherein the optical properties are different in different directions or as being optically isotropic wherein the optical properties are identical in all directions. Polycrystalline metals which possess a cubic structure such as copper, aluminum and gold, are optically isotropic, and owing to this do not respond metallographically to plane-polarized light. However, response may be introduced by deep etching such structures to produce well-formed etched facets, or by surface treatment that will produce an optically anisotropic surface film whose orientation locally bears a direct relationship to the crystallographic orientation of the grain section beneath it.

FIG. 10.—ANNEALED URANIUM UNDER POLARIZED LIGHT. MAGNIFIED 150 TIMES

When optically anisotropic metals, such as zinc, magnesium and uranium are examined with the analyzer optically crossed with the polarizer, the reflected light from the various grain sections will be of different intensities, and hence optical contrast will be established between the grains. The darkness or lightness of any one grain will depend upon the orientation of the crystallographic axes of the grain with respect to the plane of polarization. Particularly, when examined with a strain-free objective, each grain will undergo four changes of brightness or darkness as the specimen is rotated 360° with respect to the crossed polarizers. Such rotation of optically isotropic metals will induce no such contrast changes unless surface treated as described above; rather the grains will remain uniformly dark in appearance. Fig. 10 shows the metallographic appearance of uranium (optically anisotropic) under polarized light.

**Electronic Microscope.**—The electronic microscope is an instrument that is capable of much greater initial magnification and resolution (about 0.002$\mu$) than either the visible light or ultraviolet microscope (0.25$\mu$ and 0.1$\mu$, respectively). This tremendous resolving power is attendant upon the very short wave length of radiation employed in the electronic microscope. The similarity between the light and the electronic transmission microscopes is illustrated in fig. 11. It is to be noted that each has

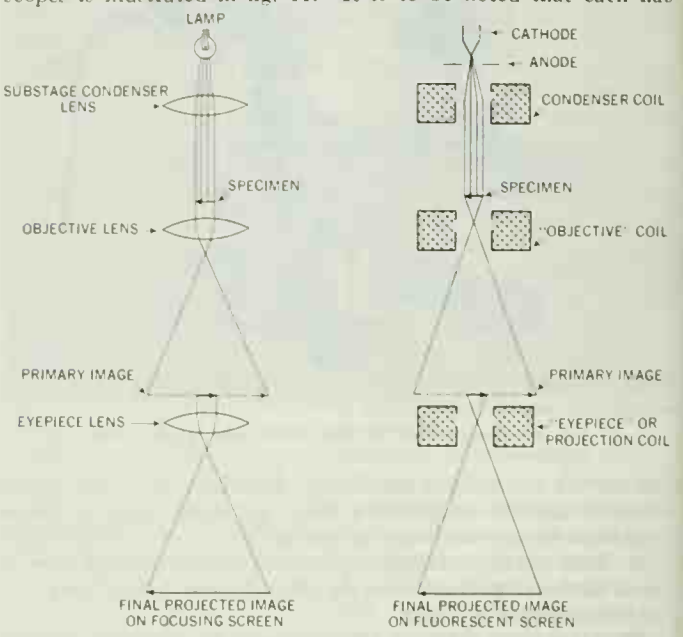



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FIG. 11.—ANALOGY BETWEEN (A) LIGHT MICROSCOPE AND (B) ELECTRONIC MICROSCOPE

similar components, differing only in the precise nature of the components. The "illumination" consists of a stream of electrons in vacuo that are accelerated to very high velocities by a potential of about 50,000 volts, giving the electron beam an equivalent wave length of about 0.05Å.

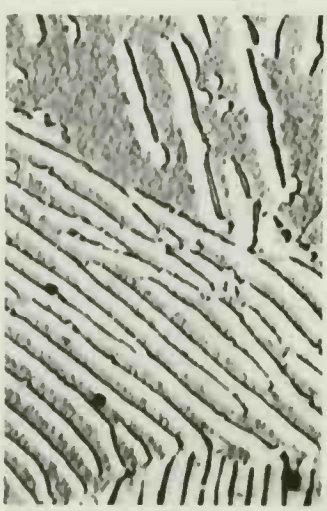


FIG. 12.—ELECTRON PHOTOMICROGRAPH OF PEARLITE. MAGNIFIED 10,000 TIMES

Because the electron beam will not pass through metal films of greater thickness than about 0.05$\mu$, it is necessary in the case of metallographic specimens to form a replica of the surface, and to use the replica as the microscope specimen. This is accomplished in the general case by flowing over the etched surface a dilute solution of an appropriate plastic that will faithfully reproduce the topography of the surface. Upon hardening, the film is stripped and contains on one side a reverse impression of the specimen surface contour. Owing to variations in thickness of the film and attendant dependency of electron scattering on thickness, contrast is established in the final image. An electron photomicro-

graph of pearlite (the lamellar structure of fig. 9) is shown in fig. 12.

## METALS AND ALLOY STRUCTURE

A pure metal, as illustrated in fig. 1 and 3, is composed metallographically of grains and grain boundaries. The grains proper possess internal symmetry, *i.e.*, the metallic ions are positioned with precise regularity in space, and are therefore true crystals even though they do not possess external symmetry. The orientations of the grains differ and give rise to grain boundaries in the structure which define the regions where the mutually adjacent grains have met. Owing to the atomic disorganization existing in the grain boundary regions, the free energy is higher than the crystalline grains proper, and in consequence, is more vigorously attacked by the etching reagent to produce optical manifestation of their location (see *Optical Metallography: Metallographic Etching*, above).

The metallographic structure of an alloy can be understood completely only with the aid of an equilibrium diagram pertaining to the alloy system of interest. Not only will such a diagram give a clue to the microstructures, but also to the thermal behaviour of the alloys, and their attendant properties.

An equilibrium diagram is determined experimentally, and consists of securing information on a variety of specific compositions with regard to equilibrium solidification temperatures, reactions occurring in the solid state, identification of phases in equilibrium and their limits of composition. Experimental techniques employed in obtaining such data consist of thermal analysis, electrical resistivity measurements, X-ray diffraction analysis, metallographic observations, and others. Particular attention is paid experimentally to isolating the system from extraneous outside influences, and to ensuring as far as possible the attainment of equilibrium conditions. These are necessary conditions in order to establish a reproducible, scientific basis for the study even though, in practice, alloys may exist in an intermediate or metastable condition. However, the constitutions of alloys tend to approach closely equilibrium conditions when cooled very slowly, or after prolonged heating at suitable temperatures.

The data so obtained in the case of a binary alloy system (a system of two components) are plotted on co-ordinates of weight or atomic per cent of the components as abscissa and temperature as ordinate. The equilibrium diagram illustrated in fig. 13 for two hypothetical component metals, A and B, is typical of an alloy system, such as copper-nickel, that exhibits mutual solubility of the components in both the liquid and solid states. In the solid state, a "solid solution" is formed. The liquidus line defines the locus of temperatures at which solidification begins upon very slow cooling; the solidus line, the locus of temperature where solidification is completed. It is therefore possible to note for any specific alloy composition on the diagram the equilibrium temperature of beginning and ending of solidification, the phase or phases in equilibrium at any temperature of interest and, through simple calculations, the compositions and relative amounts of the two phases present. Metallographically, the diagram indicates the equilibrium structures to be a single-phase solid solution, which appear like that of a pure metal or one of the alloy components, although the alloys may differ greatly in physical and mechanical properties, colour, etc.

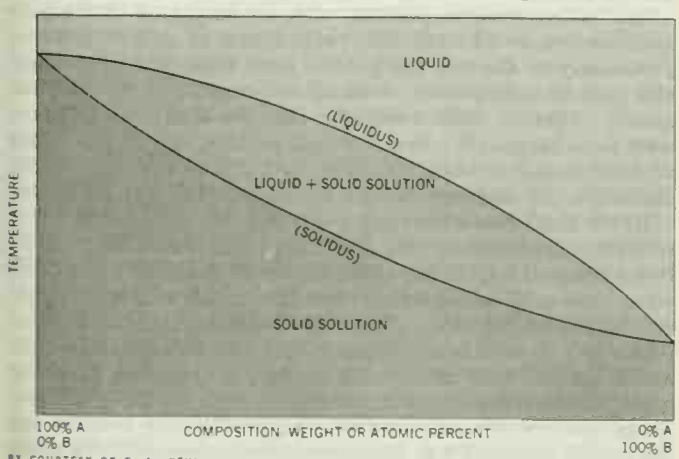



FIG. 13.—EQUILIBRIUM DIAGRAM OF AN ALLOY SYSTEM EXHIBITING COMPLETE MUTUAL SOLUBILITY OF THE COMPONENTS IN THE LIQUID AND SOLID STATES

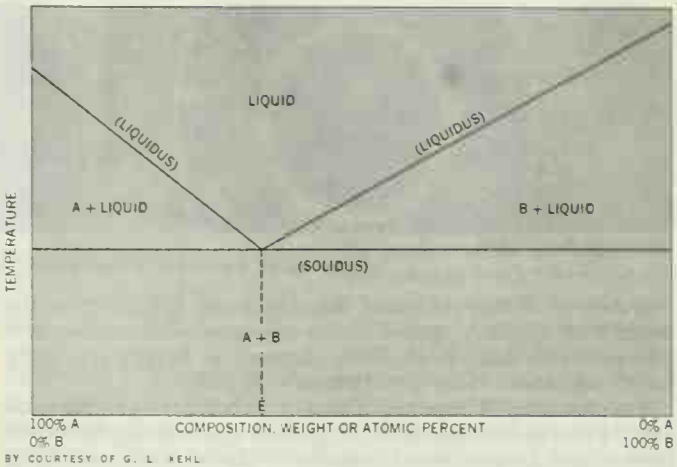



FIG. 14.—EQUILIBRIUM DIAGRAM OF AN ALLOY SYSTEM EXHIBITING MUTUAL SOLUBILITY OF THE COMPONENTS IN THE LIQUID STATE: NO DETECTABLE MUTUAL SOLUBILITY IN THE SOLID STATE

The equilibrium diagram of fig. 14 is of an alloy system in which the components are completely soluble in the liquid state, but insoluble in the solid state. Systems of this type exhibit the formation of a low melting temperature "eutectic," consisting of components A and B, that forms at the solidus temperature level from a part, or from all, of the liquid, depending precisely upon the alloy composition. The eutectic may assume various structural forms although the lamellar form (fig. 15) is one of the most common. The equilibrium diagram further indicates that alloy compositions lying to the left of composition E will exhibit structures of primary A crystals and eutectic; those lying to the right, primary B crystals and eutectic; and composition E, known as the eutectic composition, will exhibit only a eutectic structure. Owing to the specific properties of A and B components, and their relative amounts and distribution in the various alloy compositions, the overall properties of the alloys may be quite different.

Equilibrium diagrams of a variety of binary and ternary alloy systems have been compiled.

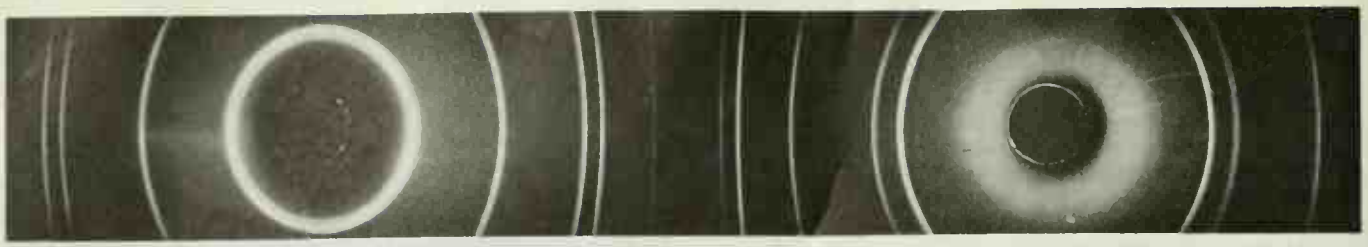
*See* also ALLOYS; HEAT-TREATMENT; IRON AND STEEL INDUSTRY: *Slowly Cooled Steels.*

## X-RAY METALLOGRAPHY

The application of X-ray diffraction techniques to metallurgical problems has contributed much to the basic knowledge of metals and alloys. The technique is principally employed to study phenomena that are related to grouping of atoms themselves, and is capable of resolution of structure between 0.1$\mu$ (the lower limit of the optical microscope) and about 0.0001m$\mu$.

The principle of X-ray diffraction analysis depends upon the impingement of an X-ray beam of appropriate wave length (or group of wave lengths) upon a suitable specimen (thin foils, metal powders, massive pieces for

FIG. 15.—LAMELLAR FORM OF EUTECTIC, CORRESPONDING TO ALLOY COMPOSITION E, FIG. 14



BY COURTESY OF G. L. KEHL

FIG. 16.—X-RAY DIFFRACTION POWDER PATTERN OF PURE SILVER USING COPPER RADIATION

reflection of X-ray, etc.), and the subsequent diffraction of the beam from regularly spaced planes of atoms when certain geometrical conditions are satisfied, expressed in Bragg's law or by Laue's equations. (*See* SPECTROSCOPY, X-RAY.)

The diffracted X-rays are generally recorded on photographic film. From measurements of the lines or spots on the diffraction pattern, and by analysis of intensity of the reflected rays, much basic information may be learned about the specimen. A typical diffraction pattern of pure silver (the specimen in the form of silver powder) is shown in fig. 16.

Among the important applications of X-ray metallography is the identification of phases in alloy structures through determining atom positions and spacing and hence the crystallography of the phases, in elucidating the mode of phase changes in solid state reactions involving movement of atoms, detection of preferred orientation and directionality attending cold working well in advance of gross observations by the optical microscope, the presences of internal strains, measurement of lattice parameter changes attending changes in temperature or the presence of solute atoms as in solid solutions, and many others.

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**METALLURGY** is the science and technology of metals. It includes the processes of producing metals by extracting them from their ores, refining or purifying them, and working them mechanically or otherwise adapting them to use. It includes also the study of the chemical and physical properties of the metals and of their structure, both atomic and crystalline, the principles of combining them to form alloys, the means of improving or enhancing their properties for particular applications, and the relations between properties, structures and uses. It includes the thermal and mechanical processing of metals as raw materials of manufacture, but not the design and manufacture of the multitude of things made of metals, except with regard to the manner in which these are affected by the metallic properties and structures.

This article traces the history and prehistory of metallurgy and discusses the various processes and techniques that have been developed and their applications, including those in nuclear engineering.

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## I. HISTORY

It is generally agreed that the first metals known to man were those which occur in the native, *i.e.*, the metallic, state, of which the very earliest would in all probability be the nuggets of gold found in the sands and gravels of river beds. Such gold, even when naturally alloyed with silver to form electrum, is too soft to find application as tools or weapons and was employed merely for jewelry or other decorative purposes. Copper is another metal which occurs in the native state in many parts of the world, sometimes in large masses and usually, as indicated in Table I (analysis 1) in a state of very high purity. Such copper, though soft, is hardened appreciably when it is hammered, and sickles or daggers capable of cutting corn or flesh could thus be produced.

About the early 3rd millennium B.C., in a manner which must have been accidental, it was discovered that copper could also be produced by heating certain bright-blue stones in a charcoal fire to a good red heat. When the ore cropped out at the surface and weathering had occurred, the ordinary wooden shovels and antler picks used by the flint miner were adequate. Further, the air and rain had washed out much of the impurities in the ore and before the middle of the 3rd millennium copper containing around 0.5% of impurities was being produced in the near east in this way (analysis 2).

As time went on and the weathered surface ore was used up, the ore body became harder and, as is demonstrated in old mines in the Tirol, the ore was won from mines, often of considerable depth, by "fire setting." Against the ore face a fire was built up and when the rocks had become sufficiently hot they were quenched with water, splitting off fragments of ore. This process is illustrated in G. Agricola's remarkable book *De Re Metallica*, 1556 (English trans. 1912; 1950), a typical example of the remarkable persistence of primitive metallurgical techniques almost down to modern times.

Ore bodies, however, are not normally composed of the pure minerals but are admixed with waste matter or gangue, and as a preliminary to the smelting process itself some sort of purification such as hand-picking, crushing and washing is generally required. There is definite evidence that the advantages of these were soon appreciated, and it is not, perhaps, out of place here to observe that in these primitive days the distinction between the miner, the engineer and the metallurgist had not yet arisen.

As the depth below the surface increases the ore not only tends to become harder, but it may also change radically in composition. A fundamental step in the whole history of civilization was taken when some early genius realized that copper may also occur in unweathered chalcopyrites. It may have been that the golden colour misled him into the belief that such ores were rich in the precious metal, but they were undoubtedly worked, and processes involving quite advanced metallurgical knowledge were gradually devised. These ores were less pure than the weathered surface material and the copper produced was correspondingly impure. By the latter half of the 3rd millennium B.C. copper was being produced from such sulfide ores and the impurities had risen to 2% to 3% (analysis 3).

TABLE I.—*Analyses*

| Analysis No. | Material | Age B.C. | Composition per cent | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Copper | Tin | Iron | Nickel | Lead | Arsenic | Bismuth | Antimony | Silver |
| 1 | Native copper | — | 99.96 | — | — | — | — | — | — | — | — |
| 2 | Copper from weathered ore | Early 3rd millennium | 99.43 | 0.02 | 0.3 | 0.005 | 0.002 | 0.1 | 0.0005 | 0.03 | 0.1 |
| 3 | Copper from pyritic ore (unweathered) | Middle 3rd millennium | 97.41 | 0.87 | 0.02 | 0.16 | 0.56 | 0.2 | — | — | — |
| 4 | Arsenical bronze | Later 3rd millennium | 95.0 | Trace | 0.3 | 0.1 | 0.3 | 4.2 | Trace | — | — |
| 5 | Low-tin bronze | Later 3rd millennium | 93.84 | 5.0 | 0.5 | 0.05 | 0.2 | 0.2 | 0.002 | 0.2 | 0.005 |
| 6 | Typical bronze | Late 3rd millennium | 86.93 | 10.62 | 0.25 | 0.49 | 0.68 | 0.77 | — | 0.32 | — |
| 7 | Bronze made from refined copper | Early ? 2nd millennium | 89.47 | 10.0 | 0.1 | 0.3 | 0.03 | 0.05 | Trace | 0.03 | 0.01 |

Such impure coppers—the term "bronze" for them is a complete misnomer—possessed two advantages. In the first place they were distinctly harder than the purer metal, while secondly there was a very distinct improvement so far as the ease of casting was concerned. As these improvements became associated with the sort of ore used, the first step was taken toward the deliberate mixing of ores to obtain a still better product. In this way arose the curious alloys which contain several per cent of arsenic, antimony, iron or lead which bridge the gap, in central Europe at any rate, between the Copper Age and true Bronze Age and which can only be adequately explained as the result of deliberate additions (analysis 4).

Such alloys possess marked advantages when compared with copper itself, but they tend to be brittle and the superiority of tin as an alloying material was soon appreciated. Starting with a tin content of 5% or less (analysis 5) these bronzes quickly settled down to a value normally about 10% to 12% (analysis 6). If the full analyses of these bronzes are compared, they will be found to fall into two groups, of which one (analysis 6) is far more impure than the other (analysis 7). There is reason to believe that the gradual deterioration in the purity of the copper produced (compare analyses 1, 2 and 3) was reversed due to the discovery of fire-refining. This process merely involves the melting of the crude copper under oxidizing conditions whereby the impurities are preferentially oxidized and can be skimmed off as a scum. The true Bronze Age had arrived. It must not be overlooked, however, that since the tin had often to be transported over relatively great distances bronze was inevitably a more expensive material, and there are good grounds to believe that the impure copper was still being produced and used for agricultural and other less exacting purposes.

The former belief that the history of metals can be divided into clear-cut periods is oversimplified. While the development of the bronze had been going on, the initial work on the production of iron had also been proceeding and copper, bronze and iron were made and used simultaneously, as indicated in Table II.

Concerning the absolute dating of prehistoric metals, then, as now, progress proceeded from discovery, and later experiment, to exploitation. Very early isolated finds are well known which date back to a period long before knowledge of that particular material had become sufficiently widely dispersed as to have any influence on the civilization of the time. How slow such dispersion was is well shown in the spread of the Hallstatt (*q.v.*) ironworking culture, which took over 500 years to travel from the Austrian Tirol to England, a distance not much more than 500 miles in a straight line. Thus it would appear reasonable to date the early Bronze Age to a time when this metal first became of real use as weapons or tools rather than to that of the earliest isolated, and therefore, possibly, accidental or experimental, find.

Meteoric iron had been known from a very early date, but the terrestrial production of the metal, which involves a much more elaborate technique than does copper, was a slow process. Whereas copper can be smelted in furnaces of a relatively simple type, the smelting of oxide of iron with charcoal demands a higher temperature and the product even then is merely a spongy mass of pasty globules of metal intermingled with a semiliquid slag. The complete separation of iron and slag demands a temperature sufficiently high to melt both and, except in the far east, this was never achieved. By repeatedly reheating the spongy bloom and hammering it, at first on stone anvils, much of the slag can be expressed and a more coherent mass of iron gradually produced.

The eye-witness account given by John Percy (*Metallurgy: Iron and Steel*, pp. 257–258, 1864) of the production of iron by primitive tribes in southern India must reproduce almost exactly the practice of early ironworkers some 4,000 years before. (*See* IRONWORK.) This wrought iron is of low carbon content and hence soft—softer, in fact, than is a well-made bronze. It is not surprising, therefore, that the latter alloy retained its value for weapons. The fact that it could be cast, whereas (except in China and possibly India) articles of iron were only made under the hammer, gave bronze a sphere of utility in which the iron could not at first compete. Reference is made in the account given by Polybius of the Celtic invasion of Italy of 223 B.C. to the poor quality of the Celtic iron. Their heavy defeat by the Romans at Addua was largely attributable to the fact that their long iron swords "easily bent and would only give one downward cut—after this the edges got so turned and the blades so bent that unless they had time to straighten them with the foot against the ground, they could not deliver a second blow." Some 2,000 years later David Livingstone recorded that he had seen an iron javelin made from much the same sort of iron light upon the cranium of a hippopotamus and "curl up like the proboscis of a butterfly."

This limited use of iron lasted until it was discovered that, due to the absorption of carbon, long continued heating of iron to a good red heat in a mass of glowing charcoal converted the soft metal into one which was much harder. Such steel has also the further great advantage that, unlike iron, it may be hardened by quenching. If heated to a red heat and quenched in water or other medium, and some very curious ones were used even down to modern times, steel becomes much harder still.

In the history of early iron and steel the Hittites played a leading part. A well-known letter of King Hattusilis III (1275–50 B.C.) to one of his contemporaries, probably the king of Assyria, after apologizing for not being able to send the iron asked for, says, "To-day now I am dispatching an iron dagger-blade to you." The gift of a single blade from one important monarch to another implies a metal of no ordinary kind, almost certainly a true steel, not impossibly in the hardened condition. It is probable that it was for the same reason that divine or supernatural powers were attributed to especially well-proved "iron" swords.

That the Greeks of the time of the writing of the Odyssey were acquainted with steel and with its heat-treatment is clearly demonstrated by the account of the blinding of Polyphemus by Odysseus:

> As when the smith.....
> .....plunges the hissing blade
> Deep in cold water, (whence the strength of steel)
> So hissed his eye around the olive wood.

Brass, the alloy of copper and zinc, despite mistranslations in the Bible and elsewhere, made its real appearance only in early Roman times. Zinc, as a metal, is a product of a much later age, and Roman brass was made by heating fragments of copper with charcoal and a zinc ore—calamine, or smithsonite (zinc carbonate)—in a closed crucible to a red heat. The charcoal reduces the ore to metallic zinc, which is a vapour at the temperature of the treatment, and this vapour gradually diffuses into the copper. As a result the melting point is lowered and, if the temperature is nicely judged, the copper-zinc alloy melts and liquid brass collects at the bottom of the crucible. Even after metallic zinc was known, this "calamine brass" was still produced by the same process and esteemed more highly than that made by melting the two metals together. The general establishment of a brass industry was one of the two major metallurgical developments which we owe to Rome.

TABLE II.—*Prehistoric and Classical Metallurgy*

| Period | Smelting and Refining | Alloying and Working |
|---|---|---|
| Prior to 4000 B.C. | Native gold and copper and meteoritic iron used occasionally without melting | Hammering to shape and to harden<br>Copper annealed about 4000 B.C. |
| 4000—3000 B.C. | Reduction of oxidized ores of copper and lead<br>Native silver used<br>Copper-arsenic alloys by smelting natural mixed ores, followed by bronzes from intentionally mixed ores of copper and tin (c. 3500 B.C.) | Melting and casting nearly pure copper, followed by copper-arsenic and copper-tin alloys (made from ores)<br>Permanent molds of stone and metal<br>Lost-wax process for complicated castings<br>Natural gold-silver alloys<br>Soldering with copper-gold and lead-tin alloys |
| 3000—2000 B.C. | Roasting and smelting of sulfide ores of copper<br>Experimental production of sponge iron<br>Tin smelted (perhaps earlier) and becomes important trade item<br>Cupellation of lead to extract silver, and of gold and silver for purification | Most jewelry techniques known before 2500 B.C.—inlay, stamping, repoussé, raising, soldering, riveting, granulation, surface colouring, etc.<br>Gold leaf<br>Wire made by cutting sheet |
| 2000—1000 B.C. | Gold purified by cementation<br>Bellows used in furnaces by 1800 B.C.<br>Wrought iron becomes important by 1600 B.C. (directly reduced from ore as sponge and forged without melting) | Bronze made from metallic tin and copper (perhaps much earlier). High-tin bronze (speculum metal) for mirrors. Leaded bronzes for statuary<br>Niello and enameling on gold<br>Silver-copper alloys blanched<br>Brass from copper and zinc oxide ores (not important before 200 B.C.)<br>Steel regularly made by carburization in hearth, perhaps hardened by quenching, 1200 B.C. |
| 1000—0 B.C. | Cast iron (China only)<br>Cast steel ("Wootz": India only)<br>Gold purified by sulfide process<br>Mercury distilled from ores<br>Amalgamation of gold ores | Vast expansion of production of iron, common nonferrous metals, and gold and silver<br>Iron and steel welded into composite tools and weapons<br>Stamping of coins, 700 B.C.<br>Gilding of bronze and silver with gold amalgam<br>Assay by cupellation, cementation, touchstone and (?) by density |

Source: Cyril Stanley Smith, The University of Chicago.

These then were the metallic materials on which successive peoples had built up their civilizations and of which they made their implements both for war and peace. In addition to these, gold, lead and silver were also produced, and used for artistic or religious purposes, in personal adornment, household utensils or equipment for the chase. Other metals such as arsenic, zinc, antimony and nickel occur only in the alloyed form, and though tin, a metal easily reduced from its ore, may well have been known from an early date, it is too soft by itself to be of real significance. Regarding nickel, a copper coin containing about 20% nickel, of the Bactrian king Agathocles (around 200 B.C.), has been reported, but for such an early date this alloy is unlikely to have been deliberate.

Since gold always occurs in the metallic state, alloyed at times with silver up to almost 40% together with smaller amounts of copper, iron or metals of the platinum group, such as palladium, there is no real extraction metallurgy of this metal. In early times the chief sources would be the dust and nuggets in the sand and gravel of alluvial deposits, the simplest of all contrivances for its recovery being by washing the gravel by hand in pans where, as a result of its much higher density, the gold remains behind, the clay and siliceous materials being washed away. A somewhat more ambitious form of apparatus is provided by carrying the material by a stream of water down an inclined sluice provided with transverse riffle bars behind which the gold collects or, so far as the finer particles are concerned, by covering the base of the sluice with some rough material on which the gold dust is mechanically entangled. It has been suggested that the legend of the Golden Fleece is related to the use of sheep skins, woolly side uppermost, for this purpose, while Agricola's book contains a woodcut in which grassy turfs are similarly employed. By Roman times mercury was used to extract the gold, but this amalgamation process falls outside the range which can properly be designated primitive.

As has already been said, native golds often contain quite considerable amounts of silver, as a result of which the colour becomes paler. These silver-gold alloys, known as electrum, may be purified in a number of ways, of which the simplest, and therefore presumably the earliest, is by heating in a crucible with common salt. In time the silver is converted into silver chloride, which passes into the molten slag, leaving a refined but usually still impure gold. By repeating the treatment purification can be effected. An alternative process was by heating the alloy with sulfur or some sulfur-bearing compound such as alum or the iron sulfate produced by the weathering of iron pyrites. There is no clear evidence when such refining of gold started, though this was probably around 600 B.C., and like other ancient technical processes it may well have been in use in certain localities long before the knowledge had reached others.

So far as the base metals present in the gold, such as copper and tin, are concerned, their removal can be effected either by mere melting in an oxidizing atmosphere or, and the process is of great antiquity, by cupellation. In essence, the gold to be purified is melted with lead in an air draft in, or on, a porous crucible. The lead is oxidized and the molten lead oxide forms a slag into which the base impurities in the gold pass. This slag is absorbed by the porous cupel, bone-ash may be used, and finally a molten bead of gold, containing only the silver and any platinum metals, remains. The base metals alone are "consumed of the fire," and it may well be that it is to this process that the references to the refining and testing of gold in the Old Testament apply. That the Greeks knew and practised this process is abundantly proved by certain specimens of gold and silver which were discovered by H. Schliemann on the site of ancient Troy.

In Troy II gold of a purity so high that it is only reasonable to believe that it must have been deliberately refined is not uncommon. By carrying out small-scale tests using the processes employed on a larger scale for the production of the metal, an early form of assaying was developed and was employed in the detection of deliberate debasement.

Although silver does occur in the native state this is not widespread, though the very earliest silver objects may well be of such an origin. It was not until it was recognized that many lead ores also contain appreciable amounts of silver that the latter metal became relatively common. The metallurgies of silver and lead are, therefore, inextricably interconnected. Lead is one of the easiest metals to extract from its ore; the commonest ore, lead sulfide (galena) needs no more than mixing with charcoal or other fuel and then roasting in the open air in a furnace, which need be little more than a hole or trench in the ground. The partial oxidation of the sulfide to lead oxide or sulfate, and the reaction of this with unchanged sulfide, produces metallic lead with the evolution of sulfur dioxide. So simple is the whole process that the early settlers in North America made lead for their bullets by smelting galena in a hollow tree stump, using the wind as a natural blast.

Owing to its softness and to the fact that, unlike most metals, lead is not hardened by hammering, both it and silver are relatively useless materials from a technical point of view. It is thought, however, that processes for the smelting and refining of lead were worked out somewhere in the region of Armenia about the early 3rd millennium B.C. This knowledge spread over the near east and both metals were common about 1500 B.C., though not until Roman times was lead used extensively. Its presence in amounts so substantial as to preclude accident in bronzes of the late 3rd millennium is evidence that by this date it had ceased to be scarce.

The crude lead produced in the manner described may also con-

tain, in addition to silver, arsenic, antimony, copper and tin. As a result of this contamination it is hardened and embrittled, and, although a superior material for the casting of religious or ornamental objects, is unfit for hammering into sheet. A refining treatment is therefore required which, since it is little more complicated than the original reduction from the ore, was devised relatively quickly. Most of the impurities present in the crude lead freeze at a higher temperature than does that metal itself. If, therefore, the impure lead is remelted the pure metal does so first and, with its silver still in solution, can be drained away, leaving a pasty dross in which most of the impurities remain.

Alternatively this dross, being more easily oxidized by the air, can be skimmed off as a semisolid crust. There is every reason to believe that this process formed part of the technique employed at Laurium, in Greece, where air was blown over the rim of the hearth on which the lead was melted. This refined lead was now ready for desilverization and of the processes available there can be no doubt that cupellation, already described in connection with gold, was the earliest. The inhabitants of Troy II were undoubtedly familiar with the process and could reduce the silver content of their lead down to 0.02%. The lead oxide produced in the process could then be resmelted with charcoal, and a soft, almost pure metal obtained.

These processes by which the early metallurgists produced their metals and alloys required the necessary equipment and tools. It may appear to be paradoxical, but more is known of the detailed construction of the earlier furnaces than of those of a later age. In these early furnaces, little more than holes in the ground lined with clay, a fire of wood was first started, after which layers of wood or charcoal and the ore were added, natural blast being provided by the wind, which was funneled, if possible, onto the furnace by the topography of the ground. At the conclusion of the operation the furnace was opened up for the withdrawal of the metal. In course of time, as the scale of operation increased, a superstructure was added to concentrate the heat and so raise the temperature attained. Due, however, to weathering or to deliberate destruction for the sake of the materials, this superstructure has generally disappeared and the design of the furnace is too often a mere matter of conjecture. A very early iron furnace from Hüttenberg, in Austria, is a mere bowl in the ground, some three feet in diameter and about the same in depth, lined with a thick layer of clay and set in a foundation of broken stone. No means of tapping out any molten slag was found nor was there anything through which an air blast could be provided. In a later one, from the Engsbachtal, a thick dome with a central vent had been built over the hearth and a taphole for the slag included. In the case of all iron furnaces, since the product was a semisolid mass, some degree of destruction of the structure was inevitable in the withdrawal of the metal.

The working tools of the pre-Iron-Age smith were little more than a stone anvil, a stone, or later a bronze, sledge hammer and withes, or bent pieces of green wood, to hold the crucible during the removal from the furnace and the pouring of the molten metal into the mold in which the casting was made. An excellent illustration of this method of holding the crucible is given in a wall painting from a tomb at Thebes.

With the introduction of iron, however, effective tongs to hold the red-hot mass during forging became essential. The earliest may well have been merely large tweezers, such as those illustrated in an Egyptian tomb of the early 13th century B.C., but these cannot have been very satisfactory. There is some reason to believe that it was not until tongs giving a much firmer grip on the bloom were available that iron became a common metal.

One of the astonishing facts in the history of the metals is the great skill shown by the gold- and silversmiths of the time. Their skills were always in step with those of the men who provided the metals, and soldering, granulation and wirework of quite remarkable perfection were done. In connection with wire it may be noted that the drawing of wire through dies was probably not invented until somewhere around A.D. 1000. Before then the method of production is clearly described in Ex. xxxix, in connection with the manufacture of the gold wire used to decorate Aaron's vestments: "And they did beat the gold into thin plates, and cut it into wires, to work it in the blue, and in the purple, and in the scarlet, and in the fine linen, . . ." If a round wire was required the strips were then hammered on an anvil, and once more or less circular in cross section, the wire was reduced to finer and finer sizes by pure tension.

This brief survey of one side of human progress during a period of some 3,000 years would be incomplete without mention of the impression that, although in the earliest stages chance must often have played a major part, the mind of the observer was sufficiently alert to appreciate what was occurring and to repeat it. Further, as experience was gained, there can be no doubt that real experimentation was carried out. This is well shown in the successive stages in the transition from the copper to the true Bronze Age, and in the gradual development from relatively useless, soft iron to a fully heat-treated steel. The men responsible for such changes were the scientists and research workers of their time.

(F. C. T.)

Over the centuries and especially during the 19th and 20th centuries, metallurgy has developed from an art dependent on trial, experience, and rule-of-thumb, into a combination of art and science involving knowledge of the principles underlying the behavior of metals—principles grounded largely in chemistry and physics. The chronology of this development through the 19th century is traced in Tables III and IV. Modern metallurgical development, so important to civilization, depends increasingly on the science of metallurgy. The art and science have thus combined to give rise to the great metallurgical industry, with its far-reaching effects in the economy and even the political relations of the world.

## II. ORES AND ORE TREATMENT

Of the 92 natural chemical elements, about 70 are metals. Metallurgy begins with the treatment of ores to extract metals from them, called production or extractive metallurgy. An ore is defined as a mixture of minerals from which a metal may be extracted with commercial profit; a mineral is a naturally occurring compound of metallic and nonmetallic elements. Thus the treatment of ores involves first, a separation of particles of different minerals with little or no change in their chemical composition, and second, a breaking down of the valuable mineral so as to isolate the desired metallic element. The first step requires crushing and usually fine grinding of the ore, so that the particles of the different minerals present become largely detached from each other, followed by a process called mineral preparation, or ore dressing, which separates most of the particles of the mineral containing the desired metal from the worthless minerals that constitute the gangue, or earth or rock with which the valuable mineral was mixed. The separation is based on some difference in physical properties such as specific gravity, response to a magnetic field, or wettability of the particle surfaces. The result is a concentration of a large quantity of ore into a smaller and richer amount, usually a very necessary step in the economical performance of the second step. As an example, ore dressing may result in an increase of the valuable metal content of the ore from as little as 1% or less to as much as 50% or more, with a corresponding decrease in the amount of material to be further treated. (*See* ORE DRESSING.)

**1. The Flotation Process.**—The process of concentrating ores by flotation was developed in the first quarter of the 20th century. It soon became the leading method of ore dressing. It depends on the fact that certain minerals, notably the sulfides, are not readily wetted by the water in which they are immersed, but instead air bubbles become attached to their surfaces and, when they are finely divided, cause them to float. Other minerals, including oxides and the common constituents of the gangue, are wetted and do not float. Thus the valuable mineral particles of an ore, which must be finely ground, can be separated from the worthless gangue. The action is promoted by addition of several substances to the water, only very small quantities being needed. These include "frothers," of which pine oil is an important ex-

ample, which make the froth stable and lasting when air is introduced in the flotation cell by agitation or by blowing. It is this froth which carries the desired mineral particles to the surface of the water in the cell. Next are "promoters" or "collectors," such as the organic compound Xanthate, which reduce wettability and assist in the attachment of air bubbles to the surfaces of floatable particles. "Conditioners," such as soda or lime, are often added to produce a slight alkalinity, which aids in frothing, and influence the behaviour of the collectors. Flotation is almost universally used in concentrating sulfide ores of copper, lead and zinc, and about 1924 it was found possible not only to float these from the gangue but also separate them from other sulfides and from each other, selectively. This is accomplished by adding a "depressant," of which lime and sodium cyanide are examples, which will so affect the surfaces of certain sulfides that they are prevented from floating, while another, not so affected, is floated. Then a "reactivator," such as copper sulfate or sodium sulfide, is added, which counteracts the effect of the depressant and causes the originally depressed mineral to float. In this way many complex ore mixtures, formerly of little value because it was not known how to treat them profitably for extraction of their valuable metal contents, have become among the principal sources of certain metals.

**2. Extraction of Metal.**—After treatment by ore dressing, the next step necessarily involves a chemical change in the ore (now a concentrate). The chemical change must break down or decompose the valuable mineral into its metallic and nonmetallic components and also complete the separation of the gangue, which could not be fully removed in the first step. Some ores are not subjected to mineral preparation either because they are rich enough without it or because the physical nature of the ore is such as to make separation of the mineral particles ineffective, resulting in large loss of the valuable mineral. An interesting fact is that the processes of mineral preparation have been so improved over the years that huge piles of tailings (the discarded gangue) are being re-treated to recover much of the mineral which formerly was not taken into the concentrate.

The second step in ore treatment is selected on the basis of several considerations, among them the chemical nature of the mineral compound, which may be a sulfide, oxide, carbonate, silicate or other. The most important iron and aluminum ores are oxides; the most important copper, zinc, and lead ores are sulfides. In a few instances, often in the case of gold, and more rarely in the case of copper and silver, the metal is present in metallic form, uncombined with a nonmetal; these are called native ores. Other factors determining the choice of method are the richness of the ore, the specific gravity of the metal, the chemical properties of the metal such as its affinity for oxygen or for sulfur, its solubility in acids or other solvents, its melting and boiling temperatures, and, of course, the relative costs of the different processes. The methods may be divided into three classes: (1) pyrometallurgy, those carried out at high temperatures obtained in fuel-fired furnaces, of which roasting and smelting are examples; (2) hydrometallurgy, those which consist of leaching the ore with a solution such as an acid or a strong alkali, often called a "wet method"; and (3) electrometallurgy, in which electricity is employed, especially to produce heat in an electric furnace or for electrolysis of a solution obtained by leaching or of a molten mixture of salts containing the metal.

A metal may be produced from an oxide by removing the oxygen from the metal with which it was chemically combined. This is a process of chemical reduction. It is perhaps the simplest and the most commonly used method, and is most often accomplished by heating the oxide with carbon. Carbon will thus act as a reducing agent, setting the metal free by taking the oxygen from it. As the metal oxide is reduced to metal, the carbon is oxidized to carbon monoxide or carbon dioxide, both of which are gases able to escape from the furnace.

The reaction requires energy, usually applied in the form of heat, to make it proceed; hence it is carried out in a furnace, either fuel-fired or electric. The temperature necessary for the reduction depends on the affinity of the metal for oxygen; all the metals may be arranged in a series in which the position of each shows the reducibility of its oxide and indicates the relative temperature required. The temperature in the furnace is usually, though not necessarily, high enough to cause the metal to become molten as it is produced. At the same time, the gangue present with the metal oxide in the furnace also melts. Since gangue is composed of substances of very high melting points, it is economical to mix the ore with a flux which will combine with the gangue to form a slag. The slag will melt at the temperature reached in the furnace, yet its melting point is usually higher and often much higher than that of the metal.

The process just described is smelting, which is defined as melting accompanied by chemical change. Nearly all iron is produced by reducing smelting of oxide iron ore using carbon in the form of coke both as reducing agent and a fuel. The operation is usually carried out in a blast furnace (*q.v.*).

Many other metals are produced by reduction of oxides, which sometimes are present as such in the ore and sometimes are formed by roasting the ore prior to smelting. Roasting is heating in air without fusion, its chief purpose being to transform sulfide minerals into oxides, the sulfur being removed from combination with the metal by oxidizing it to sulfur dioxide, which escapes as a gas. The metal usually combines with oxygen also, and its oxide is then reduced by smelting or otherwise. Tin is an example of a metal produced similarly to iron by reducing smelting of an oxide ore, while lead, zinc, copper and nickel are examples of metals found as sulfides in ores which are roasted before reduction.

Lead ores are most often smelted in blast furnaces. This type of smelting may also be applied to tin and copper, but the ores of these two metals are usually smelted in furnaces of the reverberatory type, which is heated by oil, gas or powdered coal burned at one end of the furnace. The hot gases pass over the charge, which lies on a broad shallow hearth (*see* FURNACE, METALLURGICAL). The most abundant ores of copper are sulfide ores. Instead of being smelted directly to metallic copper, these are usually smelted to matte, which is a mixture of sulfides chiefly of copper and iron. The matte is then treated by "converting," a process patterned after the Bessemer steel (*see* CONVERTER STEEL) process, in which air is blown into the molten matte, oxidizing the sulfur to sulfur dioxide, and changing the iron to oxide which combines with a silica flux to form a slag, leaving the copper as impure metallic copper. Roasting copper ore is a partial roast which has the purpose of adjusting the sulfur content to the amount desired for a suitable matte. With many copper ores roasting is omitted. Nickel ores also are smelted to matte, followed by converting. Distillation is a method of extraction used for metals of low boiling point, notably for zinc, cadmium and mercury. Zinc sulfide is roasted to oxide and may then be heated in a retort with coal as reducing agent. The temperature of reduction is above the boiling point of zinc, which is therefore evolved as vapour. The vapour condenses to liquid zinc in a condenser attached to the retort.

Some metals, instead of being reduced by carbon, are reduced by another metal, one having so high an affinity for oxygen that it will take the oxygen from the oxide of the desired metal when sufficiently heated, or by application of the same principle will take chlorine from the chloride of the metal. Thus titanium is made by reducing titanium tetrachloride with molten magnesium or sodium. Other metals sometimes produced by reduction with another metal are zirconium, manganese, chromium, vanadium, and a number of the rare metals. Some metals have such high melting points that they are reduced without melting, either with carbon or hydrogen as reducing agent. The metal may thus be produced in powder form. Such a method is applied to tungsten, molybdenum, and sometimes cobalt.

Metals whose oxides or other compounds would require excessively high temperatures for reduction by pyrometallurgy are made by electrolysis of a fused salt bath containing a compound of the metal. This is an important method in metallurgy, accounting for all production of aluminum, which by the 1960s had so increased as to exceed copper in world tonnage. The process of producing aluminum by electrolysis of a fused bath in which aluminum oxide

TABLE III.—*Chronological Table of Development of Metallurgy From* A.D. *0—1800*

| Period | Smelting and Refining | Alloying and Working | Metallurgical Science and Literature* |
|---|---|---|---|
| A.D. 0—1000 | Zinc smelted in China and India | Steel made from wrought iron and molten cast iron (China, before A.D. 600).<br>Steel made by repeated welding and forging, carbon controlled by flux, local hardening (Japan, before 8th century A.D.).<br>"Damascus" steel swords (low-temperature-forged Wootz) widespread in Islamic countries.<br>In Europe, steel still made by hearth-carburization; welded compositions common; *e.g.*, pattern-welded sword of Merovingians and Vikings. | *This table omits reference to general developments in physics and chemistry which were of fundamental importance. The growth of crystallography; of chemical atomic, molecular, and ionic theory; of thermodynamics; and of reaction kinetics provided the general background of knowledge without which metallurgical science could not have advanced. Note, however, that practical metallurgists empirically discovered many phenomena centuries before they were theoretically explained. |
| A.D. 1000—1500 | Blast furnace for carburizing and melting iron (1380) (outgrowth of bell founders' furnace).<br>Blast furnace for reduction of iron ore to cast iron (*c.* 1440).<br>Refining of cast iron to wrought iron (*c.* 1440) (did not entirely replace direct process until 19th century).<br>Desilverization of copper by liquation with lead and cupellation (*c.* 1470).<br>Bismuth smelted (15th century).<br>Parting of gold and silver with nitric acid (15th century). | Type metals (earliest, *c.* 1440, were tin-base alloys like pewter; displaced by lead-antimony before 17th century).<br>Etched decoration of armour (mid-14th century).<br>Large reverberatory furnaces for bronze melting (15th century).<br>Iron made fusible (but brittle) with antimony, etc. | Theophilus, *Schedula Diversarum Artium* (*c.* 1100) with first extant descriptions of metal working processes including casehardening, wire drawing, bell founding, gold- and silversmith work and metal pigment powders.<br>Pewter assayed by density (before 1350). |
| A.D. 1500—1600 | | Cast-iron cannon (1509).<br>Rolling mill for narrow strips of coinage alloys.<br>Widespread use of water power for working metals.<br>Tinned iron common. | Printed accounts of quantitative assaying methods, smelting, refining, and working techniques for copper, lead, and precious metals (little on iron): *Probierbüchlein* (1524), Biringuccio (1540), Agricola (1556), Ercker (1574). |
| A.D. 1600—1700 | Lead and copper smelted in reverberatory furnaces with coal.<br>Trials with coal in iron blast furnaces.<br>Zinc recovered as condensate in lead-smelting furnaces (prior to 1617). | Blister steel made by cementation (*c.* 1600, possibly earlier).<br>Brass from copper and metallic zinc (before 1627).<br>Chimney to enhance furnace draft (1648).<br>Lead shot by free fall (*c.* 1650).<br>Newton's low-melting-point alloy (1682).<br>Slitting mills for iron; wide sheet rolls for lead; three-high rolls for lead sections.<br>Superiority of bronze and brass bearings for iron shafts recognized. | Mathematical analysis of strength of beams (Galileo, 1638).<br>Glauber's *Philosophical Furnaces* describes studies of alloys (1648).<br>Law of elasticity (Hooke, 1660).<br>First observations of microstructure (Power, 1664; Hooke, 1665).<br>Expansion of steel on quench-hardening observed (Perrault, 1680).<br>Books on fine ironwork (Jousse, 1627), mint operations (Boizard, 1696), and gunfounding (St. Remy, 1697) describe metalworking procedures in full detail. |
| A.D. 1700—1800 | Coke for smelting iron (1709).<br>Zinc smelting in Europe (*c.* 1740).<br>Platinum imported from South America (*c.* 1740).<br>Puddling process for wrought iron (1783). | Malleable cast iron (1722).<br>Crucible steel (1740).<br>Powder-metallurgy platinum (1781).<br>Extrusion of lead pipe (1797).<br>Rolling of iron rods and bars. | Phlogiston theory of metal reduction (Stahl, 1703).<br>Table of chemical affinities of the metals (Geoffroy, 1718).<br>Theory of steel based on composition and structure (Réaumur, 1722).<br>Observation of three different structures in copper-zinc alloys (Geoffroy, 1723).<br>Systematic tensile and hardness tests (Musschenbroek, 1729).<br>Systematic study of platinum alloys (Lewis, 1763).<br>Principles of chemical analysis (Bergman and others beginning about 1770).<br>Observation of carbonaceous residue on acid solution of cast iron and steel (Rinman, 1774).<br>Crystallization of alloys related to geometry of parts (Grignon, 1775).<br>Chemical differences between cast iron, wrought iron, and steel studied quantitatively (Bergman, 1781).<br>High-temperature pyrometry (Wedgewood, 1782).<br>Phlogiston theory demolished (Lavoisier, 1783).<br>Carbon theory of steel clearly enunciated (Vandermonde *et al.*, 1786).<br>Comprehensive study of physical properties of all possible alloys (Achard, 1788).<br>Electrochemical reduction of copper and silver (Cruikshank, 1800). |

Source: Cyril Stanley Smith, The University of Chicago.

is dissolved was invented independently by Charles M. Hall in the United States and Paul Héroult in France in 1886. Other metals produced by this method include magnesium, sodium and calcium. The fused salt of the desired metal is mixed with other salts which are not decomposed in the electrolysis but serve to lower the melting point of the salt bath.

A radically different but very old and important method of extraction is that of hydrometallurgy (*q.v.*), or leaching. This method is applied when a compound of the metal exists in the ore, or can be formed by roasting, which will dissolve in a suitably low-cost solvent. Large tonnages of copper and zinc are produced in this way, as well as most gold and much silver, and other metals. The most common leaching agent is dilute sulfuric acid, which is used for recovery of copper and zinc. Aluminum ore (bauxite) is leached with strong caustic soda, forming a solution of sodium aluminate, from which pure aluminum oxide is precipitated and then electrolyzed in a fused salt bath to produce aluminum. This method, the Bayer process, of making pure aluminum oxide for

TABLE IV.—*Metallurgical Chronology in the 19th Century*

| Smelting and Refining | Alloying and Working | Metallurgical Science and Literature |
|---|---|---|
| Hot-blast stove (Neilson, 1823) | Oxyhydrogen furnace (Hare, 1801) | Alkali metals reduced by electrolysis (Davy, 1808) |
| Liquation-desilverized lead (Pattinson, 1833) | Research on alloy steel (Stodart and Faraday, 1820) | Meteorite structure revealed by etching (Widmannstätten, 1808) |
| Pneumatic steel (Kelly, 1851) | Duplication of true Damascus steel (Breant, 1823) | Thermoelectricity discovered (Seebeck, 1821) |
| Bessemer converter (1855) | "Nickel-silver" alloys (Frick, 1823) | Aluminum reduction (Oersted, 1825) |
| Manganese deoxidation of steel (Mushet, 1856) | Nickel steels (Fischer, 1825) | Melting points of gold, silver, platinum alloys (Princip, 1828) |
| Gas-fired regenerative steel furnace (Siemens, 1856) | Galvanized steel sheet (1836) | Cooling curves of alloys (Rudberg, 1829) |
| Zinc-crust desilverized lead (Parkes, 1856) | Electrotyping (Jacobi, 1838) | Repeated-impact tests (Hodgkinson, 1843) |
| Regenerative hot-blast stove (Cowper, 1857) | Soft bearing metals (Babbitt, 1839) | Law relating thermal and electrical conductivities (Wiedemann and Franz, 1853) |
| Electrolytic copper refining (Elkington, 1865) | Parts shaped by powder metallurgy (Osann, 1841) | Electrical resistance of alloys related to constitution (Matthiessen, 1859) |
| Basic Bessemer process (Thomas, 1875) | Three-high steel mill (Carslund, 1856) | Fatigue tests (Wöhler, 1860) |
| Pyritic smelting of copper (Holloway, 1879) | Aluminum bronzes (Debray, 1856) | Allotropy of iron suggested (von Fuchs, 1861) |
| Bessemerizing of copper matte (1880) | Tungsten steel (Mushet, 1868) | Microstructure of iron and steel (Sorby, 1864) |
| Electrolytic aluminum (Hall, Héroult, 1886) | Malleable nickel (Fleitman, 1879) | Structural theory of steel hardening (Jullien, 1865) |
| Cyanide process for gold (MacArthur and Forrest, 1887) | Manganese steel (Hadfield, 1882) | Critical point in steel observed (Tschernoff, 1868) |
| Carbonyl-nickel process (Mond, 1892) | Seamless tube piercing (Mannesmann, 1885) | Recalescence of steel (Gore, 1869) |
| Aluminothermic ferroalloys (Vautin, 1898) | Precipitation hardening observed (palladium alloy, Paillard, 1886) | Precise melting point diagram (copper-silver) (Roberts-Austen, 1875) |
| | High-speed-steel heat-treatment (Taylor and White, 1898) | Fracture and chemical state of carbon in steel related to critical point (Brinell, 1885) |
| | Silicon iron (Hadfield, 1899) | "Cellular" theory of steel (Osmond, 1885) |
| | | Practical thermoelectric pyrometer (Le Châtelier, 1887) |
| | | Thermal analysis of steels (Osmond, 1887) |
| | | Slip bands observed in deformed metal (Charpy, 1896) |
| | | Microradiography (Heycock, 1897) |
| | | Iron-carbon constitution diagram (Roberts-Austen, 1899) |
| | | Phase rule applied to alloys (Roozeboom, 1899) |

Source: Cyril Stanley Smith, The University of Chicago.

electrolysis was invented by K. J. Bayer of Germany in 1888. Gold and silver ores are leached with very dilute solutions of sodium cyanide. In the amalgamation (*q.v.*) process liquid mercury is used as a solvent for gold and silver. Tungsten ores, in which tungsten exists as insoluble tungstates, are treated to form a soluble sodium or potassium tungstate, which is then leached out with hot water. Ammonia is another leaching agent sometimes employed. Leaching is usually done at atmospheric pressure and without heating the solvent. The leaching of bauxite, however, is done under several atmospheres pressure and temperatures of 140° C. and higher. Pressure leaching is sometimes applied to complex ores, such as those containing copper, nickel and cobalt.

The solution obtained by leaching must be further treated to obtain the metal from it. This is often done by electrolysis; sometimes by cementation, in which the solution is passed over iron, for example, the metal precipitating on the iron, which replaces it in solution. Gold is usually precipitated from cyanide solution by means of zinc dust. Pure hydrated aluminum oxide is precipitated from sodium aluminate solution by "seeding" it with crystals of aluminum hydrate which serve as nuclei to start crystalization of the bulk of the alumina present. Sometimes precipitation is effected by or assisted by heating or by evaporation. In pressure leaching hydrogen is used to precipitate the metals selectively in powder form.

**3. Refining.**—As first extracted from its ore, a metal is more or less impure. In some cases it may be used industrially in this condition; more often it requires refining; *i.e.*, removal of most of the impurities from it. In many cases the impurities so removed constitute valuable by-products. Thus gold and silver are recovered in refining copper, lead and nickel. Bismuth is recovered in refining lead, cadmium in refining zinc, and the platinum-group metals in refining gold. Methods of refining include oxidation of the impurities with air, often assisted by an oxide flux. The process of making steel from pig iron or steel scrap, as in the converter and open-hearth processes, is to a large extent one of refining by oxidation. Another method is electrolytic refining. Eighty per cent or more of the copper produced is refined by electrolysis. This method is also applied to purification of silver and nickel, and in some instances to gold, lead, aluminum and other metals. In this method the impure metal to be refined is used as the anode; pure metal is deposited on the cathode. Some of the impurities dissolve in the electrolyte, while others remain insoluble at the anode and fall to the bottom of the tank in a finely divided form. This constitutes the anode slime, which is further treated to recover the valuable metals from it. Thus in copper refining, for example, gold, silver, selenium and tellurium are obtained. Refining may also be accomplished by distillation and by liquation. The latter is a method of melting or slowly cooling, allowing the impurities to separate by virtue of a difference in melting point and either settling or rising because of a difference in specific gravity.

For the processes of extracting and refining various metals, *see* articles on the individual metals, as ALUMINUM; COPPER; LITHIUM; etc.

## III. CAST AND WROUGHT METAL

The preparation of the metal in the pure or approximately pure form, generally in the liquid state, is a distinct stage in most processes. It is only the beginning of the series of operations by which the metal is brought into its finished form. Those operations vary widely according to the form in which the metal is to be finally used. Broadly, however, metallic objects may be divided according to their mode of production into two types: cast and wrought. The cast material is brought into its final shape, so far as metallurgical operations are concerned, by allowing the molten metal to fill and to solidify in a mold of suitable shape. Wrought material, on the other hand, begins its career by solidification in a mold of simple shape, and the resulting solid ingot, slab or other shape is then brought into the desired form by working, which may be done either cold or at an elevated temperature, by operations such as rolling, pressing, forging, stamping, drawing, etc.

Many metals and alloys cannot be wrought because they are, even when hot, too brittle to withstand plastic change of shape. Such materials—of which ordinary cast iron (*q.v.*) is an example—can be used only in the cast state. Finally, the finished or nearly finished material may be subjected to certain forms of heating and cooling known as heat-treatment (*q.v.*), which improve its properties to a marked extent.

The first step in bringing metal into the desired finished state consists in causing the liquid metal to fill a mold, where it solidifies as a solid casting which has the shape of the interior hollow of the mold. Although superficially simple, this process offers many difficulties. These are greatest where the metal melts at a very high temperature and in those cases where the liquid metal absorbs large volumes of gas which are liberated during solidification. A second required step often is machining after the casting has been removed from the mold.

### A. IRON AND STEEL

A large proportion of the liquid metal produced throughout the world is required for future mechanical working, such as rolling or forging and therefore is cast into molds of very simple shape. The most striking example is the production of steel ingots, which range in size from a small rectangular block weighing a few pounds

to huge, tapered, octagonal masses weighing more than 100 tons. Except in the case of crucible-melted steel, the liquid metal is first run from the refining furnace into a large ladle, generally a steel box open at the top and provided with a refractory lining. These ladles are moved about the furnace building by powerful electrically operated overhead cranes. For filling they are brought in front of the furnace, from which the liquid steel is allowed to escape through a taphole at the base. From this hole the liquid steel runs along a gutter or launder lined with refractories and falls into the ladle as a cascade from which great showers of sparks arise. From the ladle the liquid steel is afterward allowed to flow into the cast-iron ingot molds.

The solidification process is comparatively simple in a pure metal free from gas, but as steel is a complex alloy of iron with carbon and other elements, and contains dissolved gas as well as oxides, sulfides and silicates in suspension, the process becomes complex. In spite of an immense amount of laborious investigation the details of the solidification of steel are neither fully understood nor entirely under control. The principal factors which play a part in the process of ingot solidification are briefly as follows:

**1. Contraction.**—The steel after solidification occupies a smaller volume than in the liquid state. Since the layer of metal next to the wall of the mold solidifies first, and successive layers of solid metal are formed on the solid crust thus initiated, the last liquid portions are left at or near the centre of the ingot. A funnel-shaped contraction cavity or pipe is formed which may extend well down the centre of the ingot. This pipe must, for most purposes, be eliminated, and a large part of the upper portion of the ingot must be cut off and discarded. This can be partly avoided by using containers, usually of fire clay and known as sinkheads or hot tops, placed on top of the open end of the mold. The molten steel is allowed to fill these as well as the mold proper, and they consequently provide a reservoir of liquid steel from which the shrinkage cavities can be filled. This method confines the pipe more or less to the feedhead of the ingot, and the amount which has to be cropped is much reduced. Further improvement is gained by keeping the metal in the feedhead molten, which may be achieved by a gas torch or an electric arc.

**2. Gas Liberation.**—Liquid steel, like most liquid metals, is capable of dissolving large quantities of gas, especially hydrogen. Most of this gas is driven out of solution when the liquid metal crystallizes and then partly escapes to the surface. A considerable amount, however, fails to escape unaided and forms cavities or bubbles in the solidified metal. It is contended that in steel which is to be rolled or forged such gas cavities are harmless because their surfaces, when subsequently pressed together at a high temperature during rolling or forging, unite by welding. Such welding, however, is not always complete; a great many of these cavities can never weld because their walls become coated with impurities, such as silicates and sulfides, gathered from the adjacent steel during the pasty stage of solidification. These can be traced as long lines of nonmetallic enclosures in the finished steel. The formation of gas cavities or blowholes in steel can be regulated to a great extent by the manner in which the oxidizing processes in the steel furnace are conducted. If the reactions between oxide of iron and carbon are allowed to complete themselves so that the agitation or boiling of the steel in the furnace ceases, the product is a dead melted steel in which gas cavities will be comparatively few. Such steel, however, shows marked piping as described above. Even if the process is stopped at a point where there is still some oxide of iron present in the bath, the steel can be "killed" by the addition of a relatively small quantity of aluminum. Steel killed in this way pipes like dead melted metal. If, on the contrary, the steel is brought into the ingot mold while still actively generating gas—so-called wild steel—this process continues to some extent during solidification. A good deal of the gas then liberated is trapped in the solidifying steel, which, consequently, contains a large number of blowholes. The formation of these holes counteracts the effects of the normal contraction of the steel, and the steel does not appear to shrink while solidifying; it may, indeed, appear to rise in the mold. Such steel is called rising or rimming steel. It has, from the point of view of mass production, the advantage that as there is no definite pipe almost the whole of the ingot can be rolled, thus affording a larger yield of finished steel.

**3. Segregation.**—As steel is a complex substance and the rate of solidification of any but the smallest ingot is necessarily slow, the constituents have time to undergo separation or segregation which results in nonuniformity of chemical composition in different parts of the ingot. Segregation plays a very important part in affecting the quality of large steel ingots. In general, the impurities concentrate in the centre, although in several alloys the inverse may be true. It is, of course, a natural process which, under conditions of slow, undisturbed cooling in large masses, cannot be prevented except possibly to some extent by a careful choice of the composition of the steel itself. At the same time it has to be regarded as imposing a limitation on the size of the ingot, and consequently of the forgings or plates, which it is desirable to use where high and uniform quality is essential (*see* IRON AND STEEL INDUSTRY: *Ingots*).

**4. Contraction Stresses.**—Since the outer portions of an ingot necessarily solidify while the inner portions are still liquid, the latter, on subsequent solidification and contraction, exert a powerful inward pull on the outer portions. Masses of large size are therefore apt to be under severe internal stress and may sometimes crack spontaneously or when placed in a reheating furnace. The formation of such cracks can be largely avoided by correct design of the ingot molds. Part of the difficulty is also avoided by the practice, adopted also with a view to economy, of drawing the ingots from the molds while the steel is still very hot, so that the interior still may be partially liquid, and placing them in so-called soaking pits, a kind of pit furnace in which the temperature throughout the ingot has the opportunity to become equalized and the steel moreover is kept at a temperature suitable for forging or rough rolling.

### B. Nonferrous Ingots and Castings

The production of ingots or slabs of the nonferrous metals and alloys, while subject to the same general laws and phenomena as steel, differs in regard to the conditions which have to be met. Nonferrous ingots are rarely very large, so that many of the problems which arise from large size, very slow cooling and extensive segregation do not enter into the corresponding nonferrous problem. On the other hand the nonferrous ingot has frequently to meet special conditions. The quality of the surface of the cast slab is often important. In steel, so long as there are no cracks or foldings, smoothness of the surface is not essential. Brass, on the contrary, has frequently to be rolled out into a finished product with a smooth surface, so that the nature of the ingot or slab surface is very important. In the same way, blowholes lying just under the ingot skin, which are often regarded as normal in steel, are not permissible in nonferrous metal which is to be rolled into strip or sheet, since these cavities tend to open out during the annealing process following cold rolling and thus cause defects. Much more attention therefore is paid in nonferrous ingot casting to the details of mold surface, dressing, etc., and also to the method of filling the molds. In steel practice this very frequently is done by allowing the fluid metal to run into the mold from an opening in the bottom of a large ladle. In nonferrous practice, where the masses to be handled are much smaller, the molten metal often is poured directly from the ladle or even from the furnace into the open top of the mold. Many other processes for filling ingot molds have been developed, some working by gravity with or without the interposition of funnels or separators of various kinds, others by pressure applied to the liquid metal that forces it into the mold. Ingot casting of many nonferrous metals may be done by a continuous casting process. The solid bar is withdrawn from the bottom of a water-cooled mold at the same rate as molten metal is poured into the top. Because of the higher temperatures required this process is more difficult for steels, but its use is developing on a large scale (*see* IRON AND STEEL INDUSTRY: *Ingots: Continuous Casting*).

In regard to dissolved gases, while nonferrous metals do not undergo a "boiling" action in which gas is generated during refining

and melting, as in steel, they still absorb considerable quantities of gas from the atmosphere of the furnace and from other sources. In some cases this leads to difficulty in securing soundness whether in ingots or in shaped castings. Copper is an example of this kind, but the phenomenon is encountered to a marked extent also in aluminum and its alloys and in certain kinds of bronze. Two methods were evolved for freeing nonferrous metals from dissolved gas. The most positive of these is that of presolidification. It consists in allowing the molten metal or alloy to solidify very slowly, preferably in the ladle or else in the furnace where it has been melted. During this slow solidification the crystallizing metal expels the gas, which has time to escape to the surface. As soon as solidification is complete the metal is rapidly remelted and cast.

Another method of gas expulsion consists in bubbling through the molten metal a more or less inert gas which, by local reduction of the partial pressure of the dissolved gas, leads to the removal of the latter. This method is successful when nitrogen is bubbled through molten aluminum alloys. Nitrogen, however, is itself slightly soluble in many metals, so that this process is not universally applicable. In some alloys, on the other hand, one of the constituent metals is volatile, and escaping bubbles of its vapour serve to expel other gases in the same manner as bubbles of an inert gas. This is, perhaps, the reason why brass, with its large content of volatile zinc, readily yields sound castings. Hydrogen is commonly bubbled through magnesium alloy castings.

The production of shaped castings entails processes and problems widely different from those of ingot production, but it is impossible to discuss them even in outline here (*see* DIE CASTING; FOUNDING). They vary according to the nature of the metal to be cast. Some reference has already been made to cast iron. Steel offers much greater difficulty in regard to casting. The tendency of the metal to liberate gas during solidification is one of these; another is the high temperature of molten steel, which makes severe demands on the materials used as molds; another is the marked shrinkage during solidification. Castings are made in two types of mold, single-purpose molds and permanent molds. The former have to be specially prepared, sometimes by means of machines, from patterns for each casting. The use of metal or permanent molds offers many advantages where the process is applicable. The constantly repeated cost of sand molding is eliminated, but against this must be set the high initial cost of the metal mold or die. The latter usually is justified only where the same casting is required in great numbers. For many metals there is also a distinct advantage in regard to structure and strength which results from the relatively rapid solidification which takes place in a metal or chill mold. For the nonferrous metals chill casting is extensively practised, especially in the case of some aluminum alloys.

### C. Die-Casting

For the lower-melting nonferrous metals die-casting has found extensive application because of the accuracy of dimensions which can be attained and especially because of the rapidity with which the castings are made. Die castings can be used for many purposes without subsequent machining and are widely employed in light machinery, domestic and office appliances, automobile door handles and grilles, and a host of other articles.

Die-casting consists essentially in producing castings in metal dies or molds, but as a rule the process is carried out by forcing the molten metal into the mold rapidly under pressure. This is done in machines which also open the die and eject the casting, the operation being rapidly repeated. The widest use of this method is made in castings of low-melting alloys of zinc, tin and aluminum. It has been extended to magnesium alloys and even to certain types of brass and bronze. The difficulties of the process, however, increase rapidly as the melting point of the alloy rises.

### D. Precision Casting

Alloys for use when highly stressed while at high temperatures, such as for turbine blades, supercharger buckets and other parts of jet engines, guided missiles, etc., offer special problems in shaping. These alloys are made to maintain their strength and form at high temperatures, and it is not possible to soften them and make them plastic for working by heating as is commonly done with steel and most other metals. Also, most of them cannot be machined. Some can be forged, but with considerable difficulty. Often they must be cast to exact dimensions for final service. For this purpose a method known as precision casting or investment casting is employed, a process adapted from dentistry and jewelry manufacture and now used in making many small objects of intricate form with small dimensional tolerance and good surface finish. Patterns are first made by injecting wax or plastic into a master die. The patterns are placed in a sheet-metal container (flask) and covered with an investment slurry. After the assembly has been dried for about eight hours to harden the investment, the wax or plastic is melted out and the metal poured into the cavity, which forms a hot mold. In one variation the patterns are made of frozen mercury and are stored at low temperature until ready for investment, after which the mercury is allowed to melt and is poured out.

## IV. MECHANICAL WORKING

Reverting to the ingots in which a great part of the world's metal production is cast, we have to consider briefly the principal processes by which the finished products are produced. In these the metal is forced to assume new shapes by the application of large mechanical forces, which may be applied to the material while it is either hot or cold.

The purpose of subjecting metal to mechanical working is not merely that of bringing it into a desired shape. Mechanical work affects the structure and properties of most metals and alloys in a markedly favourable manner. When metal solidifies from fusion, especially if it does so in large masses and therefore slowly, it forms a crystalline structure which is relatively coarse —sometimes very coarse indeed. While it is true that whatever the treatment to which metal may be subjected it remains essentially crystalline, yet the size or scale of that structure is highly important as affecting physical behaviour. Mechanical working always breaks down the original cast structure and replaces it by a much finer and more satisfactory structure. In some metals, of which steel is the most important example, it is possible to produce a refined structure, comparable in scale with that of wrought metal, by heat-treatment alone, but this is practicable only for pieces of moderate size because larger masses cannot be cooled rapidly enough to bring about the desired changes. In addition, mechanical working, particularly in the case of steel, serves to close up and perhaps to bring about welding of cavities existing in the cast material. It also brings about a redistribution of the nonmetallic impurities. These become elongated in the direction in which the metal is caused to flow under mechanical treatment and in some cases confer upon the material something which has the appearance of grain or fibre. There is, however, no true fibre in any metal, although fibrous fractures frequently are obtained and often are regarded rightly as indications of good quality.

**1. Forging and Rolling.**—The process of forging (*q.v.*) may be carried out under hammers or presses. The former range in size from the hand sledge of the blacksmith to the largest steam hammers delivering blows of many foot-tons. For much of the heaviest forging great hydraulic presses are used in which the heated metal is pressed or kneaded into the desired shape. Forging, particularly on a large scale, is mainly applied to steel, and in that material very large pieces are sometimes handled. The tubes of heavy naval guns are probably the largest of these, but parts of large ships are also very heavy forgings. These large forgings are always made from the ingot itself, but for much of the smaller work the steel is first brought into the form of bars by rolling and only then is forged. Work of this kind merges into what is known as drop forging, in which a carefully proportioned piece of steel bar is forged between heavy dies to assume a designated shape. Huge presses are used to shape magnesium alloys in making landing gear for aircraft as well as other structural parts.

Stamping and pressing may also be regarded as allied to forging,

but while true forging is applied to highly heated metal, stamping and pressing may be done either hot or cold. Here the metal is used in the form of bar or sheet and is forced into the desired shape, usually without much change of section or real flow of metal, but rather by bending accompanied by a certain amount of drawing. Metal to be used in this way, of course, must possess an ample degree of ductility. The rolling process is used to convert ingots into forms which are small in cross section in comparison with their length. Bars and sheets, rods and wire, rails and girders and all kinds of structural sections are produced in this way. Rolling is carried out in successive stages. In the early stage the purpose is, while gradually bringing the metal toward the desired shape, to improve its quality—especially its ductility—so that it can better stand the more severe subsequent treatment. Yet for this very purpose it is, in many cases, found necessary to make the first deformations of the metal very drastic. It is found in mechanical working that if the change of shape or size forced on the material at any one stage is not sufficient to penetrate and affect the entire thickness there is risk of damage. Accordingly, where an ingot of large size has to be broken down, very large forces and correspondingly heavy deformations are applied. This occurs mainly in the rolling of steel and is carried out in very powerful machinery. The ingots are so large and heavy that they are handled by automatic appliances which take them from the furnace, feed them backward and forward through the great rolls and finally eject the finished billet from the rolling train.

While steel is broken down hot, some of the softer nonferrous metals and alloys can be treated safely cold. The essential nature of the process does not differ as between hot and cold rolling. The effect of cold rolling, however, is to produce hardening so that, after a time, the metal has to be annealed in order to soften it prior to further cold rolling. Such annealing (*q.v.*) usually consists in placing the metal in a suitable furnace and heating it to a temperature correctly chosen for each metal.

The details of rolling practice vary widely according to the metal employed and the purpose for which the product is required. Heavy plates and extremely thin sheets naturally demand entirely different treatment. Strip metal is sometimes rolled in so-called continuous mills. In these mills, which are used mainly for steel, the hot metal is fed into the first set of rolls rotating at a moderate speed. The material emerging from the first rolls is fed directly into a second set, which, since the length is increased by the passage through the first rolls, must run at a considerably higher speed. A number of sets of rolls are used in series in this way, the finished product leaving the last rolls at a very high speed. Other types of rolling result in the production of sections; *i.e.*, of material having the form of H- or I-beams, channels, angles, railway rails, etc. These are produced by the action of suitably shaped grooves cut in the rolls, but the differences in the rate of movement at the bottoms of such grooves and near the tops require careful consideration. Successive passes in such rolls must provide for the easy flow of the metal from one shape to the next.

**2. Extrusion.**—Another method of manipulating metals, more especially nonferrous alloys, for the purpose of bringing them quickly and easily into the form of bars or rods having any desired section or into the form of tubes, is that of extrusion. Here the heated billet of metal, previously produced of the correct size and shape, is placed in a heavy steel cylinder and a steel ram is forced down into the cylinder from one end. At the other end there is an aperture or die through which the metal is forced to escape in the desired form. It is possible to extrude many alloys which are not sufficiently ductile, in the cast state, to stand rolling. In other cases, rolling is still possible if the internal structure of the metal has been modified first, either by previous or by preliminary forging.

## V. POWDER METALLURGY

The methods of powder metallurgy (*q.v.*) afford a unique way of producing and shaping alloys. Materials are readily made that could not be made by ordinary methods of alloying; *e.g.*, oxide-metal alloys for applications requiring a combination of ceramic quality and toughness, graphite-metal articles for current-carrying brushes, and metals with controlled porosity for filters or for oil-less bearings. The methods are also competitive under certain conditions with other forming methods. Appropriately mixed powders are pressed to shape, then sintered to achieve bonding by diffusion.

**Cermets.**—Cermets, sometimes called ceramals, which are combinations of ceramic materials with metals, are among the more important products of powder metallurgy. Fine ceramic and metal particles are mixed and then sintered at temperatures approaching the melting point of the metal, or heated until the metal fuses, so that the metal (or alloy) serves as a binder for the ceramic particles.

Cermets came into prominence with the need for materials suitable for construction of turbine blades in jet engines, which must withstand stresses and abrasion at temperatures up to 1,800° F. (about 980° C.). Previously cermets had been used largely for hard cutting tools. Designers of rockets, missiles and space vehicles have looked to cermets, although they have the defect of brittleness, as materials having as great strength and chemical stability as it is possible to obtain at temperatures as high as 2,400° F.

Cermets are of two kinds, carbide base and oxide base. Tungsten carbide and, later, titanium carbide have been most commonly employed. Most oxide cermets use alumina, magnesia or beryllium oxide. Small additions of other oxides or carbides may be made. Metals used are most often nickel or cobalt, less often iron and alloys of these metals.

Other applications of cermets are for dies, bearings, electrical contacts, friction brake linings and electronic cathodes and in nuclear reactors.

## VI. HEAT-TREATMENT

**1. Annealing.**—While the great majority of metallic products are put into use in the condition—so far as their inner structure and strength are concerned—in which the final stages of production have left them, an increasing number of articles (more particularly those intended for important engineering uses) are subjected to some form of heat-treatment for the purpose of improving their internal structure and mechanical properties. In the case of steel castings, for example, annealing is almost universally applied for the purpose of removing some of the impurities from the intercrystalline boundaries, where they tend to form embrittling cell walls, and bringing them into the shape of small scattered globules which are comparatively harmless. The treatment breaks up the original coarse cast structure; further improvement is effected by normalizing or quenching and tempering the steel.

Simple annealing is also used for softening metal hardened by cold working, as in rolling, stamping, pressing, wire drawing, etc. If carried out at a high temperature or for a long time this may result in the formation of a coarse and brittle structure. Fortunately this occurs only rarely in the nonferrous metals, but in very mild steel it is frequently encountered. In this material, however, it is possible to produce a refining of the structure by normalizing. This consists in raising the steel to a temperature just above the critical range, maintaining it there only long enough to ensure that the whole of the piece has reached the desired temperature, and then removing the steel from the furnace and allowing it to cool rapidly in still air. The result is a marked refining of the crystal structure with a corresponding improvement in the mechanical properties. If, however, the steel is of a very soft variety and is required to possess the greatest ductility without much regard to strength, the final heat-treatment may be simply annealing at a much lower temperature, such as 680° C., which is just below the critical range of the steel. This causes the carbide of the steel to become "balled up" into little spherical masses, making the material very soft and relatively weak (see *The Effect of Structure*, below).

**2. Hardening and Tempering.**—The most important form of heat applicable to steel, whether a plain carbon steel or an alloy steel containing nickel, chromium, manganese, etc., is a double treatment known as hardening and tempering. In some cases the first stage is a true hardening, but in a great many cases it

can be called hardening only by analogy. A full discussion of these transformations could be given only after an explanation of the metallography of steel and especially of the equilibrium diagrams of carbon steels and of alloy steels (*see* IRON AND STEEL INDUSTRY: *Slowly Cooled Steels;* ALLOYS; METALLOGRAPHY: *Metals and Alloy Structure*). The general nature of the changes involved in heat-treatment of steel can be explained in an approximate manner if it is realized that the metal iron, which constitutes the great bulk of all steels, even of the more complex alloy steels, can exist in at least two allotropic states, known as the alpha and gamma states, respectively. In pure iron, the gamma state exists at temperatures between 910° C. and 1,450° C. It is a rather soft, nonmagnetic substance which crystallizes in the face-centred cubic lattice. Below 900° C., pure iron assumes the alpha form, which is also relatively soft and ductile but is—below 768° C.—strongly magnetic; this form of iron has a body-centred cubic lattice. The two kinds of iron differ most widely, however, in their power of absorbing carbon in the condition known as solid solution. Gamma iron has a considerable power of holding carbon in solid solution—up to about 2%—while in alpha iron carbon is soluble only in very minute amounts. "Soluble" as here used simply means that the metal (in this case iron) can take up a certain proportion of the other element into its own crystal structure without the formation of a second constituent or kind of crystal. Thus a carbon steel at a high temperature consists of gamma iron crystals holding carbon in solid solution, while on cooling through the transformation range, if the cooling is slow, the carbon is separated. As the iron itself undergoes transformation into the alpha form, crystals of iron carbide, cementite, $Fe_3C$, are separated. This is the condition of slowly cooled or annealed steel. By very rapid cooling—chilling or quenching—the transformation can be more or less suppressed or delayed. If certain alloying elements are present, particularly chromium and nickel, the retardation of the transformation is much facilitated, and if enough nickel or manganese is present the transformation may be entirely suppressed. In that case the iron retains the gamma condition and the steel is nonmagnetic and soft. It is in the intermediate condition, where the transformation has been retarded rather than entirely suppressed, that the steel becomes hardened.

The capacity of hardening was at one time believed to be a unique property of steel, but it is now known in the alloys of other metals also. It was long regarded as mysterious and controversy still turns on its theoretical explanation. Here, however, we are mainly concerned with the fact that by suitable quenching, from a temperature above the critical range (*i.e.*, above the temperature at which the gamma-alpha transformation occurs), all but the very softest steels can be more or less strongly hardened. In the high-carbon tool steels hardening is utilized to provide cutting tools, cutlery, etc. Even for these special purposes, however, where the greatest hardness is desirable, it is not possible to use the steel in the fully hardened state produced by direct quenching if that quenching has been drastic, as in water. The steel in that state is too brittle. The steel is therefore slightly reheated and thereby becomes tempered. When quench-hardened steel is gently heated, as the temperature rises the suppressed transformation gradually takes place to a slight but progressive extent. The steel is thereby rendered tougher but at the same time slightly softer. The degree of tempering applied is adjusted to suit the purpose for which the implement is required.

**3. Surface Hardening.**—It is often desired to make a steel part with a very hard surface, as for wear resistance in an automobile gear or crankshaft, but with a softer, tougher, and less brittle interior. This can be accomplished by casehardening by one of several methods. Steel for casehardening contains about 0.2% to 0.3% carbon, or else an alloy steel may be used. It is first carburized to a small depth below the surface by heating it for some hours while packed in carbonaceous material, such as powdered charcoal plus a carbonate, which causes carbon to be slowly absorbed until the "case" becomes a high-carbon steel while the "core" is still low in carbon. The case is then hardened by quenching. Other methods employ heating in a carburizing gas or immersing in a molten carburizing salt bath. Nitriding is a method of casehardening in which the steel piece is heated several hours in gaseous ammonia. The absorbed nitrogen produces an even harder case than carburizing and requires no heat-treatment. (See *Furnaces*, below. *See* also SURFACE HARDENING.)

**4. Age Hardening.**—While the hardening of steel was practised for centuries, heat-treatment of nonferrous metals and alloys was, until a much later time, confined to simple annealing at various temperatures, for the purpose of softening metal that has been hardened by cold working. About 1913, A. Wilm in Germany discovered the well-known structural alloy duralumin, an aluminum alloy containing about 4% copper together with about 0.5% each of manganese and magnesium. This alloy, and many others developed subsequently, notably alloys of aluminum, of copper and of nickel, is hardened and strengthened on a somewhat different principle from hardening of steel. The process is known as precipitation hardening or age hardening. It depends in every case upon the fact that the metal to be hardened (solvent metal) can, at a high temperature, hold in solid solution a larger percentage of the alloying element (solute) than it can hold at lower temperatures. The alloy is heated for a short time at a temperature sufficient to form a solid solution. In the case of duralumin, at the temperature of about 480° C. the aluminum completely dissolves the copper. If slowly cooled a copper-aluminum component would precipitate in coalesced particles which would produce little hardening. Instead the alloy is quenched in water. The rapid cooling prevents immediate precipitation and leaves the alloy temporarily in an unhardened condition consisting of a supersaturated solid solution. In this condition the alloy may be readily worked, and this is commonly done in practice. On standing four or five days at room temperature, the precipitation occurs in a restrained manner, forming precipitated particles of colloidal dimensions. Formation of these at the low temperature causes stresses in the alloy crystals which result in marked increase of hardness and strength. If duralumin is aged at 100° C. the effect is obtained in less than an hour. Many of the precipitation-hardening alloys will not harden at all at room temperature, but harden readily when moderately heated after quenching. Duralumin, the counterpart of which in the United States was called alloy 2017, was largely superseded for aircraft and numerous other structures by alloy 2024, which contains slightly more of the alloying elements and becomes somewhat stronger, though with some sacrifice of ductility. One of the strongest precipitation-hardening alloys is beryllium copper, composed of copper with addition of about 1.6% beryllium and less than 0.5% cobalt or nickel. The Brinell hardness of this alloy rises from 80 to 400, with an increase in tensile strength from 30,000 to about 200,000 lb. per square inch.

## VII. THE EFFECT OF STRUCTURE

A striking example of the effect of structure on the properties of metals is afforded by cast iron (*q.v.*). Ordinary iron castings are made with iron containing about 3% to 3.5% carbon and are cast in sand molds. Part of the carbon is combined with iron in the form of iron carbide, $Fe_3C$, a hard and brittle component called "cementite." Some of the cementite is in separate crystals and some is intimately associated with crystals of pure iron ("ferrite") forming the constituent "pearlite," which has greater toughness than cementite alone. The remainder of the carbon separates as graphite, which ordinarily occurs as flakes and stringers distributed through the cast iron. The structure of the iron and therefore its properties are profoundly affected by the relative proportions of cementite, pearlite and graphite and by the form in which these are present, even when the total carbon content and the small content of other elements has little or no variation. Often, however, the content of other elements, especially silicon and sulfur, will be varied somewhat in order to bring about a change in the distribution of the carbon between combined carbon and graphite and a change in the shape in which the components exist. The structure of the cast iron is further determined by the rate of cooling when it is cast and by subsequent heat-treatment. Thus cast iron made in sand molds, cooling relatively slowly, will have a high graphite content and this will be in the

form of flakes and stringers which tend to make the casting weak and brittle. This form of cast iron has a gray fracture and is called gray iron; for centuries it was the only kind of cast iron made. It cannot be wrought. It is still the most common type of cast iron, because of its low cost and properties satisfactory for most applications. If the iron is cast against a metal "chill," causing rapid cooling, graphite does not separate and white cast iron results. This is very hard, but is also brittle. Parts of the casting which cooled more slowly will be of gray iron, and in chilled cast iron there is a transition from a hard wearing surface to a softer but less brittle interior of gray iron. If cast parts, not too large in size, are made of white iron throughout and then are subjected to prolonged heating under proper conditions, some of the hard and brittle $Fe_3C$ will break down into ductile ferrite and graphite, but the graphite will be distributed in fine separated particles instead of the usual form; the result is malleable cast iron. In this form the brittleness of cast iron is largely overcome, although the iron cannot be wrought as is steel. Later it was learned how to make cast iron of superior strength by producing a structure in which most of the combined carbon is present as pearlite and the cementite component of the pearlite is spheroidal in shape. Further improvement is obtained by making the grain structure fine and compact. In 1948 a new kind of cast iron called ductile cast iron was introduced. In this type the graphite is entirely spheroidal, avoiding the embrittling effect of flakes and stringers. The graphite spheroids are obtained by addition of a little magnesium, added usually as a nickel-magnesium alloy, but the resulting ductility is not due directly to the magnesium, but rather to the indirect effect of the magnesium on the form of the graphite. The structure of the iron matrix in ductile iron may also be improved by altering the cooling rate and by various heat-treatments. A number of alloy cast irons are also used, in which controlled percentages of alloying elements such as nickel, chromium, copper and molybdenum are used to give directly greater strength, or greater hardness or resistance to corrosion.

## VIII. ALLOY STEELS

Special steels have been introduced for machine cutting tools which render much better service than ordinary carbon steels. The action of these high-speed steels, which generally contain a considerable amount (sometimes up to 18%) of tungsten or 9% of molybdenum, along with vanadium and chromium, depends upon the fact that in ordinary carbon steels the hardness is rapidly reduced by rising temperature. When a tool is taking a heavy cut its temperature rises rapidly, and the amount of loading which can be applied to a tool made of carbon steel is limited by the comparatively low temperature which brings about softening. In the high-speed steels the temperature which must be attained to cause softening is very much higher; the steels are for this reason said to possess "red hardness." They owe this valuable property to the peculiar manner in which the transformation temperatures are altered by the presence of the alloying elements.

In structural steel of lower carbon and alloy content, the purpose of heat-treatment is to produce not a material of high hardness but one possessing high tensile strength combined with reasonable ductility and good behaviour in the notched-bar impact test. For this purpose the steel is first hardened by quenching, but this is done more frequently in oil than in water. The subsequent tempering or drawing may be carried out at temperatures which usually lie between 400° and 600° C. Two serious difficulties have arisen in applying this heat-treatment, particularly to larger masses of steel. Because of their large heat content and the relative slowness with which heat flows from the interior to the exterior of a mass of steel, it is not possible to secure in the inner portions of a steel forging a rate of cooling sufficiently rapid to bring about hardening. The heat-treatment of large masses—and for this purpose pieces exceeding two inches in thickness must be regarded as large—thus presents grave difficulties in simple carbon and nickel steels. By the addition of suitable amounts of chromium, however, the transformations of the steel are rendered more sluggish so that even the moderately rapid rates of cooling which can be attained in large masses are sufficient to bring about hardening. Such steels, therefore, can be hardened and subsequently tempered in relatively large masses. This property is referred to as "hardenability." The alloying elements vary in the degree to which they increase the hardenability of steel. The greatest actual increase is given by manganese, but the greatest increase per unit quantity of element added is given by boron. Here, however, the second difficulty arises. Steels of this type, especially the nickel-chromium steels, exhibit the phenomenon known as "temper brittleness," which makes itself felt most strongly under the notched-bar impact test. When such steel has been tempered to show the desired degree of high ductility, it gives very low values under the impact test. This type of brittleness can be prevented by accelerating the cooling of the steel immediately after it has been tempered. Rapid cooling, however, is difficult or impossible in large masses.

Fortunately it has been discovered that the presence of a small percentage of molybdenum in the steel prevents the development of temper brittleness even if the material is slowly cooled after tempering.

In regard to iron and steel, reference has been made to the high-speed steels used for cutting tools. To these have been added many types of alloys which can furnish tools of still greater hardness and cutting power than the steels. The Stellite type of alloy contains carbon, chromium, cobalt and tungsten. It can be brought to the desired shape only by casting, as it remains hard and nonductile at all temperatures. The final shaping of the tool is done by grinding. The tools can be used to cut rapidly and up to higher temperatures than the steels, but are apt to break under a blow. Still harder and capable of resisting still higher temperatures are a group of substances whose most important constituent is tungsten carbide. Only thin strips or plates of these substances are used as facings brazed to the front of a steel tool, but with these tools it is possible to cut at fairly high speeds materials, such as toughened manganese steel, which resist all steel cutting tools. The materials themselves are known as sintered carbides. Important advances also were made in regard to steel for magnetic purposes. For permanent magnets tungsten steels were widely used, but a Japanese discovery showed that cobalt steels were markedly superior. After World War II precipitation-hardened alloys were used (*see* MAGNETISM: *Permanent Magnets*). In the development of very soft magnetic steels, for transformer cores and for the inductive winding of submarine cables, special alloys also have been developed. Steel containing very little carbon with about 4% of silicon has a lower magnetic hysteresis loss combined with a higher electrical resistance than ordinary soft steel, and its use has had wide effects in improving the economy of electric current transformers. For the sheathing of submarine cables a magnetic material having the highest possible permeability under very low magnetic fields is required. A remarkable material for this purpose is the U.S. alloy of iron with about 79% of nickel, known as permalloy (*see* MAGNETISM: *Permeable Materials*).

The immense losses caused by corrosion led to much research on this subject in regard to both ferrous and nonferrous metals. The addition of small amounts of copper to steel has been found to reduce corrosion in many circumstances, but very great resistance to corrosion has been attained by the addition to steel of considerable amounts of chromium. Stainless steel was developed in Sheffield by Harry Brearley; this kind contains 13% of chromium and, with a moderate carbon content, can be satisfactorily hardened and tempered. When properly hardened, tempered and polished, this steel resists corrosion extremely well, although there are certain conditions, such as prolonged exposure to sea water, which cause attack. For purposes where softness and ductility are required, stainless iron was developed with a very low carbon content and containing about 17% of chromium. This, however, is exceeded in properties by the austenitic stainless steels developed in Germany by Eduard Maurer and Benno Strauss. These contain still higher proportions of chromium than ordinary stainless steel, together with a high proportion of nickel. These steels retain the austenitic structure on cooling, whether fast or slow, and are thus soft, ductile and nonmagnetic, but they ordi-

narily cannot be hardened by heat-treatment and are difficult to machine. Compositions are available which can be hardened by the precipitation-hardening process. Molybdenum-chromium-nickel alloys are extremely resistant to corrosion and chemical attack of all kinds and are applied in chemical engineering and elsewhere.

The cost of these rust-resisting steels is, however, too high to allow of their use for general structural purposes, so that methods of preventing or reducing corrosion in ordinary steel are still required. Apart from paints and similar coatings, protection of steel by coating with another metal, such as zinc and tin, is widely used. Galvanized iron (really steel coated with a thin layer of zinc) is used in immense quantities. Perhaps the most striking development in protective coatings is the application of metallic chromium to this purpose. When properly deposited by electrolysis, this metal furnishes a coating of brilliant bluish-white colour which is incorrodible and untarnishable, while it is also so hard that it cannot be readily scratched.

In nonferrous metals the problems of corrosion, although different, are equally important. In regard to the alloys of copper, the production of condenser tubes immune from failure by pitting continued to offer a problem although much important progress was made. In regard to aluminum alloys, the corrosion problem stood for some time in the way of their wider application. Their natural corrosion resistance was enhanced by protective coatings. Aluminum owes its natural resistance to corrosion to a thin, transparent coating of oxide which forms on the metal immediately upon exposure to the air and which to a great extent prevents further attack. As naturally formed, however, this is neither strong enough nor impervious enough to prevent corrosion under more difficult conditions, such as exposure to sea water, etc. It was found, however, that the natural oxide coating could be strengthened and thickened by making the metal the anode in a bath containing chromic acid or sulfuric acid and gradually raising the voltage. Aluminum and many of its alloys when treated in this way became very resistant to corrosion, and this resistance can be increased further by closing the pores of the anodic oxidation film by saturating with fatty matter such as lanolin or by heating. The alloys may be protected by roll-cladding them with pure aluminum. Such material is widely used for aircraft sheathing.

## IX. OTHER DEVELOPMENTS

**1. Welding.**—Among prominent developments in the production and treatment of metals, the great expansion of welding (*q.v.*) operations in the joining of steel may be mentioned. The two principal processes are oxyacetylene and electric welding. An advanced technique for both methods was developed and welded joints are widely used. An outstanding example of the value of welded joints is afforded by the many large-diameter pipelines carrying natural gas and petroleum in remote and difficult terrains.

**2. Heat-Resistant Alloys.**—Important advances also have been made in regard to materials for use at high temperatures. The demand for these arises from the effort to improve the thermal efficiency of heat engines, stimulated by the struggle between the steam-turbine and the internal-combustion engine. A tremendous stimulation to the development of metals with high strength at elevated temperatures was provided by the gas turbine and the jet engine (*see* also *Precision Casting*, above), and, later, by rockets, guided missiles and space craft. Design of these was dependent upon developing alloys with increased high-temperature strength. The result was a demand for steels and nonferrous alloys capable of withstanding stress and oxidation at temperatures sometimes as high as 980° C. Ordinary steel becomes too weak to be used at these temperatures, and even materials which show a reasonably high strength under an ordinary tensile test carried out at the high temperatures were found to fail under much lower stresses if exposed to them for a sufficiently long time. This led to the conception of the "creep stress," which is measured by determining the highest stress which the material can bear, at a constantly maintained high temperature for long periods of time, without undergoing changes of length above a desired maximum. The stress required to rupture the material after 1,000 hours at a given temperature is another criterion for evaluating high-temperature alloys. At 980° C. some of the best materials available commercially show a stress-to-rupture value of little more than two tons per square inch. For so high a temperature, however, this constitutes a marked achievement and was attained only by a few special heat-resisting alloys. The alloy steels contain relatively large proportions of nickel, chromium and cobalt, with additions of molybdenum, tungsten, niobium and titanium. The nonferrous alloys suitable for high-temperature use consist mainly of nickel and chromium, nickel and molybdenum, nickel, cobalt and chromium, and cobalt, chromium and molybdenum or tungsten. Pure molybdenum, protected against oxidation, is a very promising material for high-temperature applications, as are titanium carbides bonded with large amounts of nickel.

**3. Furnaces.**—As metallurgy progressed, the damaging effects often produced by extremely small amounts of impurities became more and more evident. Often these result from the entrapment or dissolving of gases in the metal while molten. Gases may be avoided by melting the metal in a vacuum, usually in an electric furnace. *See* FURNACE, ELECTRIC. (AL. BU.)

## X. METALLURGY IN NUCLEAR ENGINEERING

Nuclear metallurgy includes the production, fabrication and application of metals of interest in nuclear engineering and the study of their properties. The discovery of atomic fission in 1938 resulted in the emergence of several relatively unknown metals into prominence. The way a material interacts with neutrons, *i.e.*, its neutron-capture cross section, determines its suitability for use in an atomic reactor. This criterion divides the nuclear metals into two main categories: those with high and those with low cross sections.

An element with a high cross section may fission as a result of neutron capture or it may be transmuted into another isotope or element.

Uranium and plutonium undergo atomic fission, and thorium can be converted into a fissionable isotope of uranium, $U^{233}$. These metals are referred to as nuclear fuels. Prior to 1940 uranium and thorium metals were laboratory curiosities only and plutonium was unknown. However, the metallurgy of these metals advanced so rapidly during the next decade that by the time of the 1955 Geneva conference on peaceful uses of atomic energy the information on these metals rivaled that on iron and aluminum. The control of a nuclear reactor depends upon the metals with high-capture cross sections. Because of their affinity for neutrons the metals boron, hafnium, cadmium or gadolinium are used to shut down a reactor or to control its power level of operation.

Metals with low cross sections are equally important since they do not remove valuable neutrons from the atomic reaction. Since uranium metal is highly reactive toward water or air at elevated temperatures, protective cladding of the fuel elements is necessary. Aluminum and zirconium are commonly used for this purpose because of their transparency to neutrons, ease of fabrication and corrosion resistance. Zirconium, particularly, has been used in increasing amounts in industrial and military reactors. Whereas only a few pounds of zirconium had been produced prior to 1945, within a ten-year period its production rate was increased to 1,000,000 lb. annually. Beryllium with its low cross section and low atomic weight is desirable for use as a moderator. Its function is the slowing down of high-energy neutrons produced in the fission process. Another application for low cross section metals is as liquid coolants or circulating fuels. Low-melting sodium and a sodium-potassium alloy are employed as coolants in several reactors. The liquid metal is circulated over the hot fuel elements and then to a steam generator. Another reactor uses a circulating fuel of $U^{235}$ dissolved in molten bismuth.

In addition to the usual problems associated with metals at high temperatures, there are some unique ones in nuclear metallurgy. One such problem is radiation damage, the failure of a material due to the intense radiation in a reactor. Uranium undergoes embrittlement and drastic changes in dimension as a result of irradiation. Another serious problem which eventually results in a shut-

down of the reactor is the accumulation of fission products in the nuclear fuel. Direct removal of the fission products and economic reprocessing of the fuel constitute a big challenge to the nuclear metallurgist.

*See* NUCLEAR ENGINEERING; *see* also references under "Metallurgy" in the Index. (O. N. C.)

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**METALWORK, DECORATIVE.** Decorative metalwork from the world's great civilizations—ancient Mesopotamia, Egypt, Crete, Greece, Rome, the orient, Europe during the middle ages, the Renaissance and finally post-Renaissance times—is the subject of this article. It is not concerned with sculpture but rather with the many artistic applications of metals in connection with architecture or with objects for ecclesiastical and domestic use. Before the Christian era, seven metals—gold, copper, silver, lead, tin, iron and mercury—were recognized. Important alloys (bronze, brass, electrum, pewter and steel) were also discovered during antiquity. Certain natural forms of metals were well known in prehistoric times, including copper, gold and silver, small nuggets of which, as well as of meteoric iron, were collected and used as beads or amulets. As they could be shaped by cutting, grinding and hammering, they were often fashioned into ornaments and trinkets. The use of gold and native copper marks the beginning of every ancient metal culture. The metals first found by man in their elemental state were soft because they were pure, hence they were used primarily for ornament.

**Metallurgy.**—The art of copper smelting was developed about 4000 B.C. A thousand years later, copper was produced extensively on the island of Cyprus. The Cypriot copper deposits were so great and so highly prized that control of the island was extremely desirable, and it passed successively to the Egyptians, Assyrians, Phoenicians, Greeks, Persians and Romans.

Bronze (*q.v.*), an alloy of copper and tin, is superior to pure copper for casting both simple and complicated works of art, since its melting point is much lower than that of copper. The subject of bronzes is intertwined with the history of art in all periods. The oldest-known piece of bronze is a rod found in the pyramid of Medum, the date of origin being generally accepted as about 3700 B.C. From Mesopotamia and Egypt the use of bronze spread over the Mediterranean area. The Phoenicians obtained tin from both India and Spain long before they visited the more distant shores of Britain and discovered the rich tin mines there. They were the disseminators of much knowledge of metalworking processes.

During the millennium after about 2500 B.C. the art of the founder shows little technical development. The Sumerians made bronze by mixing a copper ore with a tin ore. It was not until about 1500 B.C. that the culminating stage in bronze making was reached—that is, tin ore was reduced, the metallic tin so produced being subsequently melted along with metallic copper. In the manufacture of iron and steel there were few outstanding developments from prehistoric days until about A.D. 1860. (*See* further METALLURGY: *History*.)

**Working Processes.**—Many of the technical processes in use today are essentially the same as those employed in ancient times. The early metalworker was familiar with every process for shaping and ornamenting copper—hammering, embossing, chasing, inlaying, gilding, wire-drawing and the application of niello, enamel and gems.

*Hammering and Casting.*—All decorative metalwork was originally executed with the hammer. Indeed, hammering naturally preceded casting among early peoples. The several parts were hammered out separately and then put together by means of rivets or pinned on a solid core, soldering not having been invented. Plates of hammered copper could be shaped also into statues, the separate pieces being joined together with copper rivets. The famous life-size Egyptian statue of the Pharaoh Pepi I in the Cairo museum is an outstanding example of such work.

After about 2500 B.C. the two standard methods of fabricating metal, hammering and casting, were developed side by side. The lost-wax (or *cire perdue*) process was being employed in Egypt by about 2500 B.C., the Egyptians probably having learned the technique from Sumerian craftsmen (*see* SCULPTURE TECHNIQUES: *Modeling and Casting*). Long after the method of casting statues in molds with cores had superseded the primitive and tedious riveting process, the hammer continued as the main instrument for producing art works in the precious metals. Everything attributable to the Assyrian, the Etruscan and the Greek goldsmith is wrought by the hammer and the punch.

*Embossing.*—Embossing (or *repoussé*) is the art of raising ornament in relief from the reverse side. The design is first drawn on the surface of the metal and the motifs outlined with a tracer which transfers the essential parts of the drawing to the back of the plate. The plate is then embedded face down in an asphalt block and the portions to be raised are hammered down into the yielding asphalt. Next the plate is removed and re-embedded with the face uppermost. The hammering is continued, this time forcing the background of the design into the asphalt. By a series of these processes of hammering and re-embedding, followed finally by chasing, the metal attains its finished appearance. There are three essential types of tools—*i.e.*, for tracing, for bossing and for chasing—as well as a specialized tool, a snarling iron or spring bar, which is used to reach otherwise inaccessible areas. Ornament in relief is also produced by mechanical means. A thin pliable sheet of metal may be pressed into molds, between dies or over stamps. All these methods have been known from antiquity.

*Chasing.*—Chasing is accomplished with hammer and punches on the face of the metal. These punches are so shaped on the face that they are capable of producing any effect, either in intaglio or in relief, that the metalworker may require. The design is traced on the surface and the relief may be obtained by beating down the adjacent areas to form the background. Such chased relief work sometimes simulates embossed work, but in the latter process the design is bossed up from the back. The detailed finish of embossed work is accomplished by chasing; the term is applied also to the touching up and finishing of cast work with hand-held punches.

*Engraving.*—To engrave is to cut or incise a line. Engraving is always done with a cutting tool, generally by pressure from the hand. It detaches material in cutting. When pressure is applied with a hammer the process is called carving.

*Inlaying Processes.*—The system of ornamentation known as damascening was oriental in origin and was much practised by the early goldsmiths of Damascus; hence the name. It is the art of encrusting gold wire (sometimes silver or copper) on the surface of iron, steel or bronze. The surface upon which the pattern is to be traced is finely undercut with a sharp instrument. The gold thread is forced into the minute furrows of the cut surface

by hammering and is securely held.

Niello is the process of inlaying engraved ornamental designs with niello, a silver sulfide or mixture of sulfides. The first authors to write on the preparation of niello and its application to silver were Eraclius and Theophilus in or about the 11th century and Benvenuto Cellini during the 16th. According to each of these authors, niello is made by fusing together silver, copper and lead in certain proportions, and then mixing the molten alloy with sulfur. The black product (a mixture of the sulfides of silver, copper and lead) is powdered, and after the engraved metal, usually silver, has been moistened with a flux, some of the powder is spread on it and the metal strongly heated; the niello melts and runs into the engraved channels. The excess niello is removed by scraping until the filled channels are visible, and finally the surface is polished.

*Gilding and Enameling.*—*See* the articles GILDING; ENAMEL.

## THE ANCIENT WORLD

**Mesopotamia.**—The art of metalworking was developed early. The Sumerians were familiar with the art of embossing, in which the metal is treated as a plastic substance to be shaped into the desired forms in a manner analogous to the modeling of wax or clay, as opposed to the carving of wood or stone, in which portions of the surface are removed. Copper, malleable bronze, silver and gold are the metals usually employed.

In the museum at Baghdad, in the British museum and in the University of Pennsylvania at Philadelphia are finely executed objects in gold and beaten copper from the royal graves at Ur in ancient Sumer. An example of early embossed work is the helmet of Mes-kalam-dug, in the museum at Baghdad, which rivals the gold mask of Tutankhamen, and was made over a thousand years earlier. It was hammered up from a sheet of electrum, its ornamental details being embossed and chased. The workmanship is admirable, reflecting the greatest credit on the goldsmiths of 2600 B.C. Also outstanding is the copper relief that decorated the front of the temple at El 'Ubaid. This remarkable decoration represents an eagle, having a lion's head, holding two stags by their tails. The stags' antlers—also made of wrought copper—were developed in high relief and were soldered into their sockets with lead. This relief illustrates the high level of art and technical skill attained by the Sumerians in the days of the 1st dynasty of Ur (*c.* 2550 B.C.). In the Metropolitan Museum of Art, New York city, is a Sumerian bull's head of copper, probably an ornamental feature on a lyre, which is contemporary with the Ur finds.

The malleability of unalloyed copper, which renders it too soft for weapons, is peculiarly valuable in the formation of vessels of every variety of form, and it has been put to this use in almost every age. Copper domestic vessels were regularly made in Sumer during the 4th millennium B.C., and in Egypt a little later. Bowls and vases were also made of gold, electrum and silver. Small lead tumblerlike vessels have been found in Mesopotamia, but lead was not widely used in the copper period.

The Sumerian metalworkers were followed by the Babylonian, Assyrian, Chaldean and Persian metalworkers. In the Metropolitan Museum of Art is the bronze sword of King Adad-nirari I, a unique example from the palace of one of the early kings of the period (14th–13th century B.C.) during which Assyria first began to play a prominent part in Mesopotamian history. A magnificent example of Assyrian bronze embossed work is to be seen in the gates of Shalmaneser III, erected about 845 B.C. to commemorate that king's campaigns. The gates were made of wood, and the bronze bands, embossed with a wealth of figures in relief, are only about one-sixteenth inch thick. The bands were obviously intended for decoration, not to strengthen the gates against attack.

The Persian bronze industry was also influenced by Mesopotamia. Luristan, near the western border of Persia (Iran), is the source of many bronzes that have been dated from 1500 to 500 B.C. and that include chariot or harness fittings, rein rings, elaborate horse bits and various decorative rings, as well as weapons, personal ornaments and different types of cult objects and a number of household vessels. Many of these objects show a decided originality in the development of the animal style.

**Egypt.**—From whatever source Egypt may have obtained its metalworking processes, Egyptian work at a remote period possesses an excellence that in some respects has never been surpassed. It is not known how long the use of beaten copper preceded casting, or at what time the ancient Egyptians began to cast statues and other objects in bronze. Many bronzes have been found from as early as 2500 B.C. Throughout Egyptian history, the same smiths who worked in the precious metals worked also in copper and bronze. The finest Egyptian jewelry depends for its splendour of effect chiefly on its ingenious and richly coloured ornament, achieved by an inlay of brilliantly coloured stones, jaspers, agates, lapis lazuli, or by glass pastes in still brighter colours.

Nearly every fashionable Egyptian, man or woman, possessed a hand mirror of polished copper, bronze or silver; silver was often added to bronze to obtain a highly reflecting surface. Copper pitchers and basins for hand-washing at meals were placed in the tombs. An unusual example in the Metropolitan Museum of Art is plated with antimony to imitate silver, which was very rare in the Old Kingdom (2780–2242 B.C.). The basins and the bodies of the ewers were hammered from single sheets of copper. The spouts of the ewers were cast in molds and attached to the bodies by means of copper rivets or were simply inserted in place and crimped to the bodies by cold-hammering.

The bronzes that have survived are mainly votive statues placed in the temples from the Saite to the Ptolemaic period (663–30 B.C.), and amuletic bronzes that were buried with the dead. In its simplest form the decoration consisted of lines, representing details of clothing, ornaments and the like, cut in the bronze with engraving tools, sometimes also combined with gilding. A fine example of inlay work of the 22nd dynasty (950–730 B.C.) is a bronze plaque (counterpoise) damascened with gold wire (in the Metropolitan Museum of Art).

The evidence available suggests that in Egypt iron was known as early as copper or bronze. Beads made from meteoric iron, believed to date as early as 4000 B.C., have been found at Gerzeh in Egypt. The oldest Egyptian texts extant, *c.* 3500 B.C., refer to iron, which at this early period was reduced from ores by smelting. Employment of isolated objects made of iron, however, does not constitute a distinct stage of metal culture. The reasons for preferring copper alloys to iron for decorative objects were as strong in ancient times as they are today. Iron was used for humbler objects less likely to be preserved. Early iron objects have long since been oxidized out of existence. Fairly pure wrought iron has no distinct advantage over bronze; it is more malleable but less hard, and the early smiths were unable to cast it. A good bronze when fully work-hardened is considerably superior in hardness to primitive iron. Tools made of hardened iron, however, were in use in both Assyria and Egypt between 800 and 700 B.C. Apart from a dagger with iron blade found in the tomb of the Pharaoh Tutankhamen (*c.* 1350 B.C.), the most ancient iron weapon known to have been found in Egypt dates from the time of Ramses III, about 1200 B.C.

**Crete.**—As early as 3400 B.C. Crete was in communication with Egypt; it is likely that the earliest Cretan copper objects were imported from Egypt. The largest sword of the age comes from the Middle Minoan period (2200–1580 B.C.). The rapier, which with its hilt is one metre long, was found in the palace of Mallia. By improvement in metalworking, the short dagger was ultimately lengthened into a sword, and the Mallia sword is an example of the extraordinary skill of the Cretan metalworker in casting bronze. The hilt of the sword is of gold-plated ivory and crystal. A dagger blade found in the Lasithi plain, dating about 1800 B.C. (in the Metropolitan Museum of Art), is the earliest-known predecessor of the ornamented dagger blades from Mycenae. It is engraved with two spirited scenes: a fight between two bulls, and a man spearing a boar. Somewhat later (*c.* 1400 B.C.) are a series of splendid blades from mainland Greece, which must be attributed to Cretan craftsmen, with ornament in relief, or incised, or inlaid with varicoloured metals, gold, silver and niello. The most elaborate inlays, pictures of men hunting lions and of cats hunting birds, are on daggers from the shaft graves of Mycenae, Nilotic scenes showing Egyptian influence. The bronze was oxidized to a blackish-

brown tint; the gold inlays were hammered in and polished and the details then engraved on them. The gold was in two colours, a deeper red being obtained by an admixture of copper, and there was a sparing use of niello. *See* also CRETE: *Archaeology: Metalwork.*

**Greece.**—The Greeks, who learned much about metalwork from the Egyptians, excelled in hammering, casting, embossing, chasing, engraving, soldering and metal intaglio. Among the ancients, the great emphasis of technology was on aesthetic expression, not on practical utilization. Greek coin dies rank with the finest work of this kind that the world has ever seen. Pottery and bronze hammer- and cast-work were important crafts of ancient Greece. Vases of terra cotta were often designed to resemble those of bronze, and both kinds were widely used in antiquity. Terra cotta is breakable but otherwise practically indestructible, while bronze is subject to corrosion; a Greek bronze vase in good condition is therefore something of a rarity. The body of the vase, which was hammered out of a sheet of malleable bronze, was usually left plain; the handles, feet and overhanging lip, which were cast, were decorated. The applied elements were riveted or soldered. The Greeks were acquainted with both soft soldering, by means of silver or tin, and hard soldering, by means of a copper alloy.

It was in the time of Lysippus, the distinguished sculptor who flourished about 330 B.C., that the fine Greek beaten work for decoration of armour, vases and objects of domestic use reached its perfection. It was executed by a hammer working from behind, the outlines being afterward emphasized by chisel or punch; or metal plate was beaten into a mold formed by carving the subject in intaglio upon a resisting material. Figures in full relief, such as the exquisite tiny cupids so commonly dependent from earrings, were beaten out in two halves and then soldered together. Melted mastic was then run into the interior to strengthen these fragile creations against pressure.

A silver vase from Chertomlyk, now in the Hermitage museum at Leningrad, is Greek work of about 400 B.C. and is the finest example of the work of the Ionian Greek silversmiths. A Greek sword sheath of the end of the 5th century B.C. from south Russia, now in the Metropolitan Museum of Art, is of embossed gold; the design, which represents a contest of Greeks and barbarians, was pressed over a die. The embossed shoulder straps of a cuirass, called the bronzes of Siris, dating from the 4th century B.C., in the British museum, represent the combat between the Greeks and Amazons; they are in exceedingly high relief and are beaten into form with wonderful skill with the hammer.

Greek bronze statuettes—originally dedicatory offerings in shrines, ornamental figures on utensils, or decorative works of art—have survived in large numbers. They were usually cast solid, rarely hollow. Sometimes even large statuettes, like the Metropolitan museum Greek horse, were cast solid. The advantage of solid casting is that the mold can be used repeatedly, while in the hollow-casting process the mold is destroyed. Greek bronzes were originally golden and bright, and they were often decorated with silver or niello for colour contrast. Bronze statuary hardly existed before the introduction of hollow casting, about the middle of the 6th century B.C., after which bronze became the most important medium of monumental sculpture; its strength and lightness admitted poses that could not be reproduced in stone.

The Greeks valued iron chiefly as metal for tools and during the early period did not develop its aesthetic possibilities; but in the remains of the Greco-Roman towns of Pompeii and Herculaneum can be seen wrought-iron window grilles and similar small examples of architectural ironwork.

**Etruria.**—The Etruscans used bronze for cast and beaten work, and, although few large works remain, the museums of Europe display a marvelous variety of admirably formed small bronzes. A masterpiece of bronze Etruscan sculpture is the Chimera from Arezzo, an ex-voto from a sacred building, found in 1553 and partly restored by Cellini (in the Archaeological museum, Florence). Etruscan bronze workers produced, often for export, votive statuettes, vessels, furniture, helmets, swords, lamps, candelabra, mirrors and even chariots. An Etruscan chariot of *c.* 600 B.C. in the Metropolitan Museum of Art has a body and wheels of wood, sheathing of bronze and tires of iron, the high front embossed with archaic figures of considerable grace. The Etruscans inlaid bronze with silver and gold in a manner that proves their skill in this mode of enrichment to equal that of the Greeks and Romans. Many delicately engraved bronze objects were made in the Latin town of Praeneste (mod. Palestrina), which possessed a highly developed bronze-working industry. From Praeneste came a remarkable cylindrical container of the late 4th century B.C., now in the Villa Giulia, Rome; its richly engraved surface provides a good example of the perfection of ancient drawing. *See* also ETRUSCANS: *Art* and *Arts and Crafts.*

**Rome.**—Etruscan cities, like those of Greece, were crowded with bronze statues of gods and heroes, and Rome derived its best adornment from the pillage of Etruria and then of Greece. Distinctly Roman work is hard to trace, as the conquered Greeks worked for their masters, and the Romans copied wholesale from the Greeks. Temple statues were nearly always of bronze, but after about 190 B.C. the metal was chiefly used for architectural decorations and portraiture. The bronze doors of the Pantheon and of the Temple of Romulus in the Forum still occupy their original positions. Two bronze doors in the baptistery of the Lateran are supposed to have been brought from the baths of Caracalla by Pope Hilarius in the 5th century. Also in the Lateran church are four fine gilt-bronze fluted Corinthian columns.

Much Roman small work was exceedingly fine, though it is generally conceded that Roman productions are less aesthetically attractive than those of the Greeks. Pompeii and Herculaneum were essentially Greek towns, and the many beautiful bronzes in the Museo Nazionale, Naples, collected from the ruins of private houses there, are of Greek workmanship. These included statuettes, mirrors and all kinds of bronze work useful in a house. Many of these were originally attached to pieces of furniture.

Roman brooches, or fibulae, primarily intended to serve as a means of attachment, gradually passed into the category of ornaments. They were of two main types, one based upon the principle of the safety pin, the other upon that of a pin sliding on an open ring—the so-called penannular type. From the Romans, the round disk form was introduced to the Teutonic world. It reached its highest development in Celtic Scotland and in Ireland.

Distinguished examples of Roman embossed armour, some of them prepared for gladiators, are preserved in the Museo Nazionale at Naples, which exhibits the finds from Pompeii and Herculaneum (A.D. 79). A remarkable gladiator's helmet is also exhibited in the John Woodman Higgins armoury in Worcester, Mass. Roman embossing may also be seen in the famous visor in the form of a face found at Ribchester in Lancashire and preserved in the British museum. The British museum also has a Roman legionary sword and scabbard (the so-called sword of Tiberius) found at Mainz, Ger.; the upper part of the sheath is covered with a plaque in gilt bronze, representing in embossed work in low relief the emperor seated. A number of remarkable Roman silver treasures are housed in the British museum, including a splendid group of silver tableware that was unearthed near Mildenhall, Suffolk, Eng., in 1942 (*see* MILDENHALL).

During the closing years of the republic, brass, produced by what came later to be known as the calamine (zinc carbonate) method, became an important material for the first time. Its various uses included parade armour, as may be seen in a Roman embossed brass helmet in the Norwich museum, England. Iron was in common use for both practical and artistic purposes. The Romans did not invent any new technical processes, but they played a significant role in introducing advanced methods into less-developed provinces of the empire. *See* also ROMAN ART: *Minor Arts.*

**Barbarian Europe.**—The Celts, like the Romans, were skilful metalworkers and were among the earliest in western Europe to develop the use of enamel decoration on bronze in the champlevé technique. The barbarians who conquered and divided the Roman empire were little versed in the monumental arts and unskilled in figure representation, but in metalworking, in the making of weapons and other utilitarian objects and in the delicate ornament of the goldsmith's art they excelled. The Goths brought elements of Scythian-Sarmatian art into Europe, among them the use of

coloured vitreous pastes fused onto metal in designs incised on its surface. The process was transmitted from the Sarmatians through the Goths to other Germanic peoples.

The Germanic invaders brought with them the animal forms that represent the decorative motifs of Scythian-Sarmatian arts. The Greeks and the Egyptians found their ornamental motifs in botanical forms; the art of the Scythians and later of the Sarmatians is a veritable zoology—their belts and buckles often represented animals entwined in mortal combat. Objects of Scythian-Sarmatian origin have been found, dating from the 2nd century B.C., which resemble objects of the epoch of the barbarian invasions. The belt buckle, an indispensable part of the barbarian warrior's equipment and frequently found in graves, was the object of special care on the part of smiths, who ornamented many buckles with rich and intricate designs in niello and silver.

**British Isles.**—Late in the 6th century A.D., the metalworkers of Kent in England worked the most intricate designs and embellished their pieces with garnets and glass, enamel and niello. They also produced many beautiful examples of cloisonné work. Of slightly later date, in the British museum, is a series of remarkable objects from a cenotaph ship (found at Sutton Hoo in Suffolk) that belonged to a Saxon chieftain of about A.D. 650. Among them are a helmet and shield, both of Swedish origin; a sword belt enriched with jewels; sword belt buckles; and two decorated silver bowls of Byzantine manufacture (*see* SUTTON HOO SHIP BURIAL).

In the 9th and 10th centuries the metalsmiths of Ireland produced brooches and personal ornaments, chalices, covers for books of the Gospels, reliquaries, crosiers and other objects of religious use that were unsurpassed in the rest of Europe. The famous Ardagh chalice in the National museum, Dublin, assigned to about A.D. 900, is a remarkable example of Irish workmanship, unsurpassed by any Byzantine gold or enamel work of the same period. This two-handled chalice is made of silver alloyed with one-third part of copper, the surface being of a low white colour and decorated with bands of pierced, plaited and filigree gold as well as with enamels and pastes. The cup has more kinds of ornament, and each kind more varied, than any other known example of the same period. Forty varieties of gold wirework design have been enumerated, some being the Greek fret with Celtic varieties, others spiral trumpet-shaped lines, interlaced bands, knots and arabesques; all are different. The enamel too is of several varieties. (*See* also ROMANESQUE ART.)

**Byzantine Empire.**—Syria, Egypt and Anatolia were first the teachers and then the rivals of Constantinople (Istanbul). The fusion of antique and eastern elements resulted in the Byzantine style, the great period of which dates from the 9th to the end of the 12th century. The extensive use of embossed work, with filigree, cabochon gems and small plaques of enamel, may be seen in both the east and west during the early middle ages. The most conspicuous examples of large Byzantine metalwork are bronze church doors inlaid with silver. Many objects are still preserved in various European treasuries, which were enriched by the spoils of the sack of Constantinople in A.D. 1204. Venice, in the treasury of St. Mark, has an unrivaled series of Byzantine chalices, bookbindings and other treasures of metalwork, but it is in Kiev, Moscow and Leningrad that broadly representative series of all the categories of Byzantine artistic production may be found.

The art of bronze casting had been preserved in the Byzantine empire. The first bronze doors to be made after the art had died out in Rome were those for Hagia Sophia at Constantinople, which bear the date A.D. 838; the panels, with monograms and other ornament damascened in silver, are framed in borders cast in relief and enriched with bosses and scrolls, the whole in an admirable style. Two sets of doors in St. Mark's, Venice, of Greek workmanship and considerable but uncertain antiquity, are supposed by some to have been removed from St. Mark's at Alexandria. Next in date among surviving doors of Byzantine workmanship is the series ordered by the Pantaleone family (about 1060–80) and destined for cities in southern Italy—Amalfi, Trani, Salerno, Canosa di Puglia and Monte Sant'Angelo.

**The Muslims.**—The most magnificent example of Muslim enamel work in existence is a copper plate in the museum at Innsbruck, Aus., decorated in polychrome enamel with figure subjects, birds and animals within medallions separated by palm trees and dancers (first half of the 12th century). The Mesopotamian, or Mosil, style, which flourished from the early part of the 13th century, is characterized by a predominant use of figures of men and animals and by the lavish use of silver inlay. The most famous example of figured Mosil work in Europe is the so-called baptistery of St. Louis, in the Louvre. This splendid bowl, which belongs in style to the Mosil work of the 13th century, measures five feet in circumference and is covered with figures richly inlaid with silver, so that little of the copper is visible. It is signed by the artist.

## EUROPE FROM THE MIDDLE AGES

**Italy.**—*Damascening.*—The damascened metalwork of Mesopotamia, Syria and Egypt had long been familiar to the parts of Europe that were in touch with the east and seems to have been especially appreciated in Venice; a 14th-century candlestick in the British museum, apparently of Syrian manufacture, bears the arms of the Venetian family of Boldù. The Greco-Italian and Italian metalworkers soon set themselves to imitate the Saracenic style and technique. An admirable plate of copper in the Kunstgewerbemuseum at Vienna, damascened with an oriental interlaced pattern, is signed "Nicolo Rugina Greco da Corfu, fecce 1550." From Venice the practice of damascening passed to all the chief metalworking cities of Italy. A precious 16th-century steel gold-damascened casket in the Trivulzio collection in Milan is a signed work of Paolo Rizzo, the most celebrated damascener of Venice. Giorgio Ghisi of Mantua, etcher, damascener and goldsmith, has left his signature on a richly embossed and damascened shield in the British museum. And Benvenuto Cellini, in his autobiography, tells of improving upon the Turkish method.

*Bronze.*—From the decadence of the Roman empire Italy produced practically no decorative bronze until the 12th century, by which time Italian craftsmen had developed a style of their own, as may be seen in the bronze doors of S. Zeno, Verona (1171), made of hammered rather than cast bronze. Bonanno of Pisa, architect and sculptor, was the artist of the doors of the Pisa cathedral and of the famous west doors at Monreale (1186). These, with some other ancient doors—including those made by the bronze founder Barisanus of Trani, who was responsible for the doors of notable churches at Trani (1175), Ravello (1179) and Monreale (1186)—and the great candlestick in the Milan cathedral (*see* CANDLESTICK: Middle Ages) are landmarks in the history of bronze sculpture up to the 13th century. In contrast to the Byzantine niello-decorated doors, the Italian doors are in relief. Their subjects are taken from the Old and New Testaments or, more rarely, from the lives of saints.

Italian bronze work of the Renaissance has never been equaled. Andrea Pisano's south doors of the baptistery at Florence led to the formation of a Florentine school of sculptors in bronze that continued to flourish for three centuries. The baptistery has three pairs of magnificent bronze doors. The oldest (south) are the work (1330–36) of Andrea; the north doors are the first (1403–24) of the two assigned to Lorenzo Ghiberti following the famous competition of 1402 in which Filippo Brunelleschi and Jacopo della Quercia also took part. The east doors (1425–52), the "Gate of Paradise," Ghiberti's masterpiece, are divided into ten framed squares in which episodes of the Old Testament are represented.

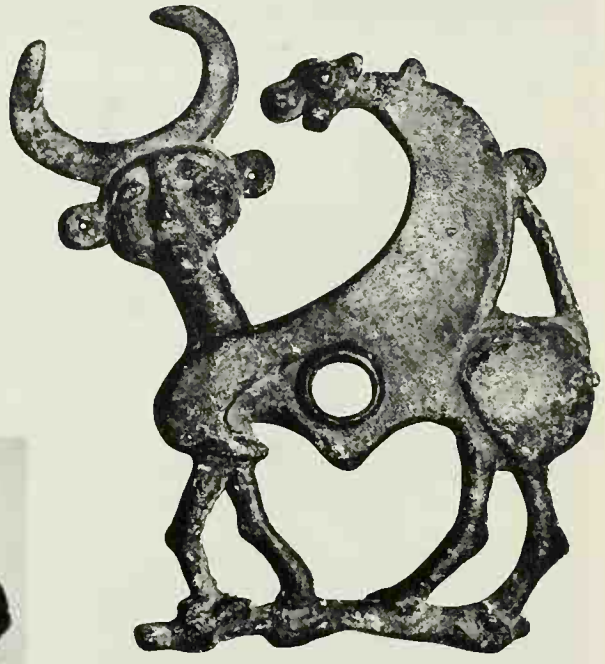
The metalsmiths' shops were schools for many of the great artists of the Renaissance—Brunelleschi, Verrocchio, Ghiberti, Pollaiuolo and Luca della Robbia all were trained as metalsmiths before they embarked upon the higher arts. The metalsmith made silver vases for the dinner tables of cardinals; knights sent sword blades to be mounted in rich hilts; ladies went to have their jewels set; princes needed medals to commemorate their victories; popes and bishops wished to place chased reliquaries on the altars of their patron saints; and men of fashion ordered medallions to wear upon their hats.

Great works in bronze were created by the most distinguished Renaissance artists. Donatello's equestrian statue of Gattamelata at Padua (1453) was one of the first great bronzes cast in the Italian Renaissance. The Venetian sculptor and architect Ales-

Egyptian dagger with iron blade from the tomb of Pharaoh Tutankhamen; *c.* 1350 B.C. Ashmolean museum, Oxford

Egyptian copper ewer plated with antimony to imitate silver; Late Old Kingdom (*c.* 2500–2200 B.C.). The Metropolitan Museum of Art, New York city

Embossed electrum helmet of Mes-kalam-dug from a royal grave at Ur in ancient Sumer; *c.* 2600 B.C. Baghdad museum



Bronze horse-bit plate from Luristan (Iran); about 1200 B.C. Denver Art museum

Iron dagger blade with engraved design showing a man spearing a boar, found in the Lasithi plain, Crete; Middle Minoan III, 1750–1580 B.C. The Metropolitan Museum of Art

Greek sword sheath of embossed gold with relief decoration representing a contest of Greeks and barbarians, from south Russia; end of the 5th century B.C. The Metropolitan Museum of Art

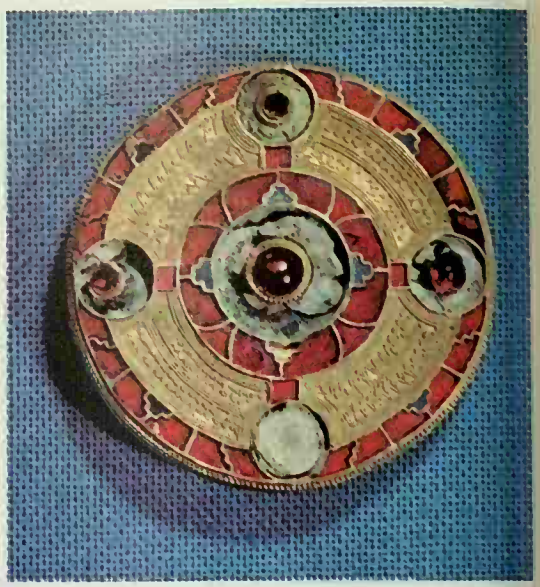
Embossed shoulder straps of a cuirass, one of a pair called the bronzes of Siris; Greek, 4th century B.C. The British museum

## METALWORK FROM THE ANCIENT WORLD

BY COURTESY OF (TOP LEFT) ASHMOLEAN MUSEUM, OXFORD, (TOP CENTRE, CENTRE LEFT, BOTTOM LEFT) THE METROPOLITAN MUSEUM OF ART, (TOP CENTRE) GIFT OF EDWARD S. HARKNESS, 1926 (CENTRE LEFT) BEQUEST OF RICHARD B. SEAGER, 1926, (BOTTOM LEFT) ROGERS FUND, 1930, (TOP RIGHT) UNIVERSITY MUSEUM, PHILADELPHIA, (CENTRE RIGHT) THE DENVER ART MUSEUM, (BOTTOM RIGHT) THE TRUSTEES OF THE BRITISH MUSEUM, PHOTOGRAPH, (BOTTOM RIGHT) J. FREEMAN & CO.

# METALWORK, DECORATIVE

Etruscan bronze incense burner in the form of a two-headed bird with four legs mounted on wheels; so-called Villanovan period, 10th–8th century B.C. The Villa Giulia, Rome



Jeweled brooch found in Jutish grave in Kent, England; 6th–7t century A.D. The British museum

Sabaean bronze bull; from South Arabia, 6th century B.C. The Metropolitan Museum of Art

Gold vase from the Marlik cemetery mound near Rudbar in northern Iran. Decoration is in high relief with double register of long-legged unicorns. *C.* 1000 B.C. Archaeological museum, Tehran

Greek gold earring with cupid dependent in full relief, from Cyme in Aeolis, Asia Minor; 4th–3rd century B.C. The British museum

Copper head of a lion from the temple of the Sumerian goddess Ninhursaga, El Ubaid near Ur. The British museum. 2400–2300 B.C.

Bronze sword of King Adad-nirari I of Assyria; reigned 1308–1275 B.C. The Metropolitan Museum of Art

## ANCIENT METALWORK

BY COURTESY OF (TOP RIGHT, BOTTOM LEFT, CENTRE) THE TRUSTEES OF THE BRITISH MUSEUM, (CENTRE LEFT, BOTTOM RIGHT) THE METROPOLITAN MUSEUM OF ART, (CENTRE LEFT) ROGERS FUND, 1941, (BOTTOM RIGHT) GIFT OF J. PIERPONT MORGAN, 1911. PHOTOGRAPHS: (TOP LEFT) DAVID LEES, (CENTRE RIGHT) PROFESSOR EZAT NAGHDAN

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART, NEW YORK

## GREEK BRONZE

The statuette, 15 13/16 in. in height and 14¼ in. in length, is believed to have been made about 470 B.C. Although there is uncertainty about the identity of the artist, the beauty and grace of the conception of the design point to the possible workmanship of Calamis, a well-known Athenian sculptor. Indeed, there is considerable basis for the conjecture that this statuette is part of a miniature model of the charioteer group which Calamis was commissioned to execute for Hieron, tyrant of Syracuse, or his son Deinomenes. The tail, parts of the legs and one ear, and the eyes, which may have been inlaid, are missing. It is cast solid, weighing 25½ lb.

# METALWORK, DECORATIVE

Etruscan bronze folding mirror engraved with figures representing Ganymede and the eagle. From Praeneste; 200 B.C. The British museum

Purse lid framed in gold and decorated with garnets and enamels (white pasteboard setting replaces original bone or ivory). From the Saxon cenotaph ship found at Sutton Hoo, Suffolk, England: c. A.D. 650. The British museum

Roman scabbard decorated with gilt bronze, the sheath for the so-called sword of Tiberius found at Mainz, Germany; 1st century A.D. The British museum

Muslim Mosil work, the so-called baptistery of St. Louis, style of the 13th century. The bowl, five feet in circumference, is covered inside and out with bands of figures inlaid with silver. The Louvre, Paris

Roman visor of embossed bronze found at Ribchester, England; c. A.D. 100. The British museum

Etruscan chariot made of wood with embossed bronze sheathing and iron tires; c. 600 B.C. Found in a tomb near Monteleone, Italy. The Metropolitan Museum of Art

Chalice from the treasury of St. Mark, Venice, an example of Byzantine metalwork of the 10th or 11th century A.D.

## ANCIENT AND MEDIEVAL METALWORK

BY COURTESY OF (TOP LEFT, TOP CENTRE, TOP RIGHT, CENTRE RIGHT) THE TRUSTEES OF THE BRITISH MUSEUM; (BOTTOM LEFT) THE METROPOLITAN MUSEUM OF ART, ROGERS FUND, 1903; PHOTOGRAPHS (TOP RIGHT) J. FREEMAN & CO., (CENTRE LEFT) ARCHIVES PHOTOGRAPHIQUES, (BOTTOM RIGHT) ALINARI

St. John the Baptist Baptizing the Multitude" and "St. John Baptizing Jesus Christ," bronze uatrefoil panels from the south doors of the baptistery of S. Giovanni, Florence, Italy, executed 330–36 by Andrea Pisano (*c.* 1290–*c.* 1347)

"The Story of Abraham," bronze relief from the east doors, the "Gate of Paradise," of the baptistery of S. Giovanni, Florence, Italy, executed 1425–52 by Lorenzo Ghiberti (1378–1455)

ion head with door ring on one of the Romanesque bronze doors of the Aachen athedral, Germany; *c.* 790–805

Bronze sanctuary knocker on the north door of the nave of Durham cathedral, England; first half of the 12th century

Relief panel from the bronze door of the cathedral of Hildesheim, Germany, regarded as the work f St. Bernward, with sculptural figures depicting Old Testament scenes; dated 1015

Detail from the bronze doors of the south side of the cathedral at Pisa, Italy, by Bonanno of Pisa; 1180

EUROPEAN BRONZE METALWORK, 8TH–15TH CENTURIES

PHOTOGRAPHS, (TOP LEFT AND RIGHT) ALINARI, (CENTRE LEFT) ANN BRECOL LEPPER, (CENTRE) JOHN R. ED S, (BOTTOM LEFT) BILDARCHIV FOTO MARBURG, (BOTTOM RIGHT) ANDERSON

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PHOTOGRAPHS, (TOP LEFT AND RIGHT) ALINARI, (CENTRE LEFT) ANN BREDOL-LEPPER, (CENTRE) JOHN R. EDIS, (BOTTOM LEFT) BILDARCHIV FOTO MARBURG, (BOTTOM RIGHT) ANDERSON

# METALWORK, DECORATIVE

Detail of grillwork around the tomb of Can Signorio Della Scala, Verona, Italy, composed of quatrefoils containing a small ladder (*scala*); 14th century

Detail of the wrought-iron *reja* (screen) in the cathedral of Pamplona, Spain; 13th century

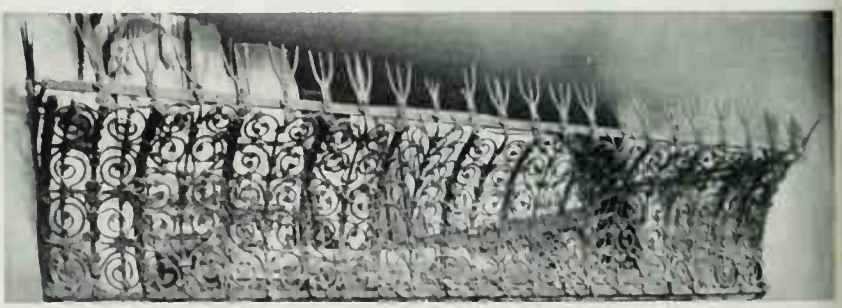
Detail of railing around cenotaph of Emperor Maximilian I, Hofkirche, Innsbruck, Aus.; designed by P. Trabel in 1568, completed 1573 by J. Schmidhammer

Section of the grille in St. Ulrich's church, Augsburg, Germany; 1470

Detail of the quatrefoil grille in the cathedral of Orvieto, Italy, signed "Conte Lelli de Senis me facit. Ann. 1337"

Detail of the so-called St. Swithun grille in Winchester cathedral, England; probably dating from the 11th century

Window *reja* of the Casa de Pilatos in Seville, Spain; mid-16th century



Screen of stamped ironwork in Westminster abbey, London, by Thomas de Leghtone; end of the 13th century

Detail of the stamped ironwork on the left door of the main façade of the cathedral of Notre Dame, Paris; 13th century

## EUROPEAN IRONWORK, 11TH–16TH CENTURIES

BY COURTESY OF (TOP ROW CENTRE RIGHT) SCHLOSSVERWALTUNG ZU INNSBRUCK; (2ND ROW ANDRAS, PHOTOGRAPH; TOP LEFT, SECOND ROW LEFT, ALINARI; (TOP CENTRE LEFT, BOTTOM LEFT) DOMINGUEZ RAMOS, MADRID; (TOP RIGHT) TONI SCHNEIDERS; (SECOND ROW CENTRE) WAYNE ANDREWS; (THIRD ROW RIGHT) J. FREEMAN AND CO. LTD.; (BOTTOM ROW RIGHT) ARCHIVES PHOTOGRAPHIQUES

sandro Leopardi cast in 1488 the bronze equestrian statue of Colleoni, left unfinished at Verrocchio's death and, in the early years of the 16th century, completed the three admirable sockets for flagstaffs that still adorn the piazza of St. Mark's. Many smaller objects of bronze also have survived. Among ecclesiastical items may be mentioned crucifixes, shrines, altar and paschal candlesticks (such as the elaborate examples at the Certosa di Pavia); for domestic use, mortars, inkstands, candlesticks and a large number of splendid door knockers and handles were executed with consummate skill. Works of this kind continued to be made throughout the 17th and 18th centuries.

*Iron.*—During the 13th and 14th centuries wrought iron came into general use for screens for chapels and tombs, and for window grilles. One of the most interesting examples of early ironwork, at Perugia, is a grille formed of framework enclosing sheet-iron panels pierced with dragons and crowned A's inscribed "Gull. Rufinelli me fecit, 1338." The quatrefoil is found in Italian grilles in great variety all through the 14th and 15th centuries and continued to be used in the 16th century also. The grillwork around the tombs of the Della Scala family at Verona is composed of a network of quatrefoils, each filled up with a small ladder (*scala*). A number of quatrefoil grilles are dated—that in the cathedral of Orvieto is signed "Conte Lelli de Senis me fecit. Ann. 1337"; that in Sta. Croce, Florence, is dated 1371.

Notable centres of artistic ironwork were Florence, Siena, Vicenza, Venice, Lucca and Rome, where important pieces may be found in the form of gates, balconies, screens, fanlights, well covers and a mass of objects for domestic use such as bowl stands, brackets and candlesticks. One of the principal masters of ironwork was Niccolò Grosso of Florence, under the patronage of Lorenzo de' Medici, who produced lanterns, cressets, banner holders and horse rings, all of the most artistic designs. Four lanterns executed by Grosso for the Strozzi palace at Florence and set up in 1500 cost 100 florins each for workmanship alone. Another artist in iron was Giacomo Cozzarelli of Siena (flourished at close of the 15th century), who designed superb lanterns and torch holders.

During the 16th and 17th centuries Venice became especially famous as a centre for ironwork, and railings and gates were sent from Venetian workshops to north Italian palaces. The decadence of 17th- and 18th-century ironwork throughout Italy paralleled that of architecture. The metal was thin and the resulting construction flimsy. Conventional or naturalistic flowers were tacked on apparently as afterthoughts. Ribbonlike bands rather than rods and bars were used, with cast ornaments pinned on. The best examples of this period are confined to Venice and northern Italy. (*See* also IRONWORK.)

*Embossing.*—The art of embossing was highly developed in the 16th century by the Italians, who even went beyond the ancients and applied it to steel; embossed parade helmets, shields and body armour of almost unbelievable excellence are to be seen in the European national armouries. At that time a close relationship existed between painter, sculptor, goldsmith and armourer. Indeed, many of the most skilful artists distinguished themselves in all these capacities; this is natural, since the skill required to emboss and chase armour in steel is but an extension of the sculptural ability needed to carve a statue. One of the greatest masterpieces of Renaissance metalwork, part of the J. Pierpont Morgan collection in the Metropolitan Museum of Art, is the embossed helmet made in 1543 for Francis I of France and signed by Filippo Negroli of Milan. It is modeled in graceful lines and lavishly embossed with coiling tendrils and foliation, with a central flower from which a cupid half emerges. The crest is fashioned as a supine female figure arising from acanthus leaves, her hands grasping the tresses of a Gorgon's head. The boldness of the embossing and the beautiful bronze-black patina give the helmet the appearance of having been cast.

**Germany.**—*Bronze.*—A magnificent series of sculpture in bronze from the entire span of the medieval period may be seen in Germany. Under Charlemagne the art of metalworking was given considerable stimulus. The bronze-mounted weapons that came into his hands as spoils of war provided metal enough that he was able to lavish bronze on his new church at Aachen without needing to draw supplies from abroad. The earliest Romanesque bronze doors, to be found at the minster of Aachen, were cast there under Charlemagne, possibly by Byzantine artist-monks. There are one large and three small doors, bearing as their sole decoration beads for framing the fields, and lion heads with door rings.

Three important works of medieval bronze have been preserved from the cathedral of Hildesheim, which was destroyed in World War II. They are the two wings of the bronze door, the triumphal column and the bronze font. The first two are regarded as the works of St. Bernward, once bishop of Hildesheim, whose name and the date 1015 appear in a broad band of script on the door. Each wing of the door is cast all in one piece, an achievement requiring exceptional skill. The surfaces are ornamented with sculptural figures depicting Old Testament scenes. On the triumphal column, rising from the bottom, are presented 28 scenes from the life of Christ. The remarkable 13th-century font was made for Hildesheim cathedral at the charge of Wilbernus, one of the canons.

Great doors were also made for Mainz cathedral shortly after the year 1000, and for Augsburg sometime between 1060 and 1065. The doors of Gniezno (Gnesen) and Novgorod cathedrals were made about 1150, probably at Magdeburg.

Smaller articles of bronze were manufactured in many places in Germany throughout the middle ages. For example, the lion-headed knockers of the west doors of the cathedral of Trier, which may date from the 11th century, bear the names of John and Nicholas of Bingen; and on the 13th-century font of Würzburg cathedral is the name of Master Eckard of Worms.

The end of the Gothic period in Germany found the great craftsman Peter Vischer of Nürnberg and his sons working on the bronze shrine to contain the reliquary of St. Sebald; this finely conceived monument of architectural form, with rich details of ornament and figures, was completed and set up in 1516. The great monument that closes the series of medieval bronze sculpture is the incomplete cenotaph of the emperor Maximilian I in the Court church of Innsbruck, Aus. Its remarkable feature is a series of 28 colossal bronze figures arranged in two rows on each side of the church, representing ancient heroes supposed to be connected by kinship with the house of Austria; they were cast between 1513 and 1533.

*Iron.*—Germany is the only country in which the ironsmiths' art remained important without a break from medieval times down to the 18th century. By the end of the 13th century pointed architecture was established, and the new style demanded the use of decorative ironwork. The designs introduced were those associated with the grandest expressions of Gothic ironwork in France. The Germans, however, did not acquire the secret of stamped work—that is, striking the hot iron into prepared dies as wax is pressed into a seal—as practised in England and France. Throughout the Gothic period imitations of natural foliage provided the basis of design.

During the 15th and 16th centuries ironwork was extensively produced at Augsburg, a notable example being the grille in St. Ulrich's church (1470) there. Its tracery, of the flamboyant order, is light and brilliant in the extreme, and the methods of construction, such as welding and collaring, are employed with great skill. Another noteworthy example in the same church is the screen to the Fugger chapel (1588), whose numerous fleurs-de-lis and prickets for candles are distinctive.

During the Renaissance, ironwork in Germany was in use everywhere and for many purposes. Smiths were their own designers, and so far as manipulative excellence went, they were highly skilful. Iron bars, circular in section, were most frequently used, and the commonest features are interlacing bars, terminations of flowers with petals and twisted centres, foliage or human heads. The Germans surpassed all in their fantastically twisted and threaded window grilles, which are marvels of forging. The style may be studied in many German cities—Augsburg, Nürnberg, Frankfurt am Main, Salzburg and Munich—and in Austria at Innsbruck. The railings round the cenotaph of the emperor Maximilian I in the Hofkirche at Innsbruck suggest a fabric of lace; they were designed by the painter Paul Trabel in 1568 and completed in 1573 by Jorg Schmidhammer. Changes in style were very

minor until the revolutionary baroque arrived and was embraced by the Germans with far less restraint than by the French. In German work the leaf designs are highly exaggerated and, rich as are the compositions, they are often crushing in their fantastic elaboration.

**The Low Countries.**—*Copper, Brass and Bronze.*—In Europe the use of brass for artistic purposes centred largely in the region of the Meuse valley in southeast Belgium, together with northeastern France, parts of Holland and the Rhenish provinces of which Cologne was the centre. As early as the 11th century the inhabitants of the towns of Huy and Dinant are found working in this metal. The word *dinanderie*, derived from the name of the town of Dinant, was used for all copper work as well as brass or bronze (whether beaten or embossed) that was employed mainly for domestic purposes; it was also applied to work prepared by casting and engraving, and sometimes by enameling, which was more usually devoted to objects for ecclesiastical use. Among the earliest examples of *dinanderie* are the font of St. Bartholomew in Liège and the censer of Lille, both of which are ascribed to Renier de Huy, at the beginning of the 12th century. From that time the art of making objects in copper, brass and bronze reached a high level of popularity and quality.

The *dinanderie* of the Low Countries was freely exported to France, Spain, Germany and England. In London the Dinant merchants, encouraged by Edward III, established in 1329 a hall that existed until the end of the 16th century. In 1466, when Dinant was sacked and destroyed by Charles the Bold, the brass founders fled to Huy, Namur, Middleburg, Tournai and Bruges, where their work was continued. The containers for water known as aquaemanales were cast from the 12th to the 15th centuries in the form of equestrian figures: lions, dragons, birds, griffins and other animals; remarkable examples may be seen in the principal medieval collections.

*Iron.*—The Belgian ironsmiths' thorough knowledge of the art is exemplified in the beautifully molded constructive ironwork in the spires of Bruges, Ghent and Antwerp. The most notable examples of 13th-century hinge work in Belgium are to be found in Liège on the treasury door of the Cathedral of St. Paul and on some presses in the Church of St. James. The former appear to be based on the same lines as the great hinges of Notre Dame in Paris, but there is no attempt to emulate their intricacy or richness of detail.

The stamped early-15th-century hinges of Hal compare favourably with any other European work of this period. The world-renowned well cover against the cathedral at Antwerp, dated 1470, is considered to be the work of José Massys, architect, clockmaker and chief smith to the municipality of Louvain. The churches of Belgium have been less systematically looted than those of England and France and still contain a great deal of their medieval furniture, which includes most of the finest specimens of ironwork in the country—font cranes of the 15th to the 17th centuries, so conspicuous in many Belgian baptisteries; stands for tapers; hanging lamps, book rests and candelabra.

**France.**—*Copper, Brass and Bronze.*—In dealing with medieval French metalwork, difficulties are posed by the enormous destruction that took place at different periods. The monumental effigies and tombs in bronze that abound in other countries, particularly from the close of the middle ages, have been almost entirely destroyed in France. Although the museums, such as those of the Louvre and the Hôtel Cluny, as well as some of the cathedral treasuries, such as Reims and Sens, preserve a considerable number of the small and more precious pieces of bronze, the larger pieces, such as doors, lecterns, fonts, candlesticks and tombs, which are so numerous in Germany and the Netherlands, have almost entirely disappeared.

By the 13th century the Limoges workshops, with copper available near the city, attained the proportions of an industry, and Limoges metalwork, for both secular and religious use, was to be found all over Europe in the middle ages. In addition to reliquaries, candlesticks, crosiers and book covers, many pieces of metalwork for the furniture of halls and chambers were exported from Limoges, and even monumental effigies such as that of Aymer de Valence in Westminster abbey. The commoner kinds of jewels, such as buckles, brooches or morses, for the belts of knights or the vestments of ecclesiastics too poor to afford to buy silver or gold, were made in enameled bronze. The guilds of Limoges were probably far more active in this kind of secular manufacture than those of Cologne, whose work seems to have been devoted to shrines, reliquaries, candlesticks, monster-shaped ewers, etc., for religious purposes. Copper and bronze depended much for their effect upon gilding, which was commonly applied to reliquaries, retables, crosses and crosiers, and to the metal divisions of the enamels. Limoges was the centre of the art of metalworking in France up to the 15th century; this status was revived indirectly in the 16th by the specialty of enameling upon metal that was brought to perfection under Léonard Limosin.

A great outburst of artistic energy is seen from the beginning of the 17th century, when works in ormolu or gilt bronze were produced in huge quantities. The craftsmanship is magnificent and of the highest quality, the designs at first refined and symmetrical but later, under the influence of the rococo style, aiming only at gorgeous magnificence. In their own sumptuous setting these fine candelabra, sconces, vases, clocks and rich mountings of furniture are entirely harmonious. The *ciseleur* and the *fondeur*, such as Pierre Gouthière and Jacques Caffiéri, associated themselves with the makers of fine furniture and of delicate Sèvres porcelain, the result being extreme richness and handsome effect.

*Iron.*—Ironwork attained a high degree of excellence in France by the 12th century. In the medieval period the smith necessarily worked quickly, and his masterpieces reflect the virility of skill applied spontaneously. The extensive use of dies to produce stamped work was first made in France early in the 13th century. French stamped work, which is in some examples richer and fuller than the English examples, is perhaps too extensive to have been produced by any one smith and his assistants. The best examples remaining are at Rouen, Noyon, Sens, Braisne, Vézelay, Mantes-Gassicourt and St. Denis, culminating in the well-known doors of Notre Dame, Paris. They are mostly within the royal domain or in churches designed by architects of the royal domain.

A statute of 1392 made it obligatory for an aspiring metalworker to submit a masterpiece before he could practise in Paris, and even in the 13th century the novice was given a verbal test concerning his craft. The required masterpiece often took a year or more to make. With such training the metalsmith was a master, and creating works of art was part of his everyday life. From the 15th century small ironwork required less and less use of the forge, for the art of the blacksmith gradually merged with the arts of the armourer and locksmith. These were versatile craftsmen who worked the cold metal into shape, sawed it, filed it, chiseled it, carved it even out of the solid.

Iron has been used for a greater diversity of objects than has any other metal, and small iron objects for personal use were esteemed as highly as similar objects made of precious metals. The ironworker produced a bewildering variety of small objects—locks, keys, hinges, knockers, caskets, candlesticks, bag frames, corkscrews, tools, etc.—many of which are excellent examples of sculpture in metal. The French Revolution was the cause of much splendid ironwork being destroyed, when in 1793 certain provinces had to gather together every available piece of iron to transform into weapons. Nevertheless, the Musée de Ferronnerie le Secq des Tournelles in Rouen houses 12,000 items of ironwork dating from Roman times to the mid-19th century.

**England.**—*Bronze.*—Casting in bronze reached high perfection in England during the middle ages. Sanctuary rings or knockers exist at Norwich and elsewhere; the most remarkable is that on the north door of the nave of Durham cathedral, from the first half of the 12th century. The Gloucester candlestick, in the Victoria and Albert museum, displays the power and imagination of the designer as well as an extraordinary manipulative skill on the part of the founder. According to its inscription, this candlestick, which stands about two feet high and is cast in bell metal and gilded, was made for Abbot Peter (the cathedral was originally an abbey church), who ruled early in the 12th century. While the outline

is carefully preserved, the ornament consists of a mass of figures of monsters, birds and men, mixed and intertwined to the verge of confusion. As a piece of casting it is a triumph of technique.

There remain in England ten effigies cast in bronze over a period of two centuries (1290–1518), among them some of the finest examples of figure work and metal casting to be found in Europe. In several instances particulars for the contracts of the tombs survive together with the names of the artists who designed and made them. The earliest examples are the effigies of Queen Eleanor, wife of Edward I (1290), and that of Henry III (1292), both in Westminster abbey. They are the work of William Torel, goldsmith of London, and it is evident that they are the first English attempt to produce large figures in metal. Torel cast his large figures by the same process (lost-wax) that he had employed for small shrines and images.

*Monumental Brasses.*—Monumental brasses were exceedingly numerous in England, where some 4,000 still exist. From the 13th through the 16th centuries, in France, northern Germany, Belgium and particularly England, it became the vogue to let into the stone slab covering a floor tomb a brass plate engraved with the figure of the deceased. The art began in Flanders and Germany, and many of the English brasses were of foreign origin; in some cases brass sheets were imported and engraved by English artists. The manufacture of unornamented brass plates centred chiefly at Cologne. The oldest English brass in existence is that of Sir John D'Abernon (d. 1277) at Stoke d'Abernon, Surrey. Traces can still be seen in many brasses of the colours that originally enlivened them.

*Iron.*—English ironworkers also developed a high level of skill by the 11th century. Throughout England, medieval church doors are found with massive iron hinges, the bands worked in rich ornamental designs of scrollwork, varying from the plain hinge band with crescent to the most elaborate filling of the door. The next important application of ironwork came with the erection of the great cathedrals and churches, whose treasures required protection. The grille known as the St. Swithun grille in Winchester cathedral, the earliest example of this class of ironwork, was probably made during the last years of the 11th century. The fully developed stamped iron in England, so familiar from examples at Lichfield, Chester, York, New Windsor, Oxford and Westminster, seems to be the work of a single smith, Thomas de Leghtone, and belongs to the end of the 13th century.

**Spain.**—Medieval Spain, with its larger Muslim population, was in close touch with oriental art. A rich effect was produced by the Moorish bronze-covered doors of Toledo (1337), Córdoba (1377) and Seville. Iron was the favourite of the Spanish metal craftsman, although there are outstanding works in bronze. Francisco de Villalpando, who won the competition for the *capilla moyor* grille of the Toledo cathedral (1540–48), executed it partly in bronze. He also made the gilt bronze pulpits, the bronze doors with admirable bas-reliefs of the Puerta de los Leones (1545–50), and the font, and the rail to the altar of the Virgin in the *coro* (1551–64) at Toledo, and the choir screens in the cathedral of his native town, Palencia. Other noteworthy examples of Spanish decorative bronze work are: the pulpits on both sides of the high altar at Santiago, with gilt reliefs by Juan Celma (1563); and the main pillars of the *coro* and one of three reading desks (called *el Aguila*, from the bronze eagle with outstretched wings), the latter by Vicente Salinas (1646), both in Toledo cathedral.

Catalan ironworkers achieved great fame. It was in northern Catalonia that the best type of early forge for smelting iron was evolved. This was the Catalan forge, which yielded an excellent malleable iron and made possible the great quantity of beautiful medieval ironwork. The earliest Spanish grilles are those in the cathedrals of Palencia and Pamplona, from the 13th century. The cathedral of Barcelona, which possessed a guild of ironworkers from the 13th century, has an extensive series of typically Spanish *rejas* (screens) of the 15th century.

The Spanish ironworker, recognizing that the inherent quality of iron, strength, was best expressed on a grand scale, created the monumental screens (*rejas*) that give Spain a unique position in the field of artistic ironwork. They may be seen in all the large cathedrals of Spain, and one of them, a remarkable wrought-iron *reja* from the central nave of the cathedral of Valladolid, executed in 1668, is installed in the Metropolitan Museum of Art.

Numerous smaller ironwork items are found throughout Spain. One interesting development was the growth in size and ornamentation of nailheads, which ultimately outgrew their original utilitarian function and became primarily ornamental on doors.

Burgos cathedral contains, besides its many notable *rejas*, another marvel of the ironworker's art, the golden stairway, with a marvelous gilded wrought-iron balustrade, designed by Diego de Siloe in 1519. The gilded iron pulpits in Ávila cathedral, dating about 1520, include panels hammered in relief with figures of apostles and arabesques. Pulpits of wrought iron are by no means uncommon; they are also found at Burgos, Santiago, Seville, Toledo and elsewhere, usually in pairs, one for the reading of the Epistles, the other for the Gospels, in close proximity to the *reja*. The small grilles for gates and windows have characteristics of the more monumental church works. One of the best-known window *rejas* in all Spain is in the Casa de Pilatos in Seville. It dates from the mid-16th century and is considered to be the work of one of the master *rejeros* employed in the cathedral of the same city. Of small iron objects belonging to the medieval period not many have survived. The richest collection is that of the Episcopal museum of Vich, in northern Catalonia. The Hispanic Society of America as well as the Metropolitan Museum of Art possesses many objects from which the skill of the Spanish smith may be studied.

*See* CHINESE BRONZE; JEWELRY; ORMOLU; SILVER AND GOLD WORK; *see* also references under "Metalwork, Decorative" in the Index.

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**METALWORKING PROCESSES** include all methods for changing the size, shape, or physical properties of a piece of metal. The types of machines used for various methods are discussed in the article MACHINE TOOLS and are quite varied depending upon the form being produced. However, the mechanism of cutting metal is essentially identical, whether the operation is turning on a lathe (*q.v.*), drilling, milling, grinding, etc. Also, the mechanisms of deformation are similar in rolling, drawing, or forging of metals. There are a number of relatively newer operations which do not fit in the general categories of cutting or deforming; these are discussed below as unconventional processes.

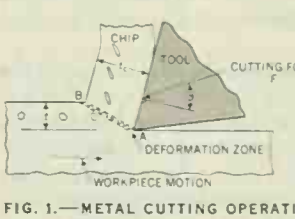


FIG. 1.—METAL CUTTING OPERATION

**Cutting.**—The mechanism of metal cutting is shown schematically in fig. 1. The process is typified by a curling chip whose thickness $t_c$ is much greater than the thickness $t$ of the layer that is removed. This thickening and foreshortening of the chip is the result of very substantial plastic deformation within the zone A-B as the chip is formed. Elements which are shown as circular in the virgin metal become elipses in the deformed chip. For typical engineering materials, such as steel, a great amount of energy is required to produce this deformation and to cause simultaneous

sliding between the chip and tool. As a crude approximation, one horsepower is required to remove mild steel at the rate of one cubic inch per minute. The direction of the cutting force $F$ is determined by the tool geometry and the friction angle $\beta$ (coefficient of friction = tan $\beta$). The magnitude of $F$ depends upon the size of cut (depth $t$ and width $b$ [in inches] perpendicular to the paper) and the stress $\sigma$ required to produce plastic deformation. If $\sigma$ is the stress (pounds per square inch) required to produce plastic flow in a tensile test, then the horizontal component of force $F_H$ is roughly approximated by

$$F_H \approx 3\sigma\, bt$$

where $3\sigma$ is equal to the energy (inch-pounds) required to remove one cubic inch of metal. Approximately two-thirds of the energy is associated with the deformation process, while the remaining

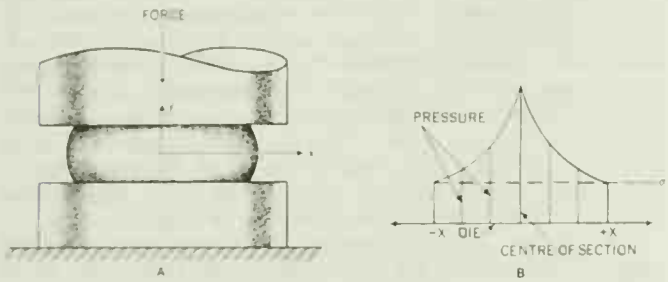



FIG. 2.—(A) SCHEMATIC VIEW OF OPEN FORGING OPERATION (Y AND X INDICATE DIRECTIONS OF STRESS). (B) DIE-WORK PRESSURE DISTRIBUTION

third is required to overcome chip-tool friction. In cutting processes, the friction is extraordinarily high due to the extreme cleanliness of the chip surface which an instant earlier had been within the virgin metal.

For economic reasons it is necessary to cut at high speeds (work relative to tool). However, all of the cutting energy is converted almost instantaneously into heat. Thus, the faster the process, the higher the rate of heat generation and the hotter the process. The limiting speed is reached when the "tool wear," which accelerates at elevated temperatures, gives rise to excessive tooling costs. For any given operation, then, there is a cost-optimum cutting speed. Operation below this speed gives excessive labour costs, while operation above the speed gives excessive tooling costs.

The chip-tool interface temperature can reach the order of 1,000° F (538° C) with "high speed steel" tooling, 1,500° F (816° C) with tungsten carbide tools, and more than 2,000° F (1,093° C) with ceramic tools. As a first approximation, the cutting temperature can be determined from the following empirical equation:

$$T = \frac{1.2\,\sigma}{\rho c}\left(\frac{Vt}{K}\right)^{\frac{1}{2}}$$

where $T$ is the temperature rise (degrees Fahrenheit); $\sigma$ is the tensile flow stress (pounds per square inch); $\rho c$ is the volumetric specific heat (inch-pounds per cubic inch per degrees Fahrenheit); $V$ is the cutting speed (inches per second); $t$ is the depth of cut (inches); and $K$ is the thermal diffusivity of the work material (square inches per second).

**Deformation.**—In deforming processes, the goal is to alter the shape of the workpiece without causing fracture. In most deformation processes the work is physically displaced by a tool (punch, die, roller, hammer, etc.). There, the mechanism of friction between tool and work produces not only friction forces but, because of the nature of the laws of plasticity, also produces extremely high pressures between tool and work. In fig. 2 a simple forging operation is shown where the metal part is squeezed, flattened, or forged as the upper die moves downward. Also shown (B) is the distribution of pressure at the die-work interface. If there were no friction, the pressure would be essentially equal to $\sigma$, the flow stress in tension. However, as friction grows, the centre pressure grows higher and higher, giving rise to a "friction hill," which may peak at several times the value $\sigma$. In cold deformation processes, or "cold working" wherein the workpiece temperature is always below its recrystallization temperature (about one-half of the absolute melting temperature), the friction coefficient can be quite low, of the order of 0.1. However, in hot working (the upper end of the range) the coefficient tends to be of the order of one. Hence, the problems associated with large loads due to the friction hill are very important in both working ranges. In essence, the friction in the outer areas "holds back" the inner areas so that a larger pressure must be exerted to push it out.

In fig. 3 a sheet of thickness $t_1$ is "rolled" down to thickness $t_2$. The peripheral velocity of the rolls is constant. However, due to volume continuity the work velocity at entrance A must be less than that at exit C. A moment's reflection will reveal that there will generally be one zone, B, where the roll and work are moving at the same speed. Between A and B, the roll moves faster than the work, and the friction pushes the work in from A toward B. From B to C, the work moves faster than the roll so that the friction force direction is reversed, being from C toward B. The result is the friction-hill pressure distribution as shown in the figure.

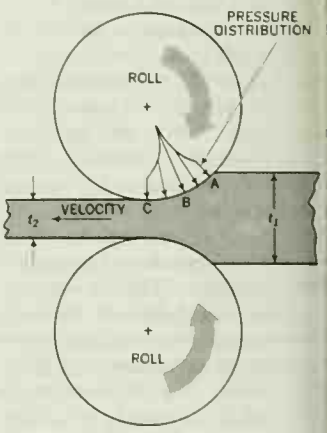



FIG. 3.—PRESSURE DISTRIBUTION IN METAL ROLLING PROCESS

As a crude rule, most plastic (as opposed to brittle) metals can be reduced in thickness by about 50% in a single forging, rolling, or drawing (pulling through a tapered die) operation. The more ductile the material, the greater the possible reduction. After a reduction, the ductility can be restored through heat treatment and further reductions obtained. Indeed, aluminum, which may be first cast in ingots several feet in diameter, is rolled through a multitude of successive steps to produce the familiar aluminum foil, which may be less than 0.001 in. thick.

Deformation of metal sheets can be carried out with very little friction in explosive forming and electrohydraulic forming, as shown in fig. 4 (A and B). In explosive forming, the workpiece, up to perhaps one inch thickness, is placed over a die. The die gap is either evacuated or well vented. Water above the work is used to transmit the pressure shock from a relatively slow-burning explosive to the work. This process is very useful when a relatively small number of large parts must be formed. The dies can be quite simple, made from cement, plastics, fibre glass, etc., while the explosive provides a very inexpensive source of power. Electrohydraulic forming is similar to explosive forming except that the shock (generally severe relative to explosive forming) is produced by generating a substantial underwater spark. A large capacitor bank is charged to high voltage. When the switch is closed, an intense spark is formed. This process is more suited to repetitive production of small parts because the cost and size of capacitor banks become very great for large workpieces.

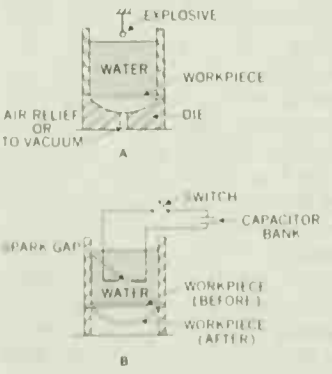



FIG. 4.—"FRICTIONLESS" DEFORMING OR FORMING PROCESSES (A) Explosive forming; (B) electrohydraulic forming

Deformation can be conducted with zero friction by using electromagnetic forces to deform the metal. In its simplest form, fig. 5 shows a magnetic forming operation (magnaform) set up to produce a dish-shaped workpiece. The coil consists of a few turns of rectangular-cross-section copper wire wound into a flat helix. When the charged capacitor bank is switched across the inductive

coil, a very strong, rapidly varying magnetic field is produced. If the workpiece is a good electrical conductor, a current is induced into the work, producing a magnetic field in opposition to the original field. Thus, the two magnetic fields repel. If the work is ferromagnetic, the ferromagnetic attraction may offset the electromagnetic repulsion, but for a material such as aluminum, the repulsive forces predominate and are sufficient for carrying out numerous forming operations. Electromagnetic, electrohydraulic, and explosive forming are inefficient from an energy point of view, since only a small amount of the discharged energy is absorbed in the plastic deformation process.

**Unconventional Metal Removal Processes.**—As engineering materials of increasing hardness are developed, they become more and more difficult to shape into a desired configuration. Diamonds, in the form of a diamond grinding wheel, are the only mechanical "tools" satisfactory for machining many materials by conventional means. Thus, there is developing a variety of methods for processing materials that do not employ the conventional tool-work relationships. These methods tend to be more costly than conventional methods and therefore are used primarily when conventional methods will not work.

*Electrical Discharge Machining (EDM).*—EDM depends upon the very high temperature of a spark to melt metal from the surface of the workpiece. The sparks are produced at a high rate (15,000–30,000 per second) by either an R-C (resistance-capacitance) electrical system or a rotary impulse generator. In fig. 6 the DC supply voltage $V_o$ charges the capacitor through the charging resistor. When the capacitor voltage $V_c$ reaches the value (50–100 v.) necessary for breakdown of the dielectric fluid (usually kerosene) between tool and work, a spark is formed somewhere within the tool-work gap, which is typically 0.001–0.005 in. thick. The ionized gas, or plasma, within the spark will attain temperatures of perhaps 10,000° F (5,538° C) and will melt a thin shallow crater in the work surface. The dynamic pressures caused by the spark bubble "blast" the liquid metal from the surface. If the values of the resistor and the capacitor are proper, after a spark duration of 10–50 $\mu$sec., the capacitor will be discharged to a voltage that will no longer maintain the spark. The spark then quenches and the process repeats. A servomotor feed control is used to advance the tool into the work at a rate which maintains the average current flow constant. It is clear that if the capacitance is increased, the energy per spark will be increased, and the metal removal per spark will also increase. However, the finished surface, composed of a multitude of craters, will be rougher. Also, greater energy infers a longer spark duration, and the remaining metal will have been heated to a greater depth. Thus, as the removal rate is increased, the surface finish is degraded and subsurface thermal damage becomes greater. It is also clear that the tool material will be eroded by the same mechanism as the work. Ratios of work to tool removal generally vary from 0.1 to 10, depending primarily on the melting temperatures of the materials.

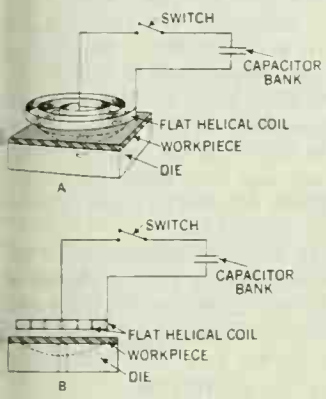



FIG. 5.—VIEWS OF ELECTROMAGNETIC FORMING OPERATION SHOWING (A) TOP VIEW AND (B) CROSS SECTION

Through EDM, a tool having a complex contour can be lowered or "sunk" into the work to produce the desired configuration. In a typical operation, worn tools are used for high-removal-rate "roughing" operations, while newer tools are used for low-rate finishing operations. When worn, the finishing tools are degraded to roughing tools, etc. The EDM process is inefficient in that only a small percentage of the input energy is used to melt the work material. Empirically it is found that electrical power at the rate of 1,000 w. will remove about one cubic inch per hour. (In conventional machining, the same power will remove more metal in one minute.) The process is clearly limited to electrical conductors and is particularly useful for very hard materials, such as tungsten carbide, or in producing very complex forms that are difficult to machine. At very low-energy input, surface roughness as small as 2 $\mu$in. has been obtained, while a roughing operation will give about 200 $\mu$in.

*Electrochemical Machining (ECM).*—ECM is basically the dissolution of metal in accordance with Faraday's law, which states that when electrons are caused to flow through an electrolyte into a metallic surface, one metallic ion will be removed each time a number of electrons corresponding to the metal valence flows through the circuit. For steel, this means that one cubic inch will be removed per minute when electrical current flows at the rate of 10,000 amp. Fig. 7 shows ECM as employed to drill long holes. It is also used for producing contoured shapes (as in EDM) and in conjunction with an electrically conducting grinding wheel in electrochemically assisted grinding.

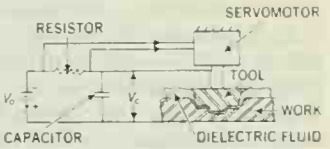



FIG. 6.—SCHEMATIC VIEW OF SIMPLE R-C (RESISTANCE-CAPACITANCE) ELECTRICAL DISCHARGE MACHINING (EDM) PROCESS

At first glance, it would appear from Faraday's law that ECM could be used to remove metal at high rates if large currents were provided. This is true up to the point where the current density (amperes per square inch) reaches a saturation value. For typical operations, current densities of the order of 200–500 amp. per sq.in. have been attained. The current density is limited by electrolyte boiling, gas evolution, or the formation of anode and cathode films. The film thickness can be greatly reduced through use of high-velocity electrolyte application. This generally enhances the surface finish, often producing one-micro-inch finishes.

In order to attain high current densities, high-conductivity electrolytes are used. Typically, sodium chloride (salt), potassium chloride, sodium hydroxide, or sulfuric acid are used. The solution chemistry is adjusted to minimize anode film formation.

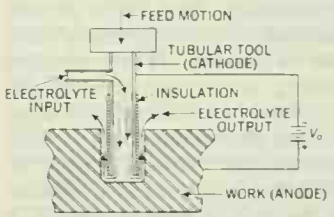



FIG. 7.—HOLE DRILLING BY ELECTROCHEMICAL MACHINING (ECM)

ECM can be used to machine or polish any conducting material, including semiconductors. The surface resulting from ECM is free of the mechanical stresses and thermal damage that result from most processing methods. Most ECM is carried out at about 15 v. Hence, the total power requirement (for steel) is 150 kw. for one cubic inch per minute. This is about 200 times as large as that required in conventional machining.

*Chemical Milling.*—Chemical milling is simple chemical dissolution without an external electric circuit. Many metals are rapidly dissolved by strong acids or bases, and if areas not to be machined are suitably masked, material can be selectively removed. The process has been successfully applied to reducing the thickness of noncritical parts of aircraft structures and of course to the art of photoengraving.

*Ultrasonic Grinding.*—This method is used to remove any brittle (as opposed to ductile) material, such as glass, ceramics, hardened steel, tungsten carbide, and semiconductors. Holes, surfaces, and contours can be produced as in EDM and ECM. The removal mechanism involves driving a sharp abrasive grit (generally boron oxide) against the brittle material, thus producing a small chip. This is similar, on a small scale, to the use of jackhammers to chip concrete. The abrasives are carried in a thick water slurry between the work and a tool made of ductile material (steel, brass, copper) to minimize tool wear.

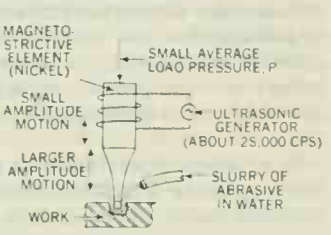



FIG. 8.—ULTRASONIC GRINDING OPERATION

The tool is forced to oscillate at about 25,000 cps (cycles per second) and an amplitude of 0.0005–0.003 in. by a tuned magnetostrictive driver, as shown in fig. 8.

The average velocity at which the tool will grind its way into the workpiece is approximated by

$$v = \frac{f}{2}\left(\frac{P}{H}\right)(aR)^{\frac{1}{2}}$$

where $v$ is the grinding rate (inches per second); $f$, the oscillatory frequency (cycles per second); $P$, the average pressure between tool and work (pounds per square inch); $H$, the crushing hardness of work (pounds per square inch); $a$, the amplitude of oscillation (inches); and $R$, the average radius of abrasive grit (inches). Tolerances of 0.002 in. are easily maintained, while tolerances of 0.0005 in. with 10 = μin. finishes can be obtained.

*Electron Beam Machining.*—This type of machining involves a stream of high-energy electrons (as in a television tube) that impinge upon the metal to be cut. The electron energy is transformed to thermal energy, thus heating the metal. If the electrons emitted from a large source are focused (electrostatically or electromagnetically) onto a small-diameter spot, the heat can easily melt any material and thereby be used for cutting or welding. The process is hampered by the fact that electrons are also absorbed by gas molecules so that the process must be carried out in a mild vacuum. The rate at which metal can be cut (melted) by electron beam techniques is empirically given by

$$\frac{Vd}{K} = 0.01\left(\frac{P}{\theta_m t k}\right)^2$$

where $V$ is the cutting speed (inches per second); $t$ is the material thickness (inches); $d$ is the electron beam spot diameter (inches); $P$ is the electron beam power (inch-pounds per second); $k$ is the thermal conductivity of the work (pounds per second per degrees Fahrenheit); $K$ is the thermal diffusivity of the work (square inches per second); and $\theta_m$ is the melting point of the work (degrees Fahrenheit).

Electron beam machining can be conducted on any material. It is even used to drill small holes in diamonds. Because the process involves melting of the work, the surface quality is generally poor.

*Laser Machining and Plasma Arc Machining.*—These methods are similar to electron beam machining in that high-intensity energy is directed at the work surface to produce melting (and some vaporization and ionization), but neither process requires a vacuum chamber. In the case of the plasma arc, hot (10,000°–20,000° F [5,538°–11,093° C]) gases, ionized as they pass through an electric arc, are directed at the work. In the case of laser machining, a burst of light from a pulsed laser is focused through a lens to give an extremely high-energy density beam. In plasma arc machining, the results are similar to those obtained from a very hot flame. However, with the electron beam and the laser beam, energy density (energy entering the metal per unit area) is so great as to form holes having much greater depth than width.

*See* also MATERIALS, STRENGTH OF; METALLURGY; METALWORK, DECORATIVE.

*See* N. H. Cook, "Manufacturing Analyses," Massachusetts Institute of Technology Publication (1963); J. S. Campbell, *Principles of Manufacturing Materials and Processes* (1961). (N. H. C.)

**METAMORPHISM,** in petrology, is the process of chemical and physical alteration that occurs in rocks under the influence of elevated temperature and mechanical stresses in the earth's crust. Following an introductory discussion of metamorphism and metamorphic alterations, this article presents a survey of methods of investigation and study of metamorphic rocks and discusses grades of metamorphism and the theories on which they are based, temperature and pressure involved in metamorphism, the texture and structure of metamorphic rocks and metamorphic differentiation.

In addition to references to related and supplementary material given in the several sections of this article, *see* also the general article GEOLOGY and articles on various rocks and rock-forming minerals, as MICA SCHIST; GNEISS; MARBLE; FELDSPAR; WOLLASTONITE, etc.

## INTRODUCTION

Petrologists divide rocks into three broad classifications: igneous rocks (*see* PETROLOGY), which have been solidified from molten substances (magmas); sedimentary rocks (*q.v.*), formed by the slow process of consolidation of sedimentary deposits; and metamorphic rocks. Metamorphic rocks, which constitute a major part of the earth's crust, are rocks that originally belonged to the other groups but that were altered in various ways. The alteration consists in part of chemical reactions among the minerals in the rocks or between incoming fluids and the original minerals. These changes in physical and chemical properties of rocks, under the new environmental pressures, transform them into new species. For example, clay sediments change to shale and slate at temperatures around 100° C.–200° C. At higher temperatures in the earth's crust, clay may change to mica schists or various types of gneisses. Limestone, originally formed as a sedimentary rock from the calcareous shells of primitive animals, changes to marble by the chemical reactions and recrystallization occurring during metamorphism.

Mechanical deformation of rocks is another common occurrence in metamorphism. This deformation is in part of a plastic nature —the rock yields more or less like metal under crustal stresses. However, crustal stresses are sometimes strong enough to crush rocks to fragments varying from pieces a foot long to fine powder.

Alterations of a physical and chemical nature are caused also by weathering of rocks in contact with the atmosphere and surface water, and by diagenesis (*q.v.*) of sediments, but such changes are generally not included in the term metamorphism. Weathering and diagenesis occur at temperatures below those at which true metamorphism takes place. On the other hand too high temperatures—above 600° C.–900° C., depending on rock type—causes silicate rocks to melt and brings us thus into the realm of magmatism and magmatic rocks. (*See* also GEOCHEMISTRY: *Geochemistry of the Lithosphere.*) Rocks exposed to these extreme physical conditions are called ultrametamorphic.

**Metamorphic Alterations.**—All kinds of rocks may be exposed to metamorphic alterations. Alterations without change of bulk chemical composition of rocks are called isochemical metamorphism. If change of bulk chemical composition is involved the term allochemical metamorphism applies (*see* also METASOMATISM).

Some chemical constituents are very mobile in rocks undergoing metamorphism. The content of such mobile constituents, as for example water and carbon dioxide, is rarely constant in a rock during metamorphic alterations. Thus, for example, a gabbro which consists of two anhydrous minerals, plagioclase feldspar and pyroxene, picks up several per cent of water if metamorphosed at low temperatures (say 300° C.) because hydrous minerals such as chlorite and hornblende are formed. On the other hand, a sedimentary rock containing hydrous clay minerals loses large amounts of water when metamorphosed at high temperatures (500° C. to 600° C.) at which essentially anhydrous minerals become stabilized. Similarly, rocks may gain or lose carbon dioxide rather readily because at high-temperature metamorphism calcite and other carbonate minerals react with quartz or silicates to form calc-silicates and carbon dioxide gas which escapes from the altered rocks.

Rocks containing calc-silicates such as wollastonite, diopside and anorthite often develop carbonates at low-temperature metamorphism. This means considerable introduction and gain of carbon dioxide. As an example of reactions involving carbon dioxide consider the following:

| low temperature | | | high temperature | | |
|---|---|---|---|---|---|
| $CaCO_3$ | + $SiO_2$ | ⇌ | $CaSiO_3$ | + | $CO_2$ |
| calcite | quartz | | wollastonite | | carbon dioxide |

The right-hand side of this metamorphic mineral reaction corresponds to high temperature and loss of $CO_2$, the left-hand side to low temperature and gain of $CO_2$.

Many rock-making chemical constituents other than water and carbon dioxide are mobilized during metamorphism thus making change of bulk chemical composition a common phenomenon.

**Types of Metamorphism.**—Metamorphism is conveniently

classified as contact metamorphism, which occurs in rather narrow zones around hot magma masses, and regional- or dynamothermal metamorphism, which encompasses vast complexes of rocks involved in the evolution of fold mountains. The latter type of metamorphism is not caused by heat from molten magmas, but rather by tectonic, or structural, stresses in the earth's crust and regional rise in crustal temperature. The reason for such regional rise in crustal temperature is not known for certain but it is probable that it is caused by dissipation of the potential energies which create fold mountains (*see* also FOLD).

*Contact Metamorphism.*—Rocks altered by contact metamorphism show little or no sign of strain such as plastic flowage or mylonitization, or crushing of minerals. In contact metamorphic rocks, recrystallization (for example: formation of coarse-grained marble from limestone, of quartzite from sandstone) and neomineralization are the most prominent features. Neomineralization means formation of new mineral assemblages more stable than the old ones. Such rocks are generally called hornfels (*q.v.*).

*Regional Metamorphism.*—Regional metamorphic rocks bear signs of mechanical strain in addition to recrystallization and neomineralization. The strain is seen as schistosity or foliation and other kind of anisotropic structures in the rock bodies, much like the structures found in rolled metal plates and drawn wires. Crystalline schists such as mica schists and green schists, many marbles, most gneisses, certain soapstones, amphibolites and granulites are regional metamorphic rocks.

*Progressive and Regressive Metamorphism.*—Rock alteration taking place at increasing temperature (and pressure) is called progressive metamorphism (for example: clay sediment altered to mica schist). Alteration at decreasing temperature is called regressive metamorphism or diaphoresis (for example: green schist formed from basic lava).

*Polymetamorphism.*—A polymetamorphic rock has been exposed to two or more periods of metamorphism. Such rocks may carry proof of their complex history in the form of structural or mineralogical relics from earlier stages in their evolution. The term palimpsest (from the Greek for scratched or scraped, that is, marked, again) structure was coined by J. J. Sederholm for features of this kind.

## METHODS OF INVESTIGATION

The basis for all geological investigations are the observations which the geologist does out in the field. Investigations of metamorphic rocks and phenomena are no exception in that respect. By making geological maps, constructing profiles of rock complexes and observing detailed structural relations of rocks in the field the geologist gets valuable information as to origin and evolution of metamorphic rocks.

The collected samples are studied by various physical and chemical methods in laboratories. Microscopic studies of thin sections or powdered rocks give information about type of minerals present, their relative amount and the microscopic texture and structure of the rocks. Chemical analyses of rocks and minerals are performed by conventional chemical methods as well as by various spectrographic techniques. Mass spectroscopy gives data on isotopic distribution in rocks and minerals. Such data are useful for age determination of rocks. There are, of course, other properties of metamorphic rocks which are studied in the laboratories. Stress and strain tests of rock samples tell about the mechanical properties such as elasticity, strength and viscosity. These data are important for the understanding of the behaviour of rocks when exposed to stresses in the earth's crust.

Fundamental thermodynamic parameters of minerals—such as their heat of formation, heat capacity, entropy, etc.—are determined in laboratories. Such data are necessary to understand the behaviour of mineral assemblages in rocks when effected by the changing pressures and temperatures in the earth. Thermodynamic data are of course necessary for calculation of the whole energy balance during metamorphism.

The above outline is a brief description of methods used to gather important data on metamorphic rocks. Such data are meaningful only if they contribute to more or less comprehensive theories of origin and evolution of metamorphic rocks. To achieve this goal the data are treated by various mathematical tools and interpreted by the aid of theoretical physics. Theoretical methods of this kind must be considered a very significant part of the investigation of metamorphism.

Syntheses of metamorphic minerals under equilibrium conditions at varying pressure and temperature conditions are important in the sense that they may give better knowledge of the pressure and temperature conditions at which rocks have formed or recrystallized. (*See* also GEOCHEMISTRY; GEOLOGY; PETROLOGY.)

## GRADES OF METAMORPHISM

Metamorphic rocks provide an illustration of the fact, established by atomic science, that the concept of "dead matter" is an illusory one. Exposed to changing geological conditions in the lithosphere, they respond by alterations—mineralogical, structural and chemical. Thus rocks tend to develop mineral assemblages, or recurring combinations, and structures best suited—*i.e.*, most stable—under the conditions of temperature, pressure and anisotropic stress which affect rocks during their evolution.

The principal processes taking place in rock bodies during metamorphism are recrystallization and neomineralization, referred to above. The change of mineral assemblages in response to varying temperature and pressure conditions makes it possible for geologists to distinguish among various grades or degrees of metamorphism. The different grades are determined by the occurrence of characteristic minerals or mineral assemblages which represent—and presumably are stable at—unlike pressure and temperature (P,T) conditions.

**Grades and Depths.**—The Swiss petrologist Ulrich Grubenmann (1850–1924) in his classification of crystalline schists distinguished among three grades of metamorphism, the epi (upper), meso (middle) and kata (downward) zones. Grubenmann believed that depth of burial in the earth's crust was the chief reason for unlike grades of metamorphism because pressure obviously increases with depth and, generally, so does temperature as shown by the geothermal gradient, or increase in temperature of the earth from the surface toward the interior, averaging about 3° C. per 100 m.

Epizonal rocks were regarded as products of shallow depths because of their content of minerals characteristic of low temperature such as chlorite, talc, serpentine and other hydrous minerals.

Mesozonal rocks carry minerals generally formed at moderate temperature (some 300° C. to 400° C.). Such rocks were consequently believed to have developed at intermediate depth in the crust.

Katazonal rocks consisting mostly of anhydrous minerals such as garnet, kyanite, hypersthene, cordierite, feldspar, etc., were considered ambassadors from the deepest portions of the earth's crust, now exposed by erosion.

**Unlike Grades and Constant Composition.**—G. Barrow, working in Scotland, demonstrated that the grade of regional metamorphism changed in horizontal direction across the Caledonian fold-mountain chain which extends in a northeast-southwest direction through the Highlands. Zones of rocks exposed to the same grade of metamorphism are approximately parallel to the axes of the mountain chain, low-grade rocks generally occupying marginal zones and high-grade rocks central zones, with rocks of intermediate grade between. Similar conditions are encountered in other areas of more or less eroded fold-mountain chains such as the Caledonian chain in Scandinavia and many Pre-Cambrian deeply eroded mountain chains in Fennoscandia (the Baltic shield), Canada, west Greenland and other areas. Barrow studied chiefly alterations of argillaceous, that is, clayey, sediments which are very responsive to changing P,T conditions. Certain index minerals were used to identify certain grades of metamorphism, one index mineral would change over to another along a more or less curved boundary line in the field. Such a line is termed isograde and represents the intersection between the earth's surface and a boundary surface separating two neighbouring zones of metamorphism. Such boundary surfaces between adjacent but unlike

zones of regional metamorphism are curved surfaces which often, but not always, show fold axes more or less parallel to the axis of the mountain chain. Chlorite, biotite, garnet, kyanite, staurolite, sillimanite were minerals used by Barrow to indicate increasing grades of regional metamorphism.

**Constant Grade and Unlike Compositions.**—V. M. Goldschmidt was the first to apply extensively physicochemical principles in a study of metamorphic rocks. His treatise of the Oslo (Kristiania) area in Norway has become classic. In this area numerous magmatic bodies of Permian age have intruded a sedimentary complex of sandstone, limestone and argillaceous schists. These sediments have been exposed to high temperature in a contact zone of varying thickness around the intrusive magmatic rocks. At a constant distance out from the rim of a given magma body the temperature in the surrounding sediments has been constant. Therefore Goldschmidt was able to study in great detail how rocks of unlike bulk chemical composition (sandstone, limestone, claystone, etc.) responded to a given temperature, viz., the crystallization temperature of the magma. In other words Goldschmidt studied the effect of a given grade of metamorphism (the grade of contact metamorphism, or the pyroxene hornfels facies of P. Eskola, discussed below) on a number of rocks of unlike chemical composition. Barrow had studied the effect of unlike metamorphic grade on rocks of nearly constant composition, viz., argillaceous sediments. We shall see below that Eskola combined both types of study; he studied the effect of various grades of metamorphism on rocks of various bulk composition.

**Chemical Equilibrium and the Phase Rule.**—The important Oslo area work led to the interesting conclusion that chemical equilibrium had been approached rather closely in sediments baked in the heat from intrusive magmas. Subsequent studies have shown that chemical equilibrium among minerals in rocks generally is attained also during regional metamorphism, probably more commonly here than under contact metamorphism. The laws of chemical equilibrium in heterogeneous systems as developed by Josiah Willard Gibbs and others are consequently applicable to metamorphic rocks, a fact largely responsible for the recent progress in metamorphic petrology. Metamorphic rocks frequently obey the chemical phase rule: $P + f = C + 2$ where $P$ stands for phases, which in petrology correspond to minerals, $f$ means degrees of freedom, and $C$ components. In silicate rocks simple oxides are conveniently counted as components; if sulfides are present sulfur is an additional component.

Under isochemical metamorphism, rocks are closed systems not permitting communication of chemical constituents with the environment. Two degrees of freedom have then generally prevailed inasmuch as pressure and temperature are independent variables, and the so-called mineralogical phase rule is valid: $P = C$. That is, a metamorphic rock formed under equilibrium conditions should have the same number of different minerals as it has components. It is interesting to note that metamorphic rocks very rarely have more minerals than components counted in terms of simple oxides, such as those of potassium, calcium, magnesium, silicon, etc. Indeed, in most metamorphic rocks the number of minerals is considerably less than the number of components. For example, many amphibolites, which are common metamorphic rocks in terrains of gneisses and crystalline schists, have only the two minerals plagioclase and hornblende, yet chemical analyses may show ten or more simple oxides. The reason for this apparent discrepancy is in part that many minerals are mixed crystals in which several atoms or ions can substitute for one another in identical structural positions. Sodium and calcium are interchangeable in plagioclase, so are silicon and aluminum to some extent. In hornblende a great number of cations substitute for one another. Magnesium, iron, titanium, aluminum, manganese, nickel and cobalt are all encountered in identical structural sites. This means that several unlike chemical elements must be counted as one component because they are identical from a mineral-chemical point of view.

**Mineral Assemblages.**—The general approach to chemical equilibrium among minerals in metamorphic rocks results in an order and regularity which invite natural classifications of such

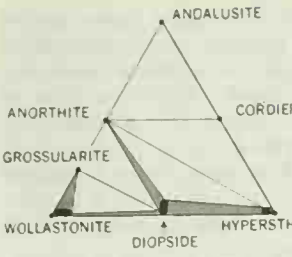



FIG. 1.—MINERAL ASSEMBLAGES OF CONTACT METAMORPHIC ROCKS

rocks. Contact metamorphic rocks can for example be placed in phase diagrams of the type shown in fig. 1. This particular three-component diagram with $Al_2SiO_5$ (andalusite), $CaSiO_3$ (wollastonite) and $(Mg,Fe)SiO_3$ (hypersthene) at the corners is only applicable to rocks with excess silica metamorphosed in the contact zones around magmas. Any one of the possible mineral assemblages shown in fig. 1 may develop. There are, however, restrictions as to the number as well as types of associated minerals at equilibrium. If chemical analysis of a hornfels places it on a joint line between two minerals in fig. 1, then only these two minerals are permitted at stable equilibrium. (Minerals containing elements not shown in the diagram may certainly occur in addition to those indicated by the phase diagram.) A hornfels falling within one of the three angles in the figure must contain the three minerals at the corners. Only one mineral can be present stably in a hornfels with bulk chemical composition coinciding with that of the mineral itself. Incidentally, such monomineralic rocks are not as rare as one may assume in view of the small chance that bulk composition of sediments should coincide with that of a pure mineral. Pure diopside hornfels and wollastonite hornfels are described from various places.

The Oslo hornfelses adjacent to the magmatic intrusives follow very strictly the rules of permitted mineral assemblages. Ten classes of hornfels were recognized by Goldschmidt in the field:

Class 1 rocks with andalusite and cordierite (albite)
Class 2 rocks with andalusite, cordierite and anorthite
Class 3 rocks with anorthite and cordierite
Class 4 rocks with anorthite, cordierite and enstatite
Class 5 rocks with anorthite and enstatite
Class 6 rocks with anorthite, enstatite and diopside
Class 7 rocks with anorthite and diopside
Class 8 rocks with anorthite, diopside and grossularite
Class 9 rocks with grossularite and diopside
Class 10 rocks with grossularite (vesuvianite), diopside and wollastonite

This sequence of classes of hornfels corresponds to increasing amounts of calcite (calcium) in an argillaceous sediment. Andalusite is the metamorphic product of the typical clay mineral kaolinite, and wollastonite forms at high temperature by interaction between calcite and silica (fig. 4).

**Metamorphic Facies.**—At grades of metamorphism different from contact metamorphism other minerals and mineral associations occur. These assemblages can be shown in diagrams similar to fig. 1, viz., with calcium, aluminum and magnesium + iron silicates at the corners. Eight grades, each with its characteristic phase diagram (called ACF diagram), have been recog-

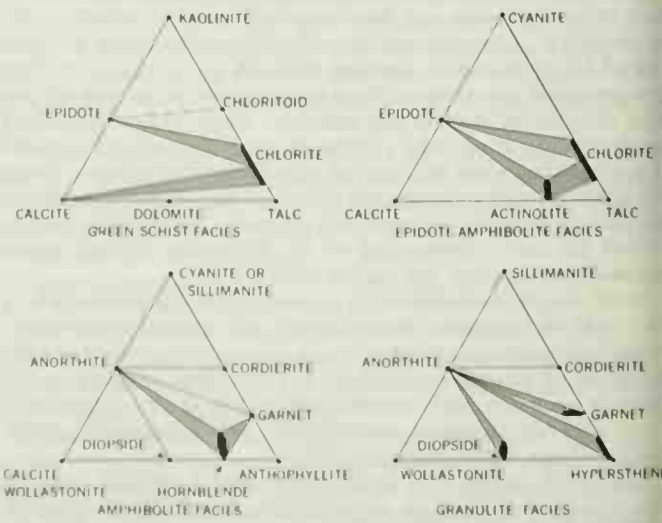



FIG. 2.—VARIOUS GRADES OR FACIES OF REGIONAL METAMORPHISM

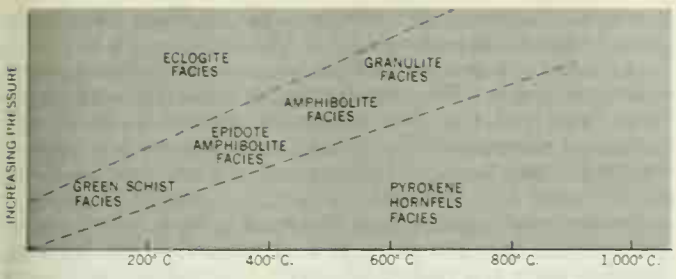



FIG. 3.—VARIOUS FACIES OF CONTACT METAMORPHISM

nized and described by Eskola in his studies of areas in Finland and Norway. The characteristic mineral association of each grade is called mineral facies or metamorphic facies, with the name of each facies chosen from the kind of rock most dominant within that grade. Basic rocks rich in calcium and magnesium are most sensitive to changes of metamorphic grades. The various facies are named after such rocks rather than acidic and alkali-rich ones. This does not mean, however, that acidic and alkaline rocks are not found in the unlike facies or grades; it only emphasizes that it is difficult to distinguish among unlike metamorphic grades in rocks such as granitic gneisses, quartzites, nepheline syenites and the like. Quartz, potash feldspar and acidic plagioclase, the chief minerals in such rocks, are stable over the whole P,T field in which most metamorphism takes place. Thus a granitic gneiss consisting of quartz, potash feldspar and albite remains a granitic gneiss with the same minerals at all grades of common metamorphism. On the other hand minerals occurring in basic rocks, being of magmatic or sedimentary origin, such as pyroxenes, hornblendes, chlorites, talc, serpentine, olivine, anorthite and epidote have narrow fields of stability. A basic rock of given bulk composition may, for example, yield a gabbro (pyroxene and plagioclase) at high metamorphic grade, an amphibolite (hornblende and plagioclase) at intermediate grade and a green schist (chlorite epidote and albite) at low grade.

The sequence of metamorphic grades from low to high grade of regional metamorphism is green schist facies, epidote amphibolite facies, amphibolite facies and granulite facies. Corresponding ACF diagrams are shown in fig. 2. Contact metamorphism belongs to the pyroxene hornfels facies.

Other facies less commonly encountered are eclogite facies, glaucophane schist facies and sanidinite facies. Fig. 3 shows the approximate positions of the various facies in a P,T diagram.

## TEMPERATURE AND PRESSURE OF METAMORPHISM

Our knowledge of temperature and pressure represented by the various metamorphic facies is unfortunately limited. It seems rather certain, however, that granulite facies, being the highest of regional metamorphic grades, corresponds to about 600° C.–700° C. Green schists must have developed at much lower temperatures, perhaps 200° C.

**Temperature.**—Assuming that chemical equilibrium was attained in metamorphic rocks at the time of recrystallization, their mineral assemblages should reveal the correct P,T conditions of metamorphism. Laboratory studies have given some information on stability relations of mineral assemblages. Such studies indicate that a temperature of 600° C.–700° C. can be assigned to the granulite facies. The two alkali feldspars, microcline and albite, constitute a complete mixed-crystal series above 600° C. At lower temperatures a gradual unmixing takes place, the two coexisting feldspar phases becoming more and more pure. At room temperature only negligible amounts of soda in microcline or potash in albite can exist stably.

In granulites, albite and microcline are often found as one single phase of solid solution whereas in lower-grade rocks albite with varying amounts of dissolved potash and microcline with varying amounts of dissolved soda are found as two independent minerals. (*See* also FELDSPAR: *Unmixing at Low Temperature.*)

A similar situation exists in the calcite-magnesite (calcium carbonate and magnesium carbonate) system. Calcite takes varying amounts of magnesium carbonate in solid solution, depending upon prevailing temperature during recrystallization. It has been determined that magnesian marbles metamorphosed in granulite facies often carry calcite with concentrations of magnesium corresponding to temperatures around 600° C.

Muscovite is a hydrous silicate occurring in many metamorphic rocks. At somewhat elevated temperature the mineral reacts with quartz and loses water whereby sillimanite and potash feldspar are produced:

$$\underset{\text{muscovite}}{KAl_3Si_3O_{10}(OH)_2} + \underset{\text{silica}}{SiO_2} \rightleftharpoons \underset{\text{feldspar}}{KAlSi_3O_8} + \underset{\text{sillimanite}}{Al_2SiO_5} + H_2O$$

Muscovite is never found in true granulites but sillimanite and potash feldspar occur frequently together. In lower-grade rocks muscovite and quartz are commonly found together. Thus the P,T conditions at which the above reaction takes place should give the lowest boundary of granulite facies, *i.e.*, the boundary line between granulite facies and amphibolite facies. At low pressures this reaction is very sensitive to pressure variations because water vapour is involved. At higher pressures, however, laboratory investigations have shown that the reaction temperature at equilibrium is close to 600° C. over a wide pressure range. This is then the third mineral system which indicates that the highest temperature in regional metamorphism is not much higher than 600° C. to 700° C. At higher temperatures silicate rocks begin to melt and magmas are born, a process called anatexis or palingenesis.

A mineral system often applied as a geologic thermometer in metamorphism is calcite + quartz and wollastonite + carbon dioxide. The phase diagram is shown in fig. 4.

**Pressure.**—Pressure also varies from one facies to another. In a general way it is known for example that pyroxene hornfels facies represent much lower pressures than granulite facies, the latter not only corresponding to the highest temperature in regional metamorphism, but also the highest pressure. Reactions among minerals with unlike molal (gram-molecular) volumes are useful geologic barometers. As an example, consider the rather rare mineral jadeite, $NaAlSi_2O_6$, which mostly is found in rocks altered or formed at high pressures (*see* JADE). Jadeite has much higher density than albite although the composition of the two minerals is nearly the same, albite having the formula $NaAlSi_3O_8$. Jadeite can form from albite according to the following reaction:

$$\underset{\text{albite}}{NaAlSi_3O_8} \rightleftharpoons \underset{\text{jadeite}}{NaAlSi_2O_6} + \underset{\text{quartz}}{SiO_2}$$

The jadeite-quartz combination has considerably less volume than albite so that high pressure favours the jadeite-quartz assemblage. Within the temperature range in which this reaction occurs stably, albite is stable at low pressures and jadeite plus quartz at high pressures. Thus eclogites, which are considered high-pressure rocks by most petrologists, have a high percentage of jadeite molecules in their pyroxene (*q.v.*). (*See* also ECLOGITE.)

## TEXTURE AND STRUCTURE OF METAMORPHIC ROCKS

The mineral assemblages of metamorphic rocks have developed by recrystallization and chemical reactions in the solid state, often under conditions of tectonic stress. Such rocks have therefore texture and structure different from those of magmatic and sedimentary rocks, the former crystallizing from melts (*see* PETROLOGY), the latter precipitating in lakes, rivers and oceans (*see* SEDIMENTARY ROCKS).

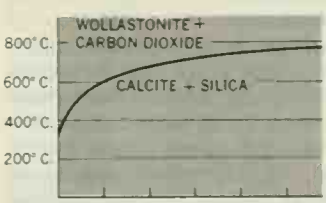



FIG. 4.—PHASE DIAGRAM OF MINERAL SYSTEM APPLIED AS A GEOLOGIC THERMOMETER

Mineral grains in metamorphic rocks are mostly without crystal faces and border against their neighbours along irregularly

curved surfaces not related to their internal crystalline structure. Such texture is called crystalloblastic. An idioblast is a mineral grain with well-developed crystal faces. During metamorphism certain minerals show greater tendency to form idioblasts than others. Garnet, for example, often forms perfect idioblasts in mica schists whereas quartz never does and feldspar only rarely.

Minerals may be placed in the so-called idioblastic series according to their tendency to develop crystal faces during metamorphism. The major members of this series are as follows: sphene, rutile, garnet, kyanite, epidote, pyroxene, hornblende, albite, chlorite, quartz, microcline. Sphene almost invariably forms idioblasts, quartz and microcline very seldom.

**Riecke's Principle and Force of Crystallization.**—A mineral growing in a metamorphic rock has to produce space for itself in a solid environment. Surrounding minerals must then either be pushed aside bodily or disintegrate chemically (for example dissolve in a pore moisture). The so-called force of crystallization or pressure of growth is of importance in this connection. Any crystal is able to grow against excess pressure if the system is supersaturated with reference to that crystal, the more supersaturated the system, the higher the pressure of growth. On the other hand, if a crystal is exposed to excess pressure in a saturated system it becomes unstable and tends to disintegrate chemically. (Excess pressure here means higher pressure on the crystal than in the rest of the system.) In solid rocks such disintegration does not necessarily mean dissolution in a fluid because liquid solutions are not always present. It generally means disintegration into individual ions, atoms or molecules which are carried away by diffusion along mineral interfaces or even through their crystalline body. This phenomenon of chemical disintegration under excess pressure is referred to as Riecke's principle. It not only explains plastic flow of solid rocks under stress, but is also important in explaining recrystallization and neomineralization. A newly stabilized mineral grows in a metamorphic rock because the rock has become somewhat supersaturated with reference to the new mineral owing, for example, to changing P,T conditions. The growing mineral surrounds itself by a field of pressure in excess of that prevailing elsewhere in the rock. Minerals present in this field of excess pressure disintegrate according to Riecke's principle and thus provide space for the newly stabilized growing mineral. Thermodynamic analysis shows that under otherwise like conditions (same P,T values, same degree of supersaturation) dense minerals develop higher pressure of growth than less dense minerals. In this connection it is interesting to note that the above-mentioned idioblastic series of minerals as determined empirically from field studies also is a density sequence, sphene and garnet being dense structures, quartz and feldspar loose, open structures.

**Analysis of Structure.**—The structure of rocks is called isotropic or massive if it is identical in all directions in space. Some contact metamorphic rocks may show such structure, but practically all regional metamorphic rocks have anisotropic structure, *i.e.*, structures with planar and linear features. Planar structure shows up well in most mica schists where the majority of mica flakes may be parallel to a given plane—the plane of foliation, or schistosity. In ideal planar structure all directions in the schistosity plane are identical. Needle-shaped minerals such as sillimanite and hornblende show statistic parallelism to the schistosity plane, but they are oriented at random within that plane. In linear structure needle-shaped minerals show preferred parallelism to a line. This line is called lineation. In most natural rocks linear and planar structures are mixed.

*Origin.*—The origin of anisotropic structure is twofold:

(1) The structure may be relic after premetamorphic anisotropic structure of various kinds. Sediments with deposition structure and lavas with flow structure may preserve their anisotropic structure as relic during metamorphic recrystallization even if not exposed to anisotropic stress. Structures formed in this manner are termed mimeoblastic. In polymetamorphic rocks anisotropic structures formed in earlier periods of metamorphism may remain as relic mimeoblastic structure through later recrystallization. In contact metamorphic rocks mimeoblastic structure is common because anisotropic stress is not likely to occur in contact zones around magmas.

(2) Anisotropic structure develops in rocks recrystallized under anisotropic stress. The stress causes strain of the rock bodies (cataclastic, with fractures, and plastic, without fractures) and consequent rearrangement of mineral grains into various types of anisotropic structures. The structure of most regional metamorphic rocks is of this kind.

The mechanism causing such structures to form is little known and probably very complex. It is assumed that the following processes occur in a rock under stress: (1) rotation and relative movement of mineral grains by slip along interfaces; (2) slip along certain crystallographic planes and lines inside mineral grains (so-called glide planes and lines); (3) dissolution (or other kind of chemical disintegration) at points of high compressive stress and redeposition at points of low stress in accordance with Riecke's principle; and (4) fracturing and crushing of mineral grains—so-called cataclasis.

*Crushing.*—Evidence of any one of these processes may be found in metamorphic rocks. If fracturing is dominating the phenomenon is called mylonitization and the produced rock a mylonite (*q.v.*). Such mylonites occur usually only in narrow zones in metamorphic terrains, demonstrating intensive shear movements along these zones with corresponding crustal stresses exceeding the crushing strength of minerals. However, many metamorphic rocks show no sign of mineral crushing.

*Rotation.*—Evidence of rotation of mineral grains during metamorphism is not uncommon, the most cited example being the so-called snowball garnet with inclusions arranged in a spiral as a result of rotation during growth.

*Slip.*—Calcite and other carbonates yield readily by slip along certain lattice planes often resulting in polysynthetic twinning and bending of grains. This is observed in many natural marbles in thin sections under the microscope. Laboratory experiments with marble blocks under stress at elevated temperature also show that gliding along crystallographic glide planes is important in rock deformation. It seems, however, that most silicate minerals deform via chemical processes more or less in harmony with Riecke's principle during regional metamorphism. Tectonic stress is generally too weak to produce crushing and lattice slip. Slow creep due to recrystallization seems more important in rock deformation.

*Orientation.*—The statistic parallelism of mineral grains in rocks with anisotropic structure may be dimensional orientation or lattice orientation. Dimensional orientation refers to the external shape of mineral grains, whereas lattice orientation refers to the internal structure of minerals. Quartz grains in schists and gneisses may, for example, have lenticular shapes unrelated to the internal crystal structure. Such quartz lenses are often dimensionally oriented parallel to the schistosity plane. This kind of anisotropic structure is most likely a result of dissolution at points of high compressive stress (*i.e.*, at mineral interfaces which are perpendicular to the highest compressive stress) and redeposition at points of low compressive stress (*i.e.*, at interfaces or surfaces more or less perpendicular to direction of least compressive stress or maximum tensile stress).

Minerals with equidimensional outline such as those belonging to the regular crystallographic system may show preferred lattice orientation which can be detected only by accurate microscopic studies.

## METAMORPHIC DIFFERENTIATION

During metamorphism, originally homogeneous rock bodies may become heterogeneous in the sense that schlieren (alternating bands of contrasted composition) and veinlets develop. Such phenomena are called metamorphic differentiation. For reasons not clearly understood minerals disintegrate chemically at certain sites in rocks and redevelop at other sites, the transfer probably being in the form of diffusion. Quartz veinlets and clusters commonly form in crystalline schists, "knots" of epidote in green stone, and segregations of diopside or other calc-silicates in crystalline limestone. Such metamorphic differentiation is most prom-

inent in strongly deformed rocks. It is therefore concluded that stress and strain are instrumental in metamorphic differentiation. Minerals which dissolve more readily than others in zones of intensive stress and shearing are leached out from such localities and may be deposited anew where stress is low, thus causing metamorphic differentiation. Interfacial tension, energy of nucleation, and force of crystallization are properties which seem significant in metamorphic differentiation.

Many features in metamorphic terrains caused by metamorphic differentiation are difficult to distinguish from features resulting from magmatic activity. Pegmatite dikes and mineral veins in crystalline schists are commonly products of metamorphic differentiation although similar rocks may also form from magmas. Some workable ore bodies in regional metamorphic terrains are probably also products of some sort of metamorphic differentiation.

*See* also references under "Metamorphism" in the Index.

BIBLIOGRAPHY.—The subject of metamorphism is treated in most elementary textbooks of petrology (*see* PETROLOGY: *Bibliography*). Principal works on the subject include T. F. W. Barth, C. W. Correns and P. Eskola, *Die Entstehung der Gesteine* (1939); U. Grubenmann and P. Niggli, *Die Gesteinmetamorphose* (1924); A. Harker, *Metamorphism* (1932); C. R. van Hise, "A Treatise on Metamorphism," U.S. Geological Survey *Monograph 47* (1904); P. Laffitte, *Introduction à l'étude des Roches Métamorphiques* (1957); H. Ramberg, *The Origin of Metamorphic and Metasomatic Rocks* (1952); E. Turner, "Evolution of the Metamorphic Rocks," Geological Society of America *Memoir 30* (1948). (H. RG.)

**METAMORPHOSIS,** in biology, refers generally to a striking change of shape or structure within a relatively short period of time, particularly a transition from one developmental stage to another, as in insects and amphibia. The term is also applied to the factor of change or transformation in general: *e.g.*, tissue, fatty, retrogressive, revisionary and ovulational metamorphoses. Every organism exhibits changes of form throughout its life, from fertilization of the egg through postembryonic development and into adult life. Some of these changes are affected by environmental influences such as diet and temperature; others are part of the normal pattern of development and remain under genetic and hormonal control. Among these changes are those related to sexual maturity (puberty) and aging (senescence). W. Etkin has interpreted metamorphosis as "a definitely delimited period in postembryonic development during which marked developmental changes in nonreproductive structures occur." Determination of what constitutes the actual period of metamorphosis is to a certain extent arbitrary. Intergrades may occur in the transitional states of pre- and postmetamorphosis. Physical changes occurring in organisms are often paralleled by profound alteration of their physiology, biochemistry and behaviour, and these factors must be considered an integral part of metamorphosis.

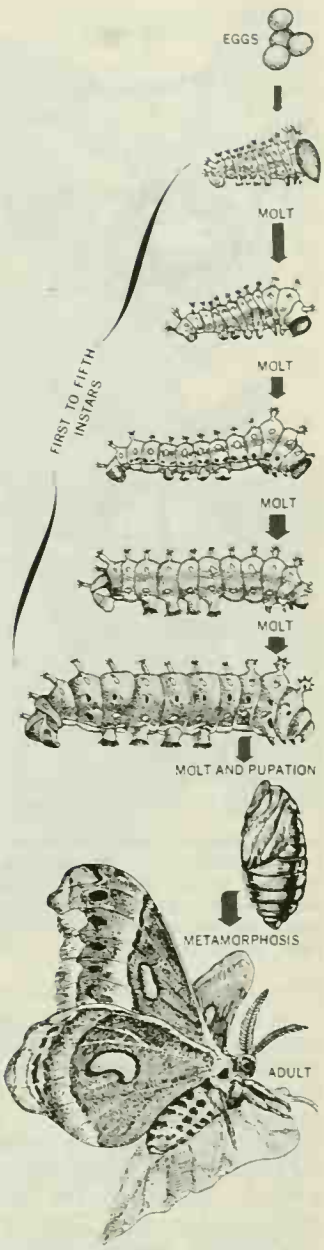
The insect larva and the frog tadpole are adapted to environments and modes of life that differ radically from those of the adult forms. These differences may be of significance in assuring that the juveniles and adults of the same species do not engage in direct competition for food, living space, etc. It is clearly apparent that the process of metamorphosis has developed during the course of evolution as a result of the selective advantage it offers to those animals possessing such patterns of development and differentiation.

## INVERTEBRATES

**Insects.**—Among the most dramatic and most thoroughly studied metamorphoses are those of insects. Since development is not the same in all insects, it is convenient to group the orders into major categories according to the pattern of structural changes, as ametabolous, hemimetabolous and holometabolous. Ametabolous development means no metamorphosis, but simply a gradual increase in size of young till adult dimensions are attained; this kind of development occurs in the Apterygota, which includes the orders Thysanura (silverfish), Collembola (springtails) and other primitive insects.

In more advanced insect orders such as the Orthoptera (grasshoppers, etc.), Isoptera (termites) and Hemiptera (true bugs) a phenomenon known as gradual or hemimetabolous metamorphosis takes place. The larvae differ from the adults (imagoes) in size, body proportion and often in colour pattern; no resting pupal stages occur. The grasshopper may be taken as an example. The newly hatched grasshopper larva (nymph) differs from the adult in proportion and in being wingless. The nymph then passes through four additional nymphal stages, each one preceded by a molt (ecdysis), during which growth occurs, wings appear and adult body proportions are gradually assumed. Following the fifth or terminal molt the adult grasshopper emerges.

Complete or holometabolous metamorphosis is characteristic of the highest orders of insects: Coleoptera (beetles), Lepidoptera (butterflies, moths), Diptera (true flies) and Hymenoptera (bees, wasps). In the common housefly the egg develops into a larva (maggot) whose larval skin hardens and darkens to form a puparium surrounding the pupa from which latter finally emerges the adult. The larva or caterpillar of the cecropia or giant silkworm moth (*Hyalophora* or *Platysamia cecropia*) grows successively through each of four larval molts with little change in form. During each molt the epidermal cells secrete a new larval cuticle under the old; the old cuticle then loses its attachment to the epidermis and is shed. At the fifth molt, which occurs within the cocoon, the animal is a pupa (chrysalis) enclosed by the heavy, brown cuticle of epidermal origin. The formation of the pupa is accompanied by a simultaneous destruction of most of the larval tissues. At the sixth or terminal molt a scaly cuticle is secreted as the animal emerges from the pupa as the adult. The pupal and adult molts comprise the actual metamorphic periods of holometabolous insects.




FROM C. D. TURNER, "GENERAL ENDOCRINOLOGY", REPRODUCED BY PERMISSION OF W. B. SAUNDERS CO.

FIG. 1.—GIANT SILKWORM MOTH, OR CECROPIA MOTH, WHICH PROVIDES AN EXAMPLE OF HOLOMETABOLOUS OR INDIRECT DEVELOPMENT IN WHICH THE LAST LARVAL INSTAR PASSES THROUGH A PUPAL STAGE BEFORE METAMORPHOSING INTO THE ADULT

In the South American bloodsucking bug *Rhodnius prolixis*, a hemimetabolous form, V. B. Wigglesworth has shown that each of the five molts is conditioned by a hormone secreted by the prothoracic gland, an organ located in the insect's thorax. At a certain time (critical period) after feeding the brain liberates a hormone that stimulates the secretory activity of the prothoracic gland. This activity not only induces molting but also elicits differentiation into the adult stage. However, in all but the fifth molt *Rhodnius* fails to assume complete adult characteristics because of the inhibitory action of another hormone, secreted by the corpora allata, a pair of small glands in the posterior region of the head. Since this hormone prevents assumption of adult structures during larval development, it has been termed the juvenile hormone.

Experiments on *Rhodnius* indicate that younger stages produce both juvenile and molting hormones, while at the time of final

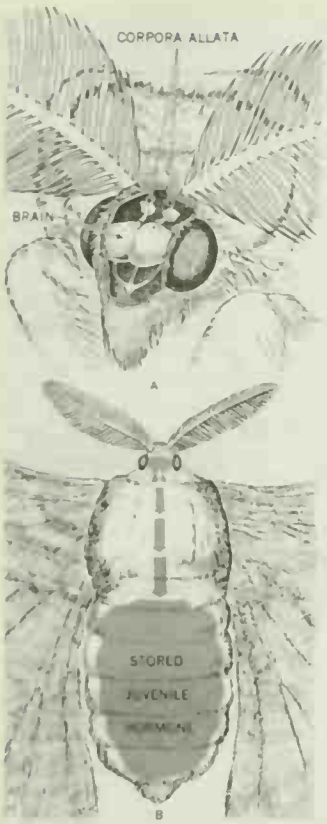



FIG. 2.—JUVENILE HORMONE IN CECROPIA MOTH. (A) BRAIN AND CORPORA ALLATA SHOWN IN CUTAWAY VIEWS. (B) JUVENILE HORMONE, SECRETED BY CORPORA ALLATA, STORED IN ABDOMEN

molt, the corpora allata have greatly reduced activity, allowing prothoracic-gland secretions to exert their full effect. When the larva is completely developed, the corpora allata no longer secrete juvenile hormone.

Mechanisms controlling metamorphosis in holometabolous insects are similar to those of *Rhodnius*. C. M. Williams has shown that in the larvae of the cecropia moth, brain and prothoracic-gland hormones promote molting, whereas juvenile hormone influences formation of larval cuticle. By the fifth molt the amount of juvenile hormone has diminished and the pupal cuticle is formed. Owing to inactivity of the corpora allata during the pupal stage, the final molt occurs in the absence of the juvenile hormone, resulting in formation of the adult. These animals pass the winter as pupae in a stage of greatly reduced activity (diapause), and the pupae will not undergo the adult molt unless subjected to cold temperatures for several weeks. The same brain–prothoracic-gland mechanism that regulates molting is involved in the termination of diapause. Diapause ends when cold temperatures stimulate the brain to secrete prothoracic-gland hormone, initiating the final step in metamorphosis.

As already indicated, the brain hormone is neurosecretory in origin. An active principle called ecdysone has been isolated and crystallized from the prothoracic-gland hormone from pupal and adult cecropia moths. The active principle of the juvenile hormone has been obtained from extracts of the abdomens of male cecropia moths where it accumulates in considerable quantity; the corpora allata secrete this hormone, the abdomen being merely a depot. Surprisingly, the female abdomen contains only a trace of juvenile hormone. These extracts are not species-specific since they produce juvenile effects when injected into the pre-adult stages of even beetles, roaches and bugs. (Extracts bearing juvenile hormonal activity have also been isolated from such animal groups as cattle, hydroids, annelid worms and sea cucumbers.)

Metamorphosis in most insects is probably similar to that described for *Rhodnius* and the cecropia moth, but in flies (Diptera) metamorphosis is regulated by a compound organ, the ring gland.

**Other Invertebrates.**—Starfishes and other echinoderms undergo a striking metamorphosis that includes a change from the larval bilateral symmetry to the adult radial symmetry (*see* ECHINODERMATA). Metamorphic patterns are also well known in crabs, lobsters and other crustaceans (*see* CRUSTACEA); and in snails, clams and other mollusks (*see* MOLLUSK). *See* also INVERTEBRATE EMBRYOLOGY; HORMONES, INVERTEBRATE.

## LOWER CHORDATES

The larval form of many urochordates (tunicates or sea squirts; relatives of vertebrates) is a tadpolelike free-swimming organism with a tail, tunic, median eye, pigmented otolith (ear) and mucous, adhesive glands in addition to the common chordate characteristics. On hatching, the larva, after a brief period of swimming, attaches by its adhesive glands to wharf pilings, rocks, etc., below lowest tide level. Within a few days or even hours it transforms rapidly into a sessile, saclike form (retrograde metamorphosis) bearing little resemblance to the larva, even losing the chordate characters except for the pharyngeal slits. Finally the gonads and their ducts develop. (*See* TUNICATA.)

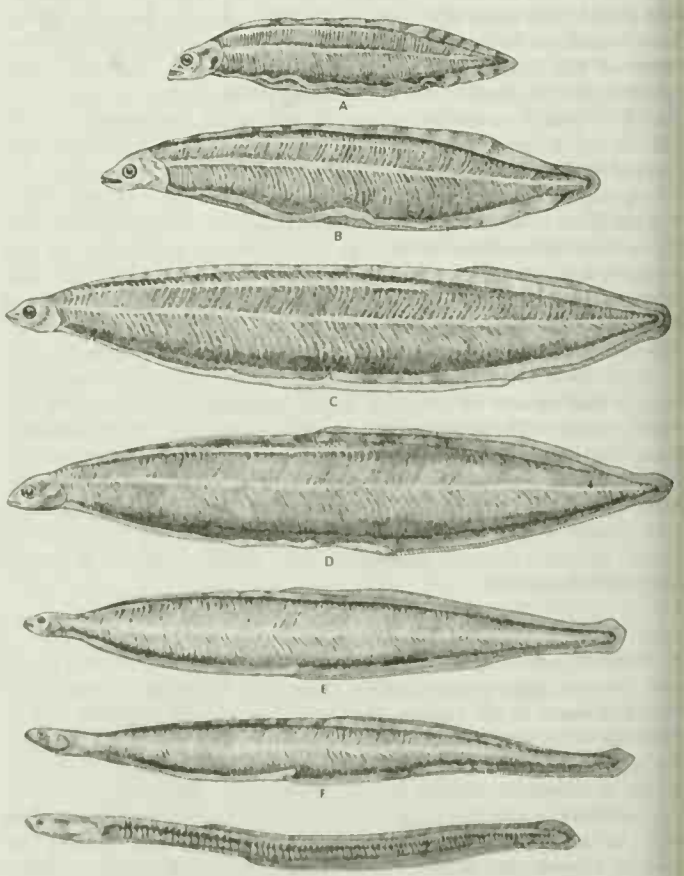
The eggs of some hemichordates develop into small, transparent ovoid larvae that resemble closely the larvae of certain echinoderms in having a simple digestive tract, characteristic shape and bands of cilia. At metamorphosis the proboscis and collar of the adult appear.

## VERTEBRATES

**Cyclostomes.**—The most primitive living vertebrates are the jawless and limbless cyclostomes, such as the lampreys. Lampreys, whether landlocked or free to move between salt and fresh water, lay their eggs in flowing streams where development takes place. The blind larva, called an ammocoete, burrows into the mud and sand of streams, feeding on organic ooze. After several years the larva then undergoes a marked metamorphosis into the adult, and migrates to the sea or lake. After a year or more the adult undergoes a secondary metamorphosis (*see* below) with the attainment of sexual maturity—gonads mature and secondary sexual characteristics appear. Migration upstream to the spawning grounds then occurs. (*See* CYCLOSTOME.)

**Fishes.**—Metamorphosis is encountered in several fishes. In flounders the young fish is bilaterally symmetrical, but in a short time this symmetry is disrupted by the migration of one eye to what will become the upperside of the bottom-dwelling adult, and the mouth and fins become distorted (*see* FLATFISH). Eels hatch from eggs laid in the Sargasso sea and pass through a marine larval stage known as the leptocephalus in which the animals are transparent; the larvae migrate to fresh water where they metamorphose to the elver stage and with continued growth and development become adults, undergoing a secondary metamorphosis (*see* below) before returning to their marine spawning grounds. (*See* EEL.)

**Amphibians.**—The embryo of the frog develops from the




BY COURTESY OF DEPARTMENT OF FISHERIES, QUEBEC

FIG. 3.—METAMORPHOSIS OF THE AMERICAN EEL: (A–C) LARVAE OR LEPTOCEPHALI OF VARIOUS SIZES, (D–F) LARVAE IN THE PROCESS OF METAMORPHOSIS, (G) GLASS EEL, MATURE STAGE

pigmented fertilized egg. At the time of hatching external gills are present, as well as prominent suckers for attachment to water plants, rocks, etc. After six days of development, when the young is about 10 mm. in length, it is termed a larva. The tail is broad and translucent, branched gills are present, the cornea of the eye is transparent, nasal pits are prominent and horny teeth are developing. The larva then attains "tadpole" appearance as the suckers are absorbed and a fold of the skin, the operculum, begins to grow backward over the external gills to form a gill chamber. Internal body organs, particularly the coiled intestine, become visible through the transparent ventral body wall.

As in many other frogs and toads, the tadpole of the wood frog (*Rana sylvatica*) grows for several months, after which it ceases to feed and then metamorphoses. The hormone thyroxin, from the thyroid gland, induces this transformation. If the thyroid gland is removed from the embryo in the late tail-bud stage, metamorphosis fails to occur, and growth continues until the death of the "giant" tadpole. Starvation will also inhibit the onset of metamorphosis. Precocious metamorphosis follows when the young tadpole has been fed for several days with extracts of the thyroid gland or the dried gland itself, or when it has been immersed in water containing the hormone. Reimplantation of the embryonic thyroid primordium elsewhere in the body of a tadpole that has been deprived of its thyroid (thyroidectomized) will bring about metamorphosis as the transplanted tissue differentiates. Thyroids from tadpoles in late metamorphosis will induce this precocious metamorphosis, whereas those from premetamorphic tadpoles will not. Strong doses of the thyroid gland or of its hormone disrupt the pattern of this change and usually result in death. Some of the more conspicuous metamorphic changes in the wood frog include: resorption of the tail; emergence of limbs; changes in the form of the head; transformation of the mouth; loss of gills, with the acquisition of lungs; changes in body proportions; shortening of the intestine, with change of diet; and development of the eyes. The horny teeth and beak, together with the fleshy mouth parts, disappear; the mouth widens quickly to the adult condition. Sexual maturity and full body size are attained in four years. The time required to attain metamorphosis varies: four months for the European frog *Rana temporaria*, more than a year for the American leopard frog and more than two years for certain bullfrogs; some toads metamorphose at four to six weeks.

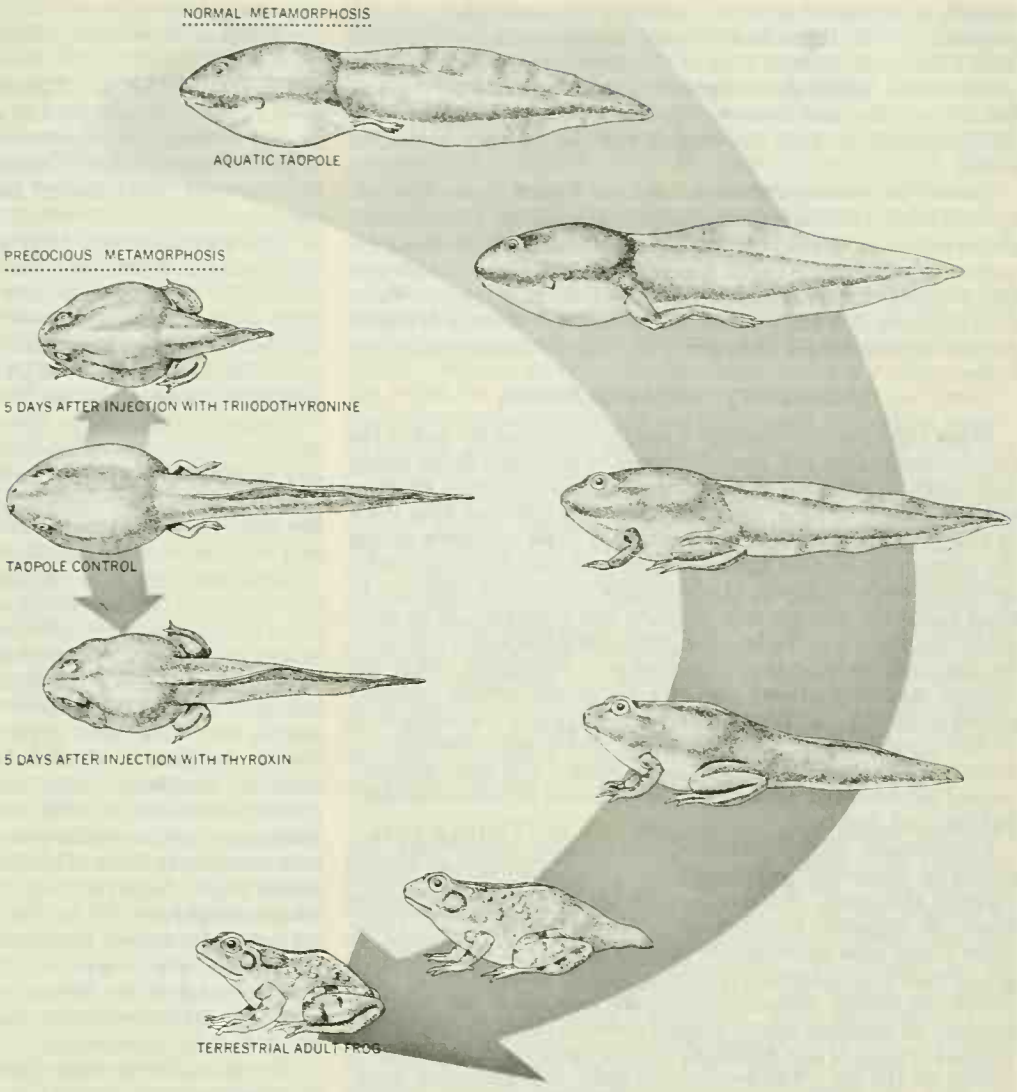



FIG. 4.—METAMORPHOSIS IN THE FROG: AT RIGHT, THE LATER STAGES OF SPONTANEOUS METAMORPHOSIS IN THE SOUTHERN BULLFROG, WHICH CAN TAKE UP TO 15 MONTHS IN ALL; AT LEFT, PRECOCIOUS METAMORPHOSIS OF A FLORIDA SWAMP FROG TADPOLE, INDUCED BY TREATING THE TADPOLE WITH THYROID HORMONES

Secretory activity of the thyroid gland is closely correlated with the rate of metamorphic change in the frog, the gland being most active at the climax of metamorphosis, then quickly diminishing thereafter to the state characterizing the premetamorphic gland. Goitrogenic compounds like thiouracil inhibit the formation and release of thyroxin. On the other hand administration of iodine induces precocious metamorphosis even in the absence of the thyroid, and lack of iodine prevents metamorphosis. Where in the body this induction takes place is not known. It has been shown, however, that proteins can be iodized in vitro (outside the body) to yield thyro-active substances.

Some amphibians fail to develop a free-swimming larval stage. In the African toad *Arthroleptella bicolor villiersi* and the Jamaican tree toad *Eleutherodactylus nubicola* no metamorphic changes occur, and development proceeds gradually from egg to young frog. But even in these forms thyroid activation parallels the gradual changes in structure.

Certain salamanders retain the larval features—external gills, tail, etc.—throughout their aquatic existence (arrested metamorphosis) but develop genital organs and eventually reproduce. The Mexican axolotl (*Ambystoma mexicanum*) and the common mud puppy (*Necturus maculosus*) are examples of these permanently larval (neotenous) forms. The tissues of these neotenous salamanders are relatively insensitive to thyroxin, yet the thyroid and pituitary glands do contain hormones. It is possible to induce some degree of metamorphosis in *Necturus*, but such individuals soon die. The axolotl has been observed to metamorphose in captivity and has been induced experimentally to assume adult form. In nature the thyroid of the axolotl produces hormone but apparently does not release it.

Removal of the hypophysis (pituitary gland) in the frog embryo or tadpole likewise prevents metamorphosis. Development of the

thyroid is depressed since it functions adequately only in the presence of the thyroid-stimulating hormone (thyrotrophin or TSH) from the anterior lobe of the hypophysis. Thyrotrophin alone will not induce metamorphosis in the absence of the thyroid, but thyrotrophin and thyroxin together are effective in provoking metamorphosis in both the normal and the hypophysectomized larvae.

Among the salamanders of the eastern United States the red-spotted newt (*Diemictylus v. viridescens*) has an aquatic larva characterized by green pigmentation, gills and a tail flattened for swimming. During its initial metamorphosis the larva transforms into a bright orange, terrestrial creature called the red eft, which has rough, dry skin and inhabits the forest floor. After a period of growth this salamander undergoes a secondary metamorphosis (*see* below).

### SECONDARY METAMORPHOSIS

Many organisms that undergo a metamorphosis at the end of the larval stage endure still another change in form and living conditions when, at the time of spawning, they leave the adult environment to return to their place of birth. Changes that take place at this time are essentially the reverse of those occurring during the primary or original metamorphosis and may be considered a secondary metamorphosis, of which there are varying degrees. In some forms the changes may be slight and transitory, as in adult toads that migrate to the breeding ponds for a few days every year. In other animals, as in the red-spotted newt mentioned earlier, the changes may be profound and of a permanent nature. After a period of growth, this newt undergoes a secondary metamorphosis to the aquatic adult, which possesses the green pigmentation, smooth skin and the tail of the larval form. The gills, however, are not reconstituted, and the animal continues to breathe through its lungs and skin.

Physiological and biochemical events also characterize the period of secondary metamorphosis. For example, the retinal pigment rhodopsin, characteristic of land animals and marine fishes, is replaced by porphyropsin, characteristic of fresh-water forms such as amphibian larvae. The larva excretes nitrogen primarily as ammonia, while the red eft excretes urea. Following secondary metamorphosis the percentage of nitrogen excreted as ammonia rises—a trend towards the larval condition. Thyroid activity is also depressed in the aquatic form, as compared to that of the eft. The events associated with secondary metamorphosis are triggered by a prolactinlike hormone of anterior-pituitary origin.

Sea lampreys migrating toward the sea have rhodopsin in their visual pigment, while those migrating toward the streams have porphyropsin.

Before returning to the spawning grounds in the Sargasso sea the European eels undergo a secondary metamorphosis. The digestive system degenerates, pigment changes take place and the eye doubles in diameter. The visual system replaces its fresh-water porphyropsin with a special deep-sea rhodopsin.

*See* also references under "Metamorphosis" in the Index.

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**METAPHOR,** a figure of speech, which consists in the transference to one object of an attribute or name that strictly and literally is not applicable to it, but only figuratively and by analogy. It is thus in essence an emphatic comparison, which if expressed formally is a simile; thus it is a metaphor when Rochester writes "Dead, we become the lumber of the world" and a simile when Dryden writes, "Errors, like straws, upon the surface flow." *See* FIGURES OF SPEECH: *Metaphor, Simile and Kindred Figures.* (G. W. A.)

**METAPHYSICS.** The term "metaphysics" derives from the title posthumously given to a treatise that Aristotle wrote after he had written the *Physics*. According to one view, this title originally meant simply "written subsequently to the *Physics*." But the word "metaphysics" then came to be used as a label for the sorts of topics dealt with in Aristotle's *Metaphysics*, or rather, as these topics are very heterogeneous, for the topics in it which have seemed most important. At some times it has been Aristotle's "theology" that has seemed most important; at other times his discussions of such notions as those of substance, essence, accident, form, matter, actuality and potentiality. Aristotle himself called his subject "first philosophy" and said that its central topic was "being *qua* being."

Whatever may be the historical origin of the term, "metaphysics" has always connoted some antithesis between physical and nonphysical inquiries. John Stuart Mill sometimes called empirical psychology "metaphysics," to contrast the science of the mental with the sciences of the physical. But the main tradition has been to use "metaphysics" as a title for philosophical as distinct from scientific or experimental inquiries. Sometimes "metaphysics" has been used just to mean what is meant in modern times by "philosophy." But more often it is used to denote one branch of philosophy, as distinct from moral philosophy, political philosophy, aesthetics and logic and, less regularly, from epistemology. Even so the contrast with physical inquiries has been a shifting one. We think of physics as a natural science, the theoretical structure of which is intrinsically connected with the results of experiments and observations. But in his *Physics* Aristotle combines a little discussion of factual, for instance mechanical, matters with a great deal of philosophical discussion of such concepts as those of motion, space and time. So whereas we should regard Kepler's study of the motions of the planets as belonging to physics and exclude from physics Zeno's purely logical arguments against the possibility of motion, Aristotle included in his *Physics* a protracted discussion of Zeno's paradoxes, with the result that we are inclined to say that Aristotle's *Physics* contains very little physics but a great deal of philosophy of physics and even some metaphysics.

The contrast between philosophy and science, or between philosophers and scientists, is itself of late origin. The word "scientist" was first coined in 1840. Before then and for some time afterward, "philosopher" was the title both for a Plato and for an Archimedes, both for a Newton or a Harvey and for a Locke or a Butler. To distinguish them it was necessary to call Sir Isaac Newton, say, a "natural philosopher," Butler a "moral philosopher" and Plato a "metaphysical philosopher." As late as 1887 scientific implements like test tubes, retorts and Bunsen burners could still be described in popular literature as "philosophical instruments."

Before this distinction between philosophers and scientists was clearly drawn, first of all by Kant, there was no easy way of distinguishing even philosophy of physics from physical science, much less of distinguishing metaphysical philosophy from natural science. There has been, however, the general though not universal practice of reserving the title "metaphysics" for inquiries or speculations which, unlike those sponsored by the Royal society, claim to rest not on premisses established by observation and experiment but on *a priori* grounds or grounds of pure reason.

Thus arguments for the existence of a first cause or of a Creator and Controller of the Universe and arguments for the existence in man of an immortal soul were typical examples of nonempirical, metaphysical arguments. Indeed theological philosophy in general, or natural theology, has always constituted a large part of what has been derided and championed as "metaphysics." Kant rightly identified the permanent problems of metaphysics with those of God, freedom and immortality. Other theories or speculations, however, would also be classed as metaphysical, though they have been connected less closely with the bases of theology than with the bases of the natural sciences, namely cosmological

theories like Democritus' theory of atoms, Descartes' theory of extension and vortexes and Leibniz' theory of monads. The quasi-biological theory of a life force and the abandoned theory of ether (in physics) would be further candidates for the title "metaphysical." For all these theories, with many others of the same general type, essentially contain assertions of the existence of natural or supernatural agencies inaccessible to direct observation and even to indirect experimental tests. Their existence was supposed to be established by pure reason.

In line with this tradition we might distinguish metaphysical from other philosophical arguments, like those of ethics and logic, by saying that the former do, where the latter do not, claim to establish by pure reason truths of existence. This is what characterizes philosophers' attempts to demonstrate the being and the nature of a first cause; of a reality behind all appearances; of a necessary being other than contingent beings; of an infinite beyond everything finite; of something immutable beneath all that changes; of something unconditioned, other than, or else within, the things and happenings the being of which is dependent on, or conditioned by, other things and happenings. Plato's "forms," Spinoza's God, Leibniz' monads, Kant's things-in-themselves and F. H. Bradley's Absolute are famous instances of entities supposedly disclosed by nonempirical or philosophical reasoning.

Metaphysical arguments, as so defined, have been accused, since Hume and Kant, of being fallacious. Pure reason (*i.e.*, reasoning from nonempirical premisses) cannot prove the existence of anything. Matters of fact, including supernatural matters of fact, cannot be deduced from nonfactual or purely conceptual premisses. Existence is not a property or attribute and cannot therefore be a defining property or attribute of anything. From no description can it follow that there exists something satisfying that description. The negation of an assertion of existence cannot be self-contradictory, so *a priori* reasoning cannot prove, though it can sometimes disprove, statements to the effect that there exists something of a certain description. Consequently metaphysics, if it claims to be or to contain a body of truths of existence, established *a priori*, is impossible. So far as this destructive argument goes, it might still be a part of the proper business of philosophers to explore, for example, the cardinal concepts of theology, and such a conceptual investigation might be called "metaphysical" in a less rigorous use of this term. But it would remain the case that such an investigation would be unable to prove, for instance, the existence of God or the immortality of the soul, just as neither Zenonian nor anti-Zenonian arguments, conceptually clarifying though they may be, can possibly prove that anything is actually in motion, or is actually stationary.

In the 1930s an even more radical polemic against metaphysics was waged by the members of the famous Vienna circle. This was a group of thinkers, mostly scientists and mathematicians, who met regularly, under the leadership of Moritz Schlick, to discuss the foundations of mathematics and natural science. As a group they combined the general outlook of Ernst Mach with the logic of Bertrand Russell and A. N. Whitehead. They were also powerfully influenced by Ludwig Wittgenstein, who was not, however, himself a member of the circle. These logical positivists, as they are often called, followed Mach in wanting to banish metaphysical theories and speculations from the sciences, but they took from Russell and especially from Wittgenstein a weapon more potent than any wielded by Mach. They took over from Russell the notion of the nonsensical and from Wittgenstein the notion of a general criterion between sense and nonsense. Their criterion was the principle of verifiability. A proposition, other than an analytic proposition, is significant if it can in principle be empirically verified or falsified. Otherwise it is nonsense. "The meaning of a proposition is the method of its verification." Metaphysical questions are therefore not merely unanswerable, as earlier challengers had maintained; they are unaskable. The nonempirical terms which they contain express no genuine concepts.

The original unmitigated principle of verifiability was soon seen to exclude too much. It had been intended to exclude primarily a certain class of pseudo-scientific speculations proffered by philosophers as solutions of very general theoretical problems in the physical, biological, social and psychological sciences. It was expected also to exclude certain sorts of near-theological speculations, together with certain sorts of very sweeping philosophical views, such as those of Hegel, Husserl and Bergson. But as originally formulated it threatened to ostracize as well ordinary moral political and aesthetic discourse, together, less certainly, with most philosophical discourse, even of quite unmetaphysical kinds. Worst of all it seemed to reduce to nonsense the scientists' own statements of natural laws and their formulations of the theoretical principles of their sciences. For these too are not conclusively verifiable or falsifiable by any finite set of experiments.

The criterion of empirical verifiability or falsifiability had therefore to be made more tolerant, with the result that the epithet "metaphysical," defined as meaning "not amenable to scientific checks," became correspondingly vaguer and less abusive. But the wheel has not turned full circle. Certain sorts of pseudo-scientific speculations are now relatively easily exposed as fraudulent; and philosophers are less inclined to try to solve by philosophical reasonings cardinal problems in scientific theory. Nor, on their other flank, are they so ready to try to construct *a priori* proofs of the existence of God and the immortality of the soul. *A priori* cosmology and *a priori* theology are both suspect, and the term "metaphysics" is widely, though not universally, treated either as a redundant synonym of "philosophy" or else as a valedictory label for those suspect philosophical enterprises. Doubtless some of the intellectual motives which generated those *a priori* cosmologies and theologies will, in due course, generate other patterns of synoptic world-views. The word "metaphysics" may then, if the hankering for labels survives, come back into ordinary or pedagogic use with yet another signification.

*See* also references under "Metaphysics" in the Index.

(G. R.)

**METAPONTUM** (Gr. METAPONTION), an ancient Greek city in Italy on the Gulf of Tarentum, near the mouth of the Bradanus (Bradano) river, about 24 mi. from Tarentum (Taranto) near the modern railway junction of Metaponto. It was founded by an Achaean colony from Sybaris and Crotona about 700 B.C. Pythagoras died at Metapontum in 497. Its support of the Athenian expedition to Sicily (415–413) was trifling. In 332 it allied itself with Alexander I of Epirus. After the battle of Cannae (216) it declared in favour of Hannibal and after the defeat of Hasdrubal at the Metaurus (207) the inhabitants of Metapontum followed Hannibal in his retreat. From this time the city sank.

At Metapontum are the remains of two temples, both dating from 510–480 B.C. The foundations only are left of one, which was probably dedicated to Apollo Lycius and was a peripteros, decorated with finely painted terra-cottas. Of the other temple, the so-called Tavole Paladine, outside the area of the ancient city, a peripteros with 6 columns in front and 12 at the sides, 15 columns are standing, with the lower part of the epistyle. There are also traces of the town walls. An archaic treasure house dedicated at Olympia by the people of Metapontum has been discovered there.

**METASOMATISM,** in petrology, refers to processes capable of changing the bulk chemical composition of solid rocks. In metasomatism substances are introduced into the rock from outside sources, and other substances are removed. The mechanism of this transfer of chemical substances through the solid rocks is complex and as yet only incompletely understood, leaving room for several schools of thought among petrologists. In some instances the mineral-building substances have been carried in fluid solutions soaking through rocks, in other cases vapours have operated, or matter has migrated through rocks as individual ions, atoms or molecules, partly through the mineral structures (volume diffusion), partly along surfaces and interfaces.

When the source of introduced material in metasomatism is a magma the process is known as contact metasomatism. Volatile substances which become enriched in residual magmas during fractional crystallization are forced into adjacent rocks to cause metasomatic alteration.

However, more commonly metasomatic alteration of rocks has

taken place without detectable magmatic source of the introduced material. This is particularly true in regional metamorphic terrains; here metasomatic change of chemical composition of rocks is frequently associated with metamorphic recrystallization and neomineralization. Although some petrologists prefer hypotheses that make a magma responsible for all metasomatic alterations, there is strong evidence that this is not so. Not only are magmatic bodies absent in many intensively altered rock complexes, but the introduced material is often of a nature inconsistent with magmatic residual solutions, or the temperature during the alteration has been too low to permit magmatic melts to operate.

**Sources of Introduced Material.**—Two kinds of sources have been suggested for introduced material in nonmagmatic metasomatism. One of these is a deep-seated source of unknown nature, which becomes activated during various kinds of tectonic, or structural, deformations, and releases mineral-making substances which migrate upward and alter the superincumbent rocks. The alteration is selective, occurring only at certain combinations of rock types and structural situations. The second kind of source is disseminated throughout in the surrounding solid rocks or localized in a limited region in these. Minerals rendered unstable during changing pressure-temperature conditions could represent such sources. When newly stabilized minerals form at the cost of unstable ones, all the original constituents cannot always be accommodated in the new mineral assemblage. Such superfluous constituents tend to migrate from the altered rocks—which are chemically open systems—and may function as sources for metasomatic alteration elsewhere.

Minerals are less stable (*i.e.*, have higher chemical potential) under high compressive stress than under tension or low compressive stress (*see* METAMORPHISM: *Riecke's Principle and Force of Crystallization*). Consequently, regions where high compressive stress has accumulated in a rock complex generally act as sources, and regions of tensile or low compressive stress act as sinks or receptacles for migrating rock-making matter in metasomatism. Many mineral veins such as quartz veins, pegmatite veins, some ore veins, calcite veins, etc., in regional metamorphic terrain have formed in this manner (*see* also ORE DEPOSITS). The vein-forming minerals have grown by metasomatic activity at sites where compression has been exceptionally low or tension high. Sites of this kind are often called pressure shadows.

**Methods of Fixation.**—The mechanism by which introduced material becomes fixed in altered rocks is at times a simple chemical interaction between old minerals and introduced matter. Examples: (1) muscovitization of sillimanite and quartz:

$$\underset{\text{sillimanite}}{3Al_2SiO_5} + \underset{\text{quartz}}{3SiO_2} + \underset{\text{introduced}}{K_2O} + H_2O \rightarrow \underset{\text{muscovite}}{2KAl_3Si_3O_{10}(OH)_2}$$

(2) biotitization of hornblende:

$$\underset{\text{hornblende}}{Ca_2Fe_4Al_2Si_7O_{22}(OH)_2} + Al_2O_3 + \underset{\text{introduced}}{K_2O} + H_2O \rightarrow$$

$$2KFe_2Al_2Si_3O_{10}(OH)_2 + SiO_2 + 2CaO$$
$$\underset{\text{biotite}}{} \quad \underset{\text{enter other minerals or escape}}{}$$

(3) dolomitization of calcite:

$$\underset{\text{calcite}}{2CaCO_3} + \underset{\text{introduced}}{MgO} \rightarrow \underset{\text{dolomite}}{CaMgC_2O_6} + \underset{\text{released and removed}}{CaO}$$

In other instances fixation of introduced material is not related to chemical reactions because the old minerals and newly formed ones have no chemical constituents in common, as for example when galena, PbS, replaces limestone, $CaCO_3$. The reason for such fixation of introduced mineral-making matter may be that nucleation is affected by the type of pre-existing minerals. Minerals do not precipitate out of a fluid solution unless the solution is somewhat supersaturated, the magnitude of needed supersaturation depending on the type of pre-existing minerals which function as nucleation sites.

Minerals introduced in a rock may grow in open space such as cracks and fissures, they may cause an expansion of the rock body, or they may replace the old minerals in a volume for volume fashion. In constant-volume replacement, old structures such as banding, etc., may persist as relics in the altered rock. It is clear that this must mean much removal of material from the rock. Material removed from an altered rock may become fixed in other rocks and cause metasomatic alteration there, as when for example basification is associated with granitization. Granitization is a term applied to the sum of complex processes by which various kinds of rocks become more or less granitic in composition without going through a liquid state. Potash, soda and silica are most frequently introduced in granitization, with microcline, sodic plagioclase and micas being the common newly formed minerals. If the original rock was basic, *i.e.*, rich in such constituents as CaO, MgO and FeO, these elements must move out of the theatre of granitization. In some cases, but by no means always, the released basic constituents have become fixed in adjacent rocks, which thereby are rendered even more basic than originally. This phenomenon is called basification. Granitization, with or without associated basification, has affected vast rock-complexes in fold-mountain zones. Thus large parts of the Pre-Cambrian shield areas (the Fennoscandian, or Baltic, shield, the Canadian-Greenland shield, etc.) consist of rocks granitized through several periods of Pre-Cambrian mountain folding.

**Examples of Rocks.**—Recognized examples of metasomatically formed rocks are dolomitized limestone, silicified limestone and dolomite, several kinds of ore bodies in limestone, certain granitized schists such as some augen-gneisses, tourmalinized schists (boron metasomatism) and scapolitized rocks. There are, however, numerous rocks and mineral occurrences which some petrologists would classify as metasomatic, others as magmatic or mere metamorphic without change of chemical composition.

For further discussion of the mineralogical and petrological processes referred to above *see* also GEOCHEMISTRY; MINERALOGY; PETROLOGY; VOLCANISM. *See* also METAMORPHISM. (H. RG.)

**METASTASIO, PIETRO** (originally PIETRO ANTONIO DOMENICO BONAVENTURA TRAPASSI) (1698–1782), Italian poet and the most celebrated librettist in Europe writing during the 18th century for the *opera seria*, was born in Rome on Jan. 3, 1698. His father, Felice Trapassi, a native of Assisi, kept a grocer's shop, and as a boy Pietro was apprenticed to a goldsmith. In 1708, however, his astonishing skill in verse improvization attracted the attention of the learned Gian Vincenzo Gravina, a man of letters, who made him his heir adoptive and hellenized his name from the prosaic Trapassi into "Metastasio." In 1712, after receiving a good education from Gravina, Metastasio was taken to Scalèa in Calabria where he studied for some months with Gregorio Caloprese, the Cartesian philosopher. At the age of 14 he wrote *Giustino*, a tragedy in the Senecan style; and in 1717 he published a book of verses. In Jan. 1718 Gravina died; three months later Metastasio entered the Accademia degli Arcadi (*see* ITALIAN LITERATURE); and in 1719 he left Rome for Naples where he took employment in a lawyer's office and entered aristocratic circles as the mellifluous author of voluptuous epithalamia.

In honour of the birthday of the empress of Austria Metastasio composed *Gli Orti Esperidi* (1721), a serenata in which the principal role was taken by Marianna Benti-Bulgarelli (1684–1734). This prima donna, La Romanina as she was called, became enamoured of the poet. In her *salon* Metastasio formed his lifelong friendship with the *castrato* Farinelli; and through La Romanina he also became acquainted with composers, such as Niccolò Porpora (from whom he took music lessons), Domenico Sarro, J. A. Hasse and Leonardo Vinci, who were later to set his works to music. In this environment Metastasio's success was assured; and at the request of La Romanina he gave up the law and composed his first *melodramma*, a lyric tragedy in three acts on the conflict of love and duty, called *Didone abbandonata* (1723, first performance 1724). *Didone* was followed, between 1726 and 1730, by *Siroe*, *Catone in Utica*, *Ezio*, *Semiramide riconosciuta*, *Alessandro nell'Indie* and *Artaserse*. In the meantime, on the recommendation of his friend and patroness Marianna Pignatelli, countess of Althann, Metastasio received an invitation (1729) from the emperor of Austria. And in March 1730 he set out for Vienna where he

lived until the end of his life, as poet laureate to the imperial court in succession to Apostolo Zeno.

During the reign of Charles VI Metastasio wrote cantatas, oratorios and 11 *melodrammi*, some of the best of which—*Demetrio, L'Olimpiade, Demofoonte, La clemenza di Tito* and *Attilio Regolo* —were performed as plays in their own right as well as set to music by practically every composer from Pergolesi to Mozart. After 1740, however, with the accession of Maria Theresa, Metastasio was not quite so well placed. Until 1771 he was extremely productive and his work was always honoured. But the empress did not permit the same lavish expenditure on operatic spectacles as her predecessor and in any case Metastasio's talents gradually went into decline. With the rise of the *opera bufa*, moreover, and the growth of the German manner, a new type of libretto came into use; and with the spread of romanticism at the end of the century Metastasio's works even fell into disrepute.

Metastasio's *melodrammi* (1723–71), 26 in number, show the influence of the classical theatre on operatic dramaturgy. A staunch supporter of orthodoxy in all its forms, he chose for preference themes typical of the French theatre in the 17th century. And in each of his works he aspired to create a delicate fusion of gallantry, morality and passion. The plots, though regular in structure, are often absurd. But the verse is based on speech rhythms and characterized by an inimitable musicality. A conflict between "reason" and "passion" is always present; and in general it may be said that Metastasio's *melodrammi* owe their phenomenal success to the pathos with which they are suffused and to an exquisite propriety of utterance that was completely in tune with the tone of life fashionable in 18th-century society.

Metastasio's other writings include a rich *Epistolario* and five *canzonette*, two of which—*La libertà* (1733) and *La partenza* (1746)—are outstanding examples of Italian verse in the Arcadian tradition. In his later years he wrote works of criticism, the most interesting being the *Estratto della Poetica d'Aristotele* (1782) which contains an exposition of his dramatic theories.

Metastasio's works ran into innumerable editions. During the 18th century his verses were translated into many European languages; and on his death at Vienna on April 12, 1782, a medal was struck in his honour with the inscription: *Sophocli Italico.*

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**METATHEORY.** For certain logical problems a theory is constructed whose subject matter is another theory. The former is then known as the metatheory of the latter. A result proved in the former which deals with the latter is known as a metatheorem.

The most notable example of a metatheory was David Hilbert's metamathematics. Hilbert set out to construct an elementary proof of the consistency of mathematics. For this purpose he needed a theory that studies mathematics and has mathematical proofs as its objects to be investigated. While the theorems of Kurt Gödel (*see* MATHEMATICS, FOUNDATIONS OF) made it unlikely that Hilbert's program could succeed, his metamathematics became the forerunner of much fruitful research. Rudolf Carnap extended this inquiry, under the headings metalogic and logical syntax, to the study of formalized languages in general.

In discussing a formalized language it is usually necessary to employ a second, more powerful language. The former is then known as the object language, while the second is its metalanguage. *See* SEMANTICS IN LOGIC. (J. G. Ky.)

**METAURO** (anc. METAURUS), a river of Italy, rises in the Etruscan Apennines (Appennino Tosco-Emiliano) and flows for 68 mi. E.N.E. into the Adriatic sea south of Fano (anc. Fanum). It was the site of a great Roman victory in 207 B.C. Hasdrubal, who had arrived in northern Italy from Spain, found four legions, commanded by Marcus Livius Salinator, at the Metaurus. The Romans, through capturing Hasdrubal's dispatches to his brother Hannibal, discovered that they intended to meet in Umbria. Claudius Nero, who was watching Hannibal in the south, thereupon boldly joined Livius by forced marches, hoping that together they might defeat Hasdrubal and that he himself might return before Hannibal discovered his absence. So it happened. Hasdrubal, faced by two consular armies, could not force the coast road, but began to withdraw by night up the Metaurus valley, possibly intending to retire to northern Italy, but more probably still hoping to join Hannibal. But before he could cross the river, he was overtaken by the Romans and forced to fight (whether north or south of the river is uncertain). With his Gallic troops on high ground on his left, he massed his main forces on the right, but Nero, who could not engage the Gauls because of the ground, led a force round to support Livius on his left and thus outflanked the enemy. Rome had won a decisive victory. *See* PUNIC WARS.

*See* B. L. Hallward in *Cambridge Ancient History*, viii, pp. 93 ff. and (for bibliography) p. 727 (1930); H. H. Scullard, *History of the Roman World from 753 to 146 B.C.*, pp. 217 ff., 438 f. (1961). (H. H. Sc.)

**METAXAS, IOANNIS** (1871–1941), Greek army officer and statesman who ruled as dictator from 1936, was born on April 12, 1871, on Ithaca. He graduated from the Officers' school in 1890 and first saw active service in the Greco-Turkish War of 1897. Thereafter he was sent to Germany for higher military training and returned with a brilliant reputation in 1903. He joined the general staff in 1912 and served with distinction in the Balkan Wars, being promoted colonel and appointed chief of the general staff in 1913. After the outbreak of World War I, his professional advice was in favour of neutrality and was directly opposed to the policy of the prime minister, Venizelos; but King Constantine refused to accept the resignation of Metaxas (1915).

Thereafter Metaxas' fortunes followed those of the royal house. He was promoted general in 1916 and remained chief of staff until the Allies deposed Constantine in 1917, when he left the country. He was tried for treason *in absentia* in 1920 but was pardoned in 1921 when he returned to Greece after the restoration of Constantine. After an abortive attempt at a *coup d'état* he left Greece in 1923, when the monarchy was again deposed; but he returned under the republic and held ministerial office for the first time in 1928. In opposition for the next seven years, he would not accept office until the abortive Venizelist revolution of March 1935 had made the restoration of the monarchy a probability.

In April 1936, under the restored King George II, Metaxas succeeded to the premiership. On Aug. 4 he suspended parliamentary government in order to defeat the threat of anarchy. From then onward Metaxas ruled as dictator with the support of the king. His government was efficient, but left-wing opponents were brutally oppressed, and his authoritarian regime did much harm to the monarchy. In economic affairs, defense and foreign relations Metaxas did much good; and in World War II, when the Italians invaded Greece on Oct. 28, 1940, he brought a united country into the western alliance. He died in Athens on Jan. 29, 1941.

**MÉTAYAGE SYSTEM,** a type of land tenure under which the cultivator uses land without owning it and pays rent in kind to the owner. Pure *métayage* is a form of share tenancy involving payment of approximately half the annual output, not a fixed amount; the métayer's family permanently occupies the land it works. The term is French and describes what was probably the dominant type of land tenure in 18th-century France, certainly in southern France.

The economic and social conditions from which *métayage* emerged in late medieval France, including great population pressure on a limited land supply, have at various times also existed elsewhere—in Italy, India, Japan, eastern Europe and southern United States—and have produced similar sharecropping systems. There is no English equivalent.

The typical métayer's holding in France was small, whether it consisted of a single compact unit or scattered plots. The land-

owner usually furnished the chief capital items possibly including livestock. Custom rather than written contracts prevailed. With the increasing use of money contracts that accompanied the growth of a market economy after 1800, *métayage* yielded largely to fee simple peasant tenure.

**Italy.**—The Italian counterpart of *métayage* is known as *mezzadria* (literally "half day"), and in a variety of impure forms is the tenure arrangement obtaining in about two-thirds of the cultivated area of central Italy. *Mezzadria* is also widespread in Lombardy where the usual association of the system with extreme poverty is not the case. *Mezzadria* tenure was imposed upon the cultivating class in central Italy by large landowners beginning about the 16th century. The pure *mezzadria appoderata* holding is small, compact and fixed in area. The tenant has permanent occupancy, receives half the produce and uses the owner's implements. The pure form is rare but Italians refer to all impure variants as *mezzadria*.

**India.**—In most of India various forms of *métayage* prevailed at least as early as the 16th century. The standard practice until well into the 19th century was for tenant cultivators to pay half the gross produce in kind, subject to adjustment for changing conditions. Cultivators at the bottom of an ill-defined pyramid of tenure rights strove to produce subsistence shares for themselves on holdings that were continually being subdivided. The English rental settlement for Madras legalized a *quasi-métayage* system by assessing the productivity of lands under the ryotwari system of property relations (small, owned holdings grouped in villages under a head man) and fixing the land revenue or tax at one-half the net produce. English policy, together with the great importation of silver, hastened the substitution of money for grain or other produce rents in most provinces. Payment in money represented a basic deviation from pure *métayage*. The Congress party and the Indian development plans attempted with modest success the liquidation of the system of pyramided landlordism under which sharecropping prevailed for centuries.

**Japan.**—In Japan, unlike France, share tenancy of the *métayage* type increased in importance as modern capitalistic institutions spread subsequent to the Meiji restoration in 1868. Here as elsewhere *métayage* represented a transition form of small holding which grew out of the elimination of bondage to the soil. The upsurge of Japanese share tenancy accompanied the industrial capitalist epoch, whereas in other countries it generally accompanied preindustrial capitalism. Land hunger and extreme rural population pressure have been so persistent during the advanced capitalist era that the essentially manorial tenant status of cultivators in the Tokugawa era (1603–1868) was carried over, except for bondage to the soil. The labour service of serfdom was commuted to a produce rent as serfs were converted into tenants. This process is the archetype of the historical origin of *métayage* in most agricultural economies where it has appeared. In Japan, small owners were also reduced to *métayage* status under pressure of market economy, high taxes and high man-land ratios in most regions (Hokkaido being a notable exception). Substantial increases in agricultural productivity were largely siphoned off for industrial accumulation. From the Meiji restoration to the great land reform following World War II, pure *métayage* was less common than various modifications, such as tenancy at will and the exaction of a fixed amount of rice. However, even where a fixed payment was nominally set, the one-half rule was widely applied except for years of poor crops.

*See* also FARM TENANCY.

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**METAZOA,** a zoological term for all animals other than Protozoa (*q.v.*). Metazoa are multicellular animals with at least two cell layers; usually divided into the Parazoa, containing only the sponges, and the Eumetazoa, including all other multicellular animals. *See* ZOOLOGY: *Morphology* and *The Phyla of the Animal Kingdom; see* also references under "Metazoa" in the Index.

**METCALFE, CHARLES THEOPHILUS METCALFE,** BARON (1785–1846), British colonial administrator chiefly remembered for his reforms in India, was born at Calcutta on Jan. 30, 1785. After an education in England he returned to Bengal as a writer in the East India company's service in 1801. Intellectually gifted and both an Old Etonian and the son of a director of the company, he was already personal secretary to the governor general, Lord Wellesley, by 1803. In Wellesley's Maratha war, Metcalfe was political assistant to Gen. Gerard Lake, and in 1808 he was sent as envoy to Ranjit Singh to secure Sikh support against the Napoleonic threat to India and afterward to secure Ranjit's acquiescence in British protection of the cis-Sutlej states. In 1811 Metcalfe became resident at Delhi. His "Delhi system" was paternalist, applied through British officials who combined the powers of collector, judge and magistrate. He restored responsibility to the village officials and settled the revenue (unfortunately overpitched) with the village proprietors. He disarmed the people, stopped suttee and stamped out dacoity and the slave trade. He supported Lord Hastings' assertion of British paramountcy in 1817, and successfully detached Amir Khan from the Pindaris.

He was appointed resident at Hyderabad in 1820 and there came into conflict with Sir William Rumbold, a director of the firm of William Palmer and a protégé of Lord Hastings. The Palmer firm had been making extortionate loans to the nizam, but Metcalfe secured the winding up of their transactions despite bitter opposition. He succeeded to the baronetcy on his father's death in Aug. 1822.

Metcalfe became a member of the supreme council in 1827, its president during Lord Bentinck's long tours up-country and, in March 1835, acting governor general, on Bentinck's departure. He freed the press in India, made English the official language and abolished transit duties. The British government refused, however, to have a company man as governor general and appointed Lord Auckland. Metcalfe was made lieutenant governor of the northwest provinces, but resigned in 1838 after he was denied the governorship of Madras. He was appointed governor of Jamaica in 1839 where Negro emancipation had created much unrest. He eased the transition, did useful judicial work, but increasingly supported the planters against the missionaries. Early in 1842 he resigned. Though suffering from cancer, he accepted the governor generalship of Canada in 1843. His experience in India unfitted him for understanding the party politics of a young democracy, and the Indian radical earned a diehard reputation in Canada. Having been raised to the peerage in 1845, he returned to England and died at Malshanger in Hampshire on Sept. 5, 1846. Of three sons by an Indian wife, one, Col. James Metcalfe, survived him.

*See* J. W. Kaye, *Life and Correspondence of Charles Lord Metcalfe* (1854); E. J. Thompson, *The Life of Charles, Lord Metcalfe* (1937). (J. B. HA.)

**METCHNIKOFF, ELIE** (ILYA ILICH MECHNIKOV) (1845–1916), Russian biologist and 1908 Nobel laureate in medicine, was born at Ivanovka in Kharkov on May 15, 1845. At the age of 17 he entered the Kharkov university and two years later went to Germany. Returning to Russia in 1867, he became a *dozent* in zoology both at St. Petersburg and at Odessa, where in 1870 he was made professor of zoology and comparative anatomy. In 1882 he went to Messina and there began his studies on the nature and habits of microbes. Thereafter he devoted himself to pathological study and in 1888 went to work in Paris with Louis Pasteur, who gave him a laboratory in the École Normale. By 1892 Metchnikoff's views on the essential importance of phagocytosis (*q.v.*) were firmly established. In that year he published *The Comparative Pathology of Inflammation*, followed in 1901 by his chief work, *Immunity in Infectious Diseases* (Eng. trans., 1905), and a more popular treatise, *The Nature of Man* (1903; Eng. trans., 1904). In later years he made a special study of the bacteria infesting the gastrointestinal tract of man. He died in Paris on July 16, 1916. The Nobel prize was awarded to him, jointly with Paul Ehrlich (*q.v.*), for his work in immunity.

See *Life* by his wife, Olga Mechnikov (1920; Eng. trans., 1921).

**METELLUS,** the name of a distinguished family of the plebeian *gens Caecilia* at Rome.

Lucius Caecilius Metellus, general during the First Punic War. Consul in 251 B.C., he gained a decisive victory at Panormus (Palermo) in Sicily over Hasdrubal, who had the larger force, a victory chiefly attributable to a panic caused among the Carthaginian elephants by his clever maneuvering. A number of these elephants figured in his triumph, and later the elephant frequently occurs on coins issued by the Metelli. The story that in 241 he rescued the image of Pallas Athene from a fire in the temple of Vesta at the cost of his eyesight is not to be found in the extract from his son's funeral oration quoted in Pliny (*Natural History,* vii. 43 [45]). Consul again in 247, he died in 221.

Quintus Caecilius Metellus, son of Lucius Caecilius Metellus, became consul in 206 B.C. and fought Hannibal's Lucanian and Bruttian supporters in 206 and 205. He was attacked by Gnaeus Naevius (*q.v.*) until the poet was imprisoned. While Scipio was absent in Africa, Metellus supported his interests against political attacks (204–202). In 201 he served on a commission to provide land for veterans; in 186 he conducted an embassy to Macedonia, afterward proceeding to the Peloponnese to investigate the quarrel between Sparta and the Achaean league.

Quintus Caecilius Metellus Macedonicus (d. 115 B.C.), praetor in 148 B.C., defeated the usurper Andriscus in Macedonia and forced him to surrender. Under his superintendence the country was made a Roman province. In 146 he attacked the Achaeans to avenge an insult offered to a Roman embassy at Corinth. He was superseded during a successful campaign by L. Mummius. On his return to Italy he received a triumph and the title of Macedonicus. Consul in 143, he subdued the Celtiberians in northern Spain. In 131, when censor with Q. Pompeius (they were the first two plebeian censors), he proposed that all citizens be compelled to marry as a measure against the fall in the free population. He was an opponent of the Gracchi, although not averse from moderate reform. He built a colonnade in the Campus Martius and two temples dedicated to Jupiter Stator and Juno.

Quintus Caecilius Metellus Numidicus, consul in 109 B.C. and commander in the Jugurthine War, won an indecisive victory over Jugurtha (*q.v.*) by the river Muthul. Thereafter he concentrated rather on wearing Jugurtha's resources down; *e.g.*, by capturing his desert stronghold, Thala (108). In 107 he was replaced in his command by his own legate, Gaius Marius (*q.v.*), but he received a triumph and the title of Numidicus. Saturninus, whom as a censor (102) he tried to remove from the senate, passed in 100 an agrarian law, inserting a provision that all senators should swear to it within five days. All complied but Metellus, who retired to Asia. After Saturninus was killed he returned (99). He died probably in 91. He was one of the chief leaders of the aristocratic party. Cicero speaks highly of him as an orator.

Quintus Caecilius Metellus Pius was surnamed Pius for his attempts to recall his father, Numidicus, from exile. He was praetor in 89 B.C. and, probably as proconsul, defeated the Marsian leader Q. Pompaedius Silo in the Social War (88). After Sulla's departure and Marius' return to Italy, Metellus refused the request of his soldiers that he should replace the consul Gnaeus Octavius (87); he retired to Africa and afterward to Liguria, resuming his proconsular command on Sulla's return (83). In the war against the Marians he gained a decisive victory at Faventia (Faenza) over Gaius Norbanus (82). Consul in 80 with Sulla, he went to Spain to fight Q. Sertorius. From his headquarters at Metellinum (Medellín) he tried to reduce Lusitania (79–78). After Pompey's arrival Metellus routed Sertorius' lieutenant L. Hirtuleius at Italica in 76 and again at Segovia in 75, which proved the decisive battle of the war; then joining Pompey he saved him from defeat near Saguntum. In 71 he returned to Rome and triumphed. He had been *pontifex maximus* from *c.* 81; he died *c.* 64 B.C.

Quintus Caecilius Metellus Creticus, Roman general. Consul in 69 B.C., he was appointed to the command of the war against Crete, the headquarters of the pirates of the Mediterranean. In 67 Pompey demanded the control of the campaign under the Gabinian law. The Cretans offered to surrender to Pompey, who instructed Metellus to cease operations. Metellus refused, and himself annexed the island. His triumph was delayed by Pompey's partisans, and he joined the opposition in the senate and helped to defeat the ratification of Pompey's Asiatic settlement. He was one of a commission of three sent (60) to investigate the state of affairs in Gaul, where disturbances were apprehended. He appears to have been alive in 54. The tomb of his daughter Caecilia Metella survives on the Appian way near Rome.

Quintus Caecilius Metellus Celer, who had been legate of Pompey in Asia in 66 B.C., was praetor in 63 and was dispatched to cut off the retreat of Catiline to the north by blocking the passes. In 62 he went to Cisalpine Gaul with the title of proconsul, although he did not become consul till 60. A supporter of the optimates and an enemy of Pompey, he successfully opposed the agrarian law that was to provide for Pompey's veterans. He also tried, though fruitlessly, to obstruct Caesar's agrarian law in 59. He died suddenly in the same year—it was usually supposed from poison administered by his wife, the notorious Clodia.

Quintus Caecilius Metellus Pius Scipio, son of P. Scipio Nasica, was adopted by Metellus Pius. He was accused of bribery in 60 B.C., and defended by Cicero. In Aug. 52 he became consul through the influence of Pompey, who had married his daughter Cornelia. In 49 he proposed that Caesar disband his army within a definite time, under pain of being declared an enemy of the state. His first command during the civil war was the province of Syria. He commanded the centre at Pharsalus and afterward went to Africa, where by Cato's influence he received the command. In 46 he was defeated at Thapsus; while endeavouring to escape to Spain he fell into the hands of P. Sittius and committed suicide.

**METEMPSYCHOSIS,** the theory of the transmigration of souls, is usually associated with the ancient Egyptians, who are said to have practised embalming to prevent or delay reincarnation, and with the teaching of Hinduism and Buddhism. The idea, however, is much older than any of these creeds and exists throughout the world.

**Primitive Cultures.**—The primitive idea of the passage of the soul, or vital essence, into some particular form is bound up with the conception of an objective soul and often with ideas as to a plurality of souls in a single individual, one of which is separable and able to go in and out through the mouth or nostrils. Thus the Poso Alfurs of Celebes believe in three souls, the *inosa* or vital principle, the *angga,* or intellectual, and the *tanoana* or divine element which leaves during sleep and which is of the same nature in many plants and animals. This conception of a separable soul is clearly based on the phenomena of dreams taken to be actual experiences undergone during sleep and postulating some sort of embodiment able to roam while the body sleeps. This soul must be small enough to leave by the mouth, and it appears as a manikin in India and in Celebes, as a snake, a weasel or a mouse in Germany, or as an insect in farther India. Thus the soul may be spoken of as "flying" and represented as a butterfly or bird—a dove, duck, raven, owl, hawk.

This belief in a separable soul with an insect or other form must obviously influence beliefs in the eschatology of the soul. Accordingly the belief is found that the soul passes into an insect on the decease of the body. Thus the Angami Nagas of Assam credit the soul with a number of subsequent existences in insect form, while the Chang Nagas hold that the souls of those who can sing become cicadas, the souls of others dung beetles. Thus the Bakongs of Borneo believe that their dead are reincarnated in the bearcats which frequent their raised coffins; wood-boring wasps and hornets take up their abode in the wooden soul figures put up by some tribes of Assam, and Nagas and Lushais regard wasps and hornets (among other insects) as souls.

If the soul can leave a person during sleep and re-enter him, it should be able to enter and be reborn in another person. The range of this conception of reincarnation is indicated by the frequency of tabu on giving children names already borne by living members of the family; identity of name implies identity of personality, and one of the two bearers would die. A belief in reincarnation within the family would naturally be strengthened by the recurrence of family resemblances. In any case a belief in the reincarnation of human souls is indicated by such rites as those of

the Kikuyu women of Kenya, who, in order to have children, worship at a *ficus* tree inhabited by the souls of the dead, or of the Konyak Nagas of Assam, who perform ceremonies over phallic cists containing skulls of deceased persons, in order to secure a birth of corresponding sex to that of the skull.

Reincarnation is not confined to animal forms. The stories of trees that grow up from the graves of lovers, such as Tristan and Iseult, and twine themselves together are familiar in Europe; and the human soul also reappears in a flower growing on the grave. In the case of flowers springing from drops of blood, as from that of Ajax, the soul is possibly regarded as located actually in the blood itself. In farther Asia and elsewhere the soul goes into the crops, and by preserving the corpse, which is smoke-dried, funeral ceremonies are accommodated to the agricultural year, to afford the crop the full benefit of the soul matter from those who have died recently. The Karens of Burma evolved a specific theory of a cycle of life on these lines (*see* HEAD-HUNTING). The Lushai theory that the soul takes the form of dew and is reincarnated in the body on which it descends may be a version of the Karen theory.

The idea of transmigration has been influenced and inevitably confused by ideas as to the external soul, generally associated with magicians, where the vital principle depends on a soul kept in an animal in the forest, or in an egg below the sea, etc., which has to be secured before the magician can be killed, and by ideas as to totemism and lycanthropy (*qq.v.*). Beliefs in the reincarnation of the soul in predatory forms such as tigers (India and Sumatra), sharks (Melanesia) or alligators (Africa) have perhaps arisen in connection with those ideas. (J. H. H.)

**Western Thought.**—Although the word "metempsychosis" and its better synonym "metensomatosis" do not appear till the late Greek and Latin writers, the idea is at least as old as the late Archaic period (*i.e.*, the 6th century B.C.), for it occurs in the Orphic writings (*see* ORPHEUS) and it is alleged that Pherecydes of Syros (fl. *c.* 550 B.C.) was the first to speak of it. In Orphism it is combined with an elaborate theory of the origin of mankind and with a doctrine of something like original sin. Man sprang from the soot from the burning bodies of the Titans slain by Zeus with his thunderbolts after they had murdered and eaten his son Zagreus. Hence man has in him a small divine element (Zagreus) and a large and wicked Titanic one, which it is his first duty to eliminate in order to rise to divine status. His soul survives bodily death and, at least in some versions of the doctrine, is rewarded or punished in another world and later reincarnated in a human or animal body, so continuing in what some documents call the "wheel" or "circle" (*cyclos*); but it has hopes of ultimate release. Two different accounts of this happy outcome are found in the earliest surviving source, Pindar. On the one hand (*Olympians*, ii), Pindar represents this world and the next as each reciprocally the place of temporary reward or punishment for conduct in the other; those who can live righteously three times on either side of the grave pass to a state of final bliss. On the other hand, in a fragment, he makes Persephone accept "satisfaction for her ancient grief" (the murder of Zagreus, whose mother she was) from some of the dead, who are reincarnated after eight years, live distinguished lives on earth and then attain the rank of heroes.

The source of all these doctrines is quite uncertain. Their influence, however, was considerable. Something of them seems to have been imported into the Eleusinian mysteries, or rather into the beliefs which the initiates deduced from the ritual thereof. Pythagoras is said, though on rather doubtful evidence, to have taught reincarnation, and certainly Empedocles did so.

More important for the history of thought is Plato, who was decidedly influenced by Orphic or Orphico-Pythagorean views and reinterpreted them after his own fashion, notably in the great myths of the *Republic*, of the *Phaedo* and of the *Phaedrus* but also elsewhere, as in the *Meno*, in the *Timaeus* and in the *Laws*. The soul, according to him, is immortal, the number of souls fixed, and reincarnation regularly occurs.

The aim of the philosopher is to purify and free the divine element in the soul and thus to return to his proper home in the company of the gods (so the *Phaedrus*). Although nothing of the kind was accepted by Aristotle, and it is inconsistent with both Epicurean and orthodox Stoic views of the soul, the Platonic doctrine with various modifications and elaborations was taken up by later schools of thought, above all by Neoplatonism, as is clear from the works both of the great Plotinus and of the lesser thinkers of that group.

In nonphilosophical literature occasional references to reincarnation are found. It is mentioned by Menander (*Theophorumene*) and satirized by Lucian (*Gallus*). In Roman literature it is found as early as Ennius, who in his Calabrian home may have been familiar with the Greek teachings which had descended to his time from the cities of Magna Graecia. In a lost passage of his *Annals*, Ennius told how in a dream he had seen Homer, who assured him that the same soul which had animated both poets had once belonged to a peacock. Persius (*Satires*, vi, 9–11) laughs at Ennius for this; it is referred to also by Lucretius (i, 121–126) and by Horace (*Epistles* ii, i, 50–52). Virgil works the idea of metempsychosis into his account of the Underworld (*Aeneid*, vi, 724 ff.).

Attempts to find metempsychosis in early Jewish literature have met with little success, but there are traces of it in Philo and it is definitely adopted in the Cabala. Within the Christian church it was held by isolated Gnostic sects during the first centuries and by the Manichaeans in the 4th and 5th centuries, but was invariably repudiated by orthodox theologians. In the middle ages these traditions were continued by the numerous sects known collectively as Cathari. The doctrine is found in Giordano Bruno at the Renaissance and in the theosophist J. B. van Helmont in the 17th century. During the classical period of German literature metempsychosis attracted much attention; Goethe played with the idea, and it was taken up more seriously by Lessing, who borrowed it from Charles Bonnet, and by Herder. Modern theosophy, drawing its inspiration from India, has taken metempsychosis as a cardinal tenet. (H. J. R.)

**Eastern Thought.**—*Hinduism.*—The belief in transmigration or rebirth has been fundamental to most of the religions and philosophies of India. The origin of the belief, however, is uncertain. It may have existed among the pre-Aryan peoples of India as an aspect of their fertility cults and ancestor worship and may have been adopted by the invading Aryans along with other features of the indigenous religions. The earliest Aryan scripture, the Rigveda (early 1st millennium B.C.), contains no clear indications of a belief in rebirth. Instead, the souls of the righteous at death travel to the World of the Fathers (the primordial ancestors), a paradisal realm presided over by Yama, the god of death, where they attain to immortality and enjoy a variety of pleasures. The alternative post-mortem existence, according to the Rigveda, is hell, a sort of dark pit, for evildoers.

The first formulation of a doctrine of transmigration is found in the early Upanishads (*c.* 600 B.C.) in which it is stated that upon death the souls of those who have lived lives of austerity, charity and piety go to the World of the Fathers and thence to the moon where they enjoy the fruits of their earthly righteousness. Then they return through rain to the earth where they "become food," are consumed by man and finally pass into the womb of woman to be reborn in new bodies. On the other hand, the souls of those who have lived evil lives are reborn as animals or insects. The corollary of this doctrine of transmigration is that of *karma* (literally "deed"): as one sows in the present life, so shall one reap in the next, good deeds resulting in a good state of rebirth, bad deeds in a bad state of rebirth. Thus a man's state of life is seen not as something fortuitous or meaningless but as the working out, for good or ill, of the effects of a previous existence and the predetermining of a future state. This process of rebirth is an endless one for the individual until he realizes the liberating truth of the identity of the soul or self (Atman) and the Absolute (Brahman). Then his soul becomes one with Brahman, and he is set free from bondage to *karma*, escaping forevermore the dreary and painful cycle of life and death.

The belief in transmigration (*samsara*) and *karma* formulated in the Upanishads became an essential teaching of the several sects of Hinduism which grew out of the orthodox Aryan tradition. It

was also taken over with important modifications by the unorthodox religions of Buddhism and Jainism which appeared in India in the 6th century B.C.

*Jainism.*—According to Jainism, *karma*—the effects of one's deeds; good or bad—is a subtle substance which adheres to the soul, hiding its natural brilliance and involving it in a corporeal state. Although all activity produces *karma*, evil deeds, particularly doing injury to other living entities (*jivas*), result in an especially dense karmic matter. It is the burden of old *karma* and the continuing acquisition of new *karma* that keep the soul bound to the endless process of transmigration. At death the soul with its covering of karmic matter is reborn in a new body, the nature of which is determined by the quality of the *karma*. The spiritual goal is to destroy through religious austerities the old *karma* and to prevent through disciplined conduct (*ahimsa*, "noninjury") the adherence of new *karma*. When the soul is finally freed from the burden of *karma*, it will rise to the top of the universe where it will dwell eternally in blissful omniscience and inactivity.

*Buddhism.*—In Buddhism, although the belief in transmigration was affirmed, the belief in an unchanging, substantial soul or self was denied. What is commonly called the self is, according to Buddhism, nothing more than a complex of psycho-physical elements and states changing from moment to moment. At death the five groups (*skandhas*, "heaps") of elements—viz., body, sensations, perceptions, impulses and emotions and consciousness—fall apart, and the individual as such ceases to exist. But the dissolution of the individual is not the end of the life process. On the contrary, it is the beginning of a new individual existence; for the *karma* of the deceased individual survives and passes in the form of "germ of consciousness" (*vijnana*) to the womb of a mother, there to grow into a new individual. The nature of the new individual will, of course, depend upon the quality of the potencies (*karma*) contained within the germ.

Five possible conditions of rebirth were generally recognized among the Buddhist schools: birth in hell, as an animal, as a ghost, as a man and as a god. None of these conditions is eternal, however, but is subject to termination, followed by another rebirth. Thus, although there is no substantial soul or unchanging self which transmigrates, there is yet a continuity of individual existences through the ceaseless generation of *karma* which keeps the "wheel of life" (*samsara*) turning. In order to stop the wheel and escape from suffering-filled phenomenal existence, it is necessary to stop the generation of *karma*. This means the total destruction of all desires or "cravings" (*trishna*) founded upon the illusion of a permanent, immutable self. When through moral discipline and meditation a state of complete passionlessness and enlightenment is attained, *karma* ceases to be generated, the process of rebirth is terminated and Nirvana, a state of eternal bliss, is achieved.

*See* IMMORTALITY; *see* also references under "Metempsychosis" in the Index. (H. P. S.)

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**METEOR,** from the Greek *meteora*, meaning "things up in the air." In astronomy it is the luminous "shooting-star" effect seen in the night sky when a small particle, known as a meteoroid, enters the earth's upper atmosphere at high speed and dissipates its kinetic energy in the form of heat, light and ionization. The word meteor is commonly used as a synonym for meteoroid, and is an adjective in referring to related aspects, such as meteor radiant or meteor velocity. It is in this broad sense that the word is used in this article. Until the 19th century the meaning of meteor was even more broad. It included not only the aurora as well, but also a wide variety of phenomena in the lower atmosphere, such as clouds, rainbows, lightning, hail, etc., which are now embraced by meteorology, the science of weather. However, the meteorologist currently incorporates the word in his language chiefly as a prefix or suffix; *e.g.*, a raindrop may be called a hydrometeor.

The vast majority of meteors burn themselves out in the upper atmosphere, but the occasional large mass that survives its fiery plunge and falls to the earth as a solid body is known as a meteorite (*q.v.*). Meteorites interest the physical chemist and the mineralogist, while the astronomer, the upper-air physicist and the radio communications engineer are concerned with meteors and their effects.

The falling of stones from the sky has been noted in literature at least as far back as 600 B.C., and there are early Chinese and European records of both single spectacular meteors and showers of shooting stars. However, not until about the beginning of the 19th century was the extraterrestrial origin of meteors and meteorites generally accepted. Serious study of the subject was really initiated by the great meteor shower of Nov. 12, 1833, which was seen all over eastern North America. Hundreds of thousands of shooting stars were observed in one night, some leaving persistent trains, but none reaching the earth. It was noted that all the meteors seemed to radiate from a point in the constellation Leo. This point, known as the radiant, was in the same position in the sky for all observers; thus, it was deduced, first, that the meteors must come from far outside the atmosphere and, second, that their apparent divergence from the radiant was simply a well-known effect of perspective, and that the meteors were really moving in parallel paths.

It was later established that the Leonid shower recurred at 33-year intervals, and occasional records of its appearances were traced back as far as 902 A.D. It appeared on schedule as a magnificent display in 1866. Since that time a few Leonids have been seen in November each year, but the numbers seen in the predicted peak years of 1899 and 1932 fell far below those of 1833 and 1866.

**Shower Meteors and Cometary Associations.**—Using the radiant point, together with the 33-year period of the Leonids, it was possible to compute the elements of the elliptical orbit which these particles pursue around the sun. A remarkable coincidence was noted between this orbit and that of Comet 1866 I (Tempel's comet). Similarly, Comet 1862 III was found to follow the path of the well-known Perseid meteors which were once known as the "Tears of St. Laurence," and which appear with great reliability each year in August. Halley's comet, which comes close to the earth both while approaching and while receding from the sun, has been tentatively connected with two annual showers, the Eta Aquarids in May and the Orionids in October. Other cometary associations are the Lyrids with Comet 1861 I, the Bielids with Comet 1852 III (Biela's comet), the Taurids with Encke's comet and the Giacobinids (or Draconids) with Comet Giacobini-Zinner. On the other hand, several prominent meteor showers, such as the Geminids, the Quadrantids and the Delta Aquarids, can be associated with no known comets. Furthermore, comets have been known to cross the earth's orbit without leaving any appreciable meteoric traces. However, despite the obvious lack of complete correlation which prevents a general conclusion being drawn, it does seem clear that at least some of the meteor showers are definitely connected with parent comets.

An elementary view of the structure of a comet (*q.v.*) is that its nucleus is made up of a large number of small solid particles of various kinds of minerals stuck together loosely by frozen gases, such as ammonia and methane, while the comet is far from the sun. As the comet approaches the sun the gases evaporate and the particles are released to form a "flying gravel bank," as it were, albeit a rather loosely knit one, as even in the densest shower the particles are many miles apart. Planetary perturbations, particularly due to Jupiter, and other selective forces associated with the sun's radiation act to disperse the particles into slightly different orbits.

The smallest particles are most widely dissipated and eventually spiral into the sun. After the comet has made several passages around the sun, the particles will be spread out along the original

*Annual Meteor Showers*

| Name of shower | Radiant position | | Mean date | Shower duration in days | Hourly visual rate | Meteor velocity (miles per second) |
|---|---|---|---|---|---|---|
| | Right ascension | Declination | | | | |
| Quadrantid | 232° | +50° | Jan. 3 | 0.5 | 40 | 25 |
| Lyrid | 272° | +34° | April 21 | 2.5 | 10 | 30 |
| Eta Aquarid | 336° | 00° | May 4 | 18 | 20 | 40 |
| Delta Aquarid | 339° | −17° | July 29 | 20 | 20 | 25 |
| Perseid | 040° | +58° | Aug. 11 | 5 | 50 | 37 |
| Orionid | 095° | +15° | Oct. 20 | 8 | 25 | 41 |
| Leonid | 152° | +22° | Nov. 16 | 4 | 15 | 45 |
| Geminid | 113° | +32° | Dec. 13 | 6 | 50 | 22 |

orbit and also over a considerable volume in space. Thus, as in the case of the Leonids, a strong meteor shower may be observed in the year that the comet is nearest the earth. The shower may last for a few hours, or even for several days if the dispersion is wide enough, while a few shower meteors may be seen in the same month in off years. In the case of the Perseid shower, which is roughly estimated to have an age of at least 40,000 years, the dispersion around the orbit is so complete that no evidence of a long-term periodicity can be found. Such well-established showers appear to have relatively few very small meteors, compared to the normal nonshower distribution that is always present. Planetary perturbations can swing the meteoric orbits so that they miss the earth entirely. This is probably what has happened to the major part of the Leonid stream, which may never again provide a brilliant display.

The Giacobinid shower is a vivid example of a newly created meteor stream. The associated comet, discovered in 1900, has an orbit that intersects the earth's path about Oct. 10, with a period of nearly 6.5 years. Hence, every 13 years there is a chance that a strong meteor shower will appear if the comet should happen to be within a reasonable distance of the earth. In 1933 and in 1946 the circumstances were favourable and rates of several hundred per minute were observed. In each case, these high rates were sustained for about half an hour only, indicating that the meteoric fragments were fairly closely bunched near the cometary orbit. Observations in the 1950s, including those made by radio methods during daylight passages, have shown that some of the meteors are appearing well ahead of or behind the comet, but the lateral spread of the orbits is still small; *i.e.*, the earth passes through the stream in an hour or two. The Quadrantids are an example of an annual shower that lasts not more than a couple of hours at maximum activity.

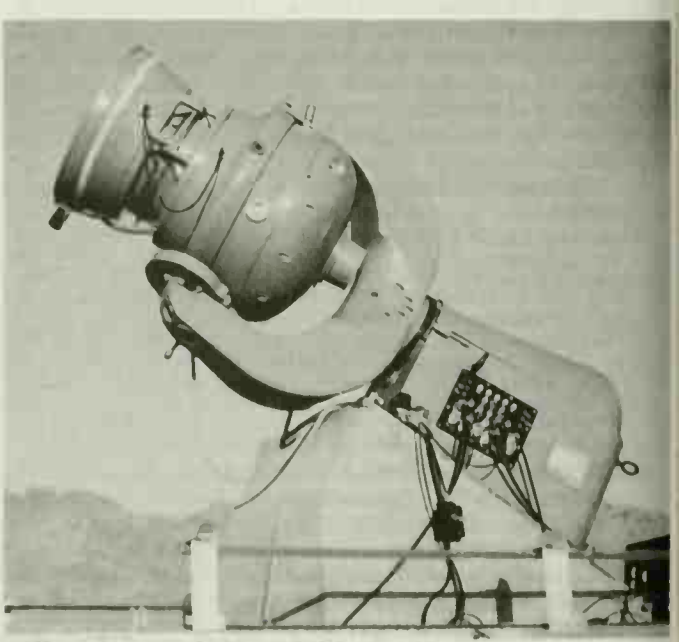
The table lists some of the stronger annual meteor showers that can be seen by the naked-eye observer. The right ascension and declination co-ordinates given will enable the amateur astronomer to locate the radiants fairly precisely, but it may be noted that for casual observations it is only necessary to ensure that the constellation for which the shower is named is visible, because, if the radiant point is above the horizon, meteors from that radiant may be seen in any part of the sky. (The Quadrantids were named after an obsolete constellation, Quadrans Muralis, which was located just east of the handle of the Big Dipper.) The shower duration is the approximate interval, bracketing the mean date, during which the shower rate exceeds one-quarter of the maximum. The hourly visual rate is the average rate at the maximum point of the shower, as seen by a single observer. It may vary widely from year to year. These rates are superimposed on the normal background rate of nonshower meteors visible on any clear, moonless night, which may be from 5 to 10 per hr. The meteor velocities given in round numbers in the last column of the table are velocities relative to the earth that have been obtained by photographic or radio methods.

Radio observations have revealed the presence of at least four very strong daylight showers. These are the Omicron Cetids (May 19), the Arietids (June 6), the Zeta Perseids (June 6) and the Beta Taurids (June 28). Each of these annual showers extends over several days, and the equivalent visual rates may run as high as 70 per hr.

**Asteroidal Associations.**—Laboratory examinations of meteorites suggest that they may be fragments of one or more large bodies, of the order of size of our earth. It is tempting to speculate that at some time in the distant past there was a planet, between Mars and Jupiter, say, which disintegrated into fragments, either due to an internal explosion or to a collision with a somewhat smaller body than itself. Qualitatively, this hypothesis could account for the creation of the asteroids, which may range in size from a few hundred miles in diameter down to the sizes of the meteorites or the brighter meteors known as fireballs. There are some serious difficulties in this theory, particularly with the cosmic time scale of the events, but until further information becomes available there does not appear to be an attractive alternative.

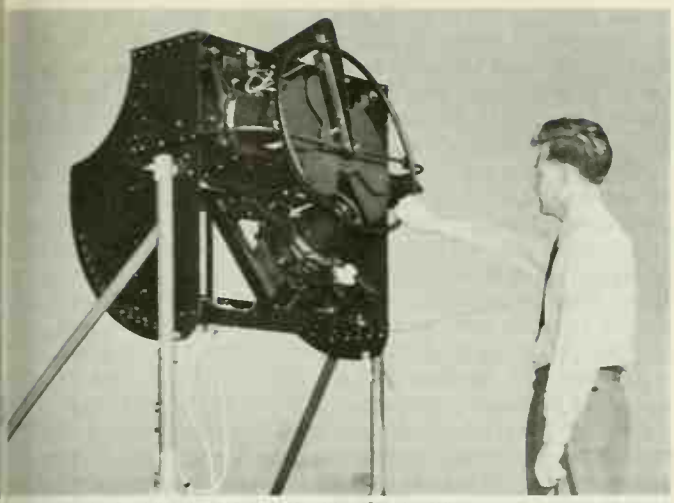
**The Origin of Meteors.**—The identification of meteorites as asteroidal fragments seems reasonable, and the association of some meteor streams with comets has been demonstrated. Therefore, one can only conclude that the origin of meteors as a class is intimately bound to the histories of both these possible parents. Whether or not the asteroidal type may extend in size down to particles of dust and thus form an appreciable part of the sporadic or background meteor activity is not yet known. It is unlikely, however, that this type can be responsible for any meteor streams in the normal sense. On the other hand, there are a few very brilliant fireballs among the cometary types, and no meteorites have been known to fall from the recognized showers. At the other end of the scale, the meteor sizes decrease through the so-called micrometeorites, which are particles small enough to be slowed up in the atmosphere without vaporizing, to the motes that make up the zodiacal dust cloud. There is no evidence that any significant fraction of the meteor population is made up of visitors from interstellar space, so the question of the origin of meteors is a part of the larger problem of the origin and evolution of the solar system.

**Meteor-Observing Techniques.**—*Visual.*—For many years, the only method of obtaining information about meteors was by naked-eye observing. The basic equipment needed is a star chart and a good clock. The watcher plots the path of the meteor among the stars on his chart, and notes the time, apparent magnitude of the meteor, colour, train duration if any, etc. A similar plot of the same meteor made at another station about 40 mi. away will enable rough measurements of height and of radiant position to be made. Such measurements cannot compare in accuracy with those made by photographic or radio methods, and visual estimates



BY COURTESY OF HARVARD COLLEGE OBSERVATORY, CAMBRIDGE, MASS.

FIG. 1.—BAKER-SUPER SCHMIDT METEOR CAMERA IN OPERATION AT A METEOR OBSERVING STATION. THE CAMERA HAS AN APERTURE OF 12 IN. AND AN OPTICAL FOCAL RATIO OF f/0.65. ITS EQUATORIAL MOUNTING ENABLES THE CAMERA TO FOLLOW THE STARS. THE OVER-ALL HEIGHT OF THE INSTRUMENT IS ABOUT 8 FT.



BY COURTESY OF NATIONAL RESEARCH COUNCIL, OTTAWA, CAN.

FIG. 2.—A BATTERY OF THREE WILLIAMSON F-24 AERIAL CAMERAS, WITH SLIGHTLY OVERLAPPING FIELDS OF VIEW, IS DIRECTED AT A SELECTED SKY AREA AND IS THEN LEFT FIXED DURING THE TIME EXPOSURE. THE TWO-SECTOR ROTATING SHUTTER (NEXT TO LENSES) CHOPS THE IMAGES OF THE METEOR TRAILS 12 TIMES PER SECOND FOR VELOCITY MEASUREMENTS. TRANSMISSION GRATINGS MAY BE PLACED IN FRONT OF THE LENSES TO CONVERT THE CAMERAS TO SPECTROGRAPHS

of meteor velocities are notoriously weak. Nevertheless, the visual observer continues to be essential to the art, particularly in the matter of determining meteor rates as a function of magnitude, and also in supplying some important correlations for the instrumental methods.

Several aids to the visual observer have been developed but not used extensively, such as wire graticules to improve his plotting accuracy. In another arrangement, the meteor path is viewed not directly, but in a rocking mirror which appears to put a number of kinks in the meteor path, from which the meteor velocity may be deduced.

Binoculars and telescopes have been employed to extend the range of visual observations from the limit of the naked eye, which is about the 5th or 6th magnitude, to the 12th or 13th magnitude. *See* STAR: *Brightness of the Stars*, for definition of magnitude.

*Photographic and Spectroscopic.*—Direct photographs of the meteor trail, taken at two points on the earth's surface several miles apart, yield by far the most accurate data for computing the orbit of an individual meteor. The camera lens is left open as long as the background light will permit, since the advent of a meteor cannot be anticipated.

A rapidly rotating shutter in front of the open lens serves to chop the photographed path into short segments from which the velocity and deceleration of the meteor can be computed. The camera mounting may be fixed or it may be guided to follow the stars. Using high-speed emulsions, cameras with *f*/4 lenses will record meteors down to about zero magnitude, and those with *f*/1.5 lenses will capture some 2nd magnitude meteors. A type of Super-Schmidt camera was developed especially for meteor photography, and, with a lens system equivalent to *f*/0.65, it can photograph 3rd to 4th magnitude meteors in a field of view 55° in diameter. (*See* fig. 1.)

A conventional camera can be converted to a meteor spectrograph by mounting a prism or a grating in front of the lens and allowing the meteor trail to act as a slit light source. The sensitivity of the spectrograph is two or three magnitudes less than that of the same camera without the grating. The rotating shutter is usually included in the system. (*See* figs. 2 and 3.) Photo-electric recording of meteors has been tried with some success, but has not been developed or used extensively.

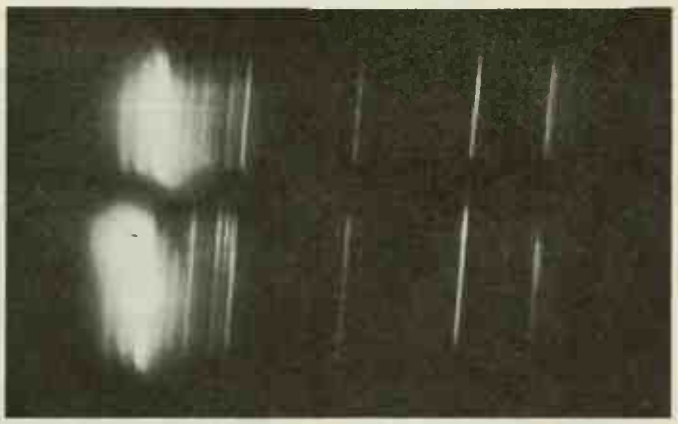
*Radio.*—There was evidence in the 1930s that radio waves could be reflected from meteor trails, and, after World War II, intensive development of new techniques in this field took place. In the radar method, short bursts of radio-frequency energy are emitted from a transmitting station on the ground. The meteor trail scatters a small fraction of this energy back to a receiver located at the same station, and by electronic methods the elapsed time of flight of the pulses, equivalent to the distance to the trail, can be measured. (*See* fig. 4.)

Alternatively, the energy may be emitted continuously in order to emphasize the amplitude variations in the received echo instead of the distance information. The radio frequencies that have been used range from 2 or 3 mc./sec. (megacycles per second, or millions of cycles per second, which is just above the broadcast band) to 500 mc./sec., though most of the work has been done in the band 25–100 mc./sec. Relatively simple antennas are usually employed, though sometimes additional complexity is introduced for height-finding or for determining the wind drifts of the enduring trails. With radar transmitters of moderate power the limiting sensitivity of a typical system may be as small as the 10th magnitude. High power and larger antennas have been used to detect 14th magnitude meteors.

It should be noted that even a large meteoric particle is far too small to be directly detected by the most powerful radars. The radio waves are scattered back not by the particle itself but by the long trail of ionized atoms created in its wake by collisions with air molecules. This ionized trail may extend from a few miles to a hundred miles long, and may endure as an effective scatterer for a fraction of a second up to many minutes. The trail acts as a linear reflector, in a sense, and the strongest echo will usually be obtained when the line of sight from the station to the trail is perpendicular to the trail. This characteristic is utilized in the radio methods of measuring radiants, and has made possible the delineation of several important daylight meteor showers which cannot be observed by the older techniques, and which were unsuspected until the advent of radio. The fluctuations in echo amplitude that are observed as the meteor crosses the line of sight are used to measure the velocity of the meteor. (*See* fig. 5.) This effect is closely analogous to the optical theory of the diffraction of light from a slit source.

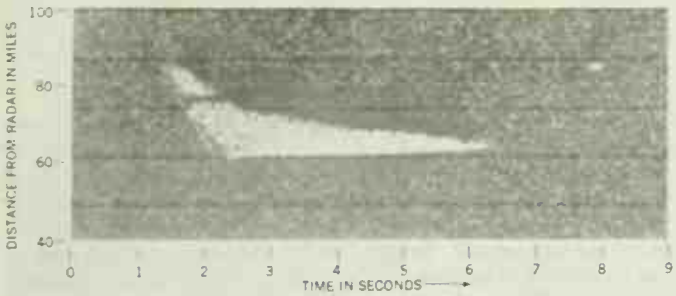
**Observational Data.**—*Heights.*—The height in the atmosphere at which a meteor appears depends on the size of the particle and on its velocity. In broad terms, a meteor moving with a velocity of 45 mi. per second (m.p.s.) will be at its brightest at a height of 65 mi., and one with a velocity of 15 m.p.s. will show a maximum light intensity at a height of about 55 mi. The fainter meteors in a given velocity class burn up at greater heights, while the brighter ones may survive to heights as low as 20 mi.

*Velocities.*—Nearly all meteoric velocities measured by photographic and radio techniques lie in the range 7 to 45 m.p.s. This includes both shower meteors and nonshower meteors, from the brightest fireballs down to about 8th magnitude. The observed



BY COURTESY OF DOMINION OBSERVATORY, OTTAWA, CAN.

FIG. 3.—SPECTRUM OF A BRIGHT METEOR PHOTOGRAPHED WITH ONE OF THE CAMERAS OF FIG. 2. THE METEOR MOVED FROM TOP TO BOTTOM OF THE PICTURE, AND THE TRAIL HAS BEEN BROKEN BY THE ROTATING SHUTTER. THE VIOLET PART OF THE SPECTRUM IS AT THE LEFT AND THE RED PART AT THE RIGHT. NEAR THE LEFT, THE VERY STRONG PAIR OF LINES IS DUE TO IONIZED CALCIUM. NEXT ARE MANY FAINT IRON LINES. IN THE CENTRE IS A CLOSE PAIR OF MAGNESIUM LINES. THEN A STRONG SINGLE LINE OF SODIUM, WHILE THE BRIGHT PAIR AT THE RIGHT IS IONIZED SILICON




BY COURTESY OF NATIONAL RESEARCH COUNCIL, OTTAWA, CAN.

FIG. 4.—ACCURATE MEASUREMENT OF DISTANCE TO THE METEOR TRAIL IS STRESSED BY THE PULSE RADAR TECHNIQUE. THE THIN, SLANTING LINE AT THE LEFT IS A TRANSIENT ECHO THAT HAS OUTLINED THE ACTUAL PATH OF THE MOVING METEOR RELATIVE TO THE STATION. THE ENDURING ECHOES FROM VARIOUS PARTS OF THE LONG IONIZED TRAIL HAVE MERGED INTO A BROAD BAND ECHO LASTING FOR FIVE SECONDS. A SHORT-DURATION ECHO FROM A MUCH FAINTER METEOR IS VISIBLE AT THE UPPER RIGHT

velocity of a meteor is slightly less than the true velocity in the absence of the earth's atmosphere because of the deceleration of the meteor. Various corrections may be applied to allow for deceleration, the attraction of the earth on the particle and the earth's rotation, in order to determine the true velocity.

*Radiants.*—The photographic method is capable of locating the radiant point in the sky with a precision of better than 0.1° of arc, which is at least 10 times more accurate than the radio methods. However, the photographic data are limited to meteors brighter than the 3rd or 4th magnitude, while the radio observations extend down to 8th magnitude meteors or fainter.

*Daily and Annual Rates.*—Three to five times as many meteors per hour are seen in the second half of a typical night compared to the first half, provided, of course, that no strong shower is present. Similarly, during an average night in the autumn almost twice as many meteors may be seen as during a spring night. Both variations are a general consequence of the earth's revolution about the sun with an orbital velocity of 18.5 m.p.s. The point in space toward which the earth is moving at any given moment is known as the "apex of the earth's way." The meteor velocity in its own orbit relative to the sun (heliocentric velocity) is added vectorially to the earth's velocity to yield the observed geocentric meteor velocity.

When the apex is above the observer's horizon the average of all the velocities observed in a given interval of time will be greater than when the apex is below the horizon, and furthermore, because they are approaching faster, there are more meteors per hour. The apex is above the horizon more frequently both after midnight and during the last six months of the year, thus causing observed rate variations. Other factors are involved as well, but the earth's motion is the major one.

*Magnitude and Mass Distributions.*—The total number of meteors seen per hour down to a given magnitude limit is between two and four times the total number seen down to one magnitude brighter than the selected limit. In the visual range the increase in numbers per magnitude is about 3.5 while for the fainter telescopic and radio meteors the ratio is probably about 2.5. Little was known in the early 1960s about the range of the still smaller particles extending down to the zodiacal dust level. Quantitatively, it is estimated that over the entire surface of the earth one fireball of the brilliance of the full moon may be seen every few days. A meteor of this brilliance would almost certainly fall to earth as a meteorite; rough guesses of the total number of meteorite falls run from 5 to 30 daily. In a 24-hour period about 1,000,000 meteors of zero magnitude (comparable to the well-known star Vega) or brighter may strike the earth's atmosphere, and in the same interval the total number of naked-eye meteors will be about 200,000,000.

The mass of a zero-magnitude meteor is probably about $\frac{1}{30}$ of an ounce, and its size, if a solid stone particle, would be comparable to a small grape. The total weight of meteoric material falling on the earth every 24 hours, from the brightest fireballs to meteors just visible to the naked eye, is of the order of 10 tons. The dust particles, which do not become incandescent, appear to be much more numerous in proportion to their sizes, and the daily accretion of dust may be in excess of 1,000 tons.

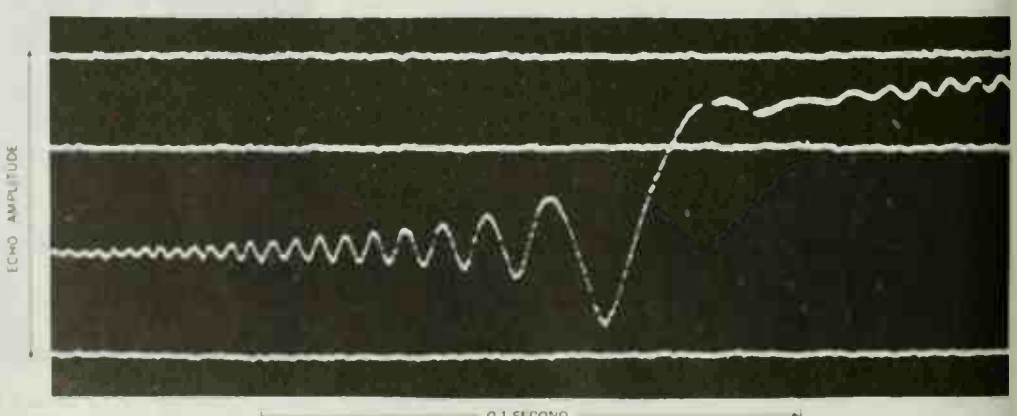
*Spectra.*—On entering the atmosphere, the surface of the meteoroid melts and vaporizes as a result of the heat evolved by collisions with air molecules, and the constituent atoms become excited and also ionized, giving rise to light emission. The major portion of the visible light consists of bright line spectra of common elements; *e.g.*, iron, calcium, magnesium, silicon, etc. Some continuous emission is also present, and oxygen and nitrogen lines are sometimes recorded, indicating that the air molecules are also excited. Meteoric spectra are similar to spectra obtained in the laboratory from meteorites but there are some significant differences.

*Ionization.*—The radio techniques are very sensitive as detectors of the ionization produced in the meteor trail. It is estimated that a 5th magnitude meteor, near the limit of naked-eye visibility, creates 5,000,000,000,000 ions and free electrons for every inch it travels, and a zero-magnitude meteor produces 100 times as much.

**Physical Theory of Meteors.**—It is assumed first that the rate at which atoms are evaporated from the meteoroid is proportional to the energy available from collisions with the air particles, and, second, that the rate at which the meteoroid itself is slowed down is proportional to the momentum transferred to the air. From these two basic hypotheses, together with reasonable assumptions about the density of the air at meteoric heights (comparable to good laboratory vacuums), it is possible to predict the light intensity and ionization production in terms of various parameters associated with the meteor and the atmosphere. The basic theory assumes the particle to be made of solid iron or stone, and modifications are needed to account for some observational evidence that many meteors may be porous bodies, or "dust balls," with a density less than that of water.

By working backward, it is possible to deduce the temperature and pressure of the air in the meteoric region. Prior to the advent of rockets and satellites, this aspect of meteor research yielded very useful data about the upper atmosphere.

In radio work the meteors are divided into two classes accord-




BY COURTESY OF NATIONAL RESEARCH COUNCIL, OTTAWA, CAN.

FIG. 5.—RADIO RECORD OF A METEOR ECHO. THIS RADIO TECHNIQUE (UNMODULATED TRANSMITTER) DOES NOT MEASURE DISTANCE BUT BRINGS OUT IN DETAIL THE RAPID AMPLITUDE FLUCTUATIONS OF THE ECHO AS THE METEOR CROSSES THE LINE OF SIGHT. IF A LOUD-SPEAKER IS USED, THE FLUCTUATIONS MAY BE HEARD AS "DOPPLER WHISTLES," FIRST DESCENDING IN PITCH, THEN RISING. THE METEOR VELOCITY CAN BE DETERMINED ACCURATELY BY MEASURING THE TIME INTERVALS BETWEEN SUCCESSIVE OSCILLATIONS

ing to the amount of ionization they create. The fainter meteors produce "underdense" trails; that is, the radio wave penetrates the long column of ionization and is scattered back by the free electrons, each acting independently. The received echo fades out as the trail expands laterally.

The brighter meteors produce "overdense" trails, so defined because the wave does not penetrate the column but is reflected from the surface of the column in a manner similar to the reflection of broadcast waves from the ionosphere. The duration of the echo in either case varies as the square of the radio wave length, and, of course, is dependent both on the amount of ionization produced initially and on the rate at which the ionized atoms diffuse and recombine.

Winds in the upper atmosphere cause the ionized trail to drift and also to twist and distort. Radio observations yield much useful information about the magnitude and direction of these winds. Visual observations of the glowing trains left by the brighter meteors also show the effects of winds.

**The Problem of Hyperbolic Velocities.**—The smallest observed velocity that a meteor can possess is about 7 m.p.s., corresponding exactly to the "escape velocity" of a rocket that just manages to break free from the earth's gravity. Particles moving in elliptical orbits about the sun will have heliocentric velocities (at the earth's distance from the sun) not greater than 26.5 m.p.s. If a particle is moving faster than this it is said to have a hyperbolic velocity; that is, it must have entered the solar system from interstellar space, and, if not stopped or perturbed, it will leave the system again, never to return. An observed velocity well in excess of 45 m.p.s., the sum of the earth's orbital velocity and the limiting elliptical velocity of a particle, would clearly denote the arrival of a visitor from outer space. For many years the possibility that a significant fraction, or even a preponderance, of the influx of meteors came from outside our system was argued intensely and at length. It is now generally agreed that the earlier data, based on visual estimates of velocities, and on rates and radiant distributions, were not sufficiently reliable or unambiguous. Modern photographic and radio techniques have been brought to bear on the problem. Several intensive surveys, some that concentrated on precise velocity measurements alone, and others that determined both velocities and radiants in order to compute the actual orbits, have shown conclusively that very few meteors, if indeed any at all, from the brightest down to the 8th magnitude, can have come from outside the solar system.

**Meteors and the Weather.**—There may be a possibility that meteors affect the world's rainfall. The formation of raindrops in the lower atmosphere is, in part at least, a process of condensation on small nuclei such as minute dust particles. Fine meteoric material, whether as debris from the visual range of meteor sizes, or as micrometeorite dust, will drift slowly down from meteoric heights to the weather region in about a month. Some statistical evidence has been presented to show a connection between rainfall and meteor showers occurring a month earlier. Although the research is intriguing, the data are extremely difficult to analyze, and the correlations deduced by the early 1960s were by no means convincing.

**Meteors and Radio Communications.**—Normally no communication can be established between a low-powered radio transmitter, using a frequency in the range 30–100 mc./sec., and a receiver several hundred miles distant, because the earth's curvature cuts off the direct wave, and the sky wave penetrates the ionosphere and is lost. However, whenever a suitably orientated meteor trail appears in the upper atmosphere, roughly halfway between the stations, the radio wave may be reflected to the receiver as long as the trail endures, which may be for a fraction of a second or for several seconds.

In a practical communication system there is a transmitter and a receiver at each end of the link, with one or both transmitters emitting unmodulated carrier waves. The message to be transmitted is stored on high-speed tape which can be started and stopped quickly. When a meteor reflection occurs, and the carrier wave is received at either end, the tape is started and the intelligence is transmitted just as long as the trail lasts. Despite the intermittent nature of the operation, this meteor system has several unique features which have led to its adoption as a useful member of the family of point-to-point communication systems. High-power ionospheric scatter systems also depend on meteor trails to a great extent. In this case, it is the myriad of small meteors that assist in maintaining a weak but continuous signal between the stations. (*See* also RADIO.)

**Meteors and Space Travel.**—Collisions with meteoric particles will be among the many hazards to face the space traveler. The kinetic energy released by a small high-speed meteoroid of iron or stone, if it were to strike a large body like a space ship, could be as much as a thousand times greater than the explosive energy of an equal weight of TNT. A pinhead particle might blast a hole in the shell of the vehicle that would allow the air within to escape in a few seconds. A meteoric pellet the size of a grape would almost certainly destroy the ship. Fortunately for the astronaut the probability of serious damage is very small. He should be able to travel for days before having to patch minor leaks in the ship's shell, while many years might elapse before a catastrophic collision took place. His chances for survival will be enhanced by steering clear of cometary orbits and the asteroidal belt between Mars and Jupiter.

*See* also references under "Meteor" in the Index.

*See* A. C. B. Lovell, *Meteor Astronomy* (comprehensive) (1954); Fletcher G. Watson, *Between the Planets* (popular) (1956).

(D. W. R. McK.)

**METEORA,** a group of monasteries on the summits of rock pinnacles in Trikkala *nomos* (department), Thessaly, Greece, behind the village of Kalabaka (anc. Aeginium, medieval Stagoi), about 32 km. (20 mi.) N.W. of Trikkala town. From the Cambunian hills two masses of rock project southward into the valley of the Peneus (Pinios), eroded into isolated columns 85 to 300 ft. high, "some like gigantic tusks, some like sugar-loaves, and some like vast stalagmites," all of iron-gray or reddish-brown conglomerate of gneiss, mica-slate, syenite and greenstone. The legendary belief is that they are the residue of the inland sea that once covered the plain of Thessaly.

The earliest monastic settlement there was a skete (*skitis*) or community of anchorites under a *protos*, centred on the rock called Doupiani. But about 1350 Athanasius, a Hesychast monk from Mt. Athos, ascended the *platys lithos* ("broad rock"), and on its summit built a chapel that was the nucleus of the monastery of the Great Meteoron, dedicated to the *Metamorphosis* (Transfiguration). In 1367 the *protos* Neilos erected four churches among the surrounding rocks, one of which, the chapel of the now deserted monastery dedicated to the *Hypapanti* (Presentation of Christ), survives; and by 1381 the then Serbian prince of Thessaly, John Urosh, had retired from his capital at Trikkala and become a monk in the Great Meteoron, whose church he rebuilt in 1388 (enlarged in 1545–55). Several more monasteries were erected in the 15th and 16th centuries after the Turkish occupation of Thessaly. Because of the confined area, the buildings were close together, but each monastery contains, besides the monks' cells and water cisterns, at least one church and a refectory, and some also a library. At one time said to have been 14 in number, they were formerly accessible only by rope and a net worked by a windlass from the top. Only five of them, the Great Meteoron, Barlaam or All Saints (Ayioi Pantes), St. Stephen (Ayios Stephanos), Holy Trinity (Ayia Triada) and Rousanou (or Rousani), are still inhabited by monks or nuns and can be reached by steps cut in the rock. The churches of the Great Meteoron and of Barlaam are decorated with remarkable frescoes of the 16th century. The monasteries suffered much during World War II and subsequent civil war; but restoration proceeded after 1960, and care has been taken to house and display some of their many treasures, works of art and manuscripts.

*See* L. Heuzey and H. Daumet, *Mission archéologique de Macédoine* (1876); D. M. Nicol, *Meteora: The Rock Monasteries of Thessaly* (1963).

(D. M. N.)

**METEOR CRATER** (also known as Crater Mound and Coon Butte), a bowl-shaped, rimmed pit 4,000 ft. in diameter in the rolling plain 19 mi. W. of Winslow, Ariz., produced by a large

meteorite. It is about 600 ft. deep inside its uplifted rim which rises nearly 200 ft. above the plain. Drillings reveal undisturbed rock under 500 to 800 ft. of fill, about 100 ft. of which are lake sediments. These sediments are under 30 ft. of blow sand, and the water level is approximately 200 ft. below this floor. Large numbers of nickel-iron fragments from gravel size to 1,400 lb. have been found in a 100-sq.mi. area; the distribution and composition of several thousand tons of sand-grain size nickel-iron droplets indicate that they are condensation droplets from a cloud of metallic vapours. Surveys show only fragments within the pit but the 1960 discovery there of coesite (*q.v.*), a high-pressure modification of silica, tended to confirm its meteoric origin. The estimated age is 50,000 years.

*See* also METEORITES: *Meteorite Craters.* (H. H. NR.; X.)

**METEORITES** are lumps of solid matter which occasionally can be seen to fall from the sky. The historical records of every civilized country in the world, from the earliest days onward, contain references to such sightings; since in most cases they were accompanied by luminous phenomena, it was customary to distinguish these objects as "fiery meteors" from the much more common "aqueous meteors," such as rain, snow, hail, etc. The origin of the two groups is entirely different, and the name meteor is no longer used for the aqueous kind, although the science dealing with them is called meteorology. Accordingly, the name "fiery meteors" also became obsolete; meteors have come to mean fast-moving luminous objects in the sky. They are also described as shooting stars or—if very conspicuous—as fireballs and are called meteorites when they fall to the ground. The science devoted to the study of meteorites is called *meteoritics*. A meteorite is usually named after the place nearest to where it fell.

As all meteorites show peculiarities not observed in any terrestrial mineral, it is possible to recognize them as such, even if their fall has not been witnessed. Recognition is particularly easy in the case of the so-called iron meteorites, which consist mainly of an alloy of iron and nickel; the other large class of meteorites, the stone meteorites, are so different in several respects from rocks formed on earth that their identification is usually no problem for the expert. They are, however, more likely to be overlooked by laymen and are, moreover, more quickly destroyed by atmospheric exposure; this is why in museums the proportion of "finds" to "falls" (*i.e.*, meteorites of which the fall has been observed) is much greater in the case of irons than in that of stones. *See* Table I, which is based on G. T. Prior, *Catalogue of Meteorites*, 2nd ed. rev. M. H. Hey (1953)

TABLE I.—*Number of Well-Authenticated Meteorites*

| | Irons | Stony irons | Stones |
|---|---|---|---|
| Finds | 503 | 55 | 304 |
| Falls | 42 | 12 | 628 |
| Total | 545 | 67 | 932 |

This table further shows that considerably more stones than irons have been seen to fall. Since there is no reason why it should be easier to observe one than the other, stone meteorites must predominate in nature; the comparatively large number of irons in collections is due to the ease with which they can be recognized. The table lists also a third and much smaller class, the stony-iron meteorites, which forms a link between the other two. A fourth class, the glass meteorites, is in several respects so different from the others that it will be treated separately (see *Glass Meteorites*, below). In Dec. 1952 the total number of well-authenticated distinct meteorites was 1,502; between 100 and 150 more were recorded before 1960.

**Phenomena of the Fall.**—The fall of a meteorite of any considerable size is accompanied by such startling light and sound phenomena that, from prehistoric times, such events have been remembered and recorded. These descriptions and the more or less successful attempts at pictorial representation agree with one another to a remarkable extent. The usual story is that a fiery mass suddenly appears in the sky, describing a shorter or longer orbit and leaving a luminous trail behind it. Near the end of its path, it disintegrates and dark fragments drop to the ground with a rumbling or hissing noise. It has occasionally been observed that the stones found in different places fitted together, thus showing that they were but fragments of the bigger mass that entered the atmosphere. The sound produced by the meteorite's flight—which is frequently described as terrifying, like the thundering of guns—is mainly due to the shock wave (often triple) accompanying the mass, followed by echoes. The speed of the falling mass is no greater than that of a stone of equal size coming down from the same height (400 to 600 ft. per second or less). Even in soft soil, therefore, the meteorites rarely bury themselves to a depth of more than a yard, and any damage done is only slight. Observation and timing of meteorites in flight show, however, that the speed at which they enter the earth's atmosphere is of a very different order; there is reliable information for falls at velocities of 8 to 10 mi. per second. For seven bright fireballs that probably ended as meteorites, velocities of 9 to 16 mi. per second have been calculated. This high speed is slowed down by the increasing resistance the meteorite encounters when it enters the denser regions of the atmosphere and kinetic energy is transformed into heat. The compressed air in front of the meteorite becomes luminous; what we notice as a fireball is mainly this mass of luminous gas of a diameter much greater than that of the solid body. The surface of the meteorite melts with the heat and gives off glowing particles which produce the luminous tail, and, later, the trail of smoke which can often be observed in the sky for some time after the disappearance of the other phenomena. As the flight of a meteorite inside the earth's atmosphere lasts only a few seconds, the heat produced on its surface has no time to penetrate deeply into the interior, which remains at about 4° C., the temperature appropriate to a body moving in an orbit near that of the earth. If picked up immediately after its fall, a meteorite is usually too hot to handle, but this superficial heat is quickly lost. Because of their better conductivity, iron meteorites are warmed to a somewhat greater depth than stone meteorites.

**Meteorite Showers.**—It has been mentioned previously that meteorites often break into fragments shortly before reaching the ground; however, sometimes the explosion occurs at a great height and the pieces produced disintegrate further during their flight through lower regions. In such cases a swarm of separate meteoritic bodies may arrive together, a phenomenon called a meteorite shower. The number of bodies in a shower can be very great; it was estimated that about 100,000 fell in 1868 at Pultusk, Pol.; perhaps 14,000 in 1912 at Holbrook, Ariz.; 2,000 to 3,000 in 1803 at L'Aigle, France; 200 to 300 in 1808 at Stannern, Moravia; and many thousands of irons in 1947 in the Sikhote-Alin region, U.S.S.R. All but the last of these observed showers consisted of stones, but from the large concentrations of iron meteorites of one and the same type which have been found in certain areas it must be concluded that other showers of iron meteorites have also occurred; the numerous fine octahedrites (see *Structure*, below) near Bethanie, South West Africa, the dozen or so hexahedrites in northern Chile and the Henbury craters in Australia (see *Meteorite Craters*, below) are examples.

The area in which the stones fall is generally a rough ellipse along the direction of flight. The larger the stone, the less will its velocity have been affected by air resistance and the farther, therefore, it travels. Accordingly, within this region, the stones are found to increase in average size in the direction of flight. Any shower contains stones of many different shapes and sizes.

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FIG. 1.—STONES FROM THE TENHAM SHOWER

**General Appearance of Meteorites.**—The shape of most meteorites is rather irregular, indicating that they all are frag-

ments of some bigger mass, but many of them at least roughly approximate a conical form. This occurs because they frequently maintain their orientation to the direction of flight, so that the forward corners are worn away by the air blast until a rough cone is produced. From both front and rear of the meteorite, molten material is constantly blown away during the period of rapid flight; but when the velocity has been sufficiently reduced, the air acts as a cooling agent and helps to solidify the rest of the liquid material, which then forms a crust. "Flow lines" in the crust and characteristic "pittings" often clearly indicate the direction of the air current. All this is true of irons as well as of stones.

On stone meteorites the molten crust is deep black and rarely more than $\frac{1}{25}$ in. thick; the contrast in colour between it and the whitish-gray interior, with its shining specks of metallic iron, is one of the most characteristic features of many stone meteorites and generally makes it easy to distinguish them from terrestrial rocks. From the more or less perfect development of the crust it is often possible to draw conclusions as to the length of time during which the surface had been exposed during flights; the gradual breaking up of the stones in a shower can sometimes clearly be read from their crusts. The crust of iron meteorites consists of an iron oxide and is black and very thin; it is seen only on fresh falls, as it is quickly replaced by a layer of rust.

**Chemical Composition.**—Meteorites consist of the same chemical elements as terrestrial matter. The quantitative distribution of the elements, however, shows marked differences from terrestrial rocks not only in the iron meteorites, but also in the stone meteorites, as shown in Table II. These are average figures. Individual meteorites show considerable deviations; *e.g.*, the nickel content of iron meteorites may be as low as 5% or as high as 34%.

That the chemical elements in meteorites and on earth are the same is most convincingly proved by their isotopic composition. Since most elements contain various kinds of atoms, it would be conceivable that the relative proportion of the atoms in meteoritic elements might not be the same as in terrestrial ones. However, the isotopic composition of many elements is constant, whatever their source. This uniformity is underlined by the discovery of certain exceptions: bombardment with cosmic rays produces an appreciable amount of the light isotope of helium, $He^3$, and traces of the radioactive isotopes $Be^{10}$ and $Al^{26}$ have also been detected in meteorites.

TABLE II.—*Composition of Meteorites and of the Earth's Crust*

| Meteorites | | | | Earth's Crust | |
|---|---|---|---|---|---|
| Irons | | Stones | | | |
| Iron | 90.8% | Oxygen | 36.3% | Oxygen | 49.4% |
| Nickel | 8.5 | Iron | 25.6 | Iron | 4.7 |
| Cobalt | 0.59 | Silicon | 18.0 | Silicon | 25.8 |
| Phosphorus | 0.17 | Magnesium | 14.2 | Magnesium | 1.9 |
| Sulfur | 0.04 | Aluminum | 1.5 | Aluminum | 7.5 |
| Carbon | 0.03 | Nickel | 1.4 | Nickel | 0.02 |
| Copper | 0.02 | Calcium | 1.3 | Calcium | 3.4 |
| Chromium | 0.01 | Sodium | 0.6 | Sodium | 2.6 |
| | | Chromium | 0.27 | Chromium | 0.03 |
| | | Phosphorus | 0.19 | Phosphorus | 0.12 |
| | | Manganese | 0.18 | Manganese | 0.08 |
| | | Cobalt | 0.14 | Cobalt | <0.001 |
| | | Potassium | 0.13 | Potassium | 2.4 |
| | | Titanium | 0.10 | Titanium | 0.58 |

**Mineralogical Composition.**—The chemical elements present in meteorites are mostly combined in well-defined compounds. Many of these minerals are also found in terrestrial rocks, but others are completely absent. Table III gives a selection of the most important meteoritic minerals.

Asterisks here indicate minerals that are known in nature only from meteorites, but can easily be prepared in the laboratory; they are not found on the earth because they would be quickly decomposed by oxygen or water. It is equally significant that some of the most abundant terrestrial minerals are missing in meteorites, especially those rich in oxygen and those usually deposited from aqueous solutions.

TABLE III.—*Important Meteoritic Minerals*

| Elements | Name of Mineral | Chemical Composition | Formula |
|---|---|---|---|
| | Diamond; Graphite | Carbon | C |
| Alloys | Kamacite | Iron with 5% to 7% nickel | Fe; Ni |
| | Taenite | Iron with 13% or more nickel | Fe; Ni |
| Sulfides, Phosphides and Carbides | *Oldhamite | Calcium sulfide | CaS |
| | Troilite; Pyrrhotine | Iron sulfide | FeS |
| | *Daubréelite | Iron-chromium sulfide | $FeCr_2S_4$ |
| | *Schreibersite; *Rhabdite | Iron-nickel phosphide | $(Fe,Ni)_3P$ |
| | Cohenite | Iron carbide | $Fe_3C$ |
| Chlorides | *Lawrencite | Ferrous chloride | $FeCl_2$ |
| Oxides | Tridymite | Silicon oxide | $SiO_2$ |
| | Magnetite | Iron oxide | $Fe_3O_4$ |
| Silicates | Plagioclase | Sodium-aluminum, and calcium-aluminum, silicate | $NaAlSi_3O_8$ and $CaAl_2Si_2O_8$ |
| | Enstatite; Hypersthene | Magnesium silicate | $(Mg,Fe)SiO_3$ |
| | Diopside | Magnesium-calcium silicate | $MgCa(SiO_3)_2$ |
| | Olivine | Magnesium-iron silicate | $(Mg,Fe)_2SiO_4$ |

**Structure.**—The minerals mentioned in Table III coalesce in characteristic ways to form the fabric of stone and iron meteorites. This structure of the meteorites can best be seen in a cross section; for the recognition of details a microscope is often essential. About 90% of the stone meteorites contain very peculiarly rounded spherules, called chondrules, sometimes easily recognizable without magnification, sometimes only of microscopic dimensions. They consist of olivine, enstatite or another of the meteoritic minerals, and are embedded in a groundmass of similar material. The structure of chondrites—as the stone meteorites containing chondrules are called—vaguely resembles that of some terrestrial rocks, the volcanic tuffs, but has several distinguishing features; *e.g.*, the eccentricity of the point from which the fibres in the chondrules diverge and the not uncommon enclosure of one chondrule inside another. The comparatively few chondrule-free stone meteorites are called achondrites.

The structure of the iron meteorites is best revealed by etching a ground cross section with dilute acid. Most iron meteorites reveal then a very unusual design, called after its discoverer the "Widmanstätten pattern." It consists of bands of kamacite with narrower borders of taenite (*see* Table III), the meshes being filled with a mixture of these two alloys. The pattern shown on the planes is to be interpreted as the section through a three-dimensional structure, a system of lamellae parallel with the faces of an octahedron. The angles at which the kamacite bands meet depend on the direction in which the section is cut and are, therefore, not characteristic; but the thickness of the bands is, and varies so considerably that the classification of the iron meteorites with octahedral structure, the octahedrites, is conveniently based on it. The octahedrites contain from 6% to about 11% nickel; the finer ones contain, on an average, proportionately more nickel.

There is another group of iron meteorites which, on etching, does not reveal the figures significant for octahedral structure. The surface of an etched plane may remain quite uniform but for the occasional appearance of very narrow straight lines in different directions called Neumann lines after their first observer. The angles of the Neumann lines and the cleavage of the meteorites which possess them indicate cubic structure; these meteorites are, therefore, called hexahedrites; they consist of the same iron-nickel alloy (about 6% nickel) as the kamacite bands of the octahedrites. Some iron meteorites containing less than 6% or more than about 11% nickel show neither Widmanstätten structure nor Neumann lines and hexahedral cleavage, and are called nickel-poor and nickel-rich ataxites ("unranged"), respectively.

The stony irons are a transition group between iron and stone meteorites. Some, the lithosiderites, contain so much iron that in sections this element appears as a coherent mass which includes

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FIG. 2.—IRON METEORITE (ABOUT 24,000 LB.)

separated stony parts and shows in the larger areas well-developed Widmanstätten structure; others, the siderolites, are very similar to stone meteorites but contain an unusually large quantity of interspersed metallic iron.

The appearance of the Widmanstätten pattern on an etched iron-nickel alloy is proof of its meteoritic origin; an artificial alloy of the same composition does not show it. For the alloy solidifies first as a whole and only later separates into the two constituents of the Widmanstätten structure, the nickel-poor kamacite and the nickel-rich taenite; such an internal rearrangement of a solid phase is an extremely slow process, and it may have taken thousands of years for the Widmanstätten pattern in meteorites to develop. If an iron-nickel alloy is cooled very slowly, a somewhat similar structure may be obtained, but only on a microscopic scale. On the other hand, in a meteorite that is heated, without melting it, up to a temperature of not less than 850° C. (1,562° F.), the Widmanstätten pattern is completely destroyed and cannot be restored; it may be difficult to distinguish such a meteorite from an ataxite.

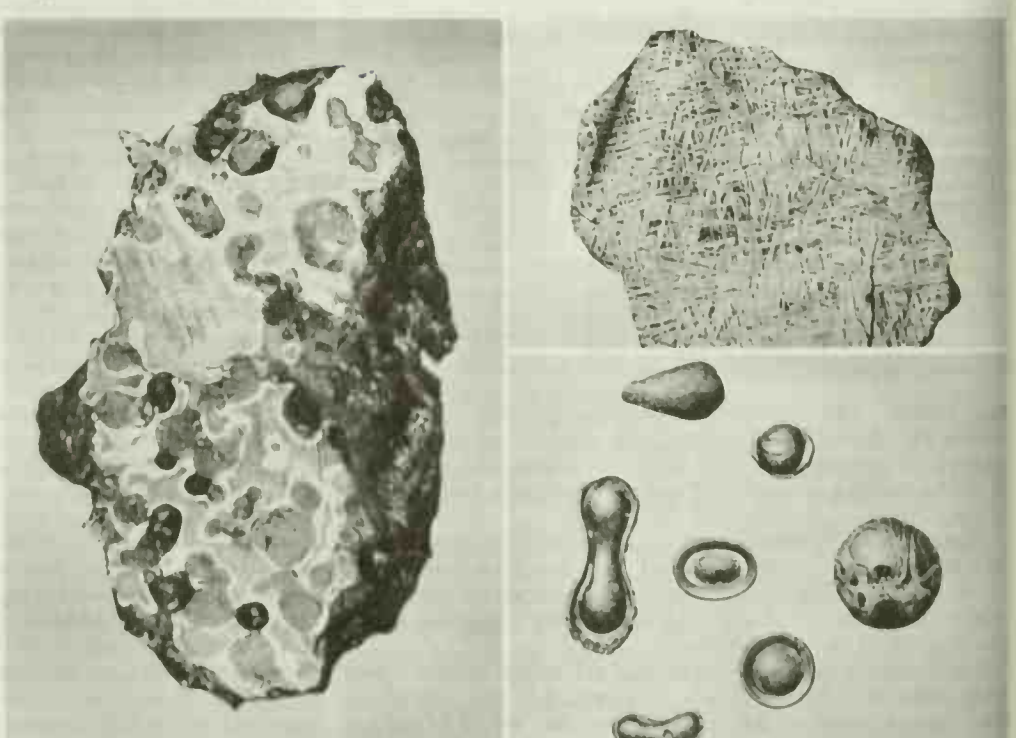
**Size.**—Meteorites can be of any size. In a large meteorite shower many of the stones are no bigger than a pea; they may, nevertheless, be covered all over by the typical black crust and to all intents and purposes be complete meteorites. It is frequently reported that still smaller bodies and "dust" also fall; in favourable circumstances, *e.g.*, when the ground is covered by snow, these black dust particles can be collected and identified as miniature meteorites. On the other hand, some meteorites are very large. The biggest known stone meteorite fell in 1948 in Norton county, Kan.; over 100 stones fell, including one of about one ton. Other large stones are those of Long Island, Kan., 1,230 lb.; Paragould, Ark., 880 lb.; Bjurböle, Fin., 730 lb., and Knyahinya, Czech., 640 lb. Still more impressive in bulk are several iron meteorites; the largest known, still lying at Hoba West Farm, near Grootfontein, South West Africa, is estimated to weigh 60 tons; it is surrounded by a thick layer of rust and must originally have weighed close to 90 tons. The largest iron seen to fall was a 1.7-ton mass, part of the Sikhote-Alin shower.

There is a brief report on a gigantic stony-iron meteorite discovered in 1920 in the Adrar desert in French West Africa, but the evidence for it is inadequate. There is, however, indirect evidence that much larger iron meteorites than that of Hoba have occasionally struck the earth, producing by their impact the so-called meteorite craters (*see* below).

**Meteorite Craters.**—A medium-sized meteorite has its flight effectively braked by the atmosphere, but a really large one strikes the ground with its cosmic velocity little checked, because the air resistance increases only with the square of the effective radius, but the kinetic energy with its cube. If the velocity at impact exceeds a few miles per second, the kinetic energy is enough to melt and even volatilize the meteorite; and as this energy is released in a very short time, it causes a violent explosion. This explains the formation of Meteor crater in Arizona, about ¾ mi. across and 600 ft. deep, which cannot be accounted for by any geological forces. Its rim of uptilted and broken strata rises 120–150 ft. above the surrounding plain; while masses of meteoritic iron from 12 cwt. down to tiny globules strewed the whole area outside the crater for several miles, no iron was found inside it. In all respects the crater matches craters known to be formed by explosions, such as shell holes. The craters at Henbury in central Australia and at Wabar in Arabia provide further evidence. At Wabar, the heat fused some native rock and volatilized part of the meteorite, for masses of a pumiceous glass matching the desert sand in composition are found. Some of this glass is black or gray and contains immense numbers of minute spheres of nickel-iron alloy, which is slightly richer in nickel than the meteoritic iron near the craters.

Since 1935 it has been proved that several other craters have been caused by the fall of meteorites, *e.g.*, those on the island of Ösel, Estonia; at Box Hole, central Australia; Dalgaranga and Wolf Creek, western Australia; Haviland, Kan.; and Odessa, Tex.; while a similar origin has been suggested but not proved for many more, and even for a number of major geographical features such as the Hungarian plain, the Nördlingen Ries and the Caribbean sea.

All proved meteorite craters are geologically recent, and all are historically ancient except two. On June 30, 1908, a major meteorite fell in the valley of the Stony Tunguska river in Siberia; it destroyed the surrounding forest, felling the trees radially outward over a radius of 20–30 mi., and produced earth tremors re-



BY COURTESY OF (LEFT) F. A. PANETH, (TOP RIGHT) THE SMITHSONIAN INSTITUTION, WASHINGTON, D.C., (BOTTOM RIGHT) THE BRITISH MUSEUM (NATURAL HISTORY), LONDON

FIG. 3.—(LEFT) LITHOSIDERITE. DARK PORTION IS STONE, LIGHTER ONE IS IRON AND SHOWS WIDMANSTÄTTEN STRUCTURE IN SOME PLACES. (TOP RIGHT) MEDIUM FINE OCTAHEDRITE, (BOTTOM RIGHT) AUSTRALITES

BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY, PHOTOGRAPH BY CLYDE FISHER

FIG. 4.—METEORITE CRATER, WINSLOW, ARIZ. (TAKEN FROM 2,000 FT.)

corded throughout the world. From the amplitude of the tremors the meteorite's mass has been estimated at 10,000,000 tons, corresponding to a diameter of about 100 yd.; on most types of terrain it would have produced a sizable crater, but the valley where it fell is in the permafrost region of Siberia, and by the time an expedition visited the spot (1927) mud flows had filled up whatever crater had been formed and there was little to be seen. Far more was learned from the Sikhote-Alin shower of Feb. 12, 1947. This fall gave rise to more than 100 small craters, the largest over 90 yd. across and 40 ft. deep. Accounts by eyewitnesses were recorded, and the craters and the meteorites studied in detail.

For the occurrence of a high-pressure modification of silica at some meteorite craters, *see* COESITE.

**Glass Meteorites: Tektites.**—During the 18th century, small rounded pieces of deep bottle-green glass began to be found in Moldavia, along the Vltava (Ger. Moldau) river near Ceske Budejovice, Czech. The nature of this material long remained a mystery; the fragments were found over too wide an area to come from a forgotten glassworks and there are no volcanic rocks nearby (nor does the material closely resemble any volcanic glass). At least 10,000 pieces have been found, mostly of about 10–20 gr. weight. Since about 1860 similar glass bodies have been found in several other parts of the world. They are generically called tektites, with special names according to origin, *e.g.*, moldavites, billitonites (found on the Malay peninsula as well as on Billiton or Belitung, Indon.), rizalites from the Philippines, javaites, bediasites from Texas and australites. Tektites from the Ivory Coast have not been given a special name.

The colour of tektites varies from green to deep brown; their composition varies considerably, but is not very different from that of some obsidians, with 70%–80% $SiO_2$, 10%–13% $Al_2O_3$, 2%–5% FeO, 1%–3% $K_2O$, etc. The Austrian geologist Eduard Suess suggested about 1900 that tektites are glass meteorites, but they differ completely in appearance and composition from the ordinary meteoritic stones. Notwithstanding a few reports about australites, it seems fairly certain that no tektite has ever been seen to fall. Detailed studies of the surface and internal structure of the australites show that they are the remains of much larger glassy lumps that have undergone ablation during passage at high velocity through the earth's atmosphere; they lie on the surface or in recent alluvial deposits, and clearly are geologically recent. The other types of tektites have curiously etched and pitted surfaces, but they are found at various geological horizons, *e.g.*, moldavites in Middle Miocene gravels and bediasites in Upper Eocene beds; it is probable that they are coeval with the beds in which they are found and that their surface structures result from terrestrial weathering.

The structure of the australites shows that they were shaped by rapid flight through the atmosphere, but this does not identify them as glass meteorites. Several other possibilities have been suggested; *e.g.*, that they are "splashes" from the impact of gigantic crater-forming meteorites. This explanation still seems the most likely for the irregular fragments of glass found at Mt. Darwin, Tasmania (tasmanites, queenstownites or darwinites) and at the Aoulleoul crater in French Equatorial Africa; the Mt. Darwin and Aoulleoul glasses are, indeed, intermediate in composition between the tektites and pure $SiO_2$, but in other respects they differ markedly from the true tektites.

Opinion is swinging between theories of a terrestrial and of an extraterrestrial origin for the tektites, according to the nature of the pieces of evidence, in themselves inconclusive, which accumulate. It is difficult to suggest any source for material as silica-rich as are the tektites other than the fusion of sedimentary rocks, which, in the solar system, are probably confined to the Earth and Mars. But, on the other hand, the internal structure and external characteristics of the australites show clearly that they were already solid, rigid bodies before they made their final flight through the Earth's atmosphere; this fact, and their distribution, seems to rule out meteorite-crater splash theories. There is also evidence that the australites entered the atmosphere at velocities exceeding the Earth's escape-velocity; but this is not definite. On the whole, an extraterrestrial origin for them seems most probable.

The large masses of almost pure silica glass (98% $SiO_2$) found in the Libyan desert seem too large and too silica-rich to be classed with the tektites, but theories that these bodies might be of terrestrial origin are unconvincing, and they remain a puzzle.

**Meteoric and Cosmic Dust.**—The fused material swept off meteorites as they pass through the atmosphere gradually drifts to earth as meteoric dust. Cosmic dust, on the other hand, consists of micrometeorites, which are bodies so small that their cosmic speed is checked in the atmosphere without appreciable heating, so that they drift to earth almost unaltered. Many attempts have been made to collect both cosmic and meteoric dusts, but it is extremely difficult to avoid contamination by dusts of terrestrial origin; at this time, therefore, not much reliable information exists.

**Frequency, Geographical and Geological Distribution.**—A statistical survey of all meteorites whose hour of fall is known shows that more hit the earth in the afternoon than in the morning. The ratio is about 8:3. Thus at least the majority of the meteorites move in "direct" orbits, *i.e.*, in the same direction around the sun as does the earth; perhaps there are no "retrograde" meteorite orbits at all, for those falling in the morning hours may have been overtaken by the faster revolving earth. The number of meteorite falls observed during the various months of the year is greatest in June and is fairly high in the adjoining months. This need not, however, be for astronomical reasons but simply because in the summer months a greater number of potential observers are likely to be out-of-doors than in winter.

It is even more difficult to assess whether there are significant differences in frequency of falls with latitude or longitude. Variations in the records may have other causes.

As for the geological distribution of meteorites, stones rapidly become unrecognizable and irons appear slowly to lose their nickel; but the mass of iron oxides might be expected to retain some nickel and to remain recognizable. Yet no meteorite, nor anything that might be the altered remains of a meteorite, has ever been found in deposits older than the Pliocene (and the iron of Skookum Gulch, Yukon, found in Pliocene gravels, is probably much younger than they). Also the quantity of coal mined from 1860 to 1960 amounts to many billions of tons; if the same average number of meteorites had fallen during the period when the coal deposits were formed as in recent years, about a thousand meteorites should have been dug out with the coal; it is impossible to assume that every miner would have overlooked such an unusual find. Nor has anything recognizable as the remains of a meteorite ever been found in quarrying or other operations. It is also significant that the collections of strange objects brought together by Stone-Age men contain glass meteorites (moldavites) but no iron meteorites.

The conclusion seems unavoidable that—quite differently from glass meteorites—the iron and stone meteorites did not begin to fall before the Pliocene, or probably later. There are indications that their frequency was then, for a time, higher than it is now; in the centuries before Christ it was general knowledge among

Mediterranean people that iron was a celestial metal (see *History of Meteoritics*, below), and the very small number of iron meteorites which can now be observed to fall could hardly have created such a widespread belief. Between 1800 and 1900 scientists made careful records of all meteorite falls; during that century the methods of communicating news steadily improved and the general level of education and the interest in natural phenomena rose, but the annual number of reports on meteorite falls, averaged over ten years, remained fairly constant at between four and five. Thus even after 1800, falls seem to have become fewer, but findings are too scarce for predicting whether or not a time is approaching when once again no meteorites will be falling on earth.

**Age of Meteorites.**—The "age" of a meteorite refers to the time that has elapsed, not since its arrival on earth, but since its solidification, wherever this may have taken place. This is the sense in which geologists speak of the age of a rock or mineral. The geological age of meteorites throws light on their origin.

Like all other rocks, meteorites contain minute traces of uranium and thorium and it should, therefore, be possible to apply to them the radioactive methods of age determination. The simple procedure for terrestrial materials cannot be used, however, because meteorites, unlike terrestrial rocks and minerals, may have been exposed to the full intensity of cosmic-ray bombardment for the whole or part of their lives; and nuclear reactions due to cosmic rays give rise to several of the same products as the breakdown of the common radioelements U, Th and K. What matters is not only the time since the meteorite was last in the liquid state, but also the size and nature of the body of which it then formed a part, the thermal and mechanical history of the mass since solidification (including the distance of the material examined from the surface of the mass, particularly during the latter part of its history) and, with nuclear reaction products of relatively short half-life, the date of its arrival on earth. The many complications have not yet been fully resolved, and some results are very difficult to understand. For example, the iron meteorites of Cape York, Torres strait and of Muonionalusta, Swed., appear to have He: (U + Th) ratios so small that their ages would seem to be less than $10^6$ years; however, the time for formation of the Widmanstätten structure of these meteorites has been estimated at about $10^8$ years. It does, however, appear from the general consensus of results that the meteorites probably originated as solid bodies at the same date (about $4.5 \times 10^9$ years ago) as the rest of the solar system but have had a complex and varied history since then. Some, it would seem, have undergone little or no reheating; others may have had quite different thermal and mechanical histories. (For the ages of tektites, see *Glass Meteorites*, above.)

**Origin of Meteorites.**—Many hypotheses have been proposed to explain how meteorites come into existence. Early 19th-century scientists believed them to be ejected from the craters of the moon; others thought that large terrestrial volcanoes might have thrown them out in past geological epochs. Later a connection with comets was assumed, or even an independent growth from gaseous interstellar matter. The theory which seems best to account for all the facts known today is that meteorites originate from the disintegration of a planet, similar in composition to the earth but smaller—perhaps a large asteroid. The irregular form and different sizes of meteorites support this theory. Despite their wide range of composition and structure, there are regularities that suggest the common origin of the meteorites (except the tektites) from one or a few bodies. The existence of a continuous series of metal to silicate ratios, from the irons through irons with minor silicate inclusions, stony irons and metal-rich enstatite chondrites to metal-poor and metal-free stones suggests an origin from a body or bodies of moderate size but probably smaller than the earth, because of the smaller proportion of oxygen retained. The few known meteorite orbits are asteroidal in character. The history of the parent body must be fairly complex; on the one hand, the brecciated character of many meteorites, the frequent presence of broken chondrules, and the chondrules themselves, suggestive of a hailstorm of molten silicates (compare, however, B. J. Levin and G. L. Slonimsky, *Meteoritika*, vol. 16, 1958), all give evidence of a highly active and turbulent period; on the other hand, the enormous single crystals of the irons and the perfect Widmanstätten structure are evidence of a long quiescent period at a moderate temperature (about 400° to 500° C.).

Tektites, which are widely regarded as glass meteorites, probably have a quite different origin; but opinions concerning them are too numerous and too fluid to summarize here. (See *Glass Meteorites* above.)

Meteorites most likely resulted from the breaking up of a small member of the solar system, but a detailed account must await the answers to certain fundamental questions of astrophysics, such as the origin of the planets. Greater understanding of the formation of meteorites in turn will clarify many puzzling problems about the solar system, its origin and final fate.

**History of Meteoritics.**—Since very ancient times men have known about meteorites falling; however, the scientific study of meteorites is hardly older than 150 years.

Long before man learned to smelt iron, he valued meteoritic iron, and there is proof that he knew of the precious metal's celestial origin; for in many languages the name for it contains a reference to the sky, and in some records its origin is contrasted with that of terrestrial metals like gold, silver and copper. The awe-inspiring phenomena accompanying the fall of meteorites convinced primitive people all over the world that meteorites came from the gods; accordingly they are found as objects of awe in many cults and frequently venerated in temples. One of the best-known instances of worship is probably that of the Ephesians; they were worshippers not of the goddess Diana and of the "image which fell down from Jupiter," as the very unfortunate translation of Acts xix, 35, runs in the authorized English version, but of Diana and of the "thing that fell from the sky," obviously a meteorite. Similarly, in Delphi, besides Apollo a holy stone was the object of adoration. The "iron shield" which fell in Rome under the reign of Numa Pompilius was put in the perpetual custody of a college of priests. The "black stone" of the Ka'ba, the holiest of holies of the Muslims, is no doubt a stone meteorite with its strange black crust. In the ruins of an ancient Mexican temple an iron meteorite was unearthed, carefully wrapped in mummy cloths. A stone that fell in 1492 near Ensisheim in Alsace was interpreted by King Maximilian I of Germany as an exhortation to a crusade against the Turks and hung by his order in the village church, where it can still be seen. In India, a stone that fell not long before 1885 was worshipped, decked with flowers and daily anointed. Many more examples could be cited.

It was just this miraculous character of meteorite falls and the favour they found with the churches which, during the period of enlightenment, made scientists suspicious of their reality. In the 18th century members of the French Academy, then the highest authority in all scientific matters, were convinced that such an irregular phenomenon as the fall of a stone from heaven was impossible, and preferred to doubt all the reports of witnesses and to change their statements to conform with acknowledged scientific theories. Following their lead, keepers in many museums of Europe discarded genuine meteorites as shameful relics of a superstitious past. It is an interesting fact that the preservation of the precious iron meteorite of Hraschina, which fell in 1751, is due to the protection given to it by the bishop of Zagreb's consistory; they collected the sworn statements of eyewitnesses and sent the document, together with the iron, to the Austrian emperor. Both came into the possession of the Vienna museum. The influence of this clerical report on the Hraschina fall went even further; it became one of the strongest weapons in the hand of the German physicist E. F. F. Chladni (1756–1827) when he began his fight against the scientific authorities who ridiculed belief in meteorites. His paper of 1794, in which he defended the trustworthiness of this and of a few similar accounts and explained meteorites as pieces of cosmical matter that enter our atmosphere, marks the beginning of the science of meteoritics. Most of his colleagues remained skeptical, but a shower of stones that fell in 1803 at L'Aigle, not far from Paris, finally convinced the Paris academy and the rest of the scientific world of the reality of the fall of meteorites. From that time astronomers, physicists, chemists and mineralogists of many countries have contributed to knowledge of them. Collec-

tions of meteorites are to be found in most natural history museums; the richest and most instructive ones are those in Vienna, Berlin, Paris, London, Moscow, New York, Chicago and Washington, D.C.

*See* also references under "Meteorites" in the Index.

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**METEOROLOGY,** the physical and chemical science of the atmosphere (Gr. *meteora* and *logos*, the science of things above —of the air and of things in the air). The subject, which is a branch of geophysics (*q.v.*), comprises the study of the whole atmosphere but, for practical and observational reasons, attention has been largely concentrated in the past on the processes in the lowest 10–15 km. (about 6–9 mi.), which give rise to weather. Certain of these processes are common to all levels of the atmosphere but other processes, *e.g.*, photochemical, magneto-hydrodynamic, arise or become more dominant at markedly higher levels. Such phenomena call for special studies, such as that of ionospheric physics, within the broader framework of meteorology (*see* ATMOSPHERE; IONOSPHERE).

The following discussion deals mainly with processes in the troposphere and stratosphere (*q.v.*). Certain branches of atmospheric physics are incidental to rather than determinative of atmospheric behaviour as a whole. These branches include: (1) atmospheric acoustics, which deals with the propagation (refraction and scattering) of sound through the atmosphere (*see* SOUND); (2) atmospheric electricity, which is the study of electric fields, currents (notably lightning), space charge and charge separation in the atmosphere (*see* ELECTRICITY, ATMOSPHERIC; LIGHTNING); (3) atmospheric optics, which deals with certain optical reflections and refractions besides scattering phenomena such as mirages, rainbows, halos, coronas, sky colours, etc. (*see* CORONA; HALO; MIRAGE; RAINBOW); (4) radio meteorology, which, except as a tool, is concerned with the effect of the troposphere—a distinction from the ionosphere is implied—on the propagation of (short) radio waves or pulses (*see* RADIO).

Below are the main divisions of this article:

I. Introduction
II. History
III. The Composition and Vertical Structure of the Atmosphere
IV. Solar and Terrestrial Radiation: Heat-balance and the Field of Temperature of the Atmosphere
V. Evaporation and Condensation in the Atmosphere
VI. Wind
VII. Atmospheric Wind Systems and Weather
VIII. The General Circulation
IX. Large-Scale Disturbances of the General Circulation
X. Small-Scale Flow Patterns

## I. INTRODUCTION

The atmosphere is characteristically in motion at all points, and its properties (see *The Meteorological Elements*, below) are continually changing. This sequence of change constitutes "weather," a term often but not necessarily referring to the atmospheric changes directly apprehensible by man. The quantitative explanation of the sequence of change is the subject matter of physical and dynamic meteorology, with which the present article is primarily concerned. A significant description of weather, *i.e.*, an effective formulation of the problems of physical and dynamic meteorology, is partly provided by synoptic weather charts (weather maps), which are also essential tools in weather forecasting. The observations on which synoptic charts are based are made by the more or less standardized procedures of instrumental meteorology (see *Bibliography*, below; *see* also ANEMOMETRY; BAROMETER; SYNOPTIC WEATHER CHART; THERMOMETRY).

The changes in the meteorological elements characterizing weather are contained between certain limits, depending on place and season. The average values of the elements and certain statistics of their spread are referred to as "climate," and their study as "climatology." This study will be discussed in outline, but a proper understanding of weather implies an understanding of climate also. For general discussion of climate and weather and weather forecasting *see* CLIMATE AND CLIMATOLOGY and WEATHER FORECASTING.

**The Meteorological Elements.**—The elements in terms of which the physical condition of the atmosphere is usually expressed are listed below. Because the elements are in general fluctuating on time scales down to a fraction of a second, some form of mean value, appropriate to the phenomenon investigated, has to be understood. For most synoptic purposes a period mean over at least a few minutes is usually employed.

*Temperature.*—The air temperature $T$ is measured with a thermometer over whose bulb the air is allowed to flow freely, but which is protected by suitable screening from solar and terrestrial radiation. An approximate measurement of ground surface temperature is made by supporting an unshielded thermometer immediately above the ground; its indications are mostly used to provide surface minima at night.

*Atmospheric Pressure.*—The pressure $p$ at any point in the atmosphere is the weight of the vertical column of atmosphere of unit cross section above the point in question. Its value at the earth's surface is usually obtained from a mercury barometer, and aloft from an aneroid barometer or, occasionally, a hypsometer. At heights greater than about 50 km. (about 30 mi.) other, more sensitive devices are necessary. The centimetre-gram-second (c.g.s.) unit of pressure is 1 dyne/cm.$^2$, pressure at sea level being about $10^6$ dyne/cm.$^2$ or approximately 1 kg. weight/cm$^2$. Atmospheric pressure is most commonly expressed in terms of a c.g.s. derived unit, the millibar (mb.), equivalent to $10^3$ dyne/cm.$^2$, so that sea level pressure is about 1,000 mb. One "standard" (conventional) atmosphere pressure is 1,013.2 mb., which is the weight of a 76 cm. (29.92 in.) column of mercury of unit cross section under "standard" gravity (980.665 cm.$^2$/sec.) at 0° C.

*Humidity.*—This term is used loosely to express the amount of (uncondensed) water vapour in the air. Precise specifications in use are: (1) vapour concentration or density $\rho_v$ (also called absolute humidity), which is the mass of vapour per unit volume of moist air; (2) humidity mixing ratio $r$, which is the mass of vapour per unit mass of associated dry air; (3) the vapour pressure $e$, which is that part of the total atmospheric pressure $p$ exerted by the water vapour; (4) relative humidity $\mu$, which is $100e/e_w$ where $e_w$ is the saturation (maximum) vapour pressure of water at air temperature $T$. (Relative humidity may also be expressed, for $T < 0°$ C., by $100e/e_i$ where $e_i$ is the saturation vapour pressure of ice at $T$.) These specifications are related as follows, ideal gas behaviour being assumed for both water vapour and dry air:

$$r = \frac{\rho_v}{\rho_a} = \frac{M_v}{M_a}\,\frac{e}{p-e}, \text{ with } \rho_a = \frac{M_a}{\mathrm{R}}\,\frac{p-e}{T}$$

where $\rho_a$ is density of dry air, $M_v$, $M_a$ are molecular weights of water vapour and dry air respectively ($M_v/M_a = 18.02/28.97 = 0.622$), R is the universal gas constant = 8.3144 joule mole$^{-1}$ °K.$^{-1}$ Each specification is useful in particular contexts; for example, the mixing ratio $r$ is constant when an element of air moves unmixed with its surroundings from one pressure level to another without condensation, whereas $\rho_v$, $e$, $\mu$ all then vary, but $\mu$ is the only direct specification of departure from saturation. Humidity is usually measured either by the change in length of hygrometric substances (hair, goldbeater's skin, etc.) giving relative humidity, or by screened and ventilated dry- and wet-bulb thermometers giving any specification required by the use of appropriate tables, or by the measurement of dew-point or frost-

point temperature. The dew-point temperature is the temperature at which the air becomes saturated with respect to water at the initial pressure of the air. The corresponding saturation vapour pressure, which is determined by temperature only, is then the actual vapour pressure of the uncooled air. Frost-point temperature is defined in a similar manner. (*See* also HUMIDITY, ATMOSPHERIC.)

*Wind Velocity.*—Wind velocity is specified by the speed and direction of motion of the air, or by component speeds along directions normal to each other. The conventional indication of direction in meteorology is given by referring to the direction from which the wind blows, the angle being measured clockwise from north, 0°; thus, *e.g.*, an "east" wind blows from the east (90°) and a "southwest" wind from the southwest (225°). Wind speed near the earth's surface is usually measured by a cup anemometer or Pitot tube and its direction by a freely pivoted vane; wind velocity up to about 30 km. in the free atmosphere is obtained by following the motion of a freely rising balloon by optical, radio or radar methods, optical methods being limited to levels below cloud. (*See* also WIND.)

*Condensation Products and Precipitation.*—Water vapour may condense into liquid or solid particles which, when formed on the ground, are termed dew or hoar frost respectively (*see* DEW; FROST) and, when formed in the air, are termed cloud (fog, if the cloud is immediately above the earth's surface). Cloudiness is measured by the fraction of sky covered with cloud (*see* CLOUD; FOG). When cloud particles become large enough to acquire a perceptible fall speed they constitute precipitation, which may be in one or more of the following forms: (1) rain, *i.e.*, liquid water, the term drizzle (*q.v.*) being used when the drops are less than about 0.2 mm. diameter (*see* RAINFALL); (2) snow, composed mainly of single though generally complex ice crystals (*see* SNOW); (3) sleet, a mixture of rain and melting snow—in the United States, sleet also refers to frozen raindrops (*see* SLEET); (4) hail, a complex of clear and opaque ice, the opacity deriving from air occluded in the ice when supercooled liquid cloud droplets impinge and freeze on the hailstone (*see* HAIL). The amount of precipitation (*q.v.*) is given by the depth of water (rain, melted snow or hail) falling through an open area of surface and collected beneath.

*Radiation.*—The number of hours of bright sunshine per day, as measured by the burning-glass sunshine recorder, is a commonly made but crude measure of solar radiation received at the earth's surface (*see* SUNSHINE). Of greater physical importance are the solar energy received directly from the sun and indirectly from the sky by scattering, and the net energy emitted by the earth's surface. The latter is the excess of the self-radiation of the earth's surface over the downward self-radiation of the atmosphere; these radiations are invisible, in the infrared, and of longer wave length than the longest effective wave length of solar radiation. Both solar and terrestrial radiation are measurable by total radiation receivers.

*Visibility.*—This is defined as the maximum horizontal distance at which reasonably sized objects may be distinguished against a sky background. It is essentially a measure of the density of aerosol (particulate material—dust, hygroscopic nuclei, etc.) in the line of sight. (*See* also VISIBILITY.)

## II. HISTORY

The weather has been a primary concern of mankind since before the dawn of civilization. This fact is reflected in fragments of the earliest writings and in the existence of numerous ancient deities associated with various weather phenomena. The earliest-known systematic treatises on meteorology are the famous *Meteorologica* of Aristotle (384–322 B.C.) and the writings of his pupil Theophrastus on winds and on weather signs. During the next 2,000 years the science of meteorology did not progress substantially beyond the point to which it had been carried by Aristotle, in spite of a number of treatises on the subject. The development of the science, like that of the other physical sciences, was forced to await the invention of the instruments by which the primary physical elements could be measured.

**The Beginning of Meteorology as a Physical Science.**—The 17th and 18th centuries, in the history of physical science, constitute essentially a period of instrumentation and establishment of the elementary physical laws of gases, liquids and solids. Especially significant for the development of meteorology were the inventions of the thermometer by Galileo in 1607 and of the barometer by Evangelista Torricelli in 1643, followed by the discovery of Boyle's law in 1659. An explanation of the trade winds, including for the first time the effect of the earth's rotation on atmospheric winds, was attempted by George Hadley in 1735. When the true nature of atmospheric air was determined by Antoine Lavoisier in 1783, and when John Dalton, in 1800, had explained the variations of water vapour in the atmosphere and the relation between the expansion of air and atmospheric condensation, the physical basis of modern meteorology was established.

**The First Weather Charts and Weather Forecasting.**—The development of the science during the 19th century occurred primarily in the field of synoptic meteorology; *i.e.*, in the organization of networks of weather observing stations, in the preparation of daily synoptic charts (*see* SYNOPTIC WEATHER CHART) and in the initiation of modern weather forecasting. The first international compilation of weather observations was made by J. B. Lamarck (with P. S. Laplace, Lavoisier and others) from 1800 to 1815. The use of synoptic weather observations by such men as H. W. Brandes (1820), W. C. Redfield (1837), J. P. Espy (1841) and many others established the existence of characteristic patterns of pressure, wind and weather (depressions, anticyclones, etc.), and empirical rules for their development, movement and the accompanying sequence of weather changes. In 1848 M. F. Maury (U.S. navy) published maps of the main wind fields over much of the earth and these were immediately turned to nautical profit by the still large number of sailing ships of those days. Following the lead of these men, between 1850 and 1875 many nations established meteorological services based on synoptic observations from networks of weather stations. International conferences (Brussels, 1853; Vienna, 1873) established international co-ordination of these national weather services by arranging for standard observational techniques and for the international exchange of weather observations by telegraph and later by wireless. The practice of weather forecasting increased rapidly during the same period, but progress in the understanding of atmospheric behaviour was not rapid before 1900. W. von Bezold and O. Neuhoff applied thermodynamics to atmospheric convection (cumulus and cumulo-nimbus clouds), and Lord Kelvin laid the foundation of the theory of atmospheric tides. These, unlike oceanic tides, were found to be dominated by the sun rather than by the moon, so that thermal influence rather than gravity was considered paramount. A relatively large semidiurnal atmospheric tide was ascribed by Kelvin to resonance in an atmosphere with a natural period of near 12 hours. These tides were not observed to have any effect on weather.

**Meteorology in the 20th Century: the Upper Air.**—The advance in weather science since 1900 has mainly arisen from an increasingly intensive exploration of the upper air by instrumented free balloons to about 20 or 30 km. height, by aircraft to somewhat lower levels and after World War II by rockets and weather satellites.

Isolated observations of temperature in the free air had been made by kites and manned balloons from about 1750 onward, but it was the introduction of the rubber balloon in the 1890s and the invention of a light meteorograph for measuring pressure, temperature and humidity which resulted in fairly frequent soundings in France, Germany and England from about 1900. The results of such soundings were of course available only when the meteorograph was recovered. An early reward of this exploration was the discovery of the stratosphere (see *The Composition and Vertical Structure of the Atmosphere*, below). Regular measurements of the winds aloft, but below the clouds, were made by observing the path of uninstrumented, free (pilot) balloons.

More and quicker observations of the free air were demanded during World War I, and aircraft were used to provide them. A cheaper method of immediate exploration was, however, required

and this, the radiosonde (radio meteorograph on free balloon), began to appear in many countries in the 1930s. It was widely exploited in World War II and thereafter. From daily or more frequent simultaneous soundings over wide areas it became possible to prepare synoptic charts of pressure and temperature at upper levels and thus to observe the evolution of the three-dimensional atmosphere. Winds were added to the picture by direction-finding on the radio transmitter of the radiosonde or by radar methods (*see* RADAR METEOROLOGY; UPPER AIR SOUNDINGS). The immediate demand for this tremendous body of knowledge arose from weather forecasting, the scope of which had increased tremendously with the widening demands of military and civil aviation. The new knowledge was equally essential to the formulation of the problems of basic meteorological theory, for it had long been realized that the behaviour of the atmosphere at one level was intimately related to its behaviour at other levels.

A considerable step forward in the formulation of synoptic meteorological problems was taken by a group of meteorologists (V. and J. Bjerknes, H. Solberg, T. Bergeron) at Bergen, Nor., at the end of World War I. They gave a detailed description of the structure and evolution of extratropical depressions in terms of air movements at a polar front, which is the sloping surface or zone separating warm air masses from cold. The model became invaluable to weather forecasting, but it was not until after World War II that any satisfactory theory of the model appeared. In that postwar period also the first serious attempts were made (following a suggestion by L. F. Richardson in 1920) to exploit the hydrodynamic equations of atmospheric motion for weather forecasting, using the observations provided by radiosondes.

## III. THE COMPOSITION AND VERTICAL STRUCTURE OF THE ATMOSPHERE

The atmosphere is a mixture of gases, most of which are practically permanent whereas others are continually entering and leaving the atmosphere. The density of the mixture is greatest at the earth's surface (about 1.2 kg./m.$^3$), and it decreases continuously with height to become vanishingly small at a few hundred to 1,000 km. elevation, the relation between density $\rho$ and height $z$ being

$$\frac{1}{\rho}\frac{\partial \rho}{\partial z} = -\frac{Mg}{RT} - \frac{1}{T}\frac{\partial T}{\partial z}$$

where $M$ is the molecular weight of the mixture, $T$ is its absolute temperature, $g$ is the acceleration of gravity and R is the universal gas constant. Thus the density decrease depends on the composition, through $M$, and on the temperature, which in turn depends partly on the composition, *i.e.*, on the heat capacity of the mixture and on its absorptive power for radiation, and partly on dynamic factors. Something will now be said on composition and temperature distribution, the latter being particularly important as it provides a convenient way of describing the vertical structure of the atmosphere.

**Composition of Dry Air.**—Dry air is nearly constant in composition up to about 100 km., the proportions of its principal constituents by volume being as follows:

| Gas | $N_2$ | $O_2$ | Ar | $CO_2$ | Ne | He |
|---|---|---|---|---|---|---|
| Volume percentage | 78.09 | 20.95 | 0.93 | 0.03 | 0.002 | 0.0005 |

The molecular weight $M_a$ of this mixture is 28.97.

Some dissociation of $O_2$, providing atomic oxygen, O, sets in at about 50 km. and has probably become complete at about 150 km. This dissociation is related to the appearance of ozone, $O_3$, in a very small but highly significant amount at levels below about 50 km.; its maximum volume percentage occurs at about 23 km. Dissociation probably occurs at higher levels for $N_2$ than for $O_2$, and for $CO_2$ at levels similar to those for $O_2$. Such dissociation is due to the absorption of solar ultraviolet radiation.

There is no good evidence for the occurrence of gravitational separation of the lighter from the heavier gases below 100 km. (62 mi.), although this has often been proposed. It appears that the mixing of gases in the vertical by the winds is far too strong to allow such separation to occur, at any rate below 100 km.

**Water Vapour in the Atmosphere.**—Water vapour is non-permanent in the atmosphere because it can undergo change of phase at atmospheric temperatures and pressures. Condensation and precipitation result in the removal of water vapour from the atmosphere. The loss is made good, on the average, by evaporation from the earth's surface, but large fluctuations of vapour content occur in the process.

The volume proportion of water vapour in air is generally greatest at the earth's surface, where it may be at the most about 2%. In this proportion the air is about 1% lighter than dry air at the same pressure and temperature (see *Humidity*, above). At 12–15 km. height the volume proportion is necessarily several orders of magnitude less than that at the maximum surface value, because of the relatively low temperature at the upper levels and the rapid drop of saturation vapour pressure with temperature.

The importance of water vapour in the structure and behaviour of the atmosphere is not, however, to be measured by its relative concentration, because (1) its very large latent heat of condensation is an important source of energy in atmospheric motion; and (2) it has very strong absorption in those infrared wave lengths in which terrestrial radiation occurs. These factors allow it to exert a strong control on the temperature of the atmosphere.

Water vapour is dissociated by ultraviolet sunlight at very high levels (*c.* 100 km.) into hydrogen (H) and hydroxyl (OH) radicals, the presence of the latter (which may perhaps arise also from other processes) being shown by their characteristic spectral emissions. As a result hydrogen probably escapes from the atmosphere into space.

**Temperature Stratification in the Atmosphere: Layer Nomenclature.**—The variation of temperature with height in the atmosphere undergoes remarkable changes from layer to layer. Fig. 1 shows the broad form of the temperature variation and a layer-nomenclature associated with it; complete unanimity has not been reached for the nomenclature above about 30 km. The lowest layer of the atmosphere, the *troposphere* or "mixed layer," in which temperature decreases at an average rate of about 6.5° C./km., is the layer in which clouds predominantly form and from which precipitation falls. In the second layer, the *stratosphere*, temperature is at first rather constant with height—it increases slowly with height in lower latitudes and decreases slowly (at less than the tropospheric rate) over the winter pole—and then increases rather rapidly to the top of the layer at about 50 km., where the temperature is about the same as at the earth's surface. The stratosphere is said to be stably stratified because vertical motion is inhibited by the thermal structure (see *Lapse-Rate and Vertical Stability*, below). The boundary between the troposphere and the stratosphere, called the *tropopause*, is often very sharp but, in middle latitudes particularly, may be less well-defined and may be multiple, through folding. Its height is about 16 km. in the tropics, about 11 km., but variable, in middle latitudes and about 9 km. over the polar caps.

The layer next above the stratosphere, the *mesosphere*, is again one of decreasing temperature, on account of which vertical motion is less inhibited than in the stratosphere. Little is known about the variation in height of its lower and upper boundaries—*stratopause* and *mesopause* respectively—with latitude or season. The temperature at the mesopause (approximately 80 km.), about 180° K. (−93° C.), is the lowest to be found in the atmosphere. Above the mesopause is a layer of increasing temperature and also of high electrical conductivity called the *thermosphere* or the *ionosphere* (*q.v.*), the latter to stress its electrical property. Its temperatures are largely conjectural above about 200 km., but satellite behaviour has narrowed the uncertainties.

**The Variation of Atmospheric Pressure With Height: Hydrostatic Equilibrium.**—The necessary relation between density, temperature and height and some observed properties of the thermal structure having been stated, it is now appropriate to relate these to another basic physical property of the air; *i.e.*, its pressure. This is achieved through a very simple but fundamental relation called the hydrostatic equation, which expresses the fact that, if the air has no vertical acceleration, the difference in pres-

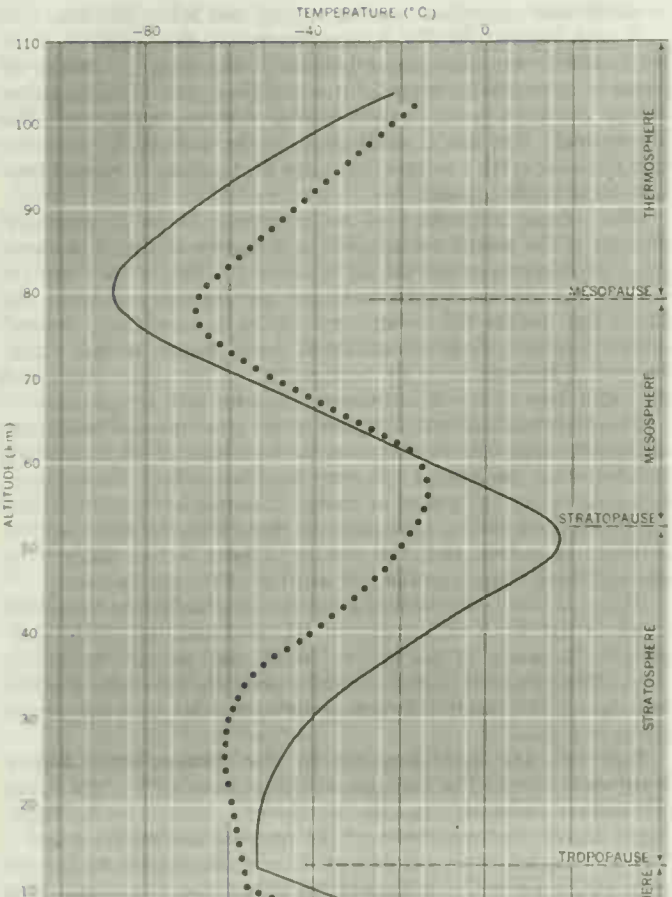



FIG. 1.—VERTICAL DISTRIBUTION OF TEMPERATURE IN THE ATMOSPHERE. THE LINES (SOLID FOR SUMMER, BROKEN FOR WINTER) REFER TO MIDDLE LATITUDES. BUT GENERAL FORM IS SAME FOR ALMOST ALL LATITUDES

sure between any two levels is the weight of the column of air of unit cross section between the levels. Thus, consider an infinitesimal layer of air of density $\rho$ and of vertical thickness $dz$; *i.e.*, of mass per unit horizontal cross section $\rho\, dz$. Its weight is then $g\rho dz$, where $g$ is the gravitational force on unit mass (so-called gravitational acceleration), and this weight is equal to the decrease of pressure $-dp$ over the height interval $dz$, so that $-dp = g\rho dz$, or $\partial p/\partial z = -g\rho$. The rate of decrease of pressure with height is then directly proportional to the density of the air, gravity being effectively constant over most heights concerned. It is in fact quite justifiable to assume the air to be without vertical acceleration, *i.e.*, to be in hydrostatic equilibrium, in nearly all contexts, for any acceleration is always very small compared with $g$.

It is evident from the above equation that, if the density were given or observed as a function of height, the pressure at any level relative to that at a datum level could be computed by simple integration. The meteorological problem does not, however, usually appear in this form, since density itself is rarely observed directly. It is much commoner to observe, *e.g.*, by radiosonde or by aircraft, the temperature, humidity and pressure of the air and from that data to estimate the heights of given pressures. Or it may be necessary to estimate the height corresponding to an observed pressure, as when an aircraft uses an aneroid barometer as an altimeter. The first of these problems is readily solved by using the equation of state of air, $p = R\rho T/M$, in the hydrostatic equation. Here due allowance can be made, if precision demands, for the effect of the (variable) water vapour present in the air on the value of $M$. Eliminating $\rho$, and writing $R/M = R$ (= .2870 $j\, g^{-1}$ °K.$^{-1}$ for dry air) the hydrostatic equation becomes $dz = -(RT/g)dp/p$ so that the relative change of pressure with height is inversely proportional to the temperature. This is an exceedingly important result for relating the distributions of pressure (mass) and temperature in the atmosphere and will be much used in the balance of this discussion. Integrating the last equation, the height $z$ of any pressure level $p$ is

$$z = -\frac{R}{g}\int_{p_o}^{p} \mathrm{Td}\,(\log p)$$

where $p_o$ is the pressure at the origin of $z$, normally the height of the station from which the sounding is made. Thus, by plotting the observed temperature against the logarithm of the observed pressure, the height of any pressure $p$ is given by measuring the area between the curve and the log $p$ axis between the relevant pressures $p$ and $p_o$. Diagrams for making this computation quickly and accurately are standard tools of meteorological services. Since heights above a common datum (*i.e.*, mean sea level) are normally required, the height of the observing station is to be added to the heights as computed above. Given a network of simultaneous soundings, the heights of pre-selected pressures at points in the network can be used to map the topography of the selected isobaric surfaces over the area of the network. Such maps, called isobaric contour charts—the topography is shown by contour lines as in the more familiar topographic maps of the earth's surface—form the working basis of the synoptic meteorology of the upper air. Isobaric surfaces have slopes of the order of 1:1000, and the approximate heights of commonly chosen surfaces are as follows:

| Pressure (mb.) | 1,000 | 750 | 500 | 300 | 200 | 100 | 50 |
|---|---|---|---|---|---|---|---|
| Approximate height (km.) | Sea level | 2.5 | 5.5 | 9 | 11.5 | 16 | 20 |

These figures show the approximate distribution of mass in the atmosphere, so that, for example, since 10% of the mass lies above the 100 mb. surface (10% of the surface pressure), 90% of the mass occurs below about 16 km.

The determination of the height of a given pressure at levels appreciably above 100 km., where the composition and therefore the molecular weight $M$ becomes somewhat uncertain, is necessarily approximate.

**Altimetry.**—The altimetry problem referred to above evidently cannot be solved precisely without a knowledge of the temperature in the column of air below the altimeter. A practical solution is provided by assuming a temperature distribution ("standard atmosphere") which approximates to the mean of that observed. Thus, in the equation $dz = -(RT/g)dp/p$, put $T = T_o - \beta z$ where $T = T_o$ at $z = O$ ($p = p_o$), and $\beta$, the rate of decrease of temperature with height ($= -\partial T/\partial z$), is called the lapse rate. Then, by integration, $z = T_o\,[1 - \left(\frac{p}{p_o}\right)^{R\beta/g}]/\beta$

The scales of aircraft altimeters are commonly fixed by setting $T_o = 288°$ K., $\beta = 6.5 \times 10^{-3}$ ° K./cm. (6.5° K./km.), $g = 980.66$ cm./sec.$^2$ and $R = 2.870 \times 10^6$ erg $g^{-1}$ °K.$^{-1}$, giving $z(\mathrm{m}) = 44310\,[1 - \left(\frac{p}{p_o}\right)^{.1902}]$. If the actual temperatures are higher than those assumed, an altimeter will read too low, in extreme cases by about 10%, and vice versa. Corrections can of course be made if the isobaric topography is known.

**Reduction of Station Level Pressure to Sea Level.**—The change of pressure with height is about $10^4$ times as great as the horizontal change, so that surface pressures over land are hardly comparable unless reduced to a standard level, which is taken as sea level unless a large amount of the land lies well above this datum. The usual procedure for effecting this reduction of pressure is to assume that a column of air lies below the station at a temperature equal to the air temperature at the station. The hydrostatic equation is then used to determine the increment of pressure to be added to the pressure at the station. This procedure generally gives reasonably smooth fields of sea-level pressure, such as are mapped for association with the current weather

A similar procedure is used in computing the height of the 1,000 mb. isobaric surface (*see* above) when the surface pressure is less than 1,000 mb.

## IV. SOLAR AND TERRESTRIAL RADIATION: HEAT-BALANCE AND THE FIELD OF TEMPERATURE OF THE ATMOSPHERE

The atmosphere and its underlying surface receive radiant heat from the sun (an infinitesimal amount of heat is received from other celestial bodies and by conduction through the earth's crust from the interior of the earth) and they lose heat to outer space by their own radiative emissions. The energy received undergoes many transformations, involving plant growth and other chemical changes, the evaporation of water and the melting of snow and ice, the generation of winds and, of course, the heating of the air and earth.

But in the long run no appreciable fraction of this energy is stored in the earth and, in particular, there is no persistent trend toward higher or lower temperature. Consequently the loss of energy from the earth by terrestrial radiation must closely approximate to the energy gained from the sun.

The radiation balance is, however, only achieved for the earth as a whole, and the pattern of imbalance in place and time is intimately related to that evolution of the atmosphere of which weather is part. Some of the more important aspects of the radiation balance and its relation to the field of temperature will now be discussed.

**Solar Radiation.**—Solar radiation, as it reaches the outside of the earth's atmosphere, is in quality quite similar to that of a black body at 5,800° K., and is effectively contained within a spectrum extending from about $0.2\mu$ wave length in the ultraviolet ($1\mu = 10^{-4}$ cm.) to about $3\mu$ in the infrared, maximum energy falling near $0.5\mu$ in the visible region (*see* fig. 2). The so-called solar "constant," which is the total energy flux through unit area normal to the solar beam at mean distance of the earth from the sun, is 2.0 cal.cm.$^{-2}$min.$^{-1}$ (0.14 watt/cm.$^2$), of which half is in the visible and most of the remainder in the infrared region. These findings are necessarily the result of some extrapolation upward of observation.

Variations in the solar constant of 2% or so, partly related to the sunspot cycle, have been claimed but no change as large as 0.1% has been established nor is it probable. There are certainly appreciable variations in the solar ultraviolet, but the energy there is so small compared with that in the rest of the spectrum that the variations can hardly affect overall heat balance considerations; they are however unquestionably important in the ionosphere.

A solar constant of 2.0 cal.cm.$^{-2}$min.$^{-1}$ corresponds to an average input of energy over the whole earth of 0.5 cal.cm.$^{-2}$min.$^{-1}$, but not all of this is effective, for a fraction of the incident energy is scattered or reflected back to space—by the gaseous atmosphere, by clouds and dust and by the earth's surface (*see* fig. 2). This fraction is called the earth's albedo, and it is estimated to be 34%; it determines the brightness (all wave lengths combined) of the earth to an extraterrestrial observer. Only the remainder (*i.e.*, 66%), which is absorbed in the earth's atmosphere or at its surface, is available for terrestrial transformation. For conciseness, the 0.5 cal.cm.$^{-2}$min.$^{-1}$ of mean solar input will be referred to as 100 units; 66 units therefore are available to the earth.

Of these available 66 units of solar energy, about 19 are absorbed in the atmosphere. Almost all the short ultraviolet (less than 1 unit) is absorbed above the mesopause and is probably mainly responsible for the increase of temperature above that level (*see* fig. 1), because absorption is an exponential process and the radiation enters from above. Two or three units, mainly in the ultraviolet, are absorbed by ozone in the lower mesosphere and stratosphere, and this gives rise to the zone of high temperature above and below the stratopause. The temperature curve passes through a maximum because the ozone increases in relative amount, and absorption can then increase initially along the path of the radiation. The amount of this absorption is sufficient to increase the temperature of the upper stratosphere by the order

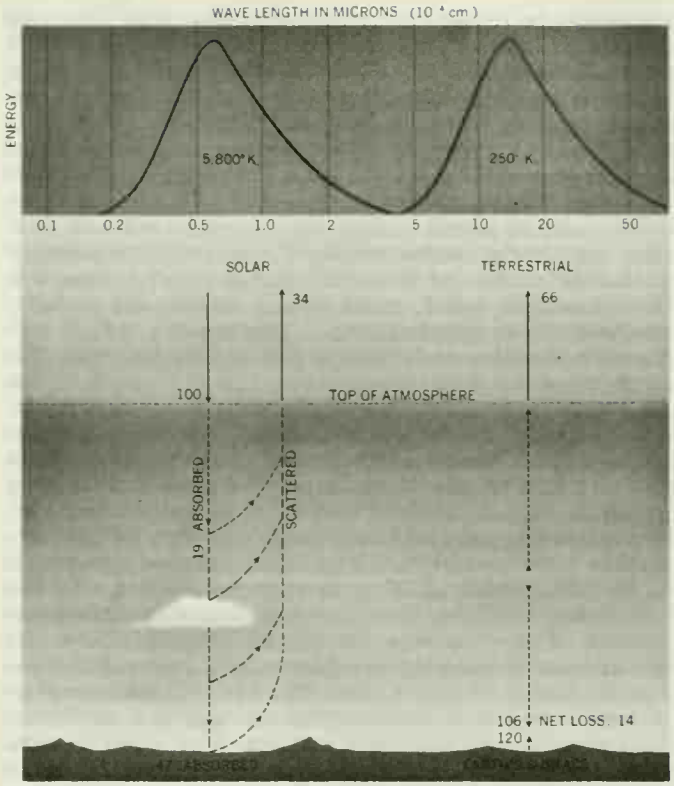



FIG. 2.—HEAT BALANCE OF THE EARTH

The upper diagram shows the energy distribution of black bodies at 5,800° K. (the approximate radiative temperature of the sun) and 250° K. (the approximate radiative temperature of the earth), the curves being drawn to provide equal areas under each because the solar and terrestrial fluxes are equal. The lower diagram represents absorption and scattering of solar radiation and emission of terrestrial radiation, the incident solar radiation (100) equals the sum of the back-scattered solar radiation (34) and the terrestrial emission (66).

of 10° K. per day, but self-radiation prevents a cumulative increase of temperature at this level. The remainder of the atmospheric absorption, about 16 units, is mainly in the near infrared, by water vapour in the troposphere. Here the very rapid increase of humidity mixing ratio downward results in practically uniform absorption per unit mass of air along the path, equivalent to a uniform rise of temperature of about 1° K. per day. Because of its uniformity the absorption exerts a negligible control on the temperature distribution in the troposphere.

The remaining 47 units of solar energy (47/66, or 71% of the available energy) are absorbed at the earth's land and sea surface. (*See* fig. 2.) The sea absorbs rather more strongly than the land, about 95% as against 90% to 85% of the incident radiation, and both much more strongly than a snow surface, whose whiteness implies its large reflection coefficient in the visible region of the spectrum. The absorption is spread over a greater depth of sea than of land, and wave-breaking turbulence in the sea spreads the absorbed energy over still greater depths. This implies that the energy absorbed at the sea surface is less immediately available to the overlying atmosphere there than on the land, which can become much hotter, but the energy has to be disposed of in both cases. It is made available to the atmosphere partly by the further radiative processes now to be discussed and partly by dynamic processes to be considered later; the joint outcome of which is that the temperature must decrease upward from the surface over a substantial depth of atmosphere—the troposphere.

Much more solar energy is of course received by unit area over the year in low latitudes than in high. Depending on differences in cloud amount and surface reflection, the heat received drops from a maximum of about 80 units at the equator to a minimum of about 40 units at the poles.

**Terrestrial Radiation.**—The terrestrial energy balance implies that the self-emission of the earth-atmosphere system to

space must be equal to the solar energy absorbed. This self-emission (66 units) originates at temperatures within the observed range of about 200° K. to 300° K. (in contrast with about 6,000° K. for the sun), and it must therefore be effectively contained, according to Planck's law, within the wave-length range 5$\mu$ to 50$\mu$; *i.e.*, beyond the longest effective wave length of the solar spectrum (*see* fig. 2). This is a fortunate simplification of the radiation balance problem.

Practically all natural surfaces, including water and snow, radiate as black bodies (perfect radiators) at terrestrial temperatures, so that the emission of the earth's surface ($= \sigma T_0^4$ where $\sigma$ is Stefan's constant and $T_0$ is the surface temperature) is readily computed. It amounts to 120 units, corresponding to $T_0 = 288°$ K., and is therefore nearly twice as great as the solar input. The maximum of this emission occurs near 10$\mu$ wave length. Now, the water vapour and carbon dioxide of the troposphere are together strongly absorbing over practically the whole spectrum of the surface emission except between about 8.5$\mu$ and 11$\mu$, so that very little or none of the surface emission escapes directly into space. It is absorbed and re-radiated, upward and downward, by the absorbing gases with an intensity depending on their temperature. Moreover, if cloud is present it will absorb completely all terrestrial radiation falling upon it—its surfaces are black bodies—and it will give black-body emission for its surface temperature. Thus, on average, 106 units are returned to the earth's surface from the overlying atmosphere, giving a net radiative loss from the surface of only 14 units. The loss from the atmosphere to space, including the small amount that may pass unabsorbed from the surface through the atmosphere, is of course 66 units. This is less than the downward emission to the surface because the escaping radiation mainly originates in the high troposphere, where the temperature is much lower than near the surface. A small part of the escaping radiation originates in the ozone layer, which has absorption bands at about 9.5$\mu$.

The presence of absorbing gases and cloud in the atmosphere causes a greenhouse effect, so that the surface temperature of the earth is much higher than it would be in their absence. An emission of 120 units from the surface and the corresponding temperature are only possible because nearly as much radiation comes back from the atmosphere. The requisite loss of 66 units from the atmosphere to space ensures that the temperature of the gas supplying this radiation shall be very much lower, about 220° K.

Another important consequence of atmospheric absorption and emission, in relation to the vertical temperature distribution, is that more radiation leaves the top of the troposphere than the net amount (upward–downward) entering it at the bottom. Thus the troposphere is continually losing heat by radiation, at a rate equivalent to a cooling of about 2° K. per day. This cooling does not occur, and the loss is made good by solar absorption and by the input of heat from the surface to the troposphere by non-radiative processes—by turbulent conduction and by evaporation of water with later condensation and precipitation. This input from the surface is the balance between the absorption of solar radiation at the surface and the net radiative emission from the surface.

The loss of heat per unit area to space is practically independent of latitude, because the troposphere is deeper in lower latitudes so that the effective temperature of the radiating gas changes little with latitude, although the surface temperature changes greatly.

**Radiation Imbalance and Thermal Balance.**—Although a global balance is achieved between solar and terrestrial radiation, it is evident from the figures given above that a radiation balance is not in general achieved locally, for, whereas the solar input decreases markedly with latitude, the terrestrial emission is almost independent of latitude. There results a surplus of energy in latitudes lower than about 35°, and a deficit in latitudes higher than this. As likewise noted above, a balance is not achieved in the vertical, more heat being lost from the body of the troposphere than is gained at the surface. Since, however, the temperature and composition of the troposphere do not in the long run change materially at any point, energy must be exported from the regions of net gain to the regions of net loss; *i.e.*, from below to above and from lower to higher latitudes. Mention has been made of the processes providing a balance in the vertical—effectively, the exchange of air between different levels with condensation of water vapour. The meridional balance also is effected by exchange of air, but between latitudes, *i.e.*, by means of the winds; but the two modes of exchange are not independent, because the winds have vertical components which are in general related to the horizontal components. Indeed, the atmosphere may be likened to a heat engine in which the boiler is the region of net radiative input and the condenser the region of net radiative loss. The winds are then created by virtue of the source-sink distribution, and they transport just sufficient energy from source to sink to maintain both on average at constant and equal strength. The field of temperature of the atmosphere has to be consistent with its radiation field and with its motions, for the latter exert their own control on temperature in ways to be examined below.

The distribution of sources and sinks of heat in and above the stratosphere is not well defined for lack of suitable observations and of a comprehensive theory of radiative absorption and emission. There is, however, evidence that between about 30 and 100 km. height the air over the summer pole is a heat source and that over the winter pole is a heat sink, with radiative equilibrium very nearly achieved elsewhere. Where this equilibrium exists the temperature distribution is automatically determined; it adjusts itself in any small volume so that the radiation emitted by the volume, a product of its composition and temperature, is equal to the radiation absorbed by it.

**Nonradiative Temperature Change and Heat Transfer in the Atmosphere.**—Changes of temperature due to radiative heat sources and sinks in the atmosphere run at the rate of 1° K. or 2° K. per day in the troposphere and rather more at some higher levels. Dynamic processes, however, can produce substantially larger rates of change, and these will now be examined.

**Adiabatic Changes in Dry Air.**—If a volume of air is compressed reversibly the mechanical work of compression is transformed into internal energy of the air compressed, and this is reflected solely in a rise in temperature of the air if it is of unchanging composition (no change of phase of water). Conversely, expansion of air leads to a fall in its temperature. If no heat is transferred between the volume of air and its environment during the compression or expansion—if, that is, the process is adiabatic—the resulting change of temperature is readily determined.

For a volume of dry air, using the equations of energy conservation and of state, it may readily be shown that in an adiabatic change the variation of temperature $T$ with pressure $p$ is given by

$$\frac{dT}{dp} = \frac{T}{p}\frac{R}{c_p} \quad \text{or} \quad \frac{T}{p^{R/c_p}} = \text{constant},$$

where $c_p$ is the specific heat of dry air at constant pressure ($\simeq 1$ joule $g^{-1}$ °K.$^{-1}$) and $R/c_p = 0.286$. Thus, for example, dry air initially at a pressure of 1,000 mb. and a temperature of 290° K. ($\simeq 17°$ C.) corresponding roughly to surface conditions, if expanded adiabatically to a pressure of 300 mb. (an upper troposphere value), would have a temperature of 206° K. ($\simeq -67°$ C.). The actual difference in temperature at any instant between these two levels is about 65% of the above difference.

Now, change of height $z$ can be related to change of pressure in the vertical by the hydrostatic equation (*see* above), so that if the change of pressure occurs as a result of change of height, the hydrostatic equation allows the first of the above equations to be written $dT/dz = -g/c_p \simeq -1°$ K./100m. The quantity $g/c_p (= -dT/dz)$ is called the *dry adiabatic lapse rate* and is the drop in temperature of a moving parcel of air per unit increase of height in adiabatic ascent. Correspondingly, the temperature will rise at the same rate in adiabatic descent. It will be noted that the rate of change of temperature is substantial, as is implied also in the example above. It is also to be noted that the symbolism $d/dT$ implies change on a moving particle of air.

**Adiabatic Changes in Moist Air.**—If moist air undergoes adiabatic compression or expansion then, provided that there is no

evaporation or condensation of water, *i.e.*, no change in composition, the relation between $T$ and $p$ or $T$ and $z$ remains practically the same (to within about 1%) as for dry air, very small changes only in $R$ and $c_p$ being needed for the water vapour present in the mixture. If, however, evaporation or condensation occurs—the former in compression of air containing condensate, the latter in expansion of saturated air—the change of temperature with pressure or height may be much reduced, because of the latent heat absorbed in evaporation or released in condensation.

The $T$, $p$ and $T$, $z$ relations for adiabatic changes in saturated air are more complex than those for dry adiabatic changes because the saturation vapour pressure is non-linear in temperature. The relations may, however, be readily computed. Thus, the value of $-dT/dz$ in saturated adiabatic ascent, which is called the *saturated adiabatic lapse rate*, is about one-third of the dry adiabatic lapse rate at 300° K., about two-thirds of it at 273° K. and about 95% of it at 240° K.

If moist air is lifted adiabatically to well beyond the level of initial saturation and if the products of condensation fall out, *e.g.*, as rain or snow, a subsequent adiabatic descent of the air would produce dry adiabatic heating. The air would then return to its initial level much warmer than it left it, by the equivalent of the latent heat released during the ascent, and it would be drier by the amount of water precipitated. An approximation to this sequence of events may occur when air rises and then descends over a mountain range, giving warm, dry foehn or chinook winds on the leeward side.

**The Significance of the Adiabatic Lapse Rate.**—No atmospheric motion is strictly adiabatic, although many, particularly those of large scale which take place fairly quickly, approximate to the adiabatic. (The change in temperature of a volume of air across the unit surface of which a given heat flux occurs is inversely proportional to the linear dimension of the volume.) In any case, the adiabatic lapse rate, dry or saturated, remains most important for the understanding of temperature change in the atmosphere under practically all conditions, and some examples will now be considered.

**Effect of Vertical Mixing on Actual Lapse Rates.**—The first inference to be made is that the vertical (up and down) motion of parcels of air in a layer tends always to bring the actual temperature distribution or lapse rate in the layer toward the adiabatic, dry or saturated, accordingly as the layer is unsaturated or saturated. For any parcel of air would, without exchanging heat with its environment, move along an adiabatic $T$, $z$ path but, since it will exchange some heat, by mixing or radiation (conduction is never important), with its environment, it will follow a path intermediate between the adiabatic and the actual or environmental lapse rate. The environmental lapse rate will then necessarily be brought toward the adiabatic by the heat exchange. Continued up and down motion and heat exchange will ultimately give rise to an adiabatic lapse rate in the layer if there is no other process in operation to maintain a non-adiabatic lapse rate. Once the adiabatic lapse rate is achieved further motion will evidently have no effect on the lapse. If the initial lapse rate is sub-adiabatic, the lower levels of the layer will be warmed and the upper levels cooled, and conversely for an initially super-adiabatic lapse rate (*see* fig. 3). The onset of vertical mixing in a sub-adiabatic layer may produce cloud in its upper levels, owing to the cooling there. If fog should be present in the layer initially, vertical mixing will tend to dissipate this because of the warming in the lower levels.

The conditions under which vertical motions will set in to produce mixing will be considered below.

**Effect of Large-scale Vertical Motion on Temperature and Lapse Rate.**—The process described in the last section is independent of the scale of vertical motion considered, but the speed at which the lapse rate adjusts itself, other things being equal, will be less the larger the scale of the moving elements. Consider therefore a large scale vertical motion which is practically adiabatic, and examine its effect on the temperature field.

It is evident from fig. 3 that air rising adiabatically from any level will bring cooler or warmer air to any higher level according as the initial lapse rate is sub-adiabatic or super-adiabatic. The direction of the temperature change is opposite for descending motion. Now, a sub-adiabatic lapse rate is more characteristic of the atmosphere, so that upward motion will usually produce a drop in temperature and descending motion a rise in temperature. The rate of change of temperature with time $t$ at any level is readily seen to be given by $\partial T/\partial t = -w(\Gamma - \gamma)$ where $w$ is the vertical velocity of the air, positive upward, $\Gamma$ is the adiabatic lapse rate, dry or saturated as appropriate, and $\gamma$ the actual lapse rate. For the troposphere, a representative value of $w$ for large-scale descent of cloud-free air ($\Gamma = 10°$ C./km.) is $-5$ cm./sec. and for $\gamma$ is 6° C./km., giving $\partial T/\partial t = 5(10-6)\ 10^{-5}$ °C./sec., or about 0.7° C./hr. warming. In sustained ascent, saturation will normally occur over some part of the path, and the rate of cooling will usually be less than the last figure ($\Gamma$ diminished for the saturated path), but comparable with it. It is to be noted that such dynamic warming or cooling rates are an order of magnitude larger than the representative rates of heating or cooling by radiation in the troposphere, as given earlier.

Large-scale vertical motion also changes the lapse rate itself, by stretching a layer of air in ascent to lower pressure and by compressing it in descent to greater pressure. Thus, adiabatic ascent causes the actual lapse rate to approach the adiabatic value and descent increases its departure from the adiabatic value. The same effects on lapse rate are produced respectively by the horizontal inflow of air, *i.e.*, *convergence*, which stretches a layer, and by the horizontal outflow of air, *i.e.*, *divergence*, which makes a layer thinner. Convergence normally reinforces the effect of ascent, and divergence that of descent, in the lower troposphere, whereas in the upper troposphere the reverse is true. The lapse rate being normally sub-adiabatic away from the earth's surface, descent and the associated divergence in the lower troposphere will give rise to a very small lapse rate or, more commonly, to an increase of temperature with height, *i.e.*, to an *inversion*, which is called a subsidence inversion. As will be seen in the next section, an inversion is unfavourable to small-scale vertical mixing motions; therefore it tends to be persistent.

**Lapse Rate and Vertical Stability.**—Referring to fig. 3, suppose a parcel of air to be displaced upward from some level, say $P$, in the layer with temperature distribution $AB$. The parcel will follow a path lying between $PB'$, the adiabatic path, and $PB$, the curve of environmental temperature. Whatever the precise path followed, the parcel will find itself in a warmer environment in the case of fig. 3(A), and in a cooler environment in the case of fig. 3(B). If the pressure of the parcel is adjusted to that of its environment as it rises, then in case (A) it will be denser than its environment and in case (B) less dense. From Archimedes' principle there will then be a downward force on the parcel in the one case and an upward force in the other. Thus the parcel will tend to fall back to its level of origin in case (A) and to be further displaced upward in case (B). The temperature distribution in (A), which is sub-adiabatic, is said to be *statically stable*, because vertical displacements are evidently resisted, whereas the temperature distribution in (B), which is super-adiabatic, is said to be *statically unstable*, because vertical displacements grow spontaneously. The argument and conclusions apply both to un-

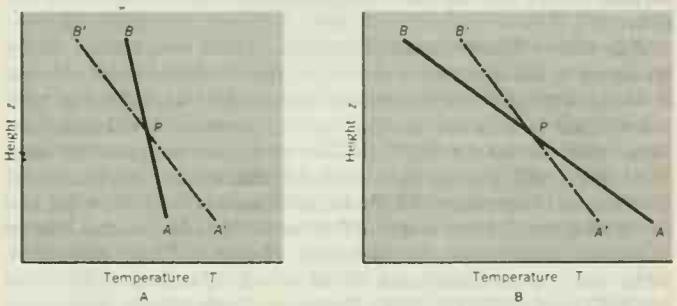



FIG. 3.—EFFECT OF VERTICAL MIXING ON LAPSE RATE IN A LAYER OF AIR. AB = INITIAL LAPSE RATE, A'B' = FINAL ADIABATIC LAPSE RATE. (A) INITIAL LAPSE RATE SUB-ADIABATIC. (B) INITIAL LAPSE RATE SUPER-ADIABATIC

saturated and to saturated air, but the critical lapse rate in the former case is the dry adiabatic and in the latter case the saturated adiabatic. Similar conclusions are reached by considering downward displacements but, for reasons given above, the critical lapse rate for instability in the downward displacement of saturated air is the saturated adiabatic only if the air contains liquid water to maintain saturation.

A lapse rate intermediate between the dry and saturated adiabatic lapse rates is said to be *conditionally unstable*, because the air is stable for unsaturated air but unstable for saturated air.

**Incidence and Properties of Different Lapse Rates.**—A lapse rate less than the saturated adiabatic, being stable both for unsaturated and for saturated air, is one in which all penetrative vertical movements of air, clear or cloudy, are resisted. It is present about half the time in the lower troposphere, practically always in the upper troposphere—into which, however, cloudy air may penetrate through finite buoyancy created in the lower troposphere—and always in the stratosphere. Its occurrence in the lower troposphere is favoured by a ground or sea surface cooler than the air immediately above it, a condition usually found in middle and high latitudes over the continents in winter and over the oceans in summer, and in general where the atmosphere is moving from a warmer to a colder underlying surface. Because small-scale vertical air motions are inhibited, flying conditions are smooth. Fog is not unusual and cloud, if present, is stratiform. Fog and cloud are formed by the slow cooling of the air at the underlying surface and by its upward propagation which is greater the stronger the wind, so that cloud is then more likely to form than fog. The only precipitation is drizzle.

Conditional instability is usual when the ground or sea surface is warmer than the air immediately above. It is very common in low latitudes; in middle latitudes it is common over the continents in summer and over the oceans in winter, and is generally to be found where the atmosphere is moving from a colder to a warmer underlying surface. As the prevailing lapse rate approaches the dry adiabatic, the wind becomes turbulent and flying conditions rough, especially over mountainous terrain. Conditional instability gives rise to penetrative vertical movements of air with cumulus and cumulo-nimbus clouds, showers and thunder, provided that there is a mechanism for lifting air to its condensation level, when the instability becomes absolute. The initial lifting may arise on a small scale, through instability in a layer of clear air below the layer in which the conditional instability is present, or by broad-scale ascent of air over high land or in regions of horizontal convergence of air, as in some parts of depressions and in tropical storms.

Absolute instability, with a lapse rate greater than that of the dry adiabatic, is practically confined to the air in the lowest few hundred metres of the atmosphere when the land surface is strongly heated by the sun or when air flows over much warmer water. The lapse rate in the first metre or so above the surface may then be 100 to 1,000 times that of the dry adiabatic. Strong vertical convection currents or thermals are then formed which, if the air is moist enough and the layer is sufficiently deep, will give rise to cumulus or cumulo-nimbus cloud in a conditionally unstable layer above. If the wind is very light and the earth's surface dusty, dust devils—small rotating columns of dusty air—occur.

**Advective Temperature Change.**—If the temperature of the air varies in the direction from which the wind blows and if there is no mechanism for changing the temperature of individual particles of air as they move—this implies, among other things, that there shall be no vertical motion—then the temperature at a fixed point will change at a rate determined by the horizontal gradient of temperature $\partial T/\partial x$ in the direction $x$ of the wind and the wind speed $V$, according to $\partial T/\partial t = -V\partial T/\partial x$. Such a change is called an advective temperature change. Thus, with $V =$ 10 m./sec. ($\simeq$ 20 knots) and $\partial T/\partial x = -1°$ C./100 km., $\partial T/\partial t =$ $10^{-4}$ °C./sec. $\simeq$ 0.3° C./hr. Rates of temperature change in the air near the earth's surface are often much larger than this for other reasons, but aloft the advective change is generally a significant fraction of the total change, vertical motion being the other main agent. Both are generally large compared with the rate of change by radiation.

**Heat Transfer and Temperature Change by Turbulence.**—In discussing radiation in the atmosphere it was shown that some heat must flow on average from the earth's surface to the air above by a nonradiative mechanism to preserve the thermal balance of the atmosphere. This mechanism is turbulent conduction, *i.e.*, conduction of heat directly, and of water vapour which is latent heat.

The wind is nearly always unsteady, and this unsteadiness is brought about by elements of air which move about rather irregularly, from level to level or at a level, bringing different velocities with them. Such motion is said to be turbulent, and the randomly moving elements, which are not however capable of precise delineation, are called turbulent elements or eddies. They carry different velocities because in general the mean velocity varies with position, in particular with height. If the lapse rate is not adiabatic the elements are subject to Archimedes buoyancy forces which accelerate or decelerate them in their paths. Each element has, statistically speaking, a finite life, because in moving it shares its excess or deficit of momentum with its changing environment. Simultaneously it shares any excess or deficit of temperature or of water vapour with its environment, and this is the process of turbulent conduction or diffusion. The process far outweighs molecular conduction and diffusion, which are of no concern except at the surface itself and in the very high atmosphere. It can, however, be formally likened in some respects to molecular conduction; it produces a flux of heat, or other transferable property such as water vapour, down the gradient of the appropriate property, the ratio of flux to gradient being called, by analogy with the molecular case, the *eddy conductivity* or *diffusivity* $K$. The eddy conductivity is not, however, a property of the fluid but of its motion, of the geometry and distance of the underlying boundary and of the lapse rate. It varies from about $10^4$ to $10^6$ times the molecular property ($10^3$ to $10^5$ cm.$^2$/sec.), the lower values occurring near the surface, in light winds and in stable lapse rates (see *Wind Velocity in Layer of Constant Shearing Stress*, below). In a neat calm and a strong inversion the molecular value is approached.

The upward vertical flux of heat $H$ by turbulence is proportional not to the lapse rate of temperature itself but to the difference of this lapse from the adiabatic value because, without mixing, the temperature of moving elements of air would change adiabatically as they changed level. Thus $H = K\rho c_p(\gamma - \Gamma)$, and the flux of heat is upward in super-adiabatic lapse rates and downward in sub-adiabatic lapse rates (including, of course, inversions). The corresponding vertical flux of water vapour $E$ (the rate of evaporation at the surface itself) is related to the vertical gradient of humidity mixing ratio $r$ by $E = -K\rho\partial r/\partial z$, and the flux of latent heat is then $LE$ where $L$ is the latent heat of water.

The average temperature condition very near the earth's surface is an inversion, but that does not imply an average downward transfer of heat because the eddy conductivity is an order of magnitude or more higher in super-adiabatic than in inversion conditions. The occurrence of the former for part of the time, *e.g.*, on land from an hour or two after sunrise until an hour or two before sunset, ensures a net upward transfer of heat from the surface over most of the globe. This heat is communicated to upper levels by convection, mainly by cumulus and cumulo-nimbus, and by the larger-scale wind systems of depressions, or areas of relatively low pressure (*see* CYCLONE), etc. The difference in heat flux between any two levels is the rate at which heat is added to or subtracted from the layer between, whence the rate of temperature change is given by $\rho c_p\ \partial T/\partial t = -\partial H/\partial z$.

**The Diurnal Variation of Temperature.**—Over land there is a marked diurnal variation of temperature, decreasing rapidly with height, which arises from the varying solar insolation, the net emission of long-wave radiation from the surface, and the diurnal pattern of $\partial H/\partial z$, itself reflecting the diurnal variation of temperature gradient from strong lapse to inversion. The diurnal variation of temperature near the ground shows a minimum near sunrise and a maximum in mid-afternoon. It ranges from zero at

the winter pole to about 30° C. in arid regions of the tropics. Where the ground is moist much of the available heat is used in evaporation with a correspondingly smaller temperature variation. Clear skies and light winds provide a large diurnal variation, overcast skies and strong winds a smaller variation, for reasons which will be apparent from the statements above. The diurnal variation falls to about 1° or 2° C. at 1 or 2 km. height, even when it is very large at the ground, and the time of incidence of the maximum is progressively retarded with height. A subsidence inversion which is common in anticyclonic weather at about 1 km. height often provides an effective ceiling to the upward propagation of the diurnal temperature wave.

The sea is a large reservoir of heat, because the absorption of solar energy is distributed in depth, and downward eddy conduction by water movements distributes the heat to lower levels, so that the diurnal variation of temperature over the ocean is at most a degree or two.

## V. EVAPORATION AND CONDENSATION IN THE ATMOSPHERE

**The Water Cycle in the Atmosphere.**—The air near the earth's surface, whether land or sea, is rarely saturated. If, then, the surface is moist and at a temperature higher than the dew-point temperature of the air, evaporation will occur—from moist ground, growing vegetation, water, snow and ice. The water vapour so formed is partly recondensed at or near the surface as dew or fog when the air temperature falls sufficiently; but in the main it is sooner or later transported aloft by convection and the large-scale upward currents of cyclones. This upward transport is associated with quasi-adiabatic cooling and ultimately, therefore, with condensation in large cloud masses which, when sufficiently developed, precipitate the condensate as rain, hail or snow, and so the water is returned to earth. During this cycle a significant amount of heat is transported upward and is released at the levels, mainly in lower and mid-troposphere, where the condensation occurs. The evaporation from the surface is greatest in the tropics, where over the oceans there is an excess of evaporation over precipitation, and this excess is transported poleward by the large-scale wind systems to give somewhat greater precipitation than evaporation in higher latitudes. The water vapour cycle thus makes a significant contribution to the upward and poleward transport of heat which is required for the thermal balance of the atmosphere.

**Evaporation and Humidity Near the Ground: Dew and Frost.**—The mechanism of the upward transfer of water vapour from the earth's surface has been described above (see *Heat Transfer and Temperature Change by Turbulence*). The rate of evaporation is proportional to the difference between the mixing ratio (or vapour pressure) at the surface itself and in the air a short distance above. If the surface is moist, the boundary value of vapour pressure is the saturation vapour pressure $e_w$ at the surface temperature $T$, so that the latter is a dominant factor in evaporation. In particular, the diurnal variation of evaporation on land follows the diurnal variation of surface temperature (but non-linearly because of the non-linear $e_w$, $T$ relation), and is thus at maximum in early afternoon. If the surface temperature falls at night to below the dew-point temperature of the air just above the surface, as it is liable to do on clear nights with a supply of moist air, the flux of vapour is reversed, *i.e.*, it becomes downward, and dew then forms on the surface (hoar frost if the surface temperature is below 0° C.). The corresponding diurnal variation of vapour pressure in the air above the surface is more complex, with two maxima, a few hours after sunrise and sunset respectively, and two minima, near sunrise and in mid-afternoon. This double wave is not completely explained, but it is commonly regarded as due to the superposition of two variations, of evaporation from the surface and of turbulent exchange of water vapour with the dryer levels aloft, the latter being at maximum in mid-afternoon when the secondary minimum of vapour pressure occurs near the surface. The diurnal range of vapour pressure is generally only a few per cent of the mean, but that of relative humidity may be very large, 50% or more, because of the diurnal variation of temperature; it is the approximate inverse of the latter.

It is often implied that evaporation from the land is slight compared with that from the sea in the same latitude, so that air which passes from sea to land and is caused to precipitate its moisture remains dry thereafter. This is by no means generally true. In fact, the higher surface temperatures which can obtain on land in summer and the larger surface roughness, compared with the sea, will lead to much higher rates of evaporation on land (if vegetation is growing) than at sea. When drying out takes place on land or the low surface temperatures of winter occur, the evaporation must of course fall, and its average value on land is probably less than that at sea. Figures are not available because evaporation is difficult to measure. For a rather uniform surface the rate of evaporation may be inferred from the measurement of wind speed and humidity at two levels within a metre or so of the surface (see *Friction and Small Scale Turbulence*, below) or, more generally, from studies of the energy balance at the surface or of the water vapour balance in a vertical column of the atmosphere.

**The Physics of Condensation Within the Atmosphere.**—If pure, filtered, moist air is cooled progressively to below the dew point, no condensation of water vapour into water droplets occurs until a fourfold supersaturation is attained, and the condensation then takes place on small ions produced by cosmic or other high-energy radiation. Such deferment of condensation is due to the fact that the saturation vapour pressure of water at a curved surface is greater than that over a plane surface (for which the dew point is defined), and the fourfold supersaturation referred to above is the measure of this excess for a body the size of a small ion ($\sim 10^{-7}$ cm.), except as slightly modified by its charge. The supersaturation required for condensation decreases rapidly with increase in size of the body on which condensation occurs, so that it is already less than 1% for a body of diameter $10^{-5}$ cm., and if this body is composed of hygroscopic material, such as common salt, condensation will occur at a relative humidity of less than 100%, but the dilution of the salt will prevent a very material increase in size.

Now, it is a matter of observation that appreciable supersaturations are never required to produce condensation in atmospheric air, so that suitable bodies, called *condensation nuclei*, on which water may condense at or below saturation, must be present in the atmosphere. They are in fact rather readily observed, *e.g.*, by the light they scatter out of an isolated sunbeam, and they may be collected and counted and the larger ones at least identified as to chemical composition. It is found that they are mainly hygroscopic. The larger nuclei (diameter of order $1\mu = 10^{-4}$ cm.) have concentrations of order 100/cm.$^3$ and are mainly the product of the disintegration of matter, a fraction being composed of sea salt from wind-blown sea spray. Smaller nuclei (diameter $<< 1\mu$), which are generally far more abundant (up to $10^6$/cm.$^3$), are mainly the product of combustion, both natural and man-made, and derive from sulfur dioxide and other active gases. Because size gives preference, the larger nuclei are generally the more effective in atmospheric condensation, but the rate of cooling and the availability of water affect the size range involved.

The overall concentration of nuclei decreases with height in clear air (and with distance from man-made sources), but rising air takes its nuclei with it, so that there appears never to be any lack of these to hinder condensation at any level in the troposphere once saturation is attained. Further, saturation is the critical humidity for condensation in rising air, though the droplet-size spectrum and the rate of growth of drops depends on, or in part determines, a very small degree of supersaturation (a fraction of 1%) in the rising air. The concentration of effective nuclei in a cloud, which is the concentration of water droplets, is from about $10^2$ to $10^3$/cm.$^3$ In a night ground fog the concentration may be much greater, because smaller nuclei are effective when the cooling takes place more slowly. There may then also be significant growth of nuclei, judged in terms of visibility, as the relative humidity increases toward saturation.

At temperatures below 0° C. condensation in rising air occurs as water on nuclei at the dew point rather than as ice at the higher frost point. Moreover, a water droplet cooled to below 0° C., as may happen in a rising cloud, does not in general freeze. Thus supercooled droplets are a common occurrence in the atmosphere, but they are less probable the lower the temperature, until at and below about −40° C. the liquid phase is evanescent and there is an immediate transition to ice. The production of ice in the atmosphere above −40° C. appears to demand a special kind of nucleus, called a *freezing nucleus*, which, being present in a supercooled water droplet, induces freezing with more or less delay. Such nuclei, which appear to be of mineral origin and to have a crystalline structure resembling that of ice, begin to be effective at about −10° C. and are the more efficient the lower the temperature. The chance that one of these may be present in a water droplet is evidently greater the larger the droplet, so that supercooling is least likely in large droplets. The decreasing incidence of supercooling at lower temperatures is also qualitatively explained. Below about −40° C. there appears to be spontaneous crystallization of a water droplet; *i.e.*, no freezing nucleus is required. Artificial freezing nuclei (AgI and $PbI_2$) have been discovered which are active at a higher temperature (−5° C. and −7° C. respectively) than natural nuclei, so that their injection into a supercooled cloud may transform it into ice earlier than would otherwise occur. The most efficient freezing nucleus of all is, of course, an ice crystal itself, effective at 0° C. Thus, if ice is formed near the colder top of a supercooled cloud and then falls to lower, warmer levels, it will initiate freezing in those levels. Since ice splinters are readily produced when a droplet freezes or an ice crystal grows, this source of freezing nuclei may be quite important in the initiation of more general freezing. As will be seen below, the transformation of supercooled water into ice in clouds has much to do with the release of precipitation from some clouds.

**The Production of Precipitation From Clouds.**—If we assume only 100 nuclei per $cm.^3$ to be effective in producing cloud droplets in a volume of air which is cooled, then, however moist the air initially, within the terrestrial limit, the complete condensation of all the vapour spread uniformly on the nuclei would not produce drops large enough to have a significant fall speed (diameter $d > 0.1$ mm.). Such a cloud could not then precipitate its moisture, and some preferential mechanism has to be invoked to account for precipitation other than drizzle ($d \sim 0.1$ mm.), which only occurs within clouds or in practically saturated air below them.

There are two processes which can and do lead to precipitation, the occurrence of either depending on meteorological factors. The first process is due to the appearance in a cloud of a relatively few large droplets, which may arise from giant nuclei ($d \sim 30\mu$) such as are produced by sea spray, or perhaps from the collision and coalescence of smaller droplets; the latter is however a very slow process. Such a large droplet has a slight but significant speed of fall relative to the small droplets, which will enable it to sweep up the larger of the latter; the smallest droplets are swept aside in the current of air around the collecting drop. The conditions for the growth of this drop to precipitation size are however quite critical, for the updraft velocity in the cloud must not be so large in relation to cloud depth that it is carried to the top of the cloud and evaporated, nor so small as to deny the growing droplet a rather long life within the cloud, which itself has a limited life. Favourable conditions appear to occur commonly in ocean cumuli, particularly in trade wind cumuli, which have low, warm bases (large saturation vapour contents), moderate updraft velocities and a supply of large sea-salt nuclei. The precipitation is in the form of large drops but the intensity is not very great. It will be noted that the solid phase is not necessarily involved; it is found, for example, that trade wind cumuli commonly precipitate without their tops rising to the freezing level.

The second process involves the ice phase, the saturation vapour pressure of which is less than that of water (supercooled) at the same temperature. If, then, a few ice crystals appear among a much larger population of water droplets in water-saturated air, the air will be supersaturated with respect to ice and the ice particles will grow preferentially. They may then reach a size sufficient to give them a significant fall speed with respect to the water droplets and to the air, and grow further by accretion. A snowflake or hailstone results, according to the water content and the speed of updraft in the cloud. Snow is the characteristic form of precipitation from extensive layer clouds, in which the updraft speed is of order 10 cm./sec., but the snow may of course melt before leaving the cloud, further growth by accretion occurring on the rain, or melting may occur between the cloud base and the ground. The raindrops are then only of moderate size and the rainfall, though it may be long continued, is not of heavy rate. Hail or large raindrops fall from cumulo-nimbus (shower) clouds, in which updraft velocities ($\sim$ 10 m./sec.) and water contents are much larger than in layer clouds, and the rate of rainfall is often large.

Whichever mechanism is operative on a particular occasion, the condition for precipitation is a rather deep cloud, *e.g.*, 3 km. deep or more, to give space for the operation of the mechanism, and high base temperatures are favourable. From the former condition it is evident that glaciation (transformation of cloud particles from water drops to ice crystals) of the cloud top is not unlikely anyway, particularly outside the tropics, so that it does not follow that the initiation of precipitation is due to ice when a cloud is glaciated. The ice mechanism may have been anticipated, though hardly in a layer cloud because of the low updraft. Again, very heavy rain demands a very deep cloud, with its top in the high troposphere, and it will always then be glaciated. It will also contain large drops and probably hail, both of which may add to precipitation production, the former by breaking up and releasing many small drops, the latter by shedding small drops into their wakes when they are unable to freeze all the water they capture. Thus, cascade processes are possible once the initial release mechanism becomes operative.

**Artificially Induced Precipitation.**—It has been supposed that clouds of sufficient depth and water content to provide significant precipitation sometimes fail to precipitate for lack of a few large droplets or of a sufficiently low temperature to produce ice at their tops. The injection of large droplets into their bases or of efficient freezing nuclei, *e.g.*, AgI, into their tops might then cause precipitation, or cause it earlier than would otherwise occur. Some success in modifying the life history of clouds along these lines has been achieved, and it appears that precipitation may be fractionally increased in topographically favourable areas by AgI seeding. There is no evidence that precipitation as a whole can be thus increased. Thin supercooled layer clouds can be dispersed when seeded by AgI but the snow produced is generally evaporated before reaching the ground.

**Causes of Condensation in the Atmosphere.**—Condensation in the air results essentially from its cooling to below the dew point, or to below the frost point when ice is already present. It is true that some fogs form before saturation is attained, but the amount of condensation is then very slight. Further, two moist but not quite saturated air masses at different temperatures can, when mixed, also give condensation because of the curvature of the saturation vapour pressure/temperature curve; but again the available water is only slight.

There are three ways in which air can be effectively cooled to produce condensation:

1. Cooling by expansion to lower pressure. Expansion as such produces adiabatic cooling according to the laws given earlier. It can occur without any change of level of the air through a local fall of pressure, but such cooling is rarely significant—the tornado and the waterspout are probably the main exceptions. The outstandingly important occurrence is expansion by ascent of more or less large masses of air, in forced and free convection, in weather systems with lower level convergence, and in uplift over mountains. The cooling is rapid and gives rise to most clouds and to all significant precipitation. In so far as the cooling which occurs during expansion is not adiabatic, one or both of the two following processes, possibly in reverse, modify the cooling rate,

but the adiabatic relation remains a good approximation.

2. Cooling by turbulent conduction of heat. If moist air flows over a cooler surface, there is a turbulent conduction of heat from the air to the surface (see *Heat Transfer and Temperature Change by Turbulence*, above). This may result in condensation as fog near the surface or, in strong winds, in low layer cloud because the cooling is then communicated to higher levels, the adiabatic cooling of forced convection being instrumental in the process. Drizzle, but not rain, may fall from the cloud so formed.

3. Radiation cooling. If a layer of air emits more radiation than it absorbs it will cool. This process is characteristic of the troposphere, but the cooling rate is generally quite slow. It may, however, be fast enough to assist significantly in producing condensation near the surface at night, when dry air overlies moist air. Once condensation has occurred in a layer of air, the enhanced radiation emitted by that layer may add significantly to the cooling and condensation.

**Forms of Atmospheric Condensation: Clouds and Precipitation.**—The forms of atmospheric condensation are varied and complex, but classification is useful and the basic cloud forms, with the typical varieties of precipitation associated with them, are given in the accompanying table. (For a more complete classification, see *The International Cloud Atlas.*)

A cloud form is normally identified by its appearance from the ground. If the sky is overcast with stratiform low cloud, there may be non-stratiform clouds above or extending upward from the former which will not be observed, and which may give precipitation not characteristic of the lower cloud. The precipitation associated with each cloud form does not necessarily occur except with the nimbus (Ns and Cb) categories, which by definition are precipitating clouds. (*See* also CLOUD.)

*Fog.*—Fogs usually originate in one of two ways; *i.e.*, by nocturnal radiative cooling of the ground or by advection. *Radiation fog* occurs on rather calm, clear nights in moist air on land, some air motion being required in order that the effect of the ground cooling shall be communicated upward. Such fog is lifted and dissipated either by an increase of wind with an accompanying increase of turbulence, or by insolational heating. Valley bottoms are particularly prone to radiation fog, because the air cooled indirectly by radiation at higher levels drains downward. *Advection fog* forms when warm, moist air blows in over a relatively cold surface. Such fog is rarely as dense as dense radiation fog, but it may occur by day or by night in much stronger winds than are present with the latter, although strong winds tend to create low stratus instead of fog. Advection fog is a common occurrence in a poleward flow of air over the ocean in summer, the most notable example being the late spring and early summer fog of the Newfoundland Grand Banks, where the Labrador current provides exceptionally cold water for the latitude and season. Except on coastlines, this fog is mainly a winter phenomenon over the land; it occurs, *e.g.*, when warm air blows in over melting snow. It is encouraged when rain falling from warm air aloft saturates colder air near the ground by evaporation (*prefrontal fog*). *Steaming fog*, or *arctic sea smoke*, is fundamentally different in origin from radiation or advection fog, because it forms over a surface much hotter than the air above. The surface being wet and the air a little distance above almost saturated and relatively cold, the intense evaporation from the surface causes condensation in filaments of air immediately above the surface. Such fog is generally quite shallow and rarely dense except in arctic air streaming out over very warm water. It is common over rivers and lakes and over hot roads after showers.

*Basic Cloud Forms and Associated Precipitation*

| Cloud type | Height of cloud base (ft.) | Cloud form | Precipitation (if present) |
|---|---|---|---|
| Stratiform | | | |
| Very low | Earth surface | Fog | Fine drizzle |
| Low | 0–8,000 | Stratus (St) | Drizzle, fine snow |
| | | Nimbo-stratus (Ns) | Light, moderate or heavy rain or snow |
| Medium | 8,000–20,000 | Alto-stratus (As) | Light to moderate rain or snow |
| High | >20,000 | Cirro-stratus (Cs) | |
| Heap (convective) | | | |
| Very low | Earth surface | Steam, arctic sea smoke | |
| Low | 1,000–8,000 | Cumulus (Cu) | |
| Low towering | 1,000–8,000 | Cumulo-nimbus (Cb) | Showers of heavy rain, hail or snow; thunderstorms |
| Medium | 8,000–20,000 | Alto-cumulus castellatus (Ac cast) | Trails of light precipitation aloft |
| Streak | | | |
| High | >20,000 | Cirrus, often tufted (Ci) | Trails of ice particles aloft |
| Stratiform-Heap | | | |
| Low | 1,000–8,000 | Strato-cumulus (Sc) | Light showers of fine rain or snow —not common |
| Medium | 8,000–20,000 | Alto-cumulus (Ac) | Trails of light precipitation aloft |
| High | >20,000 | Cirro-cumulus (Cc) | |

*Stratus.*—*Low stratus* forms in moderate or strong winds with warm air advection and a stable temperature gradient away from the surface. The cloud forms beneath the stable layer by the downward loss of heat to the surface by turbulence. Low stratus may replace fog, radiative or advective, when the wind freshens, because the downward transfer of heat which cools the upper part of the mixed layer warms the lower part. *Low strato-cumulus*, which commonly replaces stratus or is replaced by it, is also a feature of a mixed layer with a stable layer above the cloud. It arises when the underlying surface becomes a little warmer than the air above, thus making the turbulence and the cloud a little more lumpy by convection. *Cirro-stratus*, *alto-stratus* and *nimbo-stratus* are layer clouds formed by the slow ascent of air over very large areas, a process which occurs in the warm air of an extratropical depression. They are commonly observed in the sequence given (high, medium, low) as a depression advances on an observer, the uplift taking place slantwise. Cirro-stratus is an ice cloud which commonly produces a halo at 22° from the sun or moon, the halo being a common precursor, and so portent, of continuous rain from the alto-stratus and nimbo-stratus to follow.

*Convection Cloud.*—Convection is the motion resulting from a super-adiabatic lapse rate, and convection cloud therefore demands a layer with a lapse rate greater than the saturated adiabatic. It is assisted by a layer beneath with a lapse rate equal to or greater than the dry adiabatic, so that substantial volumes of rapidly rising unsaturated air may be brought up to the condensation level above which the lapse rate is greater than the saturated adiabatic. If the latter layer is shallow, *fair weather cumulus* of limited vertical extent is formed, but if it is deep *large cumulus* and ultimately *cumulo-nimbus* occur. These clouds are most common over land by day in summer (strong heating of the ground by the sun), and over the oceans in winter in equatorward moving air (cold air over warm water). A highly stable layer commonly overcaps the unstable layer in which cumulus or cumulo-nimbus clouds form, and their tops then spread out beneath the stable layer giving *strato-cumulus*, *alto-cumulus* or *anvil cirrus* according to the level of the stable layer and the intensity of the convection. Weak convection may be initiated in a layer cloud by radiative heating at its under surface from the warmer ground and air below and by radiative cooling from its upper surface. Cellular convection patterns then form, giving *strato-cumulus*, *alto-cumulus* or *cirro-cumulus* according to level. Isolated tufted cirrus of the high troposphere are probably the result of weak convection in that layer, but little is known about the circumstances attending their formation.

*Orographic Clouds.*—When air passes over hills or mountains the layer of air disturbed may, in suitable flow patterns, extend to many times the height of the hills. Where the air rises clouds may form, and they are characterized by being "tied" to the disturbance, *i.e.*, they are stationary and do not move with the wind at their level. They are commonly of lenticular form and may occur in waves downwind of the topography producing them. In high northern latitudes in winter they may occur well into the stratosphere and are called mother-of-pearl or nacreous clouds because of the iridescence they show shortly after sunset or before sunrise at ground level.

## VI. WIND

It is within everyone's experience that the wind, *i.e.*, the motion of the air, is continually changing. Near the surface it comes in gusts and lulls from a few seconds' to a few minutes' duration, varying about a mean value which itself changes slowly, from hour to hour, day to day, season to season, both in speed and in direction. The motion of the air aloft, as shown by the motion of most clouds or of balloons released into the atmosphere, is similarly variable, but is not in general the same as that of the air near the earth's surface. This variable motion itself constitutes a part of weather and, as experience again readily shows, is related to many other attributes of weather. For example, outside the tropics steady rain tends to come with relatively warm polewardmoving air, showers and bright intervals with cooler equatorwardmoving air. The study of wind (*q.v.*) is therefore at the heart of meteorology, and is the study of a special kind of hydrodynamics, the motion of a rotating gas of variable composition which is differentially heated by the sun and cooled by its own radiation into space.

**Motion in a Differentially Heated Atmosphere.**—Practically all motion of the atmosphere derives ultimately from differential heating and cooling, but the relation between cause and effect is generally quite complex and is by no means fully understood. It may be useful, therefore, to begin by considering the following highly simplified system. A block of atmosphere is at rest and is uniform in composition and temperature in the horizontal. The pressure (*i.e.*, the weight of superincumbent atmosphere) at its horizontal base and at any other horizontal level will then be uniform also, and hydrostatic equilibrium will obtain.

Suppose now that this block is heated at one end and cooled at the other. The heated end expands and the cooled end contracts, so that the pressure will decrease less rapidly with height at the warm end than at the cold end. Except at the base, the pressure at any level will now be greater at the warm end than at the same level at the cold end, and there will be a horizontal gradient of temperature at all levels. Now, any fluid tends to move from a region of high pressure to one of low pressure at the same level, so that the air aloft moves from warm to cold and thus creates high pressure at the cold base of the block and low pressure at the warm base. A return flow of air from cold to warm is thus engendered near the bottom of the block, and a compensating rising motion sets in at the warm end and a sinking motion at the cold end. A thermally driven circulation has been created. Simple circulations of this kind do not, however, dominate in the atmosphere because it is rotating, friction and turbulence set in, and a large-scale dynamic instability is created which smothers the simple type of circulation considered.

**The Forces Acting on the Atmosphere.**—As for any dynamic system, the acceleration of any unit mass of the atmosphere is given by the sum of the forces acting on it.

It is convenient to separate the vertical forces from the horizontal forces. Of the former, gravity acting downward and the vertical pressure gradient acting upward are always the most important, and if these are equal in magnitude the hydrostatic equilibrium derived earlier is obtained; *i.e.*, $-\frac{1}{\rho}\frac{\partial p}{\partial z} = g$. This relation does in fact hold to a very high degree of approximation throughout the atmosphere, because the vertical acceleration of the air is never comparable with gravity. Nevertheless, if motions arising from the lack, however small, of hydrostatic equilibrium, *i.e.*, convection, are to be considered, the relevant equation for the vertical acceleration of the air is $dw/dt = -\frac{1}{\rho}\frac{\partial p}{\partial z} - g$, where $w$ is the upward vertical velocity of the air and friction has been neglected. If the moving mass considered has a temperature excess $T'$ relative to its surroundings at temperature $T$, this equation becomes $dw/dT = gT'/T$, which is Archimedes' buoyancy equation. For $T' = 1°$ K., $T = 300°$ K., $dw/dt \simeq 3$ cm./sec.$^2$, *i.e.* $\ll g$, but this acceleration maintained over 1 km. of height would result in a vertical velocity $w \simeq 7$ m./sec. This is the order of the vertical velocity attained in strong convection in the atmosphere, but depths greater than 1 km. are usually involved; friction has been neglected in the example above. For all larger-scale atmospheric motions the hydrostatic equation may be safely used because the vertical acceleration is several orders of magnitude less than in the example.

Consider now the horizontal. The pressure varies in general with the horizontal co-ordinates, $x$, $y$ ($y$ at right angles and to the left of $x$), so that a force exists on this account exactly analogous to the vertical pressure force, with components given by $-\frac{1}{\rho}\frac{\partial p}{\partial x}$, $-\frac{1}{\rho}\frac{\partial p}{\partial y}$ in the $x$, $y$ directions. The resultant of these is $-\frac{1}{\rho}\frac{\partial p}{\partial n}$, where $n$ is the horizontal distance normal to the isobar in the direction of increasing pressure.

The next horizontal force to be considered is that arising from the earth's rotation; it is called the Coriolis force. Observations of wind are almost necessarily made with reference to the earth, so that a uniform motion with respect to the latter is in fact an accelerated motion in space as a result of the earth's rotation. An observer standing on the northern hemisphere in latitude $\phi$ is rotating anticlockwise about the local vertical with an angular velocity $\omega \sin \phi$, where $\omega$ is the angular velocity of the earth about its polar axis ($\omega = 7.29 \times 10^{-5}$ rad./sec.). Suppose a particle moves away from the observer in any horizontal direction with a speed $V$. After a time $t$ the particle will be at a distance $Vt$ from the observer. During this time, any point on the circumference of the circle centred on the observer and of radius $Vt$ will have moved anticlockwise over the arc length $Vt \times \omega\ t \sin \phi$, so that the particle at time $t$ will have been displaced to the right of its initial path on the earth by the same amount. Its motion with respect to the earth is therefore only to be accounted for by assuming the existence of a force acting at right angles and to the right of its path. The acceleration, or force per unit mass, is given by $2 \times Vt^2\ \omega \sin \phi/t^2 = 2\omega V \sin \phi$. This is the Coriolis force. In the southern hemisphere it acts to the left of the path, and at the equator it is zero ($\sin 0° = 0$). It is a deflecting force, producing change of direction but not of speed.

The remaining horizontal force is friction which, in fluids, is always present when there is a gradient of velocity and is proportional to the viscosity of the fluid. Viscous friction is, however, of no account in the atmosphere except at very high levels (thermosphere) and in micro-turbulence. Instead, another kind of friction, depending on the turbulence in the flow, may become important, but its nature and action will be discussed later on.

**The Horizontal Component Equations of Motion of the Atmosphere.**—Having stated the horizontal forces acting on any element of the atmosphere, it is now possible to write the equations for the component horizontal accelerations of the air. If $u$, $v$ are the components of velocity in the direction of the $x$ and $y$ axis respectively, then

$$\frac{du}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + lv + F_x$$

$$\frac{dv}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial y} - lu + F_y$$

where $l$ is an abbreviation for $2\ \omega \sin \phi$, the "Coriolis parameter," and $F_x$, $F_y$ represent the components of the frictional force, not yet expressed in detail.

In these equations, as elsewhere, the symbol $d/dt$ stands for the rate of change with time following an "individual" particle of air. It contrasts with $\partial/\partial t$, which is the rate of change at a fixed point. The former embraces the latter plus the advective change which arises from the motion and the gradient of the property concerned; *i.e.*, $du/dt = \partial u/\partial t + u\partial u/\partial x + v\partial u/\partial y + w\partial u/\partial z$, etc.

The above equations refer to all atmospheric motion. If there were available complete observations of atmospheric properties at any instant and if the external influences were also known, *i.e.*, the beams of radiation entering and leaving the atmosphere and the action of the underlying surface on the atmosphere, it would in principle be possible to obtain solutions of the equations for the atmospheric conditions at any later time, making use of addi-

tional laws such as those of the conservation of matter and energy and the equation of state of air. The project is not beyond attempt, but the equations and the observational problem are in fact so complex as to defy solution of the equations in their complete form. The numerical prediction of weather is essentially a problem of finding sufficiently exact approximations of the equations so that, with high-speed electronic computers, solutions may be obtained of the coarser features of the motion for useful periods within which the approximations do not lead to serious errors.

The procedure to be followed here is to take some particularly simple approximations which will give insight into the overall behaviour and evolution of the atmosphere.

**Geostrophic and Quasi-geostrophic Motion.**—The large-scale wind systems of the extratropical atmosphere, such as depressions and anticyclones, have horizontal dimensions upward of 1,000 km. and wind velocities up to about 50 m./sec. (100 knots)—in extreme cases up to about 100 m./sec. From such observations it is easy to show that for these systems the horizontal component of the acceleration of the air is almost always an order of magnitude less than the Coriolis force. The frictional force is also small compared with the Coriolis force, except rather near the earth's surface, so that in the "free" atmosphere the Coriolis force must be approximately balanced by the only remaining force, namely that arising from the horizontal pressure gradient. If there is an exact balance between these two forces, the wind is said to be *geostrophic* ("earth turning"). If this wind be represented by $V_g$ (components $u_g$, $v_g$), the last pair of equations shows that

$$v_g = \frac{1}{\rho l}\frac{\partial p}{\partial x}, \quad u_g = -\frac{1}{\rho l}\frac{\partial p}{\partial y}$$

$$\text{or} \quad V_g = \frac{1}{\rho l}\frac{\partial p}{\partial n}$$

Clearly, $V_g$ must be directed along the isobar in order that the Coriolis force, which is normal to $V_g$, shall be opposite in direction to the pressure gradient force. In the northern hemisphere, with the Coriolis force to the right of the motion, low pressure will be to the left of the motion; in the southern hemisphere, low pressure will be to the right of the motion. The equations for $V_g$ show that it may be readily computed from a chart of isobars in a level surface. Such a chart shows the pressure gradient—inversely proportional to the separation of the isobars—at all points in the area charted. In fact, an isobaric chart gives a bird's eye view of the field of geostrophic wind (*q.v.*) in the level of the chart, for the variations of density in the level are generally only a few per cent, and the variation of latitude (variation of $l$) is apparent.

The geostrophic wind equation is an exact relation—$V_g$ may evidently be regarded as a parametric form of the pressure gradient—whereas it was shown above that the pressure gradient and Coriolis forces are generally only in approximate balance in the free atmosphere. Such motion is said to be *quasi-geostrophic*, but the geostrophic wind equation (or the isobaric chart) remains a valuable diagnostic tool for its analysis. For extratropical systems of not too small horizontal dimensions (not too large curvature) the actual wind at any level above about 0.5 km. is generally within about 10% of the geostrophic speed and within about 5° of the geostrophic direction. This close relation between actual and geostrophic wind is known as Buys Ballot's law (*q.v.*).

If we take $V_g = 20$ m./sec. (40 knots, or a gale) in latitude 43° ($l = 10^{-4}$ sec.$^{-1}$), with $\rho = 10^{-3}$g./cm.$^3$, then $\partial p/\partial n$ from the equation for $V_g$ is 2 mb./100 km. This gradient is only one-five-thousandth of the vertical gradient of pressure where $\rho = 10^{-3}$g./cm.$^3$, so that the isobaric surfaces in the atmosphere have a very small slope indeed.

Since the geostrophic wind is an acceleration-free wind it has no direct prognostic value for the actual wind. The evolution of the latter depends, in fact, on the small departures of the actual from the geostrophic wind, a circumstance which adds greatly to the difficulty of sound weather prediction.

**Variation of Geostrophic Wind With Height.**—Since the large-scale wind fields of the atmosphere are quasi-geostrophic and vary materially with height, it is instructive to consider the nature of the height variation of the geostrophic wind, which is rather simply related to the horizontal field of temperature.

It was shown above (see *The Variation of Atmospheric Pressure With Height: Hydrostatic Equilibrium* and *Motion in a Differentially Heated Atmosphere*) that at any level the pressure decreases with height more slowly where the air is warm than where it is cold. Thus, a horizontal pressure differential will be built up over any layer with a horizontal gradient of temperature, with relatively low pressure at the top of the cold part of the layer and with relatively high pressure at the top of the warm part of the layer, the isotherms in the layer being normal to the pressure differential. This pressure gradient is additive, vectorially, to the pressure gradient existing at the bottom of the layer. Now, the geostrophic wind at the bottom and at the top of the layer is given by the pressure gradient at each respective level, and its change over the layer by the change of the pressure gradient, the direction of the geostrophic wind or its change being always normal and to the right (in the northern hemisphere) of the pressure gradient or its change. The change in the geostrophic wind over the layer is then directed along the isotherms with low temperature to the left in the northern hemisphere—a result analogous to the geostrophic wind relation itself, with temperature replacing pressure. The magnitude of the change in geostrophic wind is proportional to the horizontal gradient of temperature in the layer. Because of its relation to the temperature field, the change of geostrophic wind between any two levels is called the *thermal wind*.

Consider now some simple cases. If the isotherms in a layer are parallel with the isobars at the base of the layer, with low temperature over low pressure, the pressure gradient and the geostrophic wind will intensify with height. This is the characteristic condition of the mean temperate latitude troposphere, where surface pressure decreases poleward (near surface westerlies) and temperature decreases poleward also. The wind therefore increases from the west with height. If, however, the isobars and isotherms are parallel but the gradients are of opposite direction, the pressure field and geostrophic wind will decrease with height and may ultimately become reversed. This is the characteristic condition in the stratosphere outside the winter polar cap. The westerlies, strong at the tropopause, weaken above it and in summer change to easterlies at about 20 km. height. Temperature and surface pressure gradients are also opposed in the subtropical and tropical trade wind belt, where near-surface easterlies weaken with height to become strong westerlies (anti-trades) in the high troposphere. If the temperature gradient is normal to the underlying pressure gradient the wind backs or veers with height (*i.e.*, an anticlockwise or a clockwise rotation, respectively, of wind direction) according as the lower-level wind blows from cold to warm or the reverse. Thus, the variation of wind direction with height in the free atmosphere indicates whether warmer or colder air will be advected to the place of observation.

**Friction and Small Scale Turbulence.**—Frictional forces are generated by the flow of air over the surface of the earth beneath, and they propagate themselves upward to a height depending on the wind speed itself, the lapse rate of temperature and the surface roughness. The effect of friction in modifying the quasi-geostrophic balance will now be examined.

There is no slip at the boundary between air and earth; *i.e.*, the wind velocity is necessarily reduced to zero at the earth's surface itself. A rapid increase of velocity with height occurs, therefore, in the air above the surface. Such a condition, in the absence of a strong stabilizing temperature gradient, leads as in practically all such "boundary-layer" flows to the creation of turbulence in the wind (*see* above, *Heat Transfer and Temperature Change by Turbulence*). The turbulent elements or eddies moving upward and downward are an efficient means of exchanging the momentum of the air between one level and another, and so the slowly moving air very near the surface causes the air at much higher levels to be somewhat slowed down also. Equally, the

faster moving air of the higher levels causes the air very near the surface to move faster than it would otherwise do. When the lapse rate is unstable, the turbulent elements are accelerated by buoyancy and move over longer paths so that the momentum exchange is more intense and extensive, whereas in a stable lapse rate the vertical motion of the eddies is hindered.

The friction at the earth's level surface is a horizontal force per unit area, or shearing stress $\tau_0$. It may equally well be thought of as a rate of vertical transfer of horizontal momentum, which is the action just discussed of the eddies above the surface. There is in fact a horizontal shearing stress $\tau$ at all levels where the turbulence operates, but it varies in general with height, and the rate of change with height $\partial\tau/\partial z$ is the friction force on unit volume of air. Clearly, if the shearing stress is the same at the top and bottom of a layer, it experiences no net frictional force, though momentum is transferred across both top and bottom surfaces of the layer. The layer of atmosphere affected by friction, *i.e.*, over which $\tau$ is large or $\partial\tau/\partial z$ is significant, is observed to be in general at least a few hundred metres thick, and may be much more. It may then be readily shown from observation that no significant change in $\tau$ occurs over the first few tens of metres. This allows a treatment of the effect of friction in two parts, one for the bottom layer of effectively constant shearing stress ($\tau = \tau_0$), and another for the deeper layer above, in which $\tau$ varies substantially.

**Wind Velocity in Layer of Constant Shearing Stress.**—The surface friction $\tau_0$ may be measured by isolating a small part of the earth's land surface and measuring the horizontal force required to keep it in position in any wind. If the mean wind speed $V$ over a period of ten minutes or so is measured simultaneously at a number of heights $z$ above the surface, then it is found that in near-adiabatic lapse rates $V(z)$ is related to $\tau_0$ by

$$V = \frac{1}{k}(\tau_0/\rho)^{\frac{1}{2}} \log \frac{z}{z_0}$$

where $k$ is a pure number ($= 0.41$, called von Karman's constant), and $z_0$ is a length called the *roughness length* which is determined by the aerodynamic properties of the roughness elements (grass blades, etc.) composing the surface. $z_0$ turns out to be of the order of one tenth of the mean height of the roughness elements and is inferred from the observations described. The above equation gives the profile of wind velocity in the constant stress layer, and it shows that the speed increases as the logarithm of the height. This relation may also be inferred from dimensional analysis. It may also be written

$$\tau_0 = c\rho V_a^2,$$

where $V_a$ is the wind speed at a given height $z_a$, say the normal height (10 m.) of a "surface" anemometer, and $c\ (= [k/\log z_a/z_0]^2)$ is a non-dimensional *drag coefficient*. Thus, for $z_0 = 5$ cm. and $z_a = 10$ m., $c = 0.006$; and then for $V_a = 5$ m./sec. and $\rho = 1.2 \times 10^{-3}$ g./cm.$^3$, $\tau_0 = 1.8$ dyne/cm.$^2$ This is the order of surface friction in moderate winds over most surfaces. The stress is opposed to the wind direction which is constant in direction over the layer concerned.

Now, defining a coefficient of eddy viscosity $K$ (analogous to the molecular kinematic viscosity of a fluid) by the relation $\tau/\rho = K\partial V/\partial z$, and remembering that $\tau = \tau_0$ in the layer to which the above profile equation applies, it follows from the profile equation that $K = kz(\tau_0/\rho)^{\frac{1}{2}}$. With the above numerical values of $\tau_0$, $\rho$ and $z\ (= z_a)$, $K = 1.6 \times 10^3$ cm.$^2$/sec. This contrasts with a molecular kinematic viscosity of surface air of 0.15 cm.$^2$/sec. so that, at the moderate wind treated, turbulence makes the air about $10^5$ times as sticky as it would be without turbulence. Moreover, $K$ increases linearly with height, essentially because the vertical motion of turbulent elements is less inhibited the farther they are from the surface, through which air cannot pass.

These relations are somewhat modified in stable and unstable lapse rates, $K$ for a given wind speed decreasing in the former conditions—sometimes almost to molecular value—and increasing in the latter conditions.

The turbulent motions which provide the eddy viscosity are responsible also for diffusing heat and matter (water vapour, pollution, etc.), and the eddy coefficients of diffusion for these properties are practically the same as the eddy viscosity. The measurement of a velocity profile, or a knowledge of "anemometer" wind speed and $z_0$, is therefore important for the study both of surface friction and of turbulent diffusion in general.

**Wind Velocity in Upper Part of Friction Layer.**—No reference was made in the last section to the geostrophic wind in relation to the wind in the constant stress layer. An identification can now be made by considering the variation of wind velocity (speed and direction) above that layer but in the layer of frictional influence.

It is first to be noted that friction is not in general directed opposite to the wind but opposite to the direction of the change in wind velocity with height. Only if the wind direction is independent of height, as in the constant stress layer, is the friction opposite to the wind direction.

Where the wind is slowed down by friction the Coriolis force evidently cannot balance the pressure-gradient force, and the unbalanced portion of the latter is available to accelerate the air down the gradient from high to low pressure. In a steady state, however, that acceleration is unrealized, the friction force being present, but the air moves across the isobars just sufficiently to allow the gain of momentum therefrom to balance the loss of momentum in that direction by friction. The details of the motion are complicated by the fact that its down-gradient component gives rise itself to a Coriolis force along the isobar, and this too requires to be balanced by a component of the friction force. So the motion adjusts itself differently in speed and direction at different levels to achieve a balance of forces both along and across the pressure gradient. The general result is a veering of direction (in the northern hemisphere) and an increase of speed with height until the geostrophic direction and speed are approximately attained. At anemometer level the angle of inflow across the isobars may be up to about 30°, and the speed of the wind down to about one-third the geostrophic speed. The largest differences from geostrophic direction and speed occur over the roughest surfaces, *i.e.*, over the land, and where the thermal wind in the lower troposphere is opposed in direction to the surface wind, as it is, for example, in the trade winds. The smallest differences occur over the least rough surfaces, *i.e.*, over the sea, and where the thermal wind is in the same direction as the surface wind, as with the surface westerlies of middle latitudes, particularly in winter. Here the inflow may be hardly detectable and the speed may be four-fifths that of the geostrophic. The thermal wind is important because, when roughly aligned with the surface wind, it supplies momentum to low levels from a deep layer—a transfer of momentum down the gradient as implied in the equation defining $K$—whereas, when it opposes the surface wind, momentum is drained upward as well as downward from the lower atmosphere.

The depth of the frictional layer is roughly the depth over which turbulent motion is maintained. Surface-engendered ("boundary layer") turbulence inevitably falls off with height in neutral and stable lapse rates, and an average depth, in neutral conditions, is a few hundred metres; it is less in stable conditions. If there is an elevated subsidence inversion this will nearly always put a sudden stop to the turbulence. If, however, the lapse rate is unstable and suitable for cumulus or cumulo-nimbus convection turbulence is reinforced in lower levels and maintained up to the limits of the convection. The effect of surface friction is then spread over this deep layer, but the departure of the wind from geostrophic at any one level is relatively slight.

**Diurnal Variation of Wind Near the Surface.**—The diurnal variation of lapse rate in the lower atmosphere over land, due to insolation, impresses a strong diurnal variation on the wind near the surface. On a sunny day it is very gusty, but on a clear night the flow is rather smooth. The daytime turbulence allows a copious flow of momentum from the upper part of the friction layer and the surface wind is then relatively well maintained against the surface frictional loss. On a clear night, however, the relative absence of turbulence largely cuts off this flow from above and the surface wind weakens greatly, until the surface friction

has been diminished to match approximately the weakened supply of momentum from above. The surface wind speed has a maximum in the early afternoon and a minimum during the late night, and there is some veer of wind between the time of minimum and the time of maximum speed. At about 100 m. and above in the friction layer there is an opposite diurnal variation of wind speed corresponding to the diurnal variation of transfer of momentum to lower levels by turbulence.

## VII. ATMOSPHERIC WIND SYSTEMS AND WEATHER

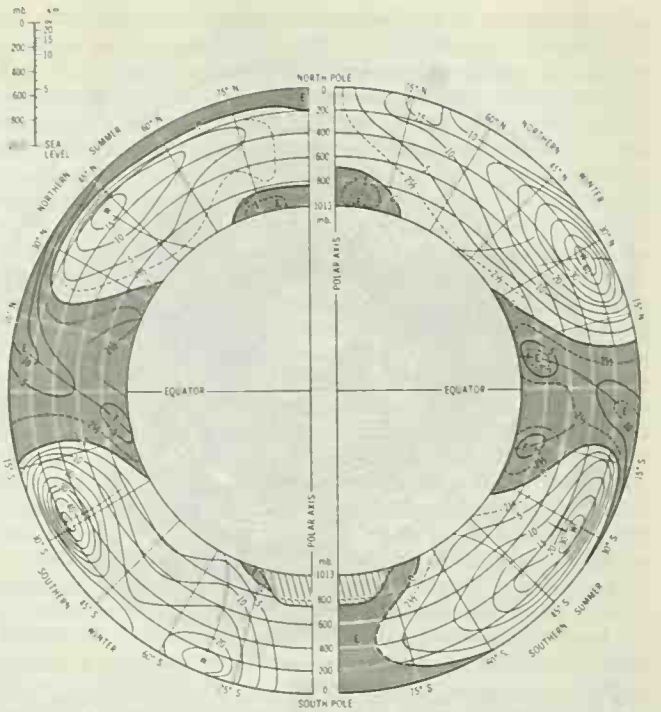
All the motions of the atmosphere below the mesopause are to be explained in terms of the principles outlined in the section *Wind*, above. (Above the mesopause there are additional, magneto-hydrodynamic forces due to the electrical conductivity of the air and the earth's magnetic field. This region will not be discussed here.) The explanation of these motions is, however, a very complex problem, because one type and scale of motion reacts on nearly every other, and there exists only an imperfect understanding of the genesis, maintenance and decay of any of these systems. Consequently the following discussion can be only descriptive and crudely qualitative.

In a continuous medium such as the atmosphere, subject to many kinds of disturbance and with governing equations which are non-linear, it is an oversimplification to speak of systems of atmospheric motion; for one system cannot be clearly demarcated from another. If there were a complete three-dimensional specification of the motion of the atmosphere over the whole globe it would in principle be possible to subject the whole field of motion to a "spectrum analysis"; *i.e.*, to resolve the motion into different wave lengths with an intensity and phase for every wave length. It would be found that the spectrum, like that of white light, is continuous whereas the use of the word "system" for the motions implies the existence of a line spectrum. However, the atmospheric wind spectrum, unlike the spectrum of white light, would have numerous bumps, implying the existence of dominant wave-length bands, and it is these bands which are not inappropriately referred to as systems. The familiar synoptic weather map shows some of them, *i.e.*, those for which the wind field at any level is given approximately by the isobars in that level, so that isobaric patterns imply wind patterns. The map, however, needs to be hemispherical in extent to show the largest systems, and it quite fails to show the small systems because of its inadequacy of scale and the lack of closely spaced observations which would be necessary to show the structure of the small systems.

A series of individual synoptic maps covering a substantial fraction of a hemisphere shows a great complex of motions in evolution but may not show immediately any global-scale features. If, however, mean values of wind velocity (or of the pressure field outside low latitudes) are formed over the globe for, say, a season and for a number of levels, a clear global pattern emerges and the systems in evidence on the individual synoptic charts for days in that season are either wholly or partly submerged. The global pattern of motion thus obtained is called the general circulation of the atmosphere. It is appropriate to discuss this first, although it is not to be explained in isolation from the spectrum of motions referred to above. It is then appropriate to discuss the large-scale disturbances of the general circulation, those appearing on synoptic weather maps. These may be identified as long waves in the westerlies, depressions and anticyclones or corresponding troughs and ridges of middle and high latitudes, and as short waves and tropical cyclones in the easterlies, covering a range of horizontal scale from several thousand to a few hundred kilometres and broadly determining the weather in the troposphere. On a smaller scale still are cumulus and cumulo-nimbus systems, tornadoes, land and sea breezes and mountain and valley winds. The end of the spectrum is found in the small-scale turbulence, some of whose properties have been already discussed.

## VIII. THE GENERAL CIRCULATION

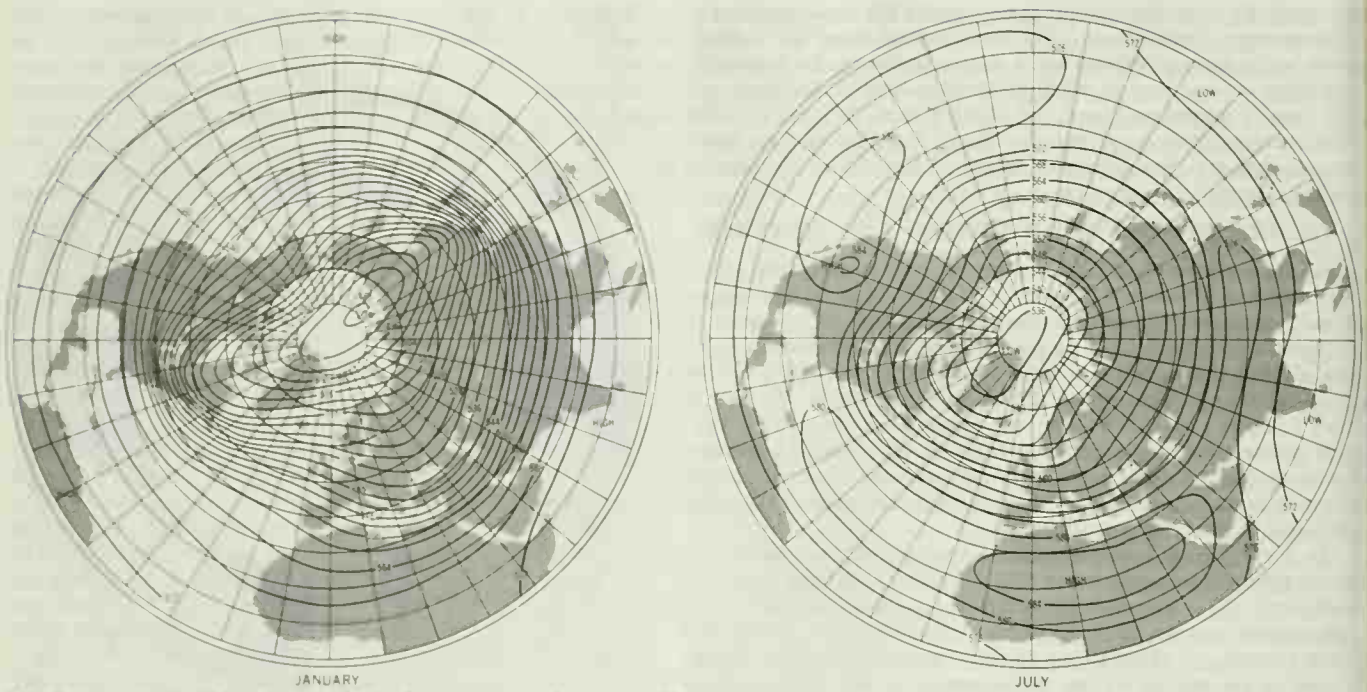
**The Global Pattern of Zonal Mean Motion.**—When mean values of the wind velocity or the pressure field are formed on a global basis, as described above, it is found that the zonal component of motion, *i.e.*, the east-west motion paraliel to latitude circles, is almost everywhere dominant. At the expense of some oversimplification the global pattern of this zonal motion is made clearest by superposing the motions for every meridional plane onto a mean meridional cross section of the atmosphere. Such cross sections are shown for the summer and winter seasons in fig. 4, in which the mean zonal wind speed is constant along each line. The pattern is seen to be essentially the same for both hemispheres and for both seasons, although the intensity is greater in winter than in summer and in the southern than in the northern hemisphere. There are lower latitude and polar surface easterlies and middle latitude surface westerlies, and everywhere except very near the equator the westerly component increases with height (easterly components decrease before leading to increasing westerlies) up to a certain level, which is practically the level of the tropopause. Above that level the westerlies decrease with height. Thus a great circumpolar westerly vortex occupies nearly all of the troposphere and lower stratosphere. It has maximum strength near the tropopause at about latitude 30°, above the transition from surface easterlies to surface westerlies—the horse latitudes. The core of fast-moving air in the upper troposphere and lower stratosphere at this latitude is called the *sub-tropical jet stream*.




FROM YALE MINTZ, "THE OBSERVED ZONAL CIRCULATION OF THE ATMOSPHERE" IN "BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY," VOL. 35, 1954

FIG. 4.—MEAN ZONAL (WEST–EAST) WIND MOTION IN M. SEC. (1 M. SEC. ≃ 2 KNOTS). WIND FROM EAST IS DESIGNATED BY NEGATIVE NUMBERS AND HEAVY SHADING. HEIGHT IS SHOWN IN TERMS OF PRESSURE AND AN EQUIVALENT HEIGHT SCALE IS AT UPPER LEFT

The field of zonal mean motion is consistent with the meridional temperature field in the troposphere and lower stratosphere, by virtue of the thermal wind discussed above. Only near the equator is there practically no meridional temperature gradient and no geostrophic control of wind; elsewhere in the troposphere the poleward decrease of temperature implies an upward increase of westerly wind, both greatest in winter; and in the stratosphere the equatorward decrease of temperature implies an upward decrease of westerly wind. There is an upper stratosphere westerly jet near the pole in winter (not shown in fig. 4), which is also consistent with the reversed temperature gradient of the winter polar stratosphere. This consistency between the wind and temperature fields does not, of course, explain the pattern shown in fig. 4. At most one can infer the strong upper westerlies of the troposphere to be a necessity, while the particular distribution of surface westerlies and easterlies and the existence of the subtropical jet pose further problems.




FROM S. HERMAS, "WETTER ANALYSE UND PROGNOSE," REPRODUCED BY PERMISSION OF SPRINGER-VERLAG

FIG. 5.—MEAN FLOW PATTERN OVER NORTHERN HEMISPHERE AT LEVEL OF THE MIDDLE TROPOSPHERE, INDICATED BY CONTOURS (IN DM.) OF THE HEIGHT OF THE 500 MB. ISOBARIC SURFACE. WIND BLOWS NEARLY PARALLEL TO CONTOURS, ANTICLOCKWISE (CYCLONICALLY) ABOUT THE CENTRE OF LOW, CLOCKWISE ABOUT THE CENTRE OF HIGH

**Meridional Circulations in the Atmosphere.**—Before these problems are studied, the components of motion in the meridional plane, *i.e.*, the meridional (north-south) and vertical motions, must be considered. The former and hence the latter are rather difficult to establish with reasonable precision, because the mean meridional motion is in general at least an order of magnitude less than the meridional motions associated with the large-scale disturbances. This is not, however, the case with the trade winds, which are relatively steady, with northeast trades in the northern hemisphere and southeast trades in the southern hemisphere. Thus the trades have equatorward motion, which is of order 1 m./sec., and since by continuity air cannot accumulate indefinitely to one side of a latitude circle, there must be a compensating poleward flow in higher levels. This is indeed observed. One may also infer mean upward motion at the conjunction of the trades (the doldrums) of order 1 mm./sec. In middle latitudes the lower and upper level meridional motions are reversed relative to the lower latitudes and appear to be somewhat weaker, whereas over the polar cap they are again of the same sense as in low latitudes, but also weak. There is then descending motion on the equatorward side of the mid-latitude cell and rising motion on its poleward side.

Although the above meridional motions are weak compared with the zonal motion they are not to be discounted, because air which moves across latitude circles produces important dynamic effects. Poleward moving air creates westerly momentum—the action of the Coriolis force—and equatorward moving air creates easterly momentum. Such creation of momentum, or the corresponding Coriolis forces, cannot be balanced in the mean cross section by a pressure-gradient force, because pressure is continuous around a latitude circle, and so there is no net east-west pressure-gradient in any level. In other words, meridional mean motion is not geostrophic.

The above refers to the mean meridional section. A chart of the distribution of mean velocity at any level over the globe (*see* fig. 5) shows quite strong meridional motions from north to south in some meridians and from south to north in others, such motions being more prominent in the northern than in the southern hemisphere. The wind blows nearly parallel to the contours and wind speed is roughly inversely proportional to the separation of the contours (with greater wind speed for a given separation of contours in low than in high latitudes). In the northern hemisphere the meridional motions appear on the surface chart as closed cyclones and anticyclones, *e.g.*, the Icelandic "low" and the subtropical oceanic "highs" of winter and summer, the Siberian winter anticyclone, etc., but aloft only troughs and ridges appear. These motions arise because the underlying earth is not uniform in thermal and geometrical properties around the latitude circles. Clearly there could be no alternating meridional mean motion around a latitude circle above a uniform earth. The troughs and ridges in the mean flow pattern, which are an expression of the meridional motion now referred to, together with the zonal component of the motion, are important features of the general circulation, but they are clearly secondary to the zonal and meridional components described earlier and are more likely to be understood when the latter are satisfactorily accounted for. Their positions are due in part to the disturbing effects of large mountain chains such as the Rockies and the Andes, but perhaps more to the thermal differences between the continents and the oceans.

**Friction and Momentum Transfer in the General Circulation.**—The pattern of fig. 4 may now be reconsidered. There is friction between the surface winds and the earth's surface, so that opposing frictional torques are set up by the surface westerlies and easterlies, tending respectively to speed up and to slow down the earth's rotation about its polar axis. The tropical easterlies and mid-latitude westerlies are clearly the more important agents of torque, because the distance of the polar cap from the earth's axis is relatively so small. Now, the earth is neither speeding up nor slowing down over the years as a result of these torques, so that they must be practically balanced. (There is some speeding up and slowing down of the earth's rotation on a seasonal basis due to an annual variation in net torque over the globe.) It may be inferred that surface easterlies may not exist without surface westerlies, and vice versa, the two being matched in extent and intensity to give zero net torque. If one were absent the earth would speed up or slow down until there was no surface wind. This argument for the necessity of matching opposing frictional torques does not of course indicate how the bands of surface easterlies and westerlies should be disposed.

Consider now the blocks of atmosphere on the equatorward and poleward sides of the horse latitudes. Surface friction is injecting westerly momentum into (extracting easterly momentum

from) the former block, yet its zonal momentum remains essentially the same, seasonal variation apart. The westerly momentum gained by surface friction must therefore be exported from the block, since no external forces operate to absorb the gain. This export must be through the sides of the block into middle latitudes where it appears as an import. This import, moreover, is necessary to make good the loss of westerly momentum through the base of these blocks by surface friction. Putting on one side the air over the polar caps, which is of little consequence in this budgeting, it is seen how the zonal momentum balance of the atmosphere must be maintained with surface friction present as required by fig. 4. The mechanism by which the horizontal export and import of zonal momentum is achieved now calls for consideration.

One possible mechanism is the mean meridional circulation described above. If $u$ is the mean westerly wind and $v$ the mean poleward wind at any level, the horizontal poleward transport of zonal momentum at that level by the meridional circulation is proportional to $uv$. Now, $v$ necessarily reverses its sense somewhere in the vertical to ensure zero transport of air across any latitude circle, as seen above. A positive value of $uv$ integrated over the whole depth of atmosphere therefore requires a particular kind or kinds of association between $u$ and $v$, an association which is possibly satisfied at about latitude 30° but which is certainly not capable of providing the poleward transport of momentum required by surface friction. In fact, observations of daily winds show that the transport is effected through the random fluctuations in zonal and meridional wind associated with the large-scale disturbances of the general circulation, and that this transport is mainly confined to the high troposphere. It is a large-scale turbulent transfer, regarding the large disturbances in the general circulation as a form of turbulence, and is formally similar to the vertical transfer of momentum in the friction layer discussed above, but different in mechanism. Thus the disturbances of the general circulation are essential to the structure of the general circulation itself. This property of the large-scale disturbances will be discussed when they are dealt with below.

Since the meridional transfer occurs aloft, whereas friction is a ground source or sink of momentum, a mechanism has to be found for transporting zonal momentum upward in the low-latitude block and downward in the mid-latitude blocks or, alternatively, for creating or destroying zonal momentum below or aloft as the balance requires. Here the meridional motions are certainly important. They have the correct sense; *e.g.*, the equatorward motion in the trade winds creates easterly motion and so balances friction, while aloft the poleward flow creates westerly momentum for export to higher latitudes. The mid-latitude cell works in the opposite sense. It is, however, probable that the vertical transfer of zonal momentum in the troposphere by turbulence up to cumulo-nimbus or even larger scale is an important part of the balancing mechanism.

**The Dynamic Explanation of the General Circulation.**—The above discussion shows essentially that the general circulation as observed is a self-consistent system, as it must be, and indicates some part of the mechanism. It does not, however, explain by any means all the main features of the circulation or why they must occur, and it has already been shown that the explanation depends on the properties of the large-scale turbulence. Although the explanation remains incomplete some further clarification is possible.

The poleward transport of zonal momentum which is concentrated in the upper troposphere is a property of large-scale disturbances which must arise (*see* below) in an atmosphere with a meridional gradient of temperature. Such a gradient must exist in the troposphere owing to differential heating from below by absorption of solar radiation, though the magnitude and pattern of the gradient will evidently depend on the efficiency with which meridional circulations and large-scale turbulence transport heat across the parallels of latitude. Thus, the poleward transport of zonal momentum aloft is also a necessity. This requirement implies that surface easterlies must be in low latitudes and surface westerlies in higher latitudes, for otherwise the momentum balance of the atmosphere with friction could not be maintained. The mechanism of the production of these winds is not, however, implied. Surface westerlies could be expected in middle latitudes by a downward transfer of westerly momentum from the tropospheric westerlies, which necessarily increase with height, provided that there is no meridional circulation opposing their creation. It has been seen that the weak meridional circulation in middle latitudes helps to create westerly wind and is indeed almost a consequence of friction once the westerly momentum appears at the surface.

Again, in lower latitudes, if the meridional circulation is given as to sense—it is however a theoretical problem to show its necessity—then the equatorward motion in lower levels is hardly possible without surface easterlies. The downward transfer of zonal momentum by cumulus convection from the upper westerlies in lower latitudes is a brake, like surface friction, on the strength of the easterlies. Alternatively, it is reasonable to regard the strength of the tropical meridional circulation as that which will provide a balance, through the Coriolis force, with the injection of westerly momentum into the easterlies from below and above.

The meridional circulation of low latitudes probably fails to extend into middle latitudes because, by its upper branch, it helps to create so strong an upper westerly flow that the system is dynamically unstable, and large-scale turbulence is generated by the instability at and poleward of the subtropical jet stream. This intense turbulence then ensures surface westerlies and, by friction, a reversed meridional circulation in middle latitudes. Where, as over the polar cap, the meridional temperature gradient almost necessarily becomes weak, the upper westerlies are less strong and a weakened form of the low-latitude meridional cell is able to become re-established, again with surface easterlies.

**Thermal Aspects of the General Circulation.**—The above dynamic discussion of the general circulation is related with the temperature field only through the thermal wind. But the general circulation, with its associated disturbances, is a thermodynamic (heat) engine. Heat enters the atmosphere from below either directly or in latent form (as water vapour) by turbulent transfer, mainly in lower latitudes, and the heat is discharged radiatively from upper levels and higher latitudes. Thus the excess of heat in low levels of lower latitudes has to be transferred upward and poleward to the sink of heat to maintain thermal balance. The particular distribution of source and sink brings into existence the winds which effect the transfer or, more exactly, the winds and the source-sink distribution achieve a working balance. The heat transfer is probably mainly brought about by the large-scale disturbances of the general circulation, though cumulus and cumulo-nimbus convection is not unimportant in vertical transfer, and the upper limb of the tropical meridional circulation is possibly as significant in the heat balance as it certainly is in the momentum balance. Clearly a zonal wind system, the dominant aspect of the field of mean motion, provides no direct poleward or upward flow of heat.

The role of water vapour is evident in cumulo-nimbus convection—latent heat is released aloft when precipitation forms—but it is effective also in the meridional transfer of heat, since some of the water vapour which is evaporated into the air in the tropics is ultimately carried poleward to condense in the migratory depressions of middle and high latitudes. It is, however, doubtful whether the essential pattern of the general circulation is dependent on the condensation of water vapour in the atmosphere.

**Fluctuations of the General Circulation.**—Some features of the seasonal variation of the general circulation are evident from fig. 4 and 5—broadly a less intense circulation in the summer, when meridional gradients of temperature are at a minimum, and some accompanying poleward displacement of the transition belts. There are also monsoon systems (*see* below).

In addition to the seasonal fluctuations there are even more striking irregular changes of pattern in a single season or from one year to another. They vary in length from two or three weeks to two or three months and have no true periodicity. There are also small amplitude changes of very much longer duration, which are referred to as "climatic variation," again with no true periodicity. On the geological time scale the amplitude of these

changes may be sufficient to cause ice ages and intervening warm (dry or wet) periods.

Typical of the year-to-year variations is the occurrence of a very severe winter in one region with a mild winter in another, or a prolonged summer drought over part of the hemisphere with excessive rains over another part. Such departures from average are associated with intensifications or weakenings of the zonal or meridional components of wind, generally accompanied by displacements from normal position of the semipermanent high and low pressure centres, or aloft of the corresponding ridges and troughs. The tracks of storms become simultaneously displaced from normal. An abnormally strong zonal circulation tends to establish settled and moderate weather conditions in middle and lower latitudes, with a maximum of storminess at higher latitudes and excessive coldness in the polar regions. An abnormally strong meridional circulation tends to establish a persistent condition of contrasting extremes of temperature, with a maximum of severe storminess in lower middle latitudes. Persistent severe cold is experienced in middle and lower latitudes in those regions dominated by the equatorward-moving polar air masses, while persistent abnormal warmth is experienced in middle and higher latitudes in those regions dominated by the poleward-moving tropical air masses. Little or nothing is known of the operation of the physical factors which control these irregular long-period fluctuations of the general circulation. Indeed, their understanding necessarily depends on that of the "normal" general circulation, but their further study may well contribute to understanding of the latter.

**Seasonal Fluctuations or Monsoons.**—The word "monsoon" is derived from an Arabic word meaning season, and was originally applied to the seasonally reversing winds, northeast in winter, southwest in summer, over the Arabian sea. More recently the term has come to be applied to any circulation which is essentially seasonal in character; hence it applies to the semipermanent cells of the general circulation which are maintained by the seasonal thermal contrasts of the continental and ocean surfaces. Since the seasonal contrast is greatest over continents in middle latitudes, the effects of this contrast on the climates of North America and Asia, the largest land masses in middle latitudes, are considered briefly below.

In North America the summer continental low and the winter continental high appear in the seasonal mean or normal pressure and wind charts, but they are frequently obscured or temporarily obliterated by the day-to-day sequence of migratory highs and lows. However, their seasonal influence, though weak, is clearly demonstrated. In winter the predominant airflow east of the continental divide consists of an intermittent sweep of cold continental polar air masses from Canada southward and southeastward to the gulf and Atlantic coasts of the United States, between the intermittent continental high in the west and the north Atlantic low in the east. Thus, a northerly wind component and a cold dry climate tend to predominate over the central and eastern part of the North American continent. At the same time the juxtaposition of this cold polar air with air from the subtropical high pressure cell over the Atlantic leads to considerable storminess and winter precipitation along, and to some distance inland from, the gulf and Atlantic coastlines. On the Pacific coast, between the continental and the north Pacific low, the prevailing wind direction has a southerly component and the predominant winter weather type is warm, wet and stormy. In summer the prevailing flow pattern is associated with high-pressure areas covering most of the oceans and relatively low pressure over the continent. The prevailing air flow over the eastern and central part of the continent has a southerly component, carrying warm, moist, tropical air from the Gulf of Mexico northward; this gives predominantly warm, sultry weather with scattered thunderstorm activity and occasional widespread convective rains east of the continental divide. On the west coast the prevailing flow is of anticyclonic or maritime polar air from the northwest around the Pacific high, the predominant type of weather being correspondingly cool and dry.

Asia, a land mass two and one-half times larger than North America, produces correspondingly the strongest monsoon circulations in the world. They are of approximately three times the extent and intensity of the North American monsoons. They are never obliterated and rarely even obscured by the day-to-day migratory pressure centres, and they completely dominate the winter and summer weather patterns over most of Asia. Asia differs from North America also in that its great mountain ranges, extending eastward from Asia Minor in the west through the Himalayas just north of the Indian peninsula into northern Burma and southern China, interpose a major obstacle to any such free northward or southward movement of air masses as occurs in central and eastern North America.

In winter the circulation over most of Asia and the adjacent ocean areas is dominated by the great symmetrically centred Asiatic anticyclone. All of Asia north of the southern mountain barrier is dry and extremely cold, with temperatures over the low-lying plains of northeastern Siberia averaging in January the lowest that are known in the world near sea level. The extremely cold continental polar air is shallow, as a result of surface cooling and subsidence aloft in the monsoon anticyclone. Consequently, the southern mountain barrier completely blocks this shallow, cold air from flowing to the Indian ocean in the way that cold waves in North America reach the Gulf of Mexico. The prevailing northeast winds over southern coastal Asia in winter are dry, and moderately warmed by downslope movement from the mountains and by insolational heating. The winter monsoon season in this area is almost rainless and quite mild.

In summer, central Asia is dry and intensely heated, even Siberia becoming quite warm, and the continent is dominated by the vast monsoon low which is centred in the hot, dry region northwest of India. The prevailing strong southwest and southerly winds that blow across the northern Indian ocean into southern and eastern Asia deposit excessive amounts of precipitation both on the south coast and along the exposed southern slopes of the great mountain barrier, where the heaviest rainfall in the world occurs during the summer monsoon. The moisture is so completely removed from the maritime tropical air masses in the course of their ascent over the mountains that central Asia remains quite arid during the hot summer season, unlike North America, where the maritime tropical air from the Gulf of Mexico and the Caribbean sea has easy access to the interior of the continent.

The summer maximum temperatures in the region of the heavy monsoon rains of southern Asia are somewhat depressed by the cloudiness and precipitation, so that in these areas the highest temperatures occur during the intermonsoonal periods in April and May in the spring, and in October and November in the autumn.

The Asiatic monsoon circulations, like the other semipermanent cells of the general circulation, vary appreciably from year to year in their exact location, intensity and duration. Correspondingly large variations occur in the time of onset, intensity and distribution of the monsoon rains, which are of vital importance to the subsistence of the dense agricultural populations of southern Asia. Consequently much attention has been paid by British and Indian meteorologists to the development of suitable statistical long-range weather forecasting techniques that might be applied to the seasonal variations of the Indian monsoon as related to other features of the general circulation, but only a partial success has attended their efforts.

## IX. LARGE-SCALE DISTURBANCES OF THE GENERAL CIRCULATION

Any daily sequence of surface and upper-air synoptic charts shows the existence of migratory large-scale wind systems, such as long waves in the westerlies—most notable in upper air charts—with a horizontal wave length of several thousand kilometres, anticyclones and smaller depressions, troughs and ridges, with their attendant characteristic weather patterns. These systems may develop from small-amplitude disturbances of the flow field, grow to maturity and then decay, but the larger-scale disturbances may be semipersistent. Their importance in the mechanism of the general circulation has already been stressed, and something will now be said of their nature.

**Dynamic Instability in Differentially Heated Air.**—The average lapse rate of temperature in nearly all parts of the atmosphere is sub-adiabatic, so that its potential energy is not spontaneously convertible to kinetic energy by the vertical displacement of parcels of air (see *Lapse Rate and Vertical Stability*, above). Such conversion does occur from time to time and from place to place, particularly in the lower troposphere, in convective motions, but these motions are mainly small in scale; *e.g.*, the scale of the cumulo-nimbus.

The origin of the energy of most large-scale motions in the atmosphere is nevertheless to be found in the potential energy of the atmosphere. Its release is brought about by a slantwise convection process arising from the existence of a horizontal gradient of temperature which is, of course, characteristic of the atmosphere outside low latitudes. Such slantwise convection is readily demonstrated by considering a model atmosphere composed of incompressible fluid. The argument for a compressible fluid is similar, but introduces needless complication. The model atmosphere is shown in vertical cross section, along a meridian, in fig. 6, a meridian being chosen because horizontal gradients of temperature are there characteristic. Lines of constant density are drawn in fig. 6, showing density decreasing upward and equatorward, which is equivalent to the troposphere and the summer mesosphere, with temperature decreasing upward less rapidly than the dry adiabatic and poleward. Now, a volume of fluid displaced upward in the section would find itself in an environment of lower density and so would sink back. But if a volume were displaced poleward as well as upward *on a slope less than that of the constant density lines*, *e.g.*, along AB, it would find itself in an environment of increasingly greater density and so would be subject to increasing buoyancy. The displacement would thus be spontaneously increased. Similarly, a volume displaced from B toward A would be accelerated downward along the path. Thus the system considered is unstable to disturbances of the kind postulated; the interchange of parcels of fluid between such points as A and B evidently decreases the potential energy of the system, and this decrease represents the kinetic energy generated. The displacement of particles out of the plane of the section in either direction, as they are displaced slantwise, provides an additional dimension to the motion without affecting the origin of the instability.

The critical slope for the generation of this instability in the real atmosphere, corresponding to the slope of the constant density lines in fig. 6, is very small indeed, of order 1 in 100 to 1 in 1,000, so that the motion must be very nearly horizontal. If it extends through the depth of the troposphere, then the circulation will have a horizontal dimension of thousands of kilometres. Moreover, a simple calculation from energy considerations shows that the velocity generated in the motion is of order 10 m./sec., so that a particle of air will spend several days executing the circulation and the motion must then be nearly geostrophic. The vertical velocities are relatively small, so that the pressure will be hydrostatic and the temperature will be related to the pressure or wind field by the thermal wind relation.

A dynamic analysis of this kind of motion, making use of the constraints to which the air is subjected, *e.g.*, that the motion must be horizontal at the earth's level surface, shows that there is a wide spectrum of possible cell sizes but that one of these will intensify most rapidly. For tropospheric conditions the optimum size is about 3,000 km. in the horizontal, and it is a reasonable presumption that this size will dominate the actual flow. Such dynamic analysis gives also the thermal and velocity fields in the early stages of the growing disturbance; the motion necessarily distorts the temperature field, and the velocity field partly reflects this distortion because the motion is quasi-geostrophic. A comparison of these predicted fields of temperature and motion with those that are actually observed (*see* below) in traveling extratropical troughs and ridges, depressions and anticyclones, shows quite remarkable agreement between them.

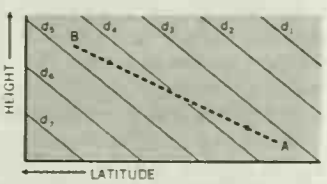



FIG. 6.—MERIDIONAL (VERTICAL) CROSS SECTION OF MODEL OF INCOMPRESSIBLE FLUID TROPOSPHERE. SLOPING LINES OF CONSTANT DENSITY $d(d_1 < d_2 < d_3 \ldots)$ ARE DRAWN SHOWING DENSITY DECREASING UPWARD AND EQUATORWARD

The motions that arise in the atmosphere because of the existence of a horizontal temperature gradient with a stable lapse rate are called *baroclinic*—a word meaning that the isobaric surfaces intersect the surfaces of constant density. These motions are undoubtedly most important to the understanding of the general behaviour of the atmosphere. They transfer heat upward and poleward and so help to satisfy the thermal balance requirement; they largely ensure that the mean lapse rate is sub-adiabatic but that areas of unstable lapse rate will develop; and they provide a meridional transfer of zonal momentum, as was seen to be required for the momentum balance of the atmosphere. Their action is one of large-scale stirring of the atmosphere, and it is evident that such stirring of air with a horizontal temperature gradient will greatly intensify this gradient in some parts of the field and weaken it in others. The intensified gradients appear in fact as fronts or frontal zones (*see* below), which are a characteristic feature of extratropical depressions.

The theory of baroclinic motion has been developed for the initial phase only of growing disturbances on certain simple basic zonal mean motions, or else for motions which evolve from observed initial states—more complex than the idealized basic flows referred to above—but with limitations imposed by neglecting all but the gross vertical structure of the atmosphere. Nevertheless, the theory is promising for the insight it provides into the way in which the atmosphere evolves and for its provision of means for objective numerical forecasting by the use of high speed digital computers.

Other things being equal, the growth rate of baroclinic disturbances is slower the less the lapse rate of temperature. Thus the stratosphere, which is highly stable, is less liable to rapid evolution than the troposphere below or the mesosphere above it. Again, for a given horizontal temperature gradient, the slope of the slantwise convection is evidently less the greater the vertical stability (*see* fig. 6), so that stratospheric disturbances can be expected to be flatter than those in the troposphere and mesosphere.

**Long Waves and Jet Streams.**—The long waves of the upper westerlies are relatively slow-moving disturbances, which tend to set the pattern of the smaller-scale synoptic disturbances apparent on charts of the lower troposphere. When the long waves are small in amplitude the circulation of air in middle latitudes is predominantly zonal but disturbed by many traveling depressions, and when the waves are of large amplitude there are strong meridional motions, equatorward and poleward, and a more cellular type of motion with rather stable anticyclonic areas is set up in the lower troposphere.

Associated with the long waves is a jet stream in the high troposphere and lower stratosphere. This jet, like the subtropical jet, is composed of a core of fast-moving air, the speed on the jet axis sometimes reaching over 100 m./sec. The speed commonly falls off to about half the maximum at a horizontal distance normal to the jet of a few hundred kilometres and in a vertical distance of two or three kilometres. The jet meanders with the form of the long waves in which it is embedded, strengthening and weakening along its length, and it is at the regions of strengthening and weakening—regions of so-called confluence and diffluence respectively—that smaller-scale disturbances develop beneath it.

When the long waves develop a large amplitude the air in the troughs and crests of the waves may become cut off from the main flow, upper cold cyclonic lows developing at the troughs and upper warm anticyclonic highs at the crests. This cutting off of cold air in the lower latitudes of the long waves and of warm air in their higher latitudes is probably one of the chief means of effecting the meridional transfer of heat which is necessary for the thermal balance of the atmosphere. In the cutting off of the upper cold low the jet may also become detached from the main long wave and form a circular jet around the low; an easterly jet is then created on the poleward side of the low.

A jet stream is an inevitable flow pattern where, as in the troposphere, there is a strong concentration of horizontal temperature gradient, which is a frontal zone, with a reversal of the temperature gradient above, as in the stratosphere. The jet is an expression of such a temperature field through the thermal wind relation, but it would hardly be appropriate to regard the jet as the consequence of the thermal field. The dynamic factors giving rise to the one imply the other.

Another feature of the jet is its association with a break in the tropopause above it. The jet axis is found above and on the warm side of the sloping frontal zone with the tropopause of tropical air above it, whereas the tropopause of the polar air is poleward of the jet and at a lower level than the tropical tropopause. There is, then, a region between the two tropopauses where a less stable stratification occurs, and air may pass rather readily from stratosphere to troposphere. Ozone, which is created in the upper stratosphere, probably passes through the tropopause break to diffuse downward through the troposphere and to be destroyed on reaching oxidizable matter at the earth's surface. Radioactive debris from high-level fission-fusion bomb clouds also probably enters the troposphere through the tropopause break, to be precipitated later in rain or to diffuse downward with the air.

The nature and behaviour of long waves is not fully understood, but they are in the class of baroclinic motions described in the previous section. Some of their properties are, however, approximately identifiable with those of waves which could appear on a rotating earth without a horizontal temperature gradient in the air, provided that a zonal wind were blowing. If a zonal wind is perturbed by being given a meridional component of motion, then the absolute spin (vorticity) of the air about a vertical axis is conserved as it moves. Now, the vertical component of the cyclonic spin of the earth decreases equatorward, so that air moving toward lower latitudes acquires cyclonic spin relative to the earth to maintain its absolute spin. Similarly, air moving poleward acquires anticyclonic spin to offset the increasing cyclonic spin of the underlying earth. A natural wave motion then ensues and it was shown by C. G. Rossby that the eastward speed of progression $c$ of such waves is given by

$$c = U - \frac{2\,\omega a \cos^2 \phi}{n^2},$$

where $U$ is the zonal speed of the basic current (positive from the west), $a$ the earth's radius and $n$ the number of waves around the latitude circle. The waves may be progressive or regressive according to their number at a mean latitude and according to the zonal wind speed. The above formula is found to have some validity in experience, though actual long waves, being baroclinic, are more complex than these so-called Rossby waves.

**Frontal Depressions.**—The disturbances which develop in the troposphere in association with long waves and with the jet stream originate in the main as waves on the polar front. They are the typical active migratory lows of middle latitudes and are carried along in the larger-scale flow of the long waves. Their growth depends on the baroclinic instability discussed above, but the details and the attendant weather phenomena depend on the characteristics of the air masses to either side of the front, or frontal zone (*see* FRONT). It is therefore necessary to consider briefly the nature of air mass properties.

**The Characteristic Properties of Air Masses.**—Air masses consist essentially of those extensive air currents of polar or tropical origin which constitute an important part of the meridional component of the general circulation. The important air masses all originate in polar or in subtropical latitudes; the middle latitudes constitute essentially a zone of modification, interaction and mixing of the polar and tropical air masses by the general circulation.

An air mass is characterized by relative uniformity in the horizontal by comparison with the frontal zones, where conditions change very abruptly in the transition from one air-mass type to another. The horizontal homogeneity of an air mass is acquired in an extensive, more or less uniform source region, and through the uniform modification of the source properties of the air mass as it journeys to other latitudes. The four basic air-mass source types are: continental polar (cold and dry, especially in winter); maritime polar (cool and moist); continental tropical (hot and dry, especially in summer); and maritime tropical (warm and moist).

The cold, dry, continental polar ($cP$) air mass in winter, having formed in subsiding anticyclonic conditions, is likely to be stable at all levels and is characteristically free of condensation forms. When heated or moistened from the ground, with strong turbulence, this air mass develops the limited convective strato-cumulus cloud forms with scattered light snow showers. When this modification occurs over the Great Lakes or other similar bodies of water in a strongly cyclonic circulation, cumulo-nimbus clouds may form to give heavy local snowfall. In this case the $cP$ air mass becomes locally maritime polar in character. In summer the strong continental heating rapidly modifies the coolness and dryness of the $cP$ air mass as it moves to lower latitudes. Daytime building of cumulus clouds is the rule, but the upper-level stability of the air mass is usually such as to prevent the formation of cumulo-nimbus clouds or showers.

The cool, moist, maritime polar ($mP$) air mass in winter is strongly heated and moistened as it moves to lower latitudes over the warm ocean surfaces. In regions of marked anticyclonic circulation this maritime influence produces limited convective strato-cumulus clouds and perhaps scattered light showers, but in areas of cyclonic or frontal activity cumulo-nimbus clouds and moderate or heavy showers characterize this air mass. In summer the ocean surface is relatively cool, and the circulation over the oceans in middle latitudes is predominantly anticyclonic rather than cyclonic. Consequently the $mP$ air mass is characterized only by strato-cumulus clouds at the top of the surface frictional layer, with occasional light drizzle.

The hot, dry, continental tropical ($cT$) air mass originates in arid or desert regions in middle or lower latitudes, principally during the summer season. This air mass is strongly heated as a rule, but its moisture content is so low that the intense dry convection normally fails to reach the condensation level. Of all the air masses, the $cT$ is the most limited in extent and plays the smallest role in world weather.

The warm, moist, maritime tropical ($mT$) air mass is at all seasons of the year the most important moisture-bearing and rain-producing mass. In winter as it moves poleward it is cooled by the ground surface, and consequently is characterized by fog or low stratus or strato-cumulus clouds with drizzle and poor visibility, depending on the wind velocity. A steep lapse rate aloft in regions of frontal or cyclonic activity ensures the occurrence of heavy frontal and convective rains. In anticyclonic circulations, especially in the subtropical highs in the source regions, only the lower stratified or limited convective condensation forms appear. Above the subsidence inversion the air mass is often as warm and dry as the $cT$ air mass at corresponding levels. In summer the characteristics of the $mT$ air mass over the oceans and in zones of frontal or cyclonic activity are essentially the same as in winter. But over warm continental areas the air mass is strongly heated, so that instead of fog and low stratus clouds, widely scattered and locally heavy afternoon thunderstorms occur unless there is a strong subsidence inversion aloft.

**The Characteristics of Fronts.**—A significant front, such as the usual polar front, consists of a sloping transition zone which sometimes approaches a true discontinuity between two air masses differing sharply in temperature and moisture content. The slope of the front is such that the cold air lies in a wedge under the warm air which, if the front is active, rises over the cold wedge, giving cloud and precipitation.

When the front advances so that warm air displaces cold air at the ground, the front is referred to as a warm front. When cold air displaces warm air at the ground, the front is referred to as a cold front. The slope of an active cold front is usually significantly greater than that of a warm front near the ground, because a rapidly moving wedge of cold air is retarded at the ground by surface friction, so that the advancing cold air mass is piled up in the form of a blunt nose at the forward edge. The

cold-front passage is likely to be marked by a violent convective squall, while the warm-front passage is relatively mild and marked primarily by the cessation of warm-front precipitation. The foremost cirrus clouds of the advancing warm-front cloud system may appear from 500 to 1,000 mi. ahead of the warm front at the ground. At the active cold front, on the other hand, the lifting of warm air by the advancing cold wedge usually extends only a relatively short distance behind the surface cold front. Convective cloud within the lower cold air mass may continue much farther behind, if the air mass is moist and unstable, as in the case of maritime polar air in winter.

Fig. 7, top and bottom, represents, in schematic cross sections normal to the front, the typical condensation forms at an active warm front and at a rapidly moving active cold front. The long arrows indicate the horizontal and vertical components of the air motion in the cross section; the short arrows attached to the abbreviated names of the cloud forms indicate the horizontal direction, by compass points, of cloud movements.

In fig. 7 (top) the cold air mass beneath the advancing warm front is assumed to be subsiding moist maritime polar air, with limited convective cloud forms beneath the subsidence inversion. If it were dry continental polar air these condensation forms would be missing. The overrunning warm air is assumed to be maritime tropical air, cooled at the ground but with typical frontal instability aloft, so that the frontal condensation forms are heavy and convective. If the air mass were less moist, or were stable aloft, the condensation forms would be much more restricted.

In fig. 7 (bottom) the warm air ahead of the cold front is assumed to be the same as that in fig. 7 (top), with a full assortment of limited convective cloud forms at the ground and of unlimited convective forms aloft in the cold-front squall, but with the high cloud system extending only a limited distance behind the cold front. The cold air mass behind the cold front is assumed to be subsiding cold dry continental polar air. If it were moist and unstable maritime polar air, extensive cumulo-nimbus shower formation would occur within the cold air, instead of only scattered cumulus clouds.

**The Development of Disturbances on Fronts.**—The typical migratory low of middle latitudes originates as a wave disturbance on a quasi-stationary front. Important disturbances never develop on a rapidly moving front, although the development of a strong disturbance on a front usually sets portions of the front into rapid motion. The front recedes at one point and advances at another, so that a growing undulation is set up which travels as a wave along the front. This wave progresses eastward along the front with a speed which varies considerably with the dimensions of the wave and the wind field at the front.

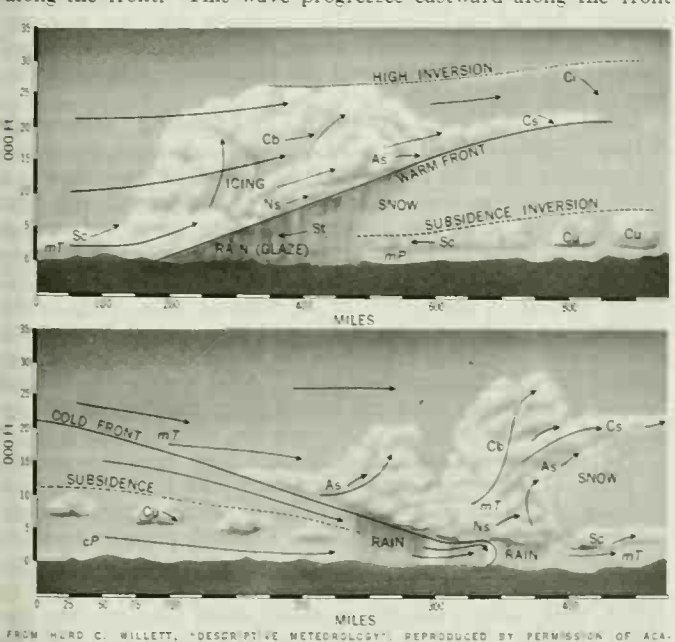



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FIG. 7.—TYPICAL FRONT CONDENSATION FORMS: (TOP) WARM FRONT; (BOTTOM) COLD FRONT

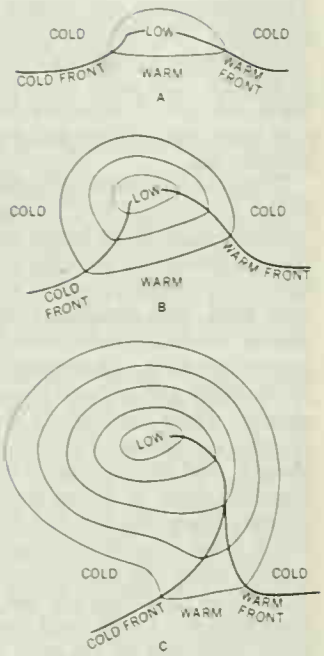


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FIG. 8.—OCCLUSION OF A WAVE ON A FRONT

The evolution of the disturbance, which is upward of a few hundred kilometres in horizontal extent, is attended by a process known as occlusion, and its essential character is represented in fig. 8. Fig. 8(A) represents the initial wave stage of the disturbance, in which the undulation of the front is of small amplitude relative to the wave length. The warm and cold fronts represent only minor displacements of the initially quasi-stationary front, and the centre of low pressure at the crest of the frontal wave is quite weak. Fig. 8(B) represents the active process of occlusion, the classical Bjerknes model (*see* WEATHER FORECASTING) of an actively deepening migratory low of middle latitudes. The cold air, with the cold front at its head, is beginning to sweep actively around the deepening low-pressure centre, tending to overtake the warm front and to narrow the warm sector. This spreading of the cold air at the ground and the replacement of cold air by overrunning warm air aloft constitutes occlusion. It represents essentially a lowering of the centre of gravity of the air-mass system in the occluding disturbance, or a loss of potential energy of the system. It is this loss of potential energy which supplies the kinetic energy of the increasing cyclonic vortex, although the release of large amounts of latent heat from the frontal precipitation sometimes contributes significantly to the ascent and outflow of warm air from the cyclonic vortex. In this stage all of the condensation phenomena of the typical warm front and cold front, as represented in fig. 7 (top) and 7 (bottom), may be observed in the respective frontal zones of the deepening flow.

Fig. 8(C) represents the intense cyclonic circulation when occlusion at the ground is practically completed; *i.e.*, when the surface warm and cold fronts with their respective condensation phenomena have joined to form an occluded front in the central portion of the low. Warm, moist air continues to be lifted aloft at the occluded front, but the amount of the lifting, the transformation of potential to kinetic energy and the condensation of water vapour begin to diminish at the point at which occlusion is completed at the ground. Consequently the cyclonic vortex, or the sea-level pressure centre, usually reaches its maximum intensity at this point, and is followed by a slow filling of the low under the influence of friction as the chief source of energy of the deepening disturbance is exhausted. It is evident that the net effect of the wave development and occlusion process is to break down completely the initial frontal equilibrium and air-mass distribution. The polar air mass, following the cold front, sweeps into lower latitudes and into regions previously occupied by the tropical air mass, which in turn is carried to higher latitudes in the upper atmosphere, thus contributing to the meridional component of the general circulation of the atmosphere. The polar front, after the impulse of one such development, may again become unstable in lower latitudes, unless the cold air has been spread so thin by the previous development that there remains insufficient potential energy to develop another occlusion. Most major polar-front systems develop a sequence, or family, of wave disturbances in the course of the completion of one major cold-air outbreak from polar to tropical latitudes.

The migratory anticyclones that follow the migratory frontal cyclones in sequence are essentially a part of the wave disturbance.

They accompany the wedges of cold air between frontal disturbances. On the other hand, one vast polar anticyclonic cell usually moves slowly southward with each major polar outbreak of cold air. The polar front, with its entire sequence of migratory highs and lows, is an active boundary between such an extensive cold polar anticyclonic cell and a major warm subtropical anticyclonic cell.

**Tropical Cyclones (Hurricanes and Typhoons).**—The hurricane or typhoon is a convective cyclonic circulation of great intensity which is fed by the latent heat liberated by the condensation of tremendous amounts of water vapour. Its initial development is restricted to regions of markedly warm ocean surface and light wind, both conditions favouring surface instability, and of general air-mass convergence, which favours instability of the atmosphere aloft. Hurricanes never form over land, nor in regions of markedly anticyclonic circulation, nor within about 6° of the equator, where the Coriolis force becomes too small to establish cyclonic circulation. They are observed generally to occur between about 6° and 25° latitude in the doldrum belt (inter-tropical convergence zone) in either hemisphere in late summer and early autumn, when this belt has its maximum poleward displacement, and in other tropical convergence zones between cells of the subtropical highs. In the northern hemisphere such favourable zones include the Caribbean sea and the Gulf of Mexico, the region of the Philippine Islands and the China sea, the doldrum belts off Cape Verde and off the west coast of Central America, and the Bay of Bengal and the Arabian sea (only during the intermonsoonal periods).

The initial formation of the hurricane takes place slowly, in a region of unstable showery conditions, light variable winds and slightly lowered pressure—conditions that are typical of the doldrum belts or of any other zone of convergence of tropical air masses. Cyclonic circulation in the disturbed area of hurricane genesis is established usually only after a lapse of several days, owing to the slow action of the Coriolis force in low latitudes. Once the cyclonic sense of circulation is well established, the inflow is restricted to the surface layer of the warmest and most humid air which thus feeds the convection from below. From this point in the development the pressure can fall rapidly at the centre and an approximate balance is then achieved between the pressure gradient and the Coriolis and centrifugal forces. In a very short time, sometimes within 24 hours, assuming the continued supply of sufficiently warm and moist air, a small and very intense vortex is established in which the warm moist air spirals upward with the release of much latent heat. The compensating outflow, as indicated by the movement of the high clouds, is located in the upper troposphere, and usually takes place ahead of the vortex and in its direction of movement. Normally, in this intense stage, the entire vortex is not more than 100 km. in diameter. The circulation and the cloud forms may extend upward to the top of the troposphere, the sea-level pressure at the centre of the storm is lowered by from 50 to 100 mb. or even more, winds of from 100 to 200 knots drive a blinding curtain of heavy rain, and incessant lightning is frequently observed. At the centre of the vortex there always occurs a small central calm, the so-called "eye" of the storm, about 10 km. in diameter, in which the rain ceases and the clouds frequently are dissipated. These effects are produced by the downward movement and adiabatic heating of air from the central upper levels of the cyclone.

**Movement of Tropical Cyclones.**—Once formed, a hurricane tends to drift with the wind at about 10,000 ft. In tropical latitudes this drift is normally westward with a slight poleward component, at a speed of some 10 to 15 knots. At some point between 20° and 30° latitude the hurricane usually recurves poleward at reduced speed through some low-pressure trough or break in the subtropical high-pressure belt, subsequently moving northeast or eastward with increasing speed as it reaches latitudes of increasing zonal west winds aloft. Some hurricanes, if they do not move inland, survive long enough as severe storms after recurvature to cross the full width of an ocean, thereby attaining a total life span of from two to three weeks. The movement of individual hurricanes may be quite abnormal and erratic, as a result of abnormal wind patterns aloft. In the autumn, especially, the circulation of a strong migratory polar anticyclone occasionally catches a poleward-moving hurricane and reverses its direction of movement.

As hurricanes move to higher latitudes during and after recurvature they usually increase in size, sometimes to a diameter ten times that of the early intense stage. At the same time they lose something of their intensity, the circulation normally does not extend so high in the atmosphere, and some of their vortical symmetry is lost as they come into contact with polar air masses and begin to develop air-mass contrasts. In other words, the hurricane becomes more like the larger and less intense extratropical lows with their air-mass contrasts and asymmetrical distribution of precipitation and other elements. However, as long as the storm remains active over the ocean it may retain hurricane intensity, with winds in excess of 70 knots. When the hurricane moves inland, the increased surface friction and perhaps decreased supply of moisture and heat—the surface is cooled by the rain—allows the storm to disintegrate very rapidly, so that winds of hurricane velocity seldom persist at the ground three hours after the storm centre crosses the coastline.

One of the most destructive features of the hurricane is the high water that the storm brings with it as it advances against a shelving coastline. As the hurricane approaches a coastline over shallow water, the water is carried by the frictional drag of the wind far inland on the right of the storm centre and is forced offshore on the left. As a result, violent currents that sweep everything before them are driven from right to left, parallel to the shore line in front of the advancing storm. In particular at the head of a shallow bay the water may be piled up to a depth of 30 ft. above normal tide, and be driven miles inland by the wind. In many parts of the world a single hurricane may claim thousands of lives through such coastal inundations.

## X. SMALL-SCALE FLOW PATTERNS

There are many small-scale flow patterns, or disturbances on larger-scale motions, which produce very characteristic and significant weather. Some of these are produced by local heating or cooling, while others are essentially dynamic modifications of flow brought about by local topography. Among the former are: (1) the mountain breeze and glacier winds which are caused by local cooling; (2) the valley breeze, dry thermal convection and cumulus convection which are caused by local heating; (3) thermal convective showers and thunderstorms and the land and sea breeze, which are caused by simultaneous adjacent local heating and local cooling. Among the latter are (1) lee waves and rotor motions; (2) foehn (föhn), or chinook, winds; (3) orographic and frontal showers and thunderstorms; and (4) tornadoes. A short discussion of these motions follows.

**Local Circulation Produced by Cooling (Drainage Winds).**—Whenever air is cooled at the ground at high elevations, the tendency exists for the cold, heavy air to drain downslope as a gravity or drainage wind. Under clear night skies and with light general winds, conditions favourable for the cooling of surface air, the cool mountain breeze which descends from exposed ridges or plateaus develops during the night from a light breeze only 200 or 300 ft. deep in the bottom of the drainage valley early in the evening, to a moderate wind of 12 or 15 knots, which by morning extends with decreasing velocity to the top of the drainage valley, perhaps several thousand feet deep. After sunrise insolational heating of the valley walls and upland slopes rapidly reverses the mountain breeze, thereby establishing the valley breeze.

The strongest drainage winds descend from extensive glaciers or glaciated plateaus in winter, and they may reach destructive violence. Great masses of air which have been cooled to extremely low temperatures are set in motion by a suitable pressure gradient, and cascade downward from the edge of the plateau through suitable drainage channels. This phenomenon is best developed in fjords, river valleys, canyons or passes which cut deep into glaciated plateaus. Particularly noted for such violent cold drainage winds are the fjords of Alaska (where the squalls are called williwaws), Greenland and Norway; the edges of the Antarctic ice

plateau; the Rhône valley of southern France (mistral); the northern Adriatic sea (bora); and the Columbia river gorge of Washington-Oregon.

Drainage winds are heated more or less adiabatically by their descent and are inevitably quite dry at lower elevations, but they must arrive also much colder than the air which they displace, for it is only their relative coldness that causes their violence. This relative coldness is possible only because of the initial extreme coldness of the descending air. In this respect these winds are the exact opposite of the similarly violent descending foehn wind, which is a forced circulation.

**Local Circulations Produced by Heating.**—For the most part the motions produced by local heating are not as readily observed at the ground as are the drainage winds, for intense surface heating causes instability and vertical convection in the free atmosphere rather than surface winds. An exception to this is the valley breeze, the reverse of the mountain breeze, which by mid-afternoon on a day with strong insolational heating may attain a velocity of 15 to 20 knots up steep rocky slopes at the head of a deep valley. But, except where the terrain slopes steeply upward, intense localized insolational heating produces thermal updrafts which are perceptible only in the free atmosphere. The local updrafts form principally over dry rocky or sand surfaces which are free of vegetation, and over sand dunes or rocky hills.

Dry thermal convection in arid regions, such as deserts, may extend with considerable violence to a height of 10,000 ft. or even more, and be quite imperceptible to the observer on the ground. On the other hand, such vertical columns of rising, heated air not infrequently acquire a spin which makes them visible as dust or sand whirls (*dust devils, sand devils*). The larger of these sand devils, which appear as nearly stationary, thin, vertical columns, are destructively violent vortices within a small radius. In more humid regions the individual convective elements are rendered visible by the cumulus cloud formation at the condensation level, which depends, as explained, on the moisture content of the surface air. If the cumulus formation develops into the cumulo-nimbus shower cloud, the circulation becomes more complex.

When cumulus convection extends into cumulo-nimbus or thundershower cloud, as soon as precipitation begins to fall from the base of the cloud the cooling, by evaporation, of the relatively dry underlying atmosphere rapidly forms an extensive mass of cool air. This cool air mass within the shower sinks and spreads out, thus forming a cool descending branch of the convective shower circulation which is frequently rather violent. It causes the strong squall of cold wind which breaks with the heavy rain in intense, newly formed showers, but which may run far ahead of the rain in older, disintegrating showers. The wind-squall cloud, or typical low roll cloud of the violent thunder squall, is formed between this outrushing cool air mass and the preceding light inflow of warm air that maintains the thunderstorm convection. The sudden drop of temperature, the shift and increase of wind velocity and the rise of atmospheric pressure which accompany the wind squall have all the features of a cold-front passage, so that it may be impossible to decide whether the shower is merely thermal convective or of the cold-front variety until the permanence of the change is noted after the passage of the shower.

Thundershowers of the thermal convective variety in middle latitudes are essentially a summer afternoon phenomenon over land, attaining their maximum frequency in regions that are primarily readily accessible to moist air masses, and secondarily characterized by the rough or mountainous terrain which favours thermal convection. A secondary maximum of thermal convective thunderstorm frequency occurs during the late night hours over extensive warm lakes and coastal waters, where the water surface is relatively warm at night, as well as in certain inland localities where a differential diurnal variation of the wind with height appears to favour nocturnal instability. The most regular occurrence of heavy afternoon convective thunderstorms throughout the year is in the tropics, particularly over tropical islands, which are open to maritime tropical air at all times, and which lie in tropical or intertropical zones of air-mass convergence. Tropical islands which lie in regions of marked anticyclonic divergence and subsistence may be quite arid and barren. In middle and higher latitudes a marked winter maximum of convective shower activity, which rarely reaches thunderstorm intensity, occurs over the relatively warm ocean areas which are accessible to cold air masses.

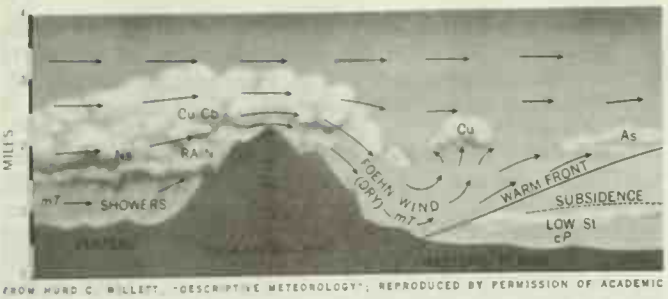
**Local Circulations Produced by Adjacent Heating and Cooling.**—Land and sea breezes are the most obvious and simple of the circulations produced by simultaneous adjacent local heating and cooling. The sea breeze blows from cold water to heated land with maximum strength at mid-afternoon in late spring and summer, and is noted wherever it occurs for its marked cooling action. The land breeze blows from cold land to warm water, with maximum strength during the early morning hours in late autumn and winter, but is rarely notable.

On a favourable day with light winds, the sea breeze usually starts along the immediate coast as a light breeze only a few hundred feet deep blowing directly onshore. It may have a cold-front character. Overhead a light offshore wind is to be expected. By mid-afternoon, at its maximum strength, the sea breeze becomes a moderate wind of up to 15 knots, with a vertical depth of perhaps 1,000 ft. and extending some 20 mi. or more inland. By late afternoon or early evening the sea breeze diminishes in intensity and tends to blow more nearly parallel to the shore as the Coriolis force gradually makes its influence felt. During the evening the breeze rapidly disappears, frequently becoming a light land breeze before midnight. The principal significance of the sea breeze is its marked cooling action. In some coastal localities, where particularly cold water lies offshore, the sea breeze on its arrival frequently carries inland coastal fog or low stratus clouds, which are formed over the cold water offshore.

**Lee Waves and Rotors.**—When wind blows across a ridge or a mountain barrier, the air stream is disturbed in a manner depending on the thermal structure and the variation of wind with height. The normal static stability of the air makes it spring-like, and the ridge can set the spring into vibration, producing a set of lee waves which are generally a few miles in length. The production of such a train of waves is favoured if the air is more stable at lower than at higher levels, and if the wind stream is uniform in direction and increases with height. An unstable layer near the ground due to solar heating is thus unfavourable to the development of lee waves. The vertical velocity of the air in these waves can be very large, more than 1,000 ft. per minute, so that they may be a serious hazard to aircraft in the downflow. Lenticular clouds may form in the wave crests, and from the heights of these it is often evident that the influence of a mountain may extend to many times its own height. When the lee waves are of large amplitude, a so-called rotor-flow, or large lee-eddy with reversed flow, may set in on the downwind side of the mountain range, beneath the lee waves, with very great turbulence. Rotors may also occur in the air aloft and downwind of the mountain (*see* MOUNTAIN METEOROLOGY).

**The Foehn (Chinook) Wind.**—The foehn (föhn) wind is essentially a large-scale turbulence phenomenon. When a strong wind aloft blows across a major mountain range and is deflected downward in the lee of the mountains, the air reaches the lower elevations as an extremely warm, dry, gusty wind, which blows erratically because of turbulent action. The most extreme foehn effects are felt on the inland side of major mountain ranges, when warm maritime air blowing inland forcibly displaces cold continental air in the lee of the mountains. Under these conditions an oscillating quasi-stationary warm front is maintained dynamically in the lee of the mountains, the temperature changing by as much as 50° F. (26° C.) at the sharp boundary between the warm and cold air mass. The development of heavy orographic precipitation on the windward side of the mountains may add considerable latent heat to the warm current, but the condensation forms are dissipated completely in the descending foehn wind. The warmth and dryness of a strong foehn, the chinook (*q.v.*), east of the continental divide in North America are such that this wind may melt and evaporate as much as two feet of snow in 24 hours.

Fig. 9 represents schematically the circulation and the condensation forms that are typical of a strong foehn wind development




FROM HURD C. WILLETT, "DESCRIPTIVE METEOROLOGY"; REPRODUCED BY PERMISSION OF ACADEMIC PRESS

FIG. 9.—FOEHN WIND CIRCULATION WITH CONDENSATION FORMS

on the eastern slope of the Rocky mountains between warm maritime tropical air from the west coast and cold continental polar air in the interior of the North American continent. This region is noted for some of the most extreme foehn wind contrasts in the world, but conditions only slightly less extreme in character are observed north of the Alps in western Europe, north of the Himalayas in central Asia, east of the Andes in the southern portion of South America and in many other regions. The foehn wind is always a warm wind whose descent is dynamically forced, in contrast with the cold, gusty, drainage winds whose descent is gravitational (*see* MOUNTAIN METEOROLOGY).

**Orographic and Frontal Showers and Thunderstorms.**—A thermal convective shower or thunderstorm involves the presence of instability from the ground upward, owing to surface heating or to an otherwise warm surface, so that air rises spontaneously from the surface in convective columns to the condensation level, above which conditional instability only is necessary (see *Lapse Rate and Vertical Stability*, above). Showers may, however, occur in air which is stable below if there is some mechanism for lifting the air to the condensation level, and if the air above the condensation level is conditionally unstable. Such forced lifting may be orographic, and it occurs also where there is surface convergence of the air, as at active fronts.

In the tropics the great majority of the showers and thunderstorms are thermally convective or orographic in character, but in middle and higher latitudes probably half of the summer thunderstorms are frontal, while nearly all of the winter storms are. The warm-front type of thundershower is distinctive in character, in that, unlike most other thunderstorms, it is restricted entirely to the upper levels of the atmosphere, being "shielded" from the ground by the passive layer of cold air beneath the warm front. Thus, while the thunderstorm is in progress aloft, the weather at the ground may be foggy and cold, in winter even freezing, conditions which are not ordinarily associated with thunderstorm activity.

Cold-front thundershowers, which accompany nearly every active cold front in summer and occur not infrequently in middle latitudes also in winter, are very similar to the thermal convective thundershowers, in that they usually build up from the ground ahead of the cold front. The thunderstorm often breaks with the frontal passage in a manner which is very similar to that of the breaking of the wind squall of an intense thermal convective storm. The occurrence of cold-front thunderstorms is markedly favoured by the advance of a cold front upslope against a mountain range, while conditions are relatively unfavourable on the lee side of the range.

Occasionally an overrunning form of cold front develops, which is of special significance for the occurrence of frontal convective squalls. In this case it may happen that the rapidly moving cold air above the surface frictional layer overrides the warm air by some distance; *i.e.*, the cold front advances more rapidly aloft than at the ground. If the air-mass stratification produced in this way is very unstable, then convective overturning takes place in a line along the front, just in advance of the position of the front at the ground. This condition is evidenced by a rapidly moving narrow line of violent convective squalls, the so-called *line squall*.

Again, in North America and elsewhere, the inflow of moist tropical air at the surface or aloft is frequently accompanied by a pattern of horizontal convergence which, in the warmer part of the year, is favourable for the development of huge masses of thunderstorms covering an elongated area extending for perhaps 200 mi. in its greatest dimension. These massive convective disturbances may or may not have a recognizable relation to fronts. The copious rain, outflowing cold air and brief wind storms which accompany them as they move along with the upper winds produce the violent weather change of the squall line. American tornadoes are usually associated with disturbances of this type. Detailed charting of their histories shows that they may develop from single thunderstorms.

**Tornadoes.**—When cold air flows in above warm air a zone of marked convective instability and of extremely sharp vertical wind shear is produced. Tornadoes are then often formed by vertical convection of warm moist air from the ground through the layer of wind shear. The vortex established by such convection is very intense and extremely destructive, but usually less than ½ mi. in diameter near the ground. When favourable conditions are established in this manner, a number of tornadoes are likely to occur. They usually move at moderate speeds from southwest to northeast. One tornado may last from a few minutes to an hour or more, leaving a path of intermittent destruction of a few hundred yards up to 40 or 50 mi. in length as the vortex repeatedly dips down to the ground and withdraws from the surface. *Waterspouts* are a similar but generally less intense phenomenon over the sea.

*See* also references under "Meteorology" in the Index.

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**METEOROLOGY, SOCIETIES OF.** The first meteorological society was the Societas Meteorologica Palatina in Mannheim, Ger. (1780–92), which published the *Ephemerides* (1781–92). Next to be organized was the Meteorological Society of London (1823–43). Contemporary societies are listed below.

The Royal Meteorological society, London, was founded in 1850 and known as the British Meteorological society until 1871; it publishes the *Quarterly Journal* (1873 *et seq.*) and *Weather* (1946 *et seq.*). The Scottish Meteorological society (founded 1855) was incorporated with the Royal Meteorological society in 1921. Société Météorologique de France, Paris (1852), publishes *La Météorologie* (1926 *et seq.*) and *Journal Scientifique de la Météorologie* (1949 *et seq.*). The American Meteorological Society, Boston (1919), publishes the *Bulletin* (1920 *et seq.*), *Journal of the Atmospheric Sciences* (1962 *et seq.*, in continuation of the *Journal of Meteorology* [1944–61]), *Meteorological Monographs* (1947 *et seq.*), *Weatherwise* (1948 *et seq.*), *Meteorological and Geoastrophysical Abstracts*, formerly *Meteorological Abstracts*

*and Bibliography* (1950 *et seq.*) and *Journal of Applied Meteorology* (1962 *et seq.*). The Meteorological Society of Japan, Tokyo (1882), publishes the *Journal* (1923 *et seq.*). Meteorological Society of China, Nanking (1924), published the *Meteorological Magazine* (1925 *et seq.*). Deutsche Meteorologische Gesellschaft, Berlin (1883), publishes *Meteorologische Rundschau* (1947 *et seq.*). Österreichische Gesellschaft für Meteorologie, Vienna (1865), publishes *Wetter und Leben* (1948 *et seq.*). Magyar Meteorológiai Társaság, Budapest (1925), publishes *Időjárás* (1897 *et seq.*). Polskie Towarzystwo Meteorologiczne i Hydrologiczne, Warsaw (1947), publishes *Przegląd Geofizyczny*, formerly *Przegląd Meteorologiczny i Hydrologiczny* (1948 *et seq.*). Société Belge d'Astronomie, de Météorologie et de Physique du Globe, Brussels (1895), publishes *Ciel et Terre* (1880 *et seq.*). Others are: Vereiniging voor Sterrenkunde, Meteorologie, etc., Antwerp (1944); Società Italiana di Geofisica e Meteorologia, Genoa (1953), successor to the Società Meteorologica Italiana (1859–1944), which publishes *Geofisica e Meteorologia* (1953); Sociedad Meteorológica, Montevideo, Uruguay (1950); Indian Meteorological Society (1957); and International Society of Bioclimatology and Biometeorology (1957), which publishes the *International Journal of Bioclimatology and Biometeorology*.

Some of the above societies, such as the British, U.S. or German, have highly active local or overseas branches.

In many countries geophysical or geographical societies embrace the fields of meteorology and climatology, as the American Geophysical union, U.S. (publishes *Transactions* [1920 *et seq.*]); Vsesoiuznoe Geograficheskoe Obshchestvo, U.S.S.R. (*Izvestiia* [1940 *et seq.*]); Geofysiska Föreningen, Sweden (*Tellus* [1949 *et seq.*]); Geofysiikan Seura, Finland (*Geophysica* [1935 *et seq.*]), and others.

There are two international organizations having somewhat different purposes. The World Meteorological organization (1951), formerly the International Meteorological organization (1878–1951), is an association of meteorological services of the world under the United Nations. Its functions are largely administrative but it publishes various manuals and the quarterly *Bulletin* (1952 *et seq.*) from its headquarters in Geneva, Switz. The International Association of Meteorology and Atmospheric Physics is one of several associations forming the International Union of Geodesy and Geophysics (an organization created at Brussels, Belg., in 1919). It publishes proceedings of its general assemblies and triennial reports. (K. C. S.)

**METHANE** (MARSH GAS) is a colourless, odourless gas occurring abundantly in nature as the chief component of natural gas, as a constituent of firedamp in coal mines and as a product of the anaerobic bacterial decomposition of vegetable matter under water (hence its alternative name, marsh gas). Methane is also produced industrially by the destructive distillation of bituminous coal in the manufacture of coal gas and coke-oven gas. The activated-sludge process of sewage disposal produces a gas which is also rich in methane.

Methane is the first and simplest member of the paraffin hydrocarbons, having the chemical formula $CH_4$. It is lighter than air, and has a specific gravity of 0.554 in relation to air. It is only slightly soluble in water, but much more soluble in ethyl alcohol and ethyl ether. Methane burns readily in air, forming carbon dioxide and water vapour. The flame is pale, slightly luminous and very hot. Methane is, in general, a very stable material. However, a mixture of methane and air, with the methane content between 5.3% and 13.9% by volume, is highly explosive. Such explosions have been a frequent occurrence in coal mines and collieries.

Although there are a number of well-known methods of preparing methane in the laboratory, such methods are of only academic interest. In most parts of the world, methane is readily available commercially in steel cylinders under pressure. Its chief source is natural gas, which, after extraction of natural gasoline, contains from 75% to 95% methane depending on the source. It is easily separated from other hydrocarbons by special processes. One method, already mentioned, of producing methane commercially from bituminous coal employs destructive distillation. A newer method is coal carbonization, which gives yields of 25%–30% methane. These methods of manufacture are important in locations where natural gas is not plentiful. The coal carbonization process is particularly important in that it has made the coal industry a part of the petrochemical field. The process also looks toward the future when natural gas sources have become depleted.

Since commercial natural gas is composed largely of methane, their uses may, for all practical purposes, be considered as identical. Because of its abundance, low cost, ease of handling and cleanliness, its chief use has been as a fuel in industrial and commercial establishments and in homes.

In the United States, natural gas is distributed through thousands of miles of pipelines to all parts of the country, and, since World War II, has made great inroads into the fuel market, particularly at the expense of coal.

Another important use is in the manufacture of carbon black (*q.v.*), although this application has been diminishing since 1950 because of the rising price of natural gas. When methane is decomposed at high temperatures in the presence of a limited supply of air, carbon is cracked out. This fluffy product of colloidal fineness is called carbon black, and is used chiefly as a reinforcing pigment to make rubber tough and wear-resistant, qualities particularly important in automobile tires.

Methane also has definite usefulness in the important field of petrochemicals, although it is not so valuable in this field as certain other paraffin hydrocarbons. For example, methane can be made to react with steam at high temperatures (800°–1,000° C.) in the presence of catalysts to form hydrogen and carbon monoxide; the latter then reacts with additional steam to form more hydrogen and carbon dioxide. This process is useful as a source of industrial hydrogen in the manufacture of ammonia, which in turn is used to produce fertilizer and explosives. Other valuable products obtained from methane are methanol and formaldehyde, both of which are produced in an oxidation process. Methanol is used as an antifreeze and formaldehyde as an organic intermediate. Successive chlorination of methane leads to methyl chloride, methylene chloride, chloroform and finally carbon tetrachloride. By nitration, nitromethane is formed; this material is a solvent, a refrigerant and a basis for the synthesis of other petrochemicals. *See* also references under "Methane" in the Index. (R. K. E.)

**METHODISM** is a descriptive term applied to a large family of churches in Great Britain, the United States and, through migration and missionary expansion, many other areas of the world. All have developed from a movement which began in the Church of England with the evangelistic work of John and Charles Wesley and George Whitefield in the 18th century. (*See* WESLEY [Family]; WESLEY, JOHN; WHITEFIELD, GEORGE.) It is represented in Great Britain chiefly by The Methodist Church (about 1,000,000 members); in the United States by The Methodist Church (nearly 10,000,000 members), three large Negro Methodist churches (about 2,500,000 members) and a few small denominations; in various regions of the British commonwealth and on the continent of Europe by autonomous Methodist churches; and on all continents by extensive mission churches. These are all brought into co-operative association in the World Methodist conference, which elects a World Methodist council and represents over 18,000,000 members. Unofficial membership or constituency includes more than 40,000,000 persons. All the larger Methodist bodies are charter members of the World Council of Churches. Former Methodist churches also have shared significantly in interdenominational unions, notably the United Church of Canada and the Church of South India. In general, Methodism stands in the English Protestant tradition, strongly influenced by Reformed theology in its modified Arminian form (*see* ARMINIANISM).

## ORIGINS AND EARLY HISTORY

**The Wesleys.**—The beginnings of Methodism lie in the evangelical conversion of the two brothers John and Charles Wesley in May 1738. This happened as a result of many causes. First was the powerful influence of home life in the Anglican manse at Epworth. Education at Oxford university also brought the dis-

cipline of the "Holy club," in which the Wesleys and Whitefield sought to live the Christian life through methodical study and devotion. These habits led to the nickname "Methodists," sometimes used in derision. Sobering experiences in the state of Georgia further prepared the way for a profound evangelical experience. The meeting of a little society in Aldersgate street, London, in the evening of May 24, 1738, during which John Wesley's "heart was strangely warmed" as Luther's preface to Romans was being read, is the event observed as Aldersgate Sunday in some Methodist churches. Within six years all the main features of the Wesleyan movement took form, and John Wesley had begun a career of "spreading scriptural holiness throughout the land."

There was no intention originally of founding a separate denomination. Wesley was anxious to uphold the church of his fathers, but he was even more concerned with infusing new life into its being. He and most of his followers accepted the Thirty-nine Articles of Religion and the Book of Common Prayer. When ecclesiastical authorities prevented the Wesleys and their preachers from occupying their pulpits, they continued their work in the open air. Field preaching became an important medium for spreading revival. Preaching houses (later called chapels) were licensed, and local preachers, following their normal occupations during the week, gave much of their leisure to preaching in their own neighbourhoods. Gradually, however, a new order of traveling preacher or itinerant came into being, and eventually a regular, full-time ministry was established.

**Early Organization.**—The Methodists were gathered into "societies," local groups, chiefly Anglicans, who voluntarily accepted the guidance of Wesley and the discipline of the "Rules of the United Societies." Early centres were London, Bristol and Newcastle. The societies met weekly, preferably at an hour not in conflict with the formal worship of the Church of England, for informal preaching, Bible reading and prayer. At regular intervals Wesley visited his societies to inquire after the devotion and regularity of each member. A system of circuits was set up, each composed of several local societies. Tickets for members retained in good standing were renewed quarterly. The only requirement for admission was "a desire to flee from the wrath to come and be saved from their sins." But admission meant the beginning of a lifelong process of training in understanding the Christian faith and growth in holy living.

In order that this goal might be attained, members of societies were organized into smaller units for more intimate Christian fellowship. At first "bands" were composed of a few persons of similar condition in life—widows, bachelors, even "backsliders." Soon, however, these bands were overshadowed by the "class" system, in accordance with which the entire membership were assigned to mixed groups, each led by a lay class leader. These also met weekly, and they became the basis for a remarkable experiment in intimate Christian community. In 1744 Wesley called his preachers together in the first Methodist conference, which continued in annual succession through the 19th and 20th centuries. In Wesley's day the conference was a purely advisory body.

**Relations With the Anglican Church.**—Until the death of the founder (1791) the connection with the Church of England was maintained, with a few significant modifications, unbroken. Neither of the Wesleys ever left the membership or the ministry of the episcopal establishment, and John Wesley made repeated efforts to provide for the ministry of the Methodists within the structure of the Anglican Church. Eventually, after the American Revolution, he had recourse to a principle of which he had been convinced for many years, the efficacy of presbyterial ordination, insofar as he was a presbyter of the Church of England and superintendent of the societies, hence an effective "scriptural bishop." On this basis he ordained ministers for the work in America in 1784 and later for special service in Scotland and England.

For long Methodists were suspected and feared by Anglicans, and charges were circulated that they were secret Stuart supporters or Jesuits. Mob violence and prejudice appeared sporadically in the early years. In particular Methodists were threatened with prosecution under the church code of the 17th-century Restoration. Methodists insisted that they were loyal Anglicans, and only dissenters from the establishment had been exempted by the Act of Toleration (1689). On the other hand a small number of sympathetic Anglican ministers continued to encourage and support the societies. As opposition declined the membership increased to 56,195 in 1789. But the ordinations and unlicensed preaching rendered inevitable, after the death of Wesley, a progressive process of separation leading to the formal organization of the Wesleyan Methodist Church (England) early in the 19th century.

## BRITISH METHODISM

**Wesleyan Methodist Church.**—In 1784, in addition to the ordinations, another critical event occurred. A legal document, the Deed Poll or Deed of Declaration, regularized and perpetuated the constitution of the Methodist societies. A hundred preachers were appointed a body in which was vested authority in matters of discipline, administration and the stationing of preachers. The Legal Hundred elected its own new members to fill vacancies. This formed the core of the annual conference, a representative body composed of ministers only, until 1878, when laymen were admitted. In 1793, after Wesley's death, it was resolved that the societies should have the privilege of the Lord's Supper wherever they unanimously desired it. After prolonged discussion a "plan of pacification" was drawn up and accepted in 1795. This declared that the sacraments, burials and services in church hours were to be conducted by the preachers only when a majority of the trustees, stewards and class leaders of the chapel approved. It was a crucial step on the way from society to church. By 1836 the separation was complete, and Methodist preachers received regular ordination. In 1848 the membership in Great Britain was 338,861, in Ireland 23,842 and in foreign stations 97,451. The total number of ministers was 1,726.

During the first half of the 19th century the dominating figure was Jabez Bunting (*q.v.*), a strong and able leader, conservative in his outlook and criticized by many for what they considered to be the autocratic nature of his administration. Though his critics became steadily more numerous and more bitter, he was four times elected president of the conference, and the church grew and institutions multiplied. In 1834 Hoxton academy was taken as a training place for ministers. Didsbury college was opened in 1842, Richmond in 1843, then Headingley, Hansworth, Hartley Victoria and, in 1925, Wesley house in Cambridge. In 1837 Wesleyan Methodism sponsored 9 children's homes and 22 schools for older children. After the middle of the century a vigorous movement for establishment of day schools was promoted. The church maintains several boarding schools and two teacher-training schools.

A new social emphasis began about 1878, when a thanksgiving fund was raised. Large mission halls were built in the principal cities of England, Scotland and Ireland. The evangelical-social Forward Movement of the 1880s will always be associated with the name of Hugh Price Hughes (*q.v.*), whose influence made it a force to be recognized by the nation as well as the church. The conscience of Methodism was quickened, and social evils such as sweated labour, poverty and squalor were made the concern of Christian people. Hughes became the first superintendent of the West London mission in 1887 and made plain the pattern of an evangelism that was concerned with the well-being of the whole man. Village Methodism shared in the quickening also. The Twentieth Century fund was initiated by Sir Robert Perks in 1898. The Royal aquarium at Westminster was purchased and a central hall and church house were erected as the headquarters of Methodism. The National Children's Home and Orphanage system is Methodist supported.

In Wales John Wesley had co-operated with George Whitefield and Howel Harris in the evangelical revival. Although Wesley differed with them on theological grounds, for a long time they worked together. But most of the early Welsh Methodists joined the Calvinistic body that became known as the Presbyterian Church of Wales (*see* CALVINISTIC METHODISM). A minority remained true to the Arminian position of Wesley and the Welsh Methodist assembly, closely related to the British conference, became the administrator of Welsh affairs.

In Scotland Methodism has only a small membership, though in

a few places strong Methodist churches continue.

Irish Methodism, established by the Wesleys in the face of fierce opposition, has always been active, especially in support of missionary enterprise, and has maintained a strong minority status. It has its own conference but appoints delegates to the British conference.

**Divisions.**—In the course of development a number of schisms arose within the main stream of British Methodism. This was owing in part to the tradition of strict authority as exercised by Wesley and Jabez Bunting; doctrine did not play a major role in these divisions. The first schism was led by Alexander Kilham (*q.v.*), who, advocating free election of class leaders, democratic rule in societies and separation from the Church of England, was expelled by the conference of 1796. He founded the Methodist New Connexion with 5,000 followers. From this group in the later 19th century came William Booth to found the Salvation Army (*q.v.*).

One of the most serious breaks occurred in 1811 with the formation of the Primitive Methodist Church, led by Hugh Bourne (1772–1852) and William Clowes (1780–1851). Bourne was a millwright who joined a Methodist society and settled in the colliery district of Harrisehead and Kidsgrove. There he was so impressed by the prevailing ignorance and debasement that he began a religious revival, with open-air preaching accompanied by prayer and singing. One result was the conversion (Jan. 1805) of William Clowes of Burslem, who forthwith joined in leadership of the revival. Lorenzo Dow of the United States introduced the camp-meeting idea (*see* CAMP MEETING), and the first such meeting was held (1807) at Mow Cop. But the camp-meeting method became incompatible with conservative Methodism, and in May 1811 the Camp-Meeting Methodists and the Clowesites, both their leaders having previously been expelled from the main body, merged to form the Primitive Methodist Church (or "Connexion"). The period 1811–43 was a time of rapid expansion, in spite of opposition and occasional mob violence. In the next decade the Primitive Methodist movement crystallized into a denomination, with headquarters in London and growing concern for witness in the cities. In 1860 there were 675 ministers, 11,384 local preachers, 132,114 members and growing centres in Australasia and the United States. Introduced in the latter country in 1829, it developed three conferences, with about 12,000 members. In Canada about 8,000 members merged in 1884 in the United Methodist Church of the dominion. In England the Primitive Methodist denomination, becoming a "church" in 1902, continued to grow and develop a number of institutions, including Hartley Victoria college, Manchester, until 1932, when its 222,021 members joined the Wesleyan and United Methodists in the new Methodist Church.

Concern over alleged decline in evangelistic fervour led to other divisions. A remarkable evangelist, William O'Bryan (*q.v.*), led a series of campaigns in the west of England. His followers became known as the Bible Christian Church. Their roots were in Methodism and their separation was not by way of rebellion so much as an attempt to concentrate on evangelism in the idiom that attracted the people of the west country. Various new groupings emerged, among them the Wesleyan Reformers, the Protestant Methodists and the Wesleyan Methodist association. In 1857 the Wesleyan Reformers and the Wesleyan Methodist association joined to form what was then called the United Methodist Free Churches.

**Movements Toward Methodist Union.**—During the second half of the 19th century the trend toward more democratic church government and the determination to apply the principles of Christianity to social problems lessened the differences between the various sections in Methodism. In 1907 the United Methodist Free Churches, the Bible Christians and the Methodist New Connexion combined to form the United Methodist Church. Finally in 1932 the larger union was effected when the Wesleyan Methodists, the Primitive Methodists and the United Methodists were consolidated and The Methodist Church, with a membership of 800,000 was legally constituted by an act of union. After a century and a half of division Methodism in Great Britain, with the exception of some small bodies, was united.

**Expansion Overseas.**—The growth of Methodism in Canada was closely associated with Methodist movements in the colonies, though the early leaders (*e.g.*, William Black, Jr.) came directly from England. With the formation of the United States, English and American preachers worked together in Canada, and the Canadian circuits were linked with conferences in the United States. By 1800, however, Canadian Methodists had turned to the British conference. A conference was organized for Upper Canada in 1834. Several branches of Canadian Methodism came into existence, which in 1874 were united in the Methodist Church of Canada. Fifty years later a larger union was effected when, in 1925, Canadian Methodists and Congregationalists combined with approximately 70% of Canadian Presbyterians to form the United Church of Canada.

Methodism in Australia began with the formation of class meetings by Thomas Bowden, a London Methodist living in Sydney. Adapting its procedure to local conditions, the Methodist Church grew quickly, its first conference organization being held in 1855. In New Zealand missionaries to the Maori in 1822 began work which spread among the English and Scottish settlers with considerable success. The most spectacular enterprise was the conversion, within a single generation from 1835, of the people of Fiji and the Friendly Islands, who remain in great majority Methodists.

Methodism in the West Indies is associated with the name of Thomas Coke (*q.v.*), the father of Methodist overseas missions, who helped found the Methodist Church at Antigua in 1786 and visited America nine times on ecclesiastical business. It was his great desire to take the Methodist witness to the far east, but he died at sea on his way to Ceylon in 1814, a year after the Wesleyan Methodist Missionary society had been formed. His companions established the work in Ceylon, whence it spread to India. The creation of the Church of South India in 1947, uniting Anglicans and Free churchmen, was an achievement in which British Methodists played a notable part.

Sierra Leone was the scene of the first Methodist work in west Africa; a missionary and three schoolteachers arrived in 1811. For many years it exerted a powerful influence in Nigeria, the Gold Coast and French West Africa, and it continued vigorous in the African states that were created in mid-20th century. In South Africa the increasing number of white settlers was a challenge to the Methodists, who had begun mission work there in 1806. The work developed quickly over a wide area, and in 1882 a South African Methodist conference was created to administer affairs south of Rhodesia. Increasingly the Methodist Church has come into conflict with the official position of the South African government on treatment of Africans.

Work in Burma began in 1887 and, through the pioneering efforts of George Piercy, in Canton and Hong Kong. The Wesleyan Missionary society sponsored these efforts, while the United Methodist Church established stations in north and south China. The victory of the Communist People's Republic in the years after World War II brought universal hardship to Methodist, as to all Christian, missions in China.

**Polity and Worship.**—The highest authority in British Methodism is the annual conference, the lineal descendant of the conferences called by Wesley. It is composed of ministers and an equal number of laymen, the number of each varying from time to time around 330. Ministers meet separately in ministerial session to give consideration to matters pertaining exclusively to the ministry. The presiding officer of conference is the president, a minister elected annually, assisted by a lay vice-president.

The organizational structure is based on geographical districts, administered by chairmen appointed by conference; and circuits, which are groups of societies or churches united in a quarterly meeting and served by superintendent ministers appointed by conference. At the base is the "society," the term used by Wesley and ever since, signifying now a local church.

Ministers are ordained in presbyterial form and are members of the conference in full connection. Methodist ordination is inextricably tied in with the decision of John Wesley in 1784, acting as a presbyter of the Church of England and a "scriptural bishop" in his administration of the societies, to ordain preachers for the work

in America. He always made a clear distinction between the preaching office and the priestly office of the ministry, reserving the administration of the sacraments to ministers properly ordained. Proper ordination he came to interpret in terms of his act of laying hands, with other presbyters, on men being set apart for the ministry in America. This act bears more directly on the ministry in America, but both lines of Methodist ministry are involved. In England a large number of unordained lay preachers supplement the work of the ordained ministers.

Forms of worship follow in general the practice of the Free church tradition with emphasis on the reading of the Word, hymns and prayer, and the proclamation of the gospel in sermons. But the Anglican tradition is seen in the form of set prayers and especially in the rituals for baptism and the Lord's Supper and in other ceremonies. The 20th-century trend, common to most Protestant churches, toward greater emphasis on doctrine and forms of worship, is seen also in Methodism.

**Doctrine.**—The doctrinal standards of Methodism are rooted firmly in the sermons and biblical notes of John Wesley and the hymns of Charles Wesley. In British Methodism John Wesley's 44 sermons and *Notes on the New Testament* (1754) constitute an official doctrinal standard for Methodist ministers. Methodism has been known for its doctrinal tolerance, a matter that Wesley emphasized: "In opinions that do not strike at the root of Christianity, we Methodists think and let think." Having made the point, however, he went on to make clear the importance of those basic doctrines.

Christian doctrine in Methodism may be considered on three levels. At the base are the indispensable beliefs of catholic Christianity in all ages: the Trinity, the person of Christ and the atonement. Hence the Apostles' Creed is accepted as a suitable if not complete affirmation of faith; the Nicene Creed has received more acceptance among Methodists in England than in America. At the second level are the central emphases of the Protestant Reformation, which played so large a part in the spiritual journey of the Wesleys. Justification by faith, the centrality of Christ and the authority of the Word of God in Scripture all find strong affirmation. The potential of the Reformation teaching of the priesthood of all believers has found actual expression in the concept of the ministry inherent in society, class, band and lay preacher. Considerable difference of opinion exists as to the relative influence of the major Reformers.

The third level covers those doctrines most particularly Methodist in emphasis. Although Wesley did not formally specify these, they all pertain to various stages of salvation and thus spring from the atonement. Undergirding all is that universal work in all men, prevenient grace—a free gift of God to all men (which they may accept or reject), that makes it possible for them to turn to him. This doctrine Wesley saw as relieving the perennial tension between the sovereign divine initiative and the free response of men, and it was on the basis of this that he attacked predestinarian Calvinism. The work of the Holy Spirit in justification is interpreted through the experience of conversion, which, as Wesley warned, must admit the "irreconcilable variability" of the operation of the Spirit. The strong doctrine of original sin which underlay Wesley's teaching has not always been maintained with vigour. In receiving forgiveness in justification the Christian may also be assured of it through the witness of the Spirit. As the work of justification brings the gift of faith and trust in God, so the work of sanctification leads on to Christian perfection. This doctrine of perfect love or Christian perfection is the culmination of the plan of salvation which begins with cleansing grace in baptism and continues through the convincing grace that brings to repentance; justifying grace through faith to regeneration; to sanctifying grace, whereby the work of God is perfected in men. All is the work of God. Wesley made perfection relative to that which is possible in a fallen world and to the limitations inherent in earthen vessels. Christian perfection in that sense is always imperfect, in contrast to the absolute perfection of God's love in Christ. Although this doctrine receded in importance generally in Methodism (which led its proponents to start several schisms), it has never been lost and in mid-20th century receives renewed attention.

Many modern Methodists have reinterpreted the historic affirmations in the direction of liberalism. But the strongest trend has been toward a recovery of the doctrinal heritage. This trend has risen in part as a result of participation in ecumenical discussions.

**Ecumenical Relations.**—The theological emphases of Methodism, as well as the principles of church order, although they contain special elements which may be regarded as the peculiar heritage of the people called Methodists, are cast in the frame of catholic and Reformed Christianity. This is the basis on which Wesley in a sermon and his followers generally proclaim the "catholic spirit." The connection historically is especially close to the Episcopalian communion and therefore is especially tense at this point. In the ecumenical movement (*q.v.*) Wesley's followers are particularly free to enter into communion with Christians with whom they may be united in love although divided in teaching and order. The spiritual kin of Methodists are found in catholic churches of ancient tradition, Protestant churches of the Reformation and Free churches led by the Holy Spirit. In 1964 discussions between Anglicans and British Methodists, directed toward eventual organic union, were actively progressing.

## UNITED STATES

Although organizations similar to Methodist societies were started in America as a result of Whitefield's visits as early as 1740, Methodism was not effectively introduced until a quarter-century later, by local preacher immigrants and without the knowledge of John Wesley. Robert Strawbridge (d. 1781) settled in Maryland about 1760 and Philip Embury (*q.v.*) went to New York about the same time. Both were Methodists from Ireland. Embury began preaching in 1766, but the priority of New York is disputed owing to uncertainty about the career of Strawbridge. Capt. Thomas Webb, a British soldier and lay preacher sent to New York in 1766, immediately became active in helping to organize societies. Wesley, informed of these happenings, sent two of his English preachers in 1769, and two others in 1771, one of these being Francis Asbury (*q.v.*). In 1773 Wesley appointed Thomas Rankin (*c.* 1738–1810) to superintend the growing work, and under his direction the first American Methodist conference convened in Philadelphia in June of that year. The return to England, soon after the beginning of the Revolutionary War, of all the active English preachers appointed by Wesley except Asbury gave opportunity for an able group of native preachers to assume leadership under Asbury's direction.

In its early years the Methodist movement was largely confined to Delaware, Maryland and Virginia, where Anglicanism was strongest and where the movement was greatly aided by Devereux Jarratt (*q.v.*), an evangelical Anglican clergyman. Because so few Anglican clergymen would co-operate with the Methodists, thereby depriving them of the sacraments, a movement was begun in 1779 among the Virginia preachers to withdraw from all connection with the Anglicans and form a new ecclesiastical body. Asbury and the other preachers north of Virginia opposed this independent movement and fortunately were able to persuade their Virginia brethren to suspend their administration of the sacraments until Wesley could be heard from, thus avoiding a division among American Methodists. During the Revolutionary War the number of Methodists increased from 4,921 (1776) to 14,988 (1784) and the number of preachers from 24 to 83. Eighty-nine per cent of the Methodist membership was south of the Mason and Dixon line.

**Organization of the Methodist Episcopal Church.**—The winning of independence brought with it the need to form the American Methodists into an independent body. This was accomplished by Wesley's appointment and consecration of Thomas Coke, already in Anglican orders, to go to America in 1784 as "superintendent," bringing with him Wesley's instructions and plans. On Coke's arrival in America with two other ministers ordained by Wesley, Asbury informed him that the American preachers must be summoned in a conference to pass on all matters pertaining to the new church, since independence had made them unwilling to accept even Wesley's dictation in regard to American affairs.

This "Christmas conference" convened in Baltimore, Md., on Dec. 24, 1784. There the Methodist Episcopal Church was or-

ganized. Asbury and Coke were chosen joint superintendents (later assuming the title of bishop). A discipline was adopted and also a Sunday service, prepared by Wesley, abbreviated from the Book of Common Prayer of the Church of England, together with Twenty-five Articles of Religion likewise abbreviated from the Thirty-nine Articles. As the church expanded, the process began in 1796 of subdividing the country into separate annual conferences, at first 6, later 102. In 1792 a general conference was formed, meeting every four years, as the lawmaking body of the church. This in 1808 became a delegated body.

**Divisions.**—Though there were a number of schisms in American Methodism, they were not caused primarily by doctrinal differences. The first, that of James O'Kelly, arose in 1792, over the question of democracy in church order, especially the appointing power of the bishop, and resulted in the withdrawal of O'Kelly and a number of other preachers with several thousand members who took the name of Republican Methodists. Most of them merged with others to form the Christian Church (General Convention, in 1931 united with the Congregationalists) or separated to join the movement led by Barton W. Stone, which became the Disciples of Christ.

A more serious division occurred in 1830. Starting as a movement to restrict the power of the bishops, the reformers advocated a wider democracy in the administration of the church. After the general conference of 1828 had rejected all their petitions, they began to withdraw, and in 1830 the Methodist Protestant Church was formed in Baltimore as a nonepiscopal church with equal lay and clerical representation in its governing body. Strongest in Maryland, Pennsylvania and adjoining states, the Methodist Protestants within four years had 14 annual conferences and 26,587 members. Many of the reforms they advocated were later incorporated in the Episcopal Methodist bodies.

The roots of the great division over slavery go back to the conference of 1784, which outlawed slavery in the Methodist Episcopal Church. Because of laws against the freeing of slaves in slave states, however, it soon became necessary to modify the antislavery position of the church. The abolition movement in the north found numerous adherents among New England and New York Methodists particularly, and their denunciation of slavery as a sin aroused increasing resentment among southern Methodists. In the general conferences of 1836 and 1840 the moderates of the north, combining with the southern delegates, outvoted the abolitionists by a large majority and imposed a gag rule on the church, prohibiting discussion of slavery in all Methodist conferences. This action led to the withdrawal of the most extreme abolitionist wing, under the leadership of Orange Scott (1800–47), LeRoy Sunderland (1802–85) and L. C. Matlack (1816–83), and the formation of the Wesleyan Methodist Church (Connection) of America in 1843. Centring principally in New England, New York and Michigan, it had about 20,000 members in 1845 and about 45,000 in the 1960s. It is to be clearly distinguished from the Wesleyan Methodist Church in England. This secession brought about a shift among the moderates of the north when they saw that in their attempt to avoid a proslavery secession they had precipitated an antislavery division.

The most serious division over slavery came as a result of the action taken by the general conference of 1844. The issue was brought to a head by the marriage of Bishop James O. Andrew to a slaveholding wife under state laws (Georgia) prohibiting manumission. After 11 days of debate a motion to suspend Bishop Andrew was passed by a substantial majority. A few days later a plan of separation was adopted by an almost unanimous vote. In Louisville, Ky., in May 1845, the Methodist Episcopal Church, South, was organized. Its first general conference met in Petersburg, Va., in May 1846. The doctrine, polity and discipline of the southern church were identical with those of the Methodist Episcopal Church, even retaining the same rule on slavery. The southern church began with a membership of 460,000, of whom 124,961 were Negroes and 2,972 Indians.

A small schism was that of the Free Methodists, who broke from the Genesee conference about 1850 charging that American Methodists had departed from the true Wesleyan heritage. There is also an American branch of the English Primitive Methodists.

**Negro Methodists.**—Before emancipation there were no independent Negro churches in the south, since Negroes were compelled to worship under white supervision. In 1860 the Methodist Episcopal Church, South had 207,766 Negro members. In the north two independent Negro churches had been formed before the Civil War, the African Methodist Episcopal (1816), which rose from the Bethel society in Philadelphia under the leadership of Richard Allen; and the African Methodist Episcopal Zion (1821), from the Zion society in New York. Both arose out of friction between white and Negro members attending the same churches. Neither had any members in the south previous to the Civil War, but with the war's end both entered the south and began a successful campaign for the winning of southern Negroes. Between 1866 and 1876 the African Methodists increased from 70,000 to 391,044, while the Zion Methodists grew from 42,000 in 1866 to 164,000 in 1868. A third large Negro Methodist church arose in the Reconstruction years made up of the Negro members of the Methodist Episcopal Church, South, which took the name Colored Methodist Episcopal Church and was renamed at the general conference of 1954 the Christian Methodist Episcopal Church.

**Movements Toward Union.**—The first step toward healing the major Methodist division, that between the north and the south, took place in 1870, when northern Methodist delegates were received by the general conference of the southern Methodists. Real progress in understanding was made at a conference attended by bishops of both branches held in 1876 at Cape May, N.J. Especially encouraging was the general agreement that both branches were valid descendants of the same Methodist ancestry. In fact, the Cape May conference was at least a generation ahead of Methodist leadership generally and the process of reunification was arduous and beset with disappointments. In 1905 a joint hymnal and order of worship were adopted by the two Episcopal Methodist bodies. Between 1906 and 1925 a movement for merging the Methodist Protestants and the two Episcopal Methodisms went forward slowly. The first plan of union voted upon, that between the northern and southern branches in the mid-1920s, was adopted by the Methodist Episcopal Church but failed to receive the necessary majority in the Church, South. The large Negro membership in the northern church was the principal stumbling block in gaining sufficient support among the southern Methodists.

In the 1930s a new plan of union, comprising the two Episcopal Methodisms and the Methodist Protestants, received the necessary support in all three churches. To this union the Methodist Protestants brought almost 200,000 members. At a Uniting conference held in Kansas City, Mo., in May 1939 The Methodist Church was formed, with a combined membership of nearly 8,000,000.

**Polity and Doctrine.**—The Methodist Church is systematically organized on a geographical plan, the central unit of which is the annual conference. One or more annual conferences comprise an episcopal area, which is simply an administrative unit to which the bishops of the church are assigned. At the general conference of 1960 a limit of 12 years was placed on the term of residence of a bishop in one area. Bishops are elected by the jurisdictional conference, of which five are geographical and a sixth is composed of annual conferences of Negro Methodist churches in the United States (except in New England and the western states, where Negro Methodist churches belong to the regional jurisdictions). The quadrennial general conference is the supreme lawmaking body of American Methodism, operating under a series of restrictive rules which safeguard Methodist foundations in doctrine and order. Ordained "traveling" ministers are members of an annual conference and receive appointment from the resident bishop each year. Equal lay participation and representation are provided for both annual and general conferences. The district superintendent, successor of the presiding elder, looks after the interests of the church in the districts into which annual conferences are divided. The official body of the station or circuit is the quarterly conference; that of the local church is the official board.

In principle the doctrinal foundations of American Methodism are the same as those of British Methodism and are officially stated in the Twenty-five Articles of Religion, Wesley's revision of the

Anglican Thirty-nine Articles. Wesley's sermons and *Notes on the New Testament* do not hold the same official standard for ministers in the United States that they do in England. No formal creedal affirmation of faith is required of members beyond the vows of baptism and membership. Nevertheless, American Methodists stand in the same general doctrinal tradition as that represented by John and Charles Wesley. In the later 19th and early 20th century this position was modified considerably through the influence of prevailing theological liberalism. In mid-20th century a strong trend was manifest toward recovery of the full Methodist heritage, without abandonment of the fruits of liberalism.

Although practices of worship vary considerably according to time and place, they generally follow the forms provided in the *Methodist Hymnal* and *Book of Worship*. The prevailing trend is toward a more formal liturgical worship which at the same time seeks to safeguard the primary purpose of proclamation of the gospel in sermon. The increasing use of the Christian year and the experimental forms of worship authorized by the general conference of 1960 are illustrative.

Various boards and organizations have been established to promote these and other interests. Among them are the Board of Education, Board of Publication, Board of Missions, Board of Economic and Social Relations, and Board of Lay Activities. Very active are the Woman's Division of Christian Service and the Methodist Youth fellowship. The antecedents of many of these go back to organizations formed shortly after the Civil War. Young people's societies started in these years were consolidated in the Epworth league in 1889 in the north and 1890 in the south, the two being united in the Methodist Youth fellowship in 1939. A later lay organization is that of Methodist Men.

**Institutions and Activities.**—The first American Methodist institution of higher learning was Cokesbury college, opened in 1787 but closed as a result of fires in 1795 and 1796. The first permanent school was McKendree college in Lebanon, Ill. (1828). By 1860 Methodists had established 34 colleges in the United States, and at the close of the Civil War both northern and southern churches entered upon a new period of educational expansion. Two Methodist theological seminaries had been opened before the Civil War—one, founded in 1839 and opened in 1841, grew into Boston University School of Theology; and Garrett Theological seminary (1853–55) in Evanston, Ill. In 1851 Northwestern university, also in Evanston, was founded by Methodists (opened 1855). Drew Theological seminary was opened in Madison, N.J., in 1867. In 1869 Boston university was chartered and in 1870 Syracuse university was established in Syracuse, N.Y. In 1872 the southern Methodists founded Vanderbilt university in Nashville, Tenn., and in later years three other universities were established in the south—Emory (Atlanta), Duke (Durham, N.C.) and Southern Methodist (Dallas). By 1960 The Methodist Church had 128 educational institutions affiliated with it, including 9 universities, 12 schools of theology and 70 colleges.

No other U.S. Protestant church developed its publishing interests comparably with the Methodists. The Methodist Publishing house was established in 1789 to supply Christian literature. Methodism pioneered in the publication of weekly periodicals, and in 1841 its oldest weekly paper, the *Christian Advocate and Journal*, which began publication in 1826, had the largest circulation of any weekly journal in the world. In 1841 the Methodist Book concern began publication of the *Ladies Repository and Gatherings of the West*, one of the first women's literary magazines in the U.S. The church in 1818 began the publication of a quarterly, the *Methodist Review* (later *Methodist Quarterly Review*), which appeared to 1941. In 1932 a new review, *Religion in Life*, made its appearance. When division came in 1844, the Church, South, also began publication of a *Quarterly Review*.

During the last quarter of the 19th century U.S. Methodists began the establishment of hospitals and homes for the sick and unfortunate. The first Methodist hospital was opened in Brooklyn, N.Y., in 1881; the first southern Methodist hospital was that at Emory university (1905) in Atlanta, Ga. By 1960 there were 72 Methodist hospitals in the United States, 77 homes for the care of the aged and 48 homes for the care of children. In addition, the Woman's Division of Christian Service owned and operated over 50 institutions, such as business girls' homes, rest homes and hospitals.

An institution started by Methodists, but later interdenominational, which has spread throughout the United States, is the Goodwill Industries, which originated in Boston, Mass., in 1907, as a plan to give unemployed handicapped people a chance to earn a living through repairing discarded clothing, furniture and other items for resale.

**Missions.**—Methodist itinerants from the beginning worked among Negroes and Indians before the formation of the Methodist Missionary society in 1819. The first foreign missionary, Melville B. Cox, went to Liberia in 1833 and a second to South America in 1835. Work was begun in China in 1847.

By 1939, the year of unification in the Methodist Church, the combined churches were maintaining 1,065 missionaries in Asia, 152 in Africa, 225 in South America and 12 in Europe. Methodist church membership in these mission fields was 679,320, including probationers. Besides these missionary churches there were autonomous Methodist churches in Japan (after World War II the Japanese Methodists became part of the United Church of Christ in Japan, with a membership of about 300,000), Korea, Mexico and Brazil.

Although World War II seriously disrupted missionary activity, particularly in the far east, the work was strongly resumed after peace was declared. Opposition by the government of Communist China, however, has made continuation of activity there almost impossible. Work is carried on in over 40 countries by almost 1,500 missionaries and about 16,000 native workers.

The three large Negro Methodist Episcopal churches also carry on missionary enterprises in Africa, the West Indies and northern South America.

American Methodists have been active at all levels in interdenominational and ecumenical enterprises, such as the National Council of Churches, the International Council of Religious Education and the World Council of Churches. In 1964 the Methodists and the Evangelical United Brethren were actively engaged in negotiations directed toward organic union.

*See* also references under "Methodism" in the Index.

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**METHODIUS:** *see* CYRIL AND METHODIUS, SAINTS.

**METHODOLOGY:** *see* SCIENTIFIC METHOD; TEACHING, METHODS OF.

**METHUEN** (originally STEDMAN), **SIR ALGERNON METHUEN MARSHALL** (1856–1924), British publisher and founder of Methuen & Co. Ltd., was born at Southwark on Feb. 23, 1856, his surname being Stedman. While conducting his own school at Godalming, Surrey, he wrote more than 20 educational works in Latin, Greek and French, which he used to form the nucleus of his own publishing house in 1889 under his name Methuen. In 1895 he gave up teaching, formally changing his surname to Methuen in 1899, and in 1910 the firm became a limited liability company. By 1914 it had become one of the largest and most successful of British publishing houses, with such authors as H. G. Wells, Arnold Bennett, Henry James, Stanley Weyman, Conan Doyle, Anthony Hope and Marie Corelli on its list.

Methuen was created a baronet in 1916 and died at Haslemere, Surrey, on Sept. 20, 1924. (J. A. W.)

**METHUEN, JOHN** (1650?–1706), English diplomat who negotiated the agreements with Portugal known as the Methuen treaties. He was the eldest son of a prosperous Wiltshire clothier, sat in parliament as member for Devizes from 1690 until his death and was lord chancellor of Ireland from 1697 to 1703. He was envoy to Portugal from 1691 to 1697 and was sent back there as ambassador in 1702, at the outset of the War of the Spanish Succession, for the purpose of detaching Portugal from France. This object was accomplished by two treaties concluded by Methuen's son Paul in Lisbon on May 16, 1703. The success was followed up when John Methuen returned to Portugal (Sept. 1703) and negotiated the celebrated commercial treaty (Dec. 27, 1703). The agreement provided for the admission of English cloth to Portugal at a low tariff, while Portuguese wines were allowed into England at rates one-third below those charged on French wines. Methuen died in Lisbon on July 2, 1706.

His eldest and only surviving son SIR PAUL METHUEN (1672–1757) was envoy to Portugal from 1697 to 1705, and succeeded his father as ambassador there (1706–08). He sat in parliament successively for Devizes (1708–10) and Brackley, Northamptonshire (1715–47). During 1715 he was appointed ambassador to Spain. He was secretary of state for the southern department from Dec. 1716 to April 1717 and held household offices from 1720 to 1730. He was knighted in 1725. Methuen died on April 11, 1757, and was buried with his father in Westminster abbey.

*See* Sir R. Lodge, "The Treaties of 1703," in *Chapters in Anglo-Portuguese Relations*, ed. by E. Prestage (1935).

**METHUSELAH,** eighth in the list of antediluvian patriarchs in Gen. v, is credited with the longest life, 969 years; he appears in the parallel list in Gen. iv, as Methushael. In each case he is the father of Lamech. Attempts have been made to find etymologies for the name and to equate it with a name in similar Babylonian lists, but all are precarious.

**METHYL ALCOHOL,** also called methanol, carbinol, wood alcohol and wood spirit, occurs throughout the vegetable kingdom in the form of esters, such as methyl salicylate (oil of wintergreen), and as complex ethers in many alkaloids, natural dyes and the lignin portion of wood. Discovered in 1661 by R. Boyle, and studied in greater detail in 1831 by Jean Baptiste Dumas and Eugène Melchior Péligot, its synthesis by M. P. Berthelot from methane through methyl chloride followed in 1858.

Methyl alcohol, $CH_3OH$, the simplest alcohol known, is the first of a long series of aliphatic alcohols. The name methyl (from the Greek words for wine and wood) is descriptive of the original source of commercial methanol. From the time of its discovery until 1930, substantially all methyl alcohol was obtained by the destructive distillation of wood. After 1930, most methanol was produced by synthetic, rather than natural, methods.

Many attempts were made, without success, to commercialize Berthelot's process for producing methyl alcohol from methane via methyl chloride. Paul Sabatier in 1905 stated the possibility of combining carbon monoxide and hydrogen to produce methanol, but he never succeeded in achieving the synthesis. The thermochemical equation $CO + 2H_2 \overset{P}{\rightleftarrows} CH_3OH + 32{,}100$ cal. shows that the forward reaction will be favoured by increased pressure and also by diminished temperatures; this is true, however, only with a suitable catalyst. The reaction was worked out 15 years later by G. Patart, a French chemist, although the Badische company in Germany was the first to develop the process commercially. In the modern method of preparing methanol either natural gas or coal is used to obtain the synthesis gas, a mixture of carbon monoxide and hydrogen, which is caused to react in the presence of a reduced zinc oxide and chromic acid catalyst at a temperature of about 400° C. and a pressure of 200 atm. The methanol synthesis closely resembles the Haber process for making ammonia. Indeed, either product can be made in the same plant by changing the reactants and catalysts and by making minor additions. Synthetic methanol also can be made by the oxidation of hydrocarbons. In contrast with the impure product produced by wood distillation, synthetic methanol is substantially a chemically pure material.

Methyl alcohol is a colourless liquid boiling at 64.5° C. and solidifying at −97.8° C. Its density at 25° C. is 0.78641. Methanol forms explosive mixtures with air and burns with a nonluminous flame. It forms azeotropic mixtures with many liquids, such as chloroform, acetone, carbon disulfide, benzene and carbon tetrachloride. The azeotropic mixture of methanol and acetone finds limited use in industry as a solvent under the name of methyl acetone. With certain inorganic solids, methyl alcohol forms addition compounds, such as $CaCl_2 \cdot 4CH_3OH$.

Methanol is a violent poison. Many cases of blindness or death have been caused by drinking mixtures containing it. Blindness and serious poisoning may also result from prolonged exposure to its vapours.

The economic production of a pure, synthetic product greatly increased the industrial uses of methyl alcohol. It is an important starting material in chemical synthesis. Its derivatives are used in great quantities for building up a vast number of compounds, among them many important synthetic resins, dyestuffs, drugs and perfumes. Large quantities are converted to dimethylaniline for dyestuffs and formaldehyde for synthetic resins. Methanol is also used in automotive antifreezes, in rocket fuels and as general solvents. *See* ALCOHOL; *see* also Index references under "Methyl Alcohol" in the Index. (D. G. Z.)

**METIC** (Gr. *metoikos*, meaning originally "one who lives with others") was the name given in Greece to resident aliens, including freed slaves. They were found in most states except Sparta, but were particularly numerous and important in Athens. Metics held an intermediate position between visiting foreigners and citizens, having both privileges and duties. At Athens they had to register with the polemarch (*see* ARCHON) and pay an establishment tax of 10 or 12 drachmae a year. They had also to pay the *eisphora* (capital levy) and other state taxes and they were liable to service in the army or navy; in the army they served in separate units unless they were specially privileged to serve in the tribal regiments. They could not contract valid marriages with citizens and they were not allowed to own landed property without the specific authority of the people, but they were a recognized part of the community and were specially protected at law. They had to have a citizen *prostates* to represent them but special provision was made for their cases to be heard in the polemarch's court. How soon their status was defined at Athens is uncertain, but it may not have been until after the Persian wars.

A 5th-century writer said that Athens needed metics "because of her crafts and her navy." They provided an important source of manpower and made an important contribution to the Athenian economy. Among them were skilled craftsmen, bankers, shippers, traders, shopkeepers and labourers. They figure largely in the accounts of the Erechtheum (*q.v.*), on which they worked side by side with citizens on skilled and unskilled work. Many of them

were rich and highly respected. Cephalus, father of the orator Lysias, was encouraged by Pericles to come with his family from Syracuse to settle in Athens. He owned a workshop producing arms, but he also moved in aristocratic circles. He is introduced as a character in Plato's *Republic* and the family mixed with Plato's friends. Pasion, a former slave, became one of the greatest Athenian bankers in the 4th century.

Because of their usefulness metics were encouraged to come to Athens, and in the 5th century their number was large. They provided 3,000 hoplites to the main field army and a substantial proportion of the triremes' crews. At the end of the 4th century, in the census of Demetrius of Phaleron, the number of adult male metics was 10,000; it must have been considerably larger in the Periclean age.

*See* M. Clerc, *Les métèques athéniens* (1893); H. Michell, *The Economics of Ancient Greece*, especially ch. iv (1940). (R. Me.)

**METIS** ("Intelligence"), in Greek mythology a daughter of Oceanus and Tethys, mother of Athena by Zeus. This is reconciled in Hesiod with the usual legend of Athena's birth by the myth that Metis' second child was destined to overthrow Zeus; that to avert this he swallowed her and that Athena was consequently born from his head. Thus was symbolized that Zeus contained the principle of intelligence and that Athena sprang from the same source.

(H. W. Pa.)

**METOCHITES, THEODORE** (Theodorus Metochita), (*c.* 1260–1332), Byzantine scholar, author, patron of learning and statesman, some of whose writings are of historical value. He was grand logothete (chancellor) under Andronicus II (1282–1328). With the fall of Andronicus he was banished for a time from Constantinople but returned in 1331 to live as a monk in the Chora monastery which he had restored. Metochites' writings, some of which are lost, some still unpublished, include works on natural history, philosophy and astronomy, as well as rhetorical pieces, letters and poetry.

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**METONIC CYCLE,** in chronology, a period of 19 years during which there are 235 lunations, so called because discovered by Meton, an Athenian astronomer (fl. 432 B.C.). Computation from modern data shows that 235 lunations are 6,939 days, 16.5 hours; and 19 solar years, 6,939 days, 14.5 hours. The relation between integral numbers of months and years expressed by Meton's rule therefore deviates only two hours from the truth. Since 19 Julian years make 6,939 days, 18 hours, the relation errs by only 1.5 hour when the Julian year is taken. *See* also Chronology.

**METONYMY** (Gr. *metonymia*, "change of name"), a form of metaphor in which the name of a thing or person is exchanged for the name of another associated with it. Examples: "twirler" (*i.e.*, curver), baseball pitcher; Knickerbocker, New Yorker; Old Dominion, Virginia. *See* Figures of Speech: *Figures of Relationship.* (G. W. A.)

**METRE.** Aristotle in his *Poetics* declared metres to be "manifestly sections of rhythms." Basically the word "metre" signifies measurement, but what element or elements in the rhythmical structure of a poem do we measure? During the Renaissance, English rhetoricians borrowed both their theory and terms from Greek and Latin prosody (or metrics), and these have persisted down to the present time, though many prosodists have questioned their usefulness.

In traditional English prosody, thus derived, syllables are designated as "short" or "long" according to their phonetic make-up and the time required (at least theoretically) to pronounce them. The repetition of short and long syllables constitutes the metre, which can be scanned (or measured) by using the breve (˘) to indicate a short and the macron (¯) to indicate a long syllable. The four basic metres are: iambic (˘¯); trochaic (¯˘); anapaestic (˘˘¯), and dactylic (¯˘˘). The spondee (¯¯) was an important variant in Greek and Latin poetry, and less common were the pyrrhic (˘˘), the tribrach (˘˘˘) and the amphibrach (˘¯˘). These last four are occasionally found in English verse.

Each recurrence of these basic metrical units is called a "foot." Thus if the verse, or single line, of the poem contains only one foot, it is called monometer; two feet, dimeter; three feet, trimeter; four feet, tetrameter; five feet, pentameter; six feet, hexameter; seven feet, heptameter; eight feet, octameter; etc., though the count seldom goes above six.

Since the 14th century classical prosody has predominated in English verse, though some traces of the older alliterative practices of Anglo-Saxon survived (*see* Alliterative Verse). One difficulty with the adoption of the metrical system was that it did not entirely fit the English language, which is Germanic in origin, with strong expiratory stress on certain more or less fixed syllables. Greek and Latin were also highly inflected languages, with case endings to indicate grammatical functions. Even by the time of Chaucer most of these inflections had been lost in English, and either word order (subject, verb, object or other complement) or prepositions took their place. These practices affected the number and position of the short syllables and the degree of stress on the long ones. In Chaucer's language a vestige of the inflection survived as an indefinite terminal *-e*, often already mute, sometimes pronounced as the *a* in "sofa," or as the *ee* in "see" when stressed as the rhyme sound, as in the beginning of "The Pardoner's Tale":

In Flāun|drēs whīl|ōm wās| ă cōm|pănyē
Of yōng|ĕ fōlk,| thăt hāun|tēdēn| fōlyē, . . .

The regularity of Chaucer's verse was partly the result of the French influence on English, which caused a more even stress on all syllables than in earlier or later English. By the 16th century the basic Germanic inheritance of the English language had reasserted itself, with a return to strong tonic stress on accented syllables and relatively light stress, usually with rapid pronunciation (*i.e.*, shorter duration of sound), on the unaccented syllables.

One school of prosodists has argued since the 16th century that what constitutes rhythm in English verse is still the pattern of accents, or stressed syllables. Actually, a long syllable in Latin or Greek did not always have exactly twice the duration of a short syllable, but the long and short syllables could be defined with more precision than in English. Furthermore, as inflectional endings were lost, the unstressed syllables in English words were spoken less distinctly and more rapidly. These facts support the accent prosodists in abolishing the use of the breve and the macron, and using symbols to indicate stressed (′) and unstressed (ˣ) syllables, as in:

When win|ter winds| are pierc|ing chill, . . .

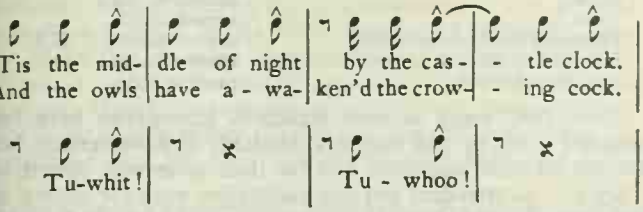
Degrees of stress can be indicated by the use of additional symbols, such as secondary accent (ˈ), or weak accent (ˌ), and the like. But usually the Latin terms (iambic, trochaic, anapaestic, dactylic) are retained, and the difference in metrical analysis is one of degree rather than kind. For example, the metrical stress (a lightly stressed syllable in a position where the metrical pattern calls for a stress) can be indicated by the breve over the macron (ᵕ), and each reader can use his own judgment as to degree of stress:

Of Măn's| First Dĭs|ŏbē|dĭĕnce, ănd| thĕ Frūit

(The syllables *-di-ence-*, with two joining unstressed vowels, are elided.)

The other school of prosodists, which has also existed since the 16th century, is that of the timers. They insist that time is the basis of all rhythm in poetry, and that therefore what must be measured is the recurrence of sounds in time patterns. They find in musical terminology a ready-made technique of analysis. If a note is assigned to each syllable, the stressed syllable may receive a half note, the more lightly stressed syllable (or secondary accent) a fourth note, the unstressed (short) syllable an eighth note. This technique can be applied readily to iambic or trochaic metre, read in ¾ time. Sidney Lanier read the irregular, 4-stress verse of Coleridge's *Christabel* (intended to be

accentual rather than metrical) in $\frac{3}{8}$ time. Here the pauses (silences) can be more neatly indicated by "rests" than by any conventional metrical notation:




The chief objection to musical scansion is that it is highly subjective, especially in the observance of pauses. It is also likely to result in artificial reading because each measure covers precisely the same time (duration). Yet two readers, no matter how competent, seldom read a poem with exactly the same degree of stress on words and syllables or the same duration of pauses. The musical analogy works best with lyric poems, especially those that come nearest to actual song; it is least satisfactory for narrative or dramatic verse.

The acoustics of verse can be accurately measured by the oscillograph and other scientific instruments. By such means it is possible to determine exact pitch (frequency of vibration), volume (loudness), timbre (resonance) and time (duration). Without scientific instruments it is not possible to define the exact meaning of stress or accent (or long or short syllables). A stressed syllable usually differs in volume and duration from an unstressed syllable, and it may also, though not always, differ in pitch.

Actually, on the oscillograph the sounds of spoken verse are continuous, with differences in degree of the four qualities of sound named above, so that syllables, words and metrical feet do not exist in this measurement. Furthermore, acoustics, being concerned only with sound, does not take into account symbolic or linguistic meanings of the sounds, whereas the words of a poem do have meanings aside from their music (sound effects), and the syllables exist also as linguistic units. Thus as an imprecise but still roughly approximate indication of the rhythmical structure of verse, the old method of arbitrarily counting feet and marking the syllables as long or short (or stressed and unstressed) is still useful and convenient.

It is important to understand, however, that English verse is not consistently metrical. The chief value of metrical analysis is to explain the rhythmical structure of an existing poetic work, not to prescribe how a poem should be written. However, metrics can set limits to variations and substitutions in the metre; these variations must not be so frequent that the basic metre is unrecognizable, or even in doubt. An irregularity often encountered is the substitution of one metrical foot for another:

The gŏds| tŏ-dāy| stănd frĭend|lў, thăt| wĕ măy,
Lŏvers|ĭn peăce,| lĕad ōn| ŏur dăys| tŏ ăge!

Substitution is common in the first foot, and not unusual after the caesura, or at the end of the line. Least substitution is found in trochaic metre; most in anapaestic, with which iambic combines easily, as does also trochaic with dactylic. The spondee in the hexameter (*q.v.*) is not a variation but part of the conventional pattern, like rhyme in English. It is substituted in iambic and trochaic metres to give weight and emphasis. Note Pope's illustration of dullness by the use of spondees:

And ten| low words| oft creep| in one| dull line.

John Donne, on the other hand, used heavy stresses for emphasis of meaning and emotion:

One short| sleep past,| we wake| eternally
And Death| shall be| no more:| Death, thou| shalt die!

English verse can be light as well as heavy. In fact, blank verse (*q.v.*) frequently has only three or four genuinely stressed syllables in the ten, often when an article, a preposition, an unemphatic monosyllable or an unaccented syllable of a polysyllabic word stands in the stressed position. Another not uncommon irregularity is an extra unaccented syllable in blank verse. When this comes after the caesura, usually in the second or third foot, it is called an epic caesura; at the end of the line it is called extra metrical. This variation is frequent in Shakespeare's later blank verse, and Milton permitted the epic caesura. Nearly all English poets, in fact, have composed by ear, not by counting syllables; but, except in free verse (*q.v.*), the underlying pattern of the rhythms is metrical. *See* also ALLITERATIVE VERSE; VERSE.

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**METRICAL PSALMS,** the Psalms of the Old Testament strictly translated into metrical and strophic form so that they may be sung to hymn tunes, in this connection often called "psalm tunes" (*see* HYMN). The earliest metrical psalmody was the work of Clément Marot in the court of Francis I of France; his *Trente Pseaulmes de David* (1542) were written for the casual pleasure of the court. But John Calvin, alive to the possible liturgical usefulness of metrical psalms as a vehicle of congregational worship in a Reformed church whose austere principles would forbid the singing of anything but Scripture, and noting the popularity of Marot's small collection, caused a complete French psalter, with music, to be produced for the church at Geneva (1562).

Meanwhile in England Thomas Sternhold (d. 1549) began producing psalms in ballad metre for the pleasure of the young King Edward VI. After Sternhold's death, others took over the work (Sternhold having completed about 40 psalms), and the complete English metrical psalter was published (1562). The Scottish metrical psalter (1564) owed much to the influence of Geneva on certain Puritan exiles who had stayed there during the Marian persecutions. At the same period as these official psalters appeared Miles Coverdale's *Goostly Psalmes* and Archbishop Matthew Parker's psalter.

Puritan England and Scotland confined their congregational singing to metrical psalms for another century and a half. A metrical psalm was often appended also to evensong in Anglican use. Many psalters were produced during the 17th century, including H. Ainsworth's of 1612 (which the Pilgrim Fathers took with them to the new world), E. Prys's Welsh psalter, *Llyfr y Psalmau* (1621), and those of W. Barton (1644) and F. Rous (1st English ed. 1643), which were especially consulted by the revisers of the Scottish psalter in the preparation of their recension of 1650. The first American metrical psalter was the Bay Psalm Book (1640), which was revised in 1758 by Thomas Prince. The revision found little favour, and where metrical psalms were used in America the English version, especially that of Tate and Brady (*see* below) replaced the Bay Psalm Book. Among many poets who made versions of selected psalms was Milton.

In England the 1562 book was variously called "Sternhold and Hopkins" (from its two chief authors) and the "Old Version"; from the edition of John Day (1563) onward, many editions of the "Old Version" were published for the sake of giving currency to new music. It was not seriously challenged by other versions until the "New Version" of 1696 was produced by N. Tate and N. Brady. After 1696 hymnody gained acceptance, and metrical psalmody gave place to psalm paraphrases used as hymns (of which the most notable are those of Isaac Watts, James Montgomery and H. F. Lyte). In Scotland, where the 1650 psalter has appeared in countless musical editions, the current edition of 1929 is published in association with the *Church Hymnary* (1927). *See* also HYMN, with bibliography. (E. R. Ro.)

**METRIC SYSTEM:** *see* WEIGHTS AND MEASURES and PHYSICAL UNITS.

**METROCLES** (fl. late 4th century B.C.), a Cynic philosopher, born of a good family at Maroneia in Thrace, was, like his sister Hipparchia, a pupil of Crates of Thebes (*see* CRATES), having previously studied under the Peripatetic Theophrastus, whom he found excessively attached to the conventions of well-to-do society. He is the first philosopher recorded to have made a collection of instructive anecdotes and sayings, a common form of literary activity among later moralists. (F. H. SH.)

**METRODORUS,** the name of several ancient Greek philosophers. Three of them must be distinguished:

1. The elder Metrodorus of Lampsacus (5th century B.C.), a pupil of Anaxagoras, is remembered for his allegorical interpretation of Homer's *Iliad* and for having represented the Olympian pantheon as an image of the human body (each god having his seat in a separate organ).

2. Metrodorus of Chios (fl. 4th century B.C.), a pupil of Democritus, may have tried to reconcile his master's atomism with Eleatic views but was also known as a skeptic.

3. The younger Metrodorus of Lampsacus (*c.* 330–278/277 B.C.) was a pupil and friend of Epicurus.

**METROLOGY** is the science of measurement. It is of fundamental importance in many human activities, especially those concerned with the acquisition and application of scientific knowledge and the regulation of trade by legal systems of weights and measures. Lord Kelvin once remarked that "when you can measure what you are speaking about and express it in numbers you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind" (*Popular Lectures and Addresses*, vol. i, p. 80, Macmillan, 1891). For various aspects *see* GEODESY; INSTRUMENTS, ELECTRICAL MEASURING; MENSURATION; PHYSICAL UNITS; SURVEYING; WEIGHING MACHINES; WEIGHTS AND MEASURES. This article outlines the scope and organization of metrology; defines units and standards of measurement and their functions in the process of measurement; discusses random and systematic errors of measurement; provides a table of the accuracies currently attainable in some of the more basic operations of metrology; and gives detailed descriptions of the standards of length and mass and how they are maintained. The time standard is not discussed here in detail (*see* TIME MEASUREMENT), but it is necessary to refer to the subject of the unit of time, the second, now defined for science in terms of the tropical year instead of the mean solar day (which remains the basis for civil purposes), because of the established uncertainties in the diurnal period of the earth's rotation. Official replacement of the astronomical by an atomic standard was authorized in 1964 for the measurement of time intervals by the employment of the so-called cesium-beam frequency standard, which is capable of providing a more conveniently accessible as well as a more accurate standard for the second based on a natural resonance period of the cesium atom. A correlation extending over a period of three years has been made between astronomical (ephemeris) time and atomic time from which the frequency of the cesium-beam standard was found to be 9,192,631,770 ± 20 cycles per second, and this value has been adopted by several observatories as a provisional basis for an atomic scale of time interval reproducible to the equivalent of about one cycle (or 1 part in 10,000,000,000).

**Scope and Organization.**—To conduct orderly trade, a society must create and maintain a proper system of weights and measures. Many, therefore, consider that metrology is restricted to measurement of the three fundamental quantities, length, mass and time, from which all the other mechanical quantities, *e.g.*, area, volume, density, velocity, acceleration, force, pressure, energy and power, are derived. However, a comprehensive system of practical measurement should include at least three other fundamentals, taking in the measurement of temperature and related quantities, of electric and magnetic quantities and of photometric quantities.

Accordingly, in 1954, the tenth General Conference of Weights and Measures formalized the following six basic quantities and units of a practical international system of measurement (the symbols for the units are given in parentheses):

| Quantity | Unit |
|---|---|
| Length | metre (m.) |
| Mass | kilogram (kg.) |
| Time | second (sec.) |
| Thermodynamic temperature | degree Kelvin (° K.) |
| Intensity of electric current | ampere (amp.) |
| Luminous intensity | candela (cd.) |

Since 1887 many national standards laboratories have been founded to set up and maintain standards of measurement, both for the six basic quantities and for their systematic derivatives. They also do attendant test and verification work for science and industry. Examples are the National Bureau of Standards (NBS) in the United States, the National Physical laboratory (N.P.L.) in the United Kingdom and similar bodies in many other countries. Some laboratories, notably the NBS, incorporate the national office of weights and measures and are, therefore, also concerned with legal metrology, but in the United Kingdom this work is the duty of the board of trade standard weights and measures department.

The international metric organization created by the Metric Convention of 1875 (amended in 1921) also has a central laboratory, the International Bureau of Weights and Measures, Sèvres (near Paris), with duties analogous to those of the national laboratories but concerned especially with international co-ordination of all scientific work relating to the maintenance and improvement of the metric system of units and standards. This organization acts under the authority of the General Conference of Weights and Measures (meeting every six years) with the aid of an elected executive body, the International Committee of Weights and Measures (meeting every year). The committee manages the affairs of the bureau between general conferences and, with the help of various expert advisory committees, makes recommendations on units and standards of measurement.

**Units and Standards of Measurement.**—It is important to distinguish between units and standards of measurement. Measuring a quantity consists of ascertaining its ratio to another fixed quantity of the same kind known as the unit of that kind of quantity. A unit is essentially an abstract conception and cannot be utilized as a basis of measurement until it has been defined in one of two ways: by reference to arbitrary material standards or by reference to natural phenomena (including physical constants, physical situations and the properties of specified substances). Both methods have been used at different times. In the metric system the unit of length was defined (1889–1960) by the separation of two lines on a particular metal bar, but is now referred to a certain number of wave lengths of a particular spectrum line; the unit of mass, once the mass of a certain volume of water, is now the mass of a particular cylinder of platinum-iridium. The unit of time has long been defined by reference to specific phenomena, and temperature is scaled for practical purposes of measurement by reference to such temperatures as the triple point and boiling point of water (*see* WATER: *Water as a Standard*).

Measurement always involves comparison. Usually the quantity to be measured is compared with a standard whose value is known in terms of the unit of that quantity. The standard in its turn must be calibrated in terms of the unit; this is ultimately the duty of the standards laboratory.

**Random and Systematic Errors.**—No measurement is ever absolutely accurate; some degree of experimental error is always present. Experimental error may be random or systematic. Random error is mostly due to uncontrolled and erratic minor disturbances of the conditions (*e.g.*, temperature) under which any given measurement is conducted. How far random errors affect the reliability of the final result can then be assessed by statistical analysis.

A measurement may, in principle, be free from significant random error and yet be subject to an appreciable but elusive systematic error which remains undetected. Only by rigorous examination of all the processes involved in a measurement can the possible sources of systematic error be traced and eliminated or evaluated. For instance, where an observer has a physiological bias in the interpretation of readings it can often be arranged

that the bias operates an equal number of times in opposite directions. Evaluation of systematic error is best done by the observer himself from his personal knowledge of all the experimental conditions under which his measurements are made. The most satisfactory way of assuring that the measurement of a physical standard or constant is free from unsuspected systematic error is to make two or more determinations by entirely different methods, if possible in different laboratories and with different observers. If each determination gives the same result within the limits of the independently assessed experimental errors, then the probability is that the major systematic errors have been eliminated.

**Accuracies of Measurement Attained.**—The present achievements in accuracy for a representative list of quantities, including the six basic quantities already mentioned, are given in the accompanying table. An important distinction is preserved between the fundamental group—length, mass and time—and the three other basic and eight other derived quantities. The main characteristic of a fundamental standard, apart from its arbitrary nature and the need that it should not change with the passage of time, is the accuracy of comparison, or the degree of precision attained when copies are compared with their prototype. A derived standard—the other three basic standards are in some sense derived standards—is characterized by two qualities, accuracy of realization and accuracy of comparison. The first, representing the accuracy of evaluation of the standard (or reference) derived either solely in terms of the fundamental standards or partially in terms of one or more of these standards with the aid of certain theoretical considerations, is usually inferior to the second, representing the accuracy of comparison for two samples of the same standard. For each item in the table there is a value, or a range of values, for which measurement is most precise, and the highest accuracy attained in the most favourable circumstances, as indicated in the appended notes, is quoted.

| Quantity | Standard or reference | Nature | Accuracy of realization (parts per million) | Accuracy of comparison (parts per million) |
|---|---|---|---|---|
| *Length | wave length of light | natural | — | 0.01† |
| | material standards | material | 0.05‡ | — |
| *Mass | international kilogram | material | — | 0.002§ |
| *Time and Frequency¶ | second (atomic) | natural | — | 0.0001‖ |
| | second (ephemeris) | natural | 0.002♀ | — |
| | second (mean solar) | natural | 0.01♂ | — |
| Volume | litre | derived□ | 1 | — |
| | cubic decimetre | derived | 0.5° | — |
| Velocity | velocity of light | natural | 1▲ | — |
| Acceleration | earth's gravitational acceleration | natural | 1✦ | 0.02● |
| Force | load standard | material** | 40 | — |
| Pressure | standard barometer | material†† | 5 | — |
| *Temperature | thermodynamic scale | theoretical | 50‡‡ | 0.5§§ |
| Electric resistance | ohm | theoretical | 10 | 1 |
| *Electric current | ampere | theoretical | 10 | 1‖ |
| Quantity of heat | joule | theoretical | 20 | — |
| *Luminous intensity | candela | natural¶¶ | 2,000 | 1,000 |
| Sound pressure | — | derived | 10,000♀♀ | — |

*These are the six basic quantities of the international system of measurement.

†Reproducibility of primary wave-length standard (orange line of krypton-86); modern interferometric techniques of wave-length comparison are capable of a precision of 0.002.

‡For interferometric determinations of high-quality metre and yard end standards and line standards of modern construction, using photoelectric microscopes with line standards.

§Comparisons of standard kilograms.

‖Reproducibility of atomic second equivalent to 9,192,631,770 cycles of cesium-frequency standard.

¶Frequency and time interval are inversely related.

♀Accuracy of determination of astronomic (ephemeris) second in terms of cesium-frequency standard over a period of three years; ephemeris second is the fraction 1/31,556,925.9747 of tropical year for 1900.0 at 12h ephemeris time.

♂Since 1885, mean solar day (=86,400 mean solar sec.) has been subject to variations ranging through 7 parts in 100,000,000, with a general tendency to become longer.

□Derived from the kilogram of water; 1 l.=1.000028 cu.dm.

°Reproducibility of the volume of an accurately constructed cube with 9-cm. sides, measured interferometrically.

▲Reproducibility of measurements made at optical and microwave frequencies.

✦Using ballistic methods.

●Accuracy of relative comparisons, completed in a few hours, between stations within a few miles of one another; for stations in different parts of the earth, accuracy is 0.5.

**Involving mass and earth's gravitational acceleration; accuracy quoted refers to a 112,000-lb.-force (51,000-kg.-force) standard deadweight machine.

††Involving length and density of a mercury column and earth's gravitational acceleration.

‡‡In 1954, thermodynamic scale of temperature was defined by assigning to triple point of water the value 273.16° K., exactly (the ice point is 0.01° K. lower); experimental uncertainty of realization is about 0.01° K.

§§Reproducibility of triple point of water.

‖Relative comparison is not of amperes but of volts.

¶¶In the sense that temperature of the black body (whose luminance determines the unit of luminous intensity) is freezing point of a pure metal, namely platinum; in determining luminous intensity of a source of different spectral energy distribution, account must be taken of relative luminous efficiencies at different wave lengths, values of which have been internationally agreed upon.

♀♀Representing accuracy to which laboratory standards of sound pressure are maintained in calibration of standard microphones; in the most favourable cases this accuracy probably could be improved upon by a small factor.

## STANDARDS OF LENGTH

**Types of Standard.**—A standard length may be defined as the distance, under specified conditions, between two parallel lines engraved upon a material standard bar (line standard), or between two flat and parallel end surfaces of such a bar (end standard). Alternatively, reference may be made to a natural phenomenon or standard; *e.g.*, the length of a pendulum beating seconds at sea level in the latitude of London was legally specified as the means of re-establishing the standard yard of 1824 should its replacement become necessary through damage or destruction. The metre, originally intended to be equal to a ten-millionth part of the earth's meridional quadrant, was first represented by a platinum end standard (the *mètre des archives*); this, too, was to be reinstated, if necessary, by means of the seconds pendulum under specified conditions of use. These intentions to relate standard lengths to a certain natural phenomenon miscarried, because the accuracy of realization attainable was found to be far lower than was possible from comparisons of the prototype reference bar with its material copies, through which the standard length could at any time be more reliably reproduced if the need arose. The international prototype metre, a line standard of platinum-iridium (90% Pt, 10% Ir), became established as the primary reference for the metre in 1889, when it replaced the *mètre des archives*, and remained the supreme arbiter on length in the metric system until it was superseded by the light-wave standard.

In 1960, the eleventh General Conference of Weights and Measures declared the metre to be equal to 1,650,763.73 vacuum wave lengths of the orange radiation emitted under specified conditions by the krypton atom of mass 86. This definition in terms of a natural standard, adopted after many years of study, is known to reproduce the metre represented by the former international prototype within the limit of uncertainty (about 1 part in 5,000,000) of this material standard and its national copies. The new standard is reproducible to 1 part in 100,000,000.

The yard, with its multiples and divisions, is also used for precise measurements of length, particularly in engineering science and technology in the nonmetric countries. The imperial standard yard (a bronze line standard constructed in 1845 and defined by the Weights and Measures act, 1878) is steadily contracting at the rate of about 1 part in 1,000,000 every 23 years (over 1½ millionths of an inch per annum). For this and other reasons, in the U.K. the yard (36 in.) became legally redefined on July 31, 1963, as equal to 0.9144 m. (or 1 in. = 25.4 mm. exactly). In the U.S. and the British Commonwealth (apart from India, which changed to the metric system) this definition was adopted for science and technology in 1959; it was given statutory force in the U.S. and Canada and so the yard for all purposes is effectively based on the primary wave-length standard through the adopted relationship with the metre. This eliminates the confusion previously arising from the slightly divergent definitions of the yard.

**The Light-Wave Standard.**—The idea of using the wave length of light as a standard of length was first propounded by J. Babinet in 1827, during the period when the wave theory of light was being developed. It was not until 1893, however, when A. A. Michelson and J. R. Benoît made the first direct measurement of the metre in terms of wave lengths of cadmium red light, that the concept was shown to be realizable in practice. During 1905–06 Benoît, C. Fabry and A. Perot repeated the determination, using improved methods and apparatus. Their originally announced value of the cadmium wave length $\lambda_R$, 0.64384696 micrometre ($\mu$m.; 1 $\mu$m. = one-millionth of a metre) in air under specified conditions, confirmed the earlier value within the experimental accuracies assigned to the two measurements.

In 1907 the international angstrom (Å) was adopted as the unit of measurement for wave lengths in spectroscopy by assigning the value 6438.4696 Å to $\lambda_R$ in standard air (the modern specification for standard air in spectroscopy and metrology is:

dry air at 15° C. under a pressure of 1,013,250 dynes per square centimetre and containing 0.03% by volume of carbon dioxide). The angstrom thus defined represents a length nominally equal to the ten-thousand-millionth part of one metre. In 1927 the seventh General Conference of Weights and Measures gave provisional sanction to determinations of length being made by reference to the value 0.64384696 $\mu$m. of $\lambda_R$ in standard air as an alternative to direct reference to material standards of the metre; the reciprocal of this value, or the number of wave lengths in the metre, was given as 1,553,164.13 $\lambda_R$.

The concordance of the two independent determinations of the metre in light waves indicated that a natural standard of length was reproducible to an accuracy at least as high as that attainable in the comparison of material standards. This was further confirmed by seven other determinations of the metre made in the national laboratories of Japan, the U.K., Germany and the U.S.S.R. during the period 1927–40. The average of the nine results for the number of waves of cadmium red light in the metre is 1,553,164.12 $\lambda_R$ in standard air (or $\lambda_R = 0.64384696$ $\mu$m.)—a value which, by happy chance, is identical with that earlier adopted for spectroscopy and, provisionally, for metrology. Furthermore, there was no evidence of any systematic change, during the period 1893–1940, in the length maintained by the former international prototype metre and its national copies as compared with the wave length of light.

At the ninth General Conference of Weights and Measures (1948) a resolution was adopted recognizing that the metre might eventually be defined in terms of the wave length of highly monochromatic light emitted by a pure isotope such as krypton-86, mercury-198 or cadmium-114 (natural cadmium is a mixture of eight different isotopes). In 1953 an advisory committee of the International Committee of Weights and Measures recommended that the new definition be based on the wave length in vacuum of the selected radiation and that its value in terms of the metre be assessed by direct comparison not with the metre but with the wave length in vacuum of cadmium red light, which could be calculated with the requisite precision. For this purpose the committee recommended starting from the above value of $\lambda_R$. Converting this to the vacuum condition by means of an agreed value of the refractive index $n$ of standard air, namely $n = 1.000276381$, the vacuum wave length $\lambda_{vac} = n\lambda_R$ is 0.644024907 $\mu$m., to be used as the reference to the metre. This procedure received the sanction of the tenth General conference (1954) and in 1957 the advisory committee reviewed the results of investigations on the spectroscopic qualities and wave lengths of the best isotopic radiations. The orange radiation of krypton-86 was selected and the eleventh General Conference redefined the metre to be equal to 1,650,763.73 vacuum wave lengths of this light. The angstrom therefore exactly equals, by definition, the ten-thousand-millionth part of one metre.

**Interferometry of Length.**—Instruments used to measure the metre in light waves are known as interferometers and the process of measuring with such instruments is described as interferometry (*see* INTERFEROMETER). One basic form of interferometer consists of two opposed, semitransparent mirrors separated by the distance to be measured. These are set parallel, as in the Fabry-Perot interferometer, or nearly parallel, as in the Fizeau, or wedge, interferometer. The process of length interferometry is basically this: a beam of monochromatic light waves incident on the interferometer is divided by one of the mirrors into two coherent parts which are then reflected and transmitted by the mirrors. When the two parts recombine they have traveled different distances; the path difference is equal to twice the mirror separation. Recombination produces a pattern of alternate bright and dark bands or fringes because the two trains of light waves mutually interact or interfere. In the basic form of the Michelson interferometer, both mirrors are fully reflecting and a suitably disposed semitransparent mirror divides the incident beam of light into two parts; one part is directed to and reflected by one mirror and the other is directed to and reflected by the second mirror, both parts then being received by the semitransparent (or beam-dividing) mirror where they are recombined and give rise to the pattern of interference fringes. From the positions of these fringes in the field of view, suitably measured in, say, four monochromatic beams of different wave lengths of known relationships one to the other, it is possible to calculate the distance between the mirrors in numbers of waves, and hence to find the mean value of that distance in terms of the metre (or yard) or its divisions.

In a variant of the Fabry-Perot and Fizeau interferometers, more convenient for measuring end standards, one of the mirrors is fully reflecting and the other acts as the beam divider. Because they are flat and parallel, the terminal faces of modern end standards can serve as mirrors in one of the basic forms of interferometer, which then provides the means of indicating their relative positions and thus evaluating their separation directly in terms of light waves.

Measuring a line standard is not so direct because its length is the distance between its two defining lines, which are viewed by microscope. The simplest method of adapting the combination of line standard and observing microscope to interferometric measurement is to mount the standard on a suitably displaceable carriage under a fixed microscope. Attached to one end of the standard is a fully reflecting mirror, preferably arranged to be one of the mirrors in an interferometer of the Michelson type. The interferometer is used, as described above, to evaluate the distance between the two positions of this mirror when the carriage is adjusted so that first one line and then the other is set to a suitable datum in the microscope field. The accuracy of setting to defining lines became much greater with the photoelectric microscope, in which a photomultiplier cell or, better still, a phototransistor replaced the function of the human eye. In one form of this instrument an image of the defining line produced by the microscope objective is caused to oscillate across a slit in front of the cell or transistor, and the variation of current through the device is transformed electronically into an indication of the line position, with a sensitivity of 0.00002 mm. or better for settings on good-quality lines.

Interferometers are commercially available for calibrating, in terms of the primary standard wave length, high-quality standards of length of the end and line types (including the precision scale) required for the practical measurement of length in science and technology. Although the potential measuring accuracy of the light-wave standard is 1 part in 100,000,000 for a length of 1 m., in practice the accuracy depends to a great extent on the precision of manufacture of the material standards of length.

**Line Standards: Mode of Comparison.**—The classical method for the comparison under microscopes of two line standards is as follows: the bars are placed side by side on two parallel girders in a water bath mounted on a carriage that can be moved at right angles to the length of the bars. This arrangement is known as a transverse comparator. Each bar is symmetrically supported on two rollers so spaced that the distance between the defining lines ruled on its exposed neutral plane is least affected by flexure. Two micrometer microscopes are rigidly held in brackets supported so as to be unaffected by the motion of the carriage. Each girder has independent adjustments by means of which the defining lines can be brought into focus in the two microscopes. In the best modern comparators each microscope can rotate through 180° about its optical axis and its objective lens is enclosed in a cell with an optically flat glass window at its base which is submerged below the surface of the water in the bath. The water is continuously stirred and the temperature read from accurately calibrated thermometers.

Readings are taken by means of the microscopes alternately on the two defining lines of each bar and then again with the microscopes rotated through 180° to minimize the effect of any asymmetries in the illumination and in the sectional profiles of the defining lines. The comparison is repeated with each of the bars turned end for end on the two girders and the whole operation is then repeated once more in a symmetrical fashion. In an important determination, several bars (six or eight) may be included, and each is compared against all the others. Photoelectric microscopes increased in use for comparisons of the highest precision.

**Subdivision.**—The divisions of a scale are calibrated in a

similar way, except that the carriage of the comparator moves in the direction of the length of the bar. The microscopes are fixed successively at a series of suitable intervals apart, *e.g.*, 1 dm. (decimetre), 2 dm., 3 dm., etc., for a metre scale divided in decimetres, and each interval of 1 dm., 2 dm., etc., is compared with every other interval of the same magnitude throughout the scale. By computation from the results so obtained the value of each decimetre is determined in relation to the whole length of the scale. Smaller intervals are calibrated in a similar manner.

**End Standards: Mode of Calibration.**—The most familiar form of end standard is the slip or block gauge made of hardened steel with highly finished, flat and parallel measuring faces. It was first introduced by C. E. Johansson (Sweden) in 1896. In sizes up to 4 in. (about 100 mm.), the rectangular section of this form of gauge has been found particularly suitable for a wide variety of measurements in precision engineering. Greater lengths than 4 in., up to 1 yd. or 1 m. and larger, are more convenient to construct and use in the form of cylindrical steel rods or bars with only the ends hardened (*see* GAUGES AND COMPARATORS).

An interesting feature of block gauges and end gauges is that it is possible to wring two or more gauges together, by bringing their cleaned faces into extremely close contact with a combined sliding and twisting motion, to form additive combinations which are strongly adherent. This adherence is due to molecular forces of cohesion. The minimum separation of two polished, flat surfaces in good wringing contact is of the order of 0.000005 mm. This wringing property allows the precision engineer and the standards laboratory to build up a large number of combination standards by selection from a set containing a limited number of gauges arranged in a suitably graded series of sizes.

Measuring machines of different types and varying sensitivity are used for comparing end standards by contact measurement. In these the standard is measured between two opposed anvils, one of which may be fixed, or may be movable by means of a micrometer screw, while the other is capable of operating some form of sensitive indicator which amplifies small movements by mechanical, optical, electrical or pneumatic means. The two standards to be compared are inserted between the anvils, and if the whole difference between them is sufficiently small, the movement of the indicator over a calibrated scale suffices to determine it. If the difference is greater, the indicator is brought to a fixed mark by an adjustment of the moving anvil, the difference in length being then ascertained by the difference in reading of the micrometer drum.

End standards for fractions of the fundamental units are compared in wrung combinations of equal nominal size, in suitable, highly sensitive comparators or end-measuring machines. The basic end standard (36 in.) is compared with a combination of two 18-in. standards or of three 12-in. standards. Intercomparison of the two 18-in. standards or the three 12-in. standards then gives the size of each of the smaller standards in terms of the 36-in. standard.

**Measurements of Longer Distances.**—The invar tapes and wires used for measuring long base lines and other distances in geodetic surveys, or for civil-engineering purposes, are verified under microscopes on a long measuring bench in the standards laboratory by a process depending on addition, starting from line standards representing the fundamental units of length. In the first place a bar, 4 m. or 12 ft. 6 in. long and graduated in metres or yards and fractions thereof, is compared metre by metre, or yard by yard, etc., with the standard line bar in a large transverse microscope comparator. The bar is in turn compared either with suitable reference marks engraved on metal plates let into the masonry base of the measuring bench (usually 50 m. long) at intervals corresponding to the length of the bar, or else directly with the divisions of the graduated tape to be verified, which is suspended in single or multiple catenary (and sometimes supported on a flat surface) under tension. In the best work an accuracy of 1 part in 2,000,000 is achieved in the standardization of a 24-m. tape. The tapes after verification, either directly or by comparison with the bench marks, are used in catenary suspension to determine base lines in the field by comparing them against temporary bench marks set up at distances roughly equal to the length of the tape. Although invar is the material commonly used for the construction of geodetic standards of length because of its low thermal expansivity, the mechanical properties of invar are poor and the tapes require careful manipulation in use to avoid damage. Some precise surveying has been done with steel tapes (having a much higher thermal expansion but better mechanical properties, including stability) for which the relation between length and electrical resistance, determined in the laboratory over a wide range of ambient temperatures, is used in the field to determine length from measurements of electrical resistance.

Light-wave interferometry has been successfully employed to establish the distances between the datum marks on a 50-m. measuring bench in the laboratory and even for distances up to nearly 1 km. under suitable atmospheric conditions in the field. Interferometry over distances of several metres, using radio microwaves in the millimetre range of wave lengths, has been used to determine the velocity of propagation of electromagnetic waves.

An instrument known as the geodimeter, originally developed by E. Bergstrand in Sweden to measure the velocity of light, has been successfully applied to the measurement of geodetic base lines to an accuracy of about 2 parts in 1,000,000. The method is based on the classical toothed-wheel experiment used by A. H. L. Fizeau to determine the velocity of light. It depends on measuring, by electronic means controlled by a quartz crystal frequency standard, the time taken by high-frequency light pulses, generated in a beam transmitter situated at one end of the base, to travel to a mirror placed at the other end (say 20 km. away) and back to the transmitter. As the velocity of light is known to 1 part in 1,000,000, the distance traveled can be calculated to a similar order of accuracy provided the effect of the atmospheric conditions along the base can be properly assessed. An analogous but more convenient instrument for measuring long bases, depending on the principle of the radar transponder used for aircraft recognition, was developed by T. L. Wadley in 1956. The mekometer, an instrument developed at the N.P.L. by K. D. Froome and R. H. Bradsell, utilizes a beam of light that is polarization modulated at a frequency of 9,000,000,000 c.p.s., instead of being amplitude modulated at a frequency of 10,000,000 c.p.s. as in the geodimeter. In tests made during 1961 on the N.P.L. 50-m. (147-ft.) mural base, a displacement of the remote mirror by 0.025 mm. (0.001 in.) was easily detectable. The mekometer has applications for distance measurement up to 500 m. in surveying and large-scale metrology; *e.g.*, for accurate positioning of magnet units and other components of the large accelerators used to study the fundamental particles of physics (electrons, protons, etc.).

## STANDARDS OF MASS

**General Description.**—The kilogram was originally defined as the mass of a cubic decimetre of water under certain conditions, and its first material representation was the *kilogramme des archives*, a solid cylinder of platinum constructed in the late 18th century. But practical realization of the definition proved inconvenient and insufficiently precise, and the specification in natural terms became superseded by the platinum standard; this in its turn was replaced in 1889 by the international prototype kilogram, also a solid cylinder, of height equal to its diameter, made of the same platinum-iridium alloy as the international metre.

In the British system the imperial standard pound—representing the avoirdupois pound (symbol lb.) of 7,000 grains (symbol gr.)—was constructed in 1844 in the form of a solid cylinder of platinum. The relation 1 lb. = 0.4535924277 kg. was determined in 1883 by the board of trade standard weights and measures department in co-operation with the International Bureau of Weights and Measures, but when given legal sanction in the U.K. by order in council (Statutory Rules and Orders, 1898, No. 411) for use as a conversion factor for purposes of trade, the rounded value, namely 1 lb. (U.K.) = 0.45359243 kg. (equivalent to 1 kg. = 2.2046223 lb. [U.K.]), was adopted. Subsequent determinations of the ratio of the pound (U.K.) to the kilogram gave the results: 1 lb. (U.K.) = 0.453592343 kg. (1922) and 0.453592338 kg. (1933). These are in very close agreement but are about 1 part

in 5,000,000 smaller than the result obtained in 1883, the change probably being due to abrasion in early years caused by excessive use of the standard. A value 0.453592383 kg. in 1961 suggested that now that the standard was rarely used it might tend to become heavier owing, perhaps, to the formation of a thin film on its surface. As in the case of the yard and metre, a recommendation was made to redefine the pound in terms of the kilogram, using a relationship acceptable in the U.S. and the British Commonwealth, and the value 1 lb. = 0.45359237 kg. was adopted for science and technology by six national laboratories in 1959. The U.S. adopted this value legally and it was included in the Weights and Measures act passed by the British parliament in 1963.

**Materials.**—It was well to choose platinum and particularly platinum-iridium for constructing the ultimate standards. The degree of consistency, within 2 parts in 100,000,000, with which recomparisons of various national copies of the kilogram have in general repeated the original determinations convincingly demonstrates the suitability of the standards as well as the perfection of the balances used in the comparisons. The following results were obtained for the British copy (no. 18) at the International Bureau of Weights and Measures:

| Year | Mass (kg.) | Year | Mass (kg.) |
|---|---|---|---|
| 1889 | 1.000000070 | 1933 | 1.000000058 |
| 1924 | 1.000000051 | 1948 | 1.000000071 |
| | | 1961 | 1.000000059 |

The recommended materials for reference standards of mass (usually designated as weights) of nominal value greater than 0.5 g. (6 gr.) are, in order of preference with regard to stability: (1) platinum-iridium (90/10); (2) platinum; (3) austenitic stainless steel (25% chromium, 20% nickel); (4) nonmagnetic nickel-chromium (80/20); and (5) brass, plated to a minimum thickness of 0.015 mm. (0.0006 in.) with rhodium, platinum or chromium over a suitable underplating, or with tin-nickel alloy (65/35). Pure nickel is not a suitable plating material because of its magnetic properties and its liability to "fog" in service. For smaller weights, materials (1), (2), (3) and (4) above are preferred, with the addition of (6) gold alloy, (7) tantalum and (8) aluminum (for standards of 0.1 g., 1 gr. and smaller).

**Buoyancy Corrections.**—In the comparison of two standard masses in air, allowance must be made for the upward buoyant effect of the volumes of air they respectively displace. The upthrust on each standard is proportional to its volume and the density of the air. If $M$ is the weight of a standard of density $\rho$, obtained by weighing in air against a mass standard of density $\rho_w$, its mass is $M + M\rho_a [(1/\rho) - (1/\rho_w)]$, where $\rho_a$ is air density. In practice, each member of a set of weights, including the fractional weights, is standardized on the basis of balancing, in air of density 0.0012 g./ml. (gram per millilitre), a standard of the same nominal mass having a suitably rounded value of density representing that of the larger members of the set, namely 8.0 g./ml. In service, these values of density should be used in the assessment of buoyancy corrections when significant. For many purposes the representative value of the air density quoted above is suitable, but if high accuracy is required, allowance should be made for variations of air density from that value. This procedure is much simpler than that of calibrating weights according to their true masses, which involves a knowledge of the actual density of each weight and the individual application of its buoyancy correction.

**Methods and Technique of Weighing.**—In all methods of weighing, either a null method is used or allowance is made for small changes in the inclination of the beam of the balance from weighing to weighing. In the former, the load on one arm is adjusted so as to achieve a certain reproducible position of the beam, indicated by the pointer position or graticule reading. In the latter, when the deflection of the beam has been made small by adjusting the weights, the change in load necessary to achieve some fixed arbitrary position of the pointer is calculated from the deflection by using the sensitivity, which is separately determined.

In the most commonly practised method of weighing on an orthodox balance, complete equality of the arms of the balance is assumed, and the weight of an object is assumed to equal the weights added to one pan in order to balance the addition of the object to the other. The effect of inequality of the arms is eliminated by using either the method of substitution (ascribed to J. C. de Borda) or the method of double weighing (ascribed to C. F. Gauss). In substitution weighing the object to be weighed is first counterbalanced by means of accessory weights; other weights are then substituted for the object and are equal to it when they have been adjusted so that the first position of the beam has been regained. In double weighings, the ordinary single weighing is repeated with the loads in the two pans interchanged, thus eliminating the effects of asymmetry of the beam or of the temperature. This principle of weighing can be extended to eliminate the effects of progressive changes of rest point by repeating the weighings in reverse order; such weighings are described as "double-double" and are usually reserved for the work of the very highest precision on specially well-adjusted balances. If the balance is of the free-swinging type, time is saved by using the method of swings. To a first approximation the effective rest point is midway between successive extremities of swing, but in refined work one more extremity is taken into account. Many modern balances are damped and have internal optical projection and built-in mechanisms for weight loading; some are two-knife single-pan balances which use the substitution method of weighing exclusively. All this makes weighing much easier.

For accurate comparison of primary standards, great care must be taken to preserve constancy of temperature in the balance room to maintain a steady relationship between the arm lengths of the balance; the observer should work outside the room, all the manipulations of the balance and the standards being effected by remote controls. Movements of the balance beam are observed either through a telescope or by noting the movement across a scale of a spot of light reflected by a small mirror attached to the beam.

For weighing very small quantities, microbalances (usually made of fused silica) are used and are often constructed with the beam torsionally supported on a fine, horizontal, silica fibre at right angles to the beam and with the pans supported from its ends by means of silica fibres fused directly to it. Differences in load on the two pans are compensated by suitable rotation of one end of the torsion fibre, the amount of rotation being optically observed on an accurately divided torsion head. Loads as small as 0.1 g. are weighed to an accuracy approaching 1 part in 10,000,000. *See* also BALANCE.

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**METRONOME,** an instrument for denoting the speed at which a musical composition is to be performed. Its invention is generally although erroneously ascribed to Johann Nepomuk Maelzel (1772–1838), a native of Ratisbon; its actual inventor was a Dutch musician named Dietrich Nikolaus Winkel (*c.* 1776–1826). The metronome consists essentially of a pendulum swung on a pivot; below the pivot is a fixed weight and above it is a sliding weight. The rate at which the pendulum swings is adjusted by moving the sliding weight up or down. In its simplest form the metronome is put in motion by hand and allowed to continue swinging until it is stopped or comes to rest. A scale of numbers, usually from 40 to 208, is marked on the pendulum above the pivot; the upper edge of the sliding weight is placed under the number that indicates the speed at which the music is to be played; *e.g.*, M.M. (Maelzel's metronome) 𝅗𝅥 = 60, ♩ = 72 or ♩ = 108. The number 60 shows that 60 oscillations are to occur each minute and that a minim (half note) will receive one beat. Lower numbers denote slower, and higher numbers quicker, beats. The conventional metronome, housed in a pyramidal case, is actuated by a hand-wound clockwork whose escapement makes a ticking sound at each beat; the device continues beating and ticking till the works run down. Many versions of the metronome have been made. One can be made to strike a bell at the first of any number of beats; other models are operated by electricity or can be carried in a pocket.

**METROPHANES KRITOPOULOS** (1589–1639), Greek Orthodox patriarch of Alexandria, important for his exposition of the Orthodox faith. Born at Veroia, Macedonia, he became a monk and keeper of the seal of the patriarch of Constantinople. Cyril Lucaris (*q.v.*) sent him with a letter of recommendation to the archbishop of Canterbury, George Abbot, and he studied in Oxford (1617–*c.* 1623) and then in Helmstedt (1624–25), where he composed his treatise on the creed. He then visited various German universities. In Geneva he was commissioned by Lucaris to negotiate on church union with the Calvinists. In 1630 he returned to the east from Venice, becoming bishop of Memphis (*c.* 1631–36) and then patriarch of Alexandria (1636). In 1638 he took part in the synod of Constantinople, which condemned the Calvinistic doctrines of Lucaris. He died on May 30, 1639, in Walachia.

His *Homologia* is an exposition of Greek Orthodox doctrine in the form of a treatise. He appears to be moderately friendly toward Protestantism. In contrast to the current 17th-century Orthodox view, he counts only three sacraments, like the early Greek Fathers. His doctrine of the church tries to take into account the fact of the divisions in Christendom, but his teaching on communion, grace, scripture, tradition and the priestly office adheres to the teaching of the early, undivided church. He attacks the *filioque* clause, unleavened eucharistic bread and papal authority.

For the text of the *Homologia, see* J. Michalcescu, *Die Bekentnisse und wichtigsten Glaubenszeugnisse der griechisch-orthodoxen Kirche,* pp. 182–252 (1904); biography by K. Dyobuniotis (1915). (F. v. L.)

**METROPOLITAN,** originally a bishop of the Christian church resident in the chief city or metropolis of a civil province of the Roman empire who, for ecclesiastical purposes, administered a territorial area coextensive with a civil province. The title established itself firmly in the organization of the church and was regularized by its first appearance in conciliar documents in 325 at the Council of Nicaea. Following the pattern of civil government, the expanding church created ecclesiastical provinces, over each of which was a metropolitan assisted by his suffragan bishops, each of whom was in charge of a diocese (*q.v.*) within his province. Substantially this system of ecclesiastical administration and the responsibilities and obligations of metropolitans have continued unchanged in the modern Roman Catholic, Orthodox and Anglican churches. The metropolitan's comprovincials render canonical obedience to him and are disciplinarily subject to him. It is incumbent upon him to convoke and to preside at provincial synods. He possesses visitational jurisdiction throughout his province and takes the chief part, assisted by his suffragans, in the consecration of bishops.

The Roman pontiffs, in consolidating their patriarchal authority in western Christendom, conferred the pallium on metropolitans of whom they approved who then took the additional title of archbishop (*q.v.*). With this title was associated spiritual authority and, chiefly through this, the title metropolitan became regarded as being particularly associated with temporalities. A distinction between these two titles still remains in the Roman Catholic Church, but in the Church of England the two titles are regarded as synonymous. Both the archbishop of Canterbury and the archbishop of York carry the three titles metropolitan, archbishop and primate.

*See* F. Claeys Bouuaert in R. Naz (ed.), *Dictionnaire de droit canonique,* vol. vi, col. 875–877 (1957); A. Fliche and V. Martin, *Histoire de l'église,* vol. ii, p. 401 (1947). (J. W. L.)

**METROPOLITAN AREA.** The terms metropolis and metropolitan area commonly refer to a major city together with its suburbs and the nearby cities, towns and countryside over which the city exercises a commanding influence. Literally construed, metropolis means "mother city," and by implication there are progeny or dependents scattered about and attached to the maternal figure.

**Metropolitan Cities.**—Ancient Greek cities that planted colonies or subordinate towns abroad were called metropolitan cities. The transfer of coals from the Athenian altar fires to the temple of a new settlement invested the latter with the traditions and the divine protection of the parent city, binding the two irrevocably together. In like manner other Greek and Aegean cities established dependent settlements throughout the Mediterranean lands. The notion of a filial relation among towns persisted into 17th-century Europe, although by then the relationship had become attenuated to commercial dependence alone. During the middle ages the term metropolitan was used to denote the principal ecclesiastical city of a region, the seat of an archbishop from which he presided over the bishoprics in the area. Lyons, Mainz and Canterbury were metropolitan cities in this sense of the word.

With the progressive secularization of western society the term lost its sacred import. In modern times political capitals have been characterized as metropolitan cities. The term is also applied to a great city which exercises economic dominance over an entire political area or nation. The political capital and the economic centre of a nation are often one and the same city, as in the cases of Rome, Paris and most notably London. Another connotation of metropolitan is the existence of a huge agglomeration of population that reaches beyond the jurisdictional boundaries of a great city. References to metropolitan Munich, metropolitan New York and metropolitan Ōsaka are expressions of that usage. Megalopolis, literally "large city," is sometimes used to describe a city that towers far above other cities in its region in size and in the concentration of wealth and influence it possesses. Striking examples of the megalopolis are the great entrepôt cities that have sprung up on the margins of the nonindustrialized parts of the world, such as Manila, Jakarta, Bombay. Megalopolis has also been used to designate a cluster or string of urbanized communities as, for example, the cities, suburbs and related rural areas stretching along the northeastern seaboard of the United States from Boston, Mass., to New York city and south beyond Washington, D.C. Such a more or less continuously built-up area also may be referred to as a conurbation (as defined by the U.K. census). The urbanized area (U.S. census) is the physical city as distinguished from the legal, or political, city and the metropolitan community. A related concept is that of the city region or urban region, which includes communities that are physically separate from the main urban area but that have close functional links. A suburb may be any outlying district or community smaller than the metropolis; more specifically, it is an organized community outside the political boundaries of a city and usually it is residential in character, with limited local facilities and services.

Until recently, although outlying settlements were oriented toward a principal city—the metropolis—for certain marketing, financial or administrative functions, in other respects they maintained autonomous economic and social existences. Prior to the 20th century local transit, transport and communications facilities

were too few, too slow or too costly to provide frequent service over distances of more than a few miles from any given point. Therefore, the mere fact of proximity among settled places had little or no bearing on the development of interrelations.

**Patterns of Growth.**—A new connotation of metropolitan emerged in the 20th century as a result of a series of dramatic improvements in local transportation and communication facilities. The motor vehicle and the all-weather road, the substitution of electric for steam power and the efficient transmission of electricity, the telephone, the pipeline, the radio and television expanded the scope of easy daily contact from a radius of less than 10 miles to a radius of 50 or more miles. Thus it became possible for large hinterlands to be brought directly and immediately under the influences of urban centres.

This attachment of hinterlands to large urban centres began with the radial extension of electric rail lines and commuter train service. Very soon afterward, however, the construction of hard-surfaced roads gave the motor vehicle an opportunity to demonstrate its value as a means of maintaining close linkages with outlying places. City institutions were enabled to extend their services into surrounding areas with a frequency and thoroughness that were not previously conceivable. Power lines and other communications carriers followed close upon the motor road.

In its early stages the metropolitan area exhibited a well-marked axiate pattern. The radiating routes, both rail and highway, drew out long tentacles of urban settlement, leaving the intervening zones relatively undisturbed. Often the strips of continuous urban development connected and engulfed two or more towns. The axiate pattern was prevalent in Europe where the urban penetration of hinterlands rested largely on rail transportation. Later, especially where the motor vehicle came into very general use as in the United States and Canada, the network of streets and roads was expanded. Urban settlement then filled in the spaces lying between radial routes.

Almost immediately the increased accessibility of the central city and the consequent spread of its influence dissolved the self-sufficiency of hinterland communities and initiated their absorption into a more inclusive urban system. In the general reorientation that followed, many locally provided services—marketing, financial, legal, managerial, medical and even recreational—gravitated to the central city. Consumer services in the hinterland were refashioned after the pattern prevailing in the metropolitan centre and were supplied from that source. Some outlying communities, having lost their reason for being, dwindled and disappeared, while others adopted a more or less specialized role in the expanded territorial division of labour. At the same time, improved transportation and communication facilities relaxed the spatial confinement that had for so long gripped the city. Urban population followed by urban institutions of all kinds surged into the countryside, running out first along the radial thoroughfares and then spreading over the intervening rural lands. As rapid growth enveloped the lands close by the central city's boundaries and then extended deeper into the hinterland, the central city found its growth rate subsiding and passing in many cases into absolute losses.

The dispersion of central city elements over adjoining lands gave a new importance to suburbs. The suburb itself is not a recent phenomenon. As early as the 12th century the outskirts of the European town were dotted with clusters of settlement, or *faubourgs*. But nothing like the ring of dense settlement encircling the modern city existed prior to the advent of the metropolitan area. Moreover, the suburbs of the late medieval period were usually occupied by labourers and their families and others who were not accorded the protection of municipal law. In contrast, the modern suburb in countries like the U.S. and the U.K. first attracted members of upper socioeconomic groups who could afford the time and cost involved in daily trips to the city's centre. Later, suburbs attracted all classes of the population, partly as a consequence of the spread of industrial and other employment opportunities and partly owing to a further cheapening of transportation. Still, suburban areas have retained certain distinctive population features. Their residents include relatively few unattached persons and childless couples; the two-generation family predominates. Furthermore, suburban residents, as compared with the occupants of central cities, are somewhat younger, better educated and much more concentrated in clerical, managerial and professional occupations. These differences have led some observers to conclude that metropolitan centres tend to lose their leadership resources to the suburbs and are threatened with a declining ability to manage their affairs and to generate cultural innovations, and that to the extent that members of the leadership categories who have moved to the suburbs retain their positions in the central cities a kind of absentee control of central city affairs may develop.

**Problems of Governments.**—A source of far more serious and urgent problems lies in the governmental chaos that characterizes metropolitan areas, especially in the United States. As metropolitan areas develop they overreach and include neighbouring cities, villages and other minor civil divisions; they often embrace two or more counties, and not infrequently they sprawl across state boundaries. They typically contain a multiplicity of units of local government ranging from as few as 15 in the smallest to 400 or more in the largest areas. In the area served by the Northeastern Illinois (Chicago) Metropolitan Area Planning commission, for example, there are 900 semi-autonomous governmental units, and this does not include those in the contiguous Calumet (Gary-Hammond-Whiting-East Chicago) metropolitan area across the state line in Indiana. Since the several local government units derive their respective and unequal powers from an external authority, *i.e.*, the state, they bear no obligation to their neighbours and none particularly to the metropolitan area, a unit that has no legal status. Lacking a unified administrative organization, the parts of what in fact is an economic and social unity are unable to act in concert in matters of common concern. Public health, water supply, sewage disposal, police and fire protection, traffic control, planning and many other urban needs are left to the option of each unit that has appropriate powers—and are neglected by units that are without sufficient powers. Nor is there an equitable distribution of fiscal responsibility. Some units, notably the central city, provide a variety of services for the entire area, paying the capitalization and operating costs of those services, or at least of the public facilities they require, while receiving no financial assistance from other civil divisions in the area.

Numerous attempts have been made to achieve governmental unification to avoid the confusion created by the emergence of metropolitan areas. Examples of such attempts generally regarded as successful in at least some respects include metropolitan Toronto, Tokyo-to and Greater Miami (*see* TORONTO: *The Municipality of Metropolitan Toronto;* TOKYO: *Administration;* and MIAMI: *Metropolitan Government*). Most such attempts, however, have met with failure. Hence various kinds of partial solutions to the problem have been devised. One class of these is the special service district. Two or more civil divisions, or parts thereof, join together, sometimes creating a legal entity, for the mutual provision of a particular service such as water distribution, sewage disposal or public health protection. Special service districts have proliferated in metropolitan areas. While they no doubt have met urgent needs in their localities, they have further complicated the administrative compositions of the areas. A second class of *ad hoc* arrangement for dealing with common problems is represented by the metropolitan authority. The authority is a special administrative unit established on the basis of enabling legislation to deal with a single metropolitan-wide need; for example, water supply, development of recreational resources or transportation planning and development. The Port of New York authority, established in 1921 by interstate compact between New York and New Jersey, is one example. It is managed by gubernatorial appointees and is thus independent of local politics and insulated against local influence. The effectiveness of this type of authority is indicated by its rapid spread among the larger metropolitan areas. Efficient as it has proven to be, however, the authority is no more than a partial solution to the problems of metropolitan government. Other proposals have been suggested and tried, namely, city-county consolidation and municipal federation,

but they have not found wide acceptance. Failure to resolve the problem of metropolitan government has not deterred the steady growth of metropolitan areas. For further discussion of problems of metropolitan government *see* HOUSING: *Housing in the United States.*

Many countries do not have a tradition of local self government or home rule and therefore do not face the same problems of fragmented and overlapping governmental units that characterize the United States. The prefectoral system in France, for example, provided a mechanism for dealing with the problems of greater Paris, and similar centrally imposed governmental bodies exist in many metropolitan areas.

**Standard Metropolitan Statistical Areas.**—The unofficial character of metropolitan areas prevents accurate representation of them in statistics. Thus, approximations of the actual areas must be used. The U.S. employs a unit called a standard metropolitan statistical area (SMSA) which includes at least one city of 50,000 or more population (two or more such cities may be included in one SMSA) or "twin cities" (neither with less than 15,000 population) whose combined population is 50,000 or more. Included also are all contiguous divisions (usually counties) that are functionally attached to the central city or cities. Population growth in such areas has exceeded that in the remainder of the U.S. in every decade since 1900. Since 1920, growth of metropolitan areas outside of central cities has increased two to six times as fast as it has within them. From 1950 to 1960 SMSA's absorbed over 90% of all U.S. population growth.

*See* also CITY; CITY GOVERNMENT; CITY PLANNING; LOCAL GOVERNMENT.

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**METSU** (METZU, METSUE), **GABRIEL** (1630–1667), Dutch painter of everyday subjects, was the son of Jacob Metsu, a painter of Leiden, by his third wife, Jacomina Garnyers. According to Arnold Houbraken, Metsu was taught by Gerard Dou. He was registered among the first members of the painters' corporation at Leiden, and he was still a member in 1649. In 1650, or soon after, he settled at Amsterdam. He became a citizen of Amsterdam in 1659. He died there in 1667 and was buried on Oct. 24.

Among Metsu's early work were pictures on religious subjects, painted under the influence, successively, of Jan Steen and Rembrandt, but sacred art was ill suited to his temper, and he turned to other subjects for which he was better fitted. That at one time he was deeply impressed by the vivacity and bold technique of Frans Hals can be gathered from the surprising success with which he depicted the low life of the market and tavern; in contrast, with wonderful versatility, he painted with equal success incidents of high life and the drawing room. In no instance, however, no matter what the subject, do the artistic lessons of Rembrandt appear to have been lost upon him.

In the United States samples of Metsu's work may be seen at the National Gallery of Art, Washington, D.C. ("The Intruder"), and at the Metropolitan Museum of Art, New York city ("The Music Lesson" and "The Artist and His Wife"), among other galleries. The National gallery, London, has Metsu's "The Duet" and "The Music Lesson" (or "Music Party"), and other of his pictures are at Buckingham palace.

**METTERNICH, CLEMENS LOTHAR WENZEL,** PRINCE VON (1773–1859), Austrian statesman who played a decisive role in bringing about the victorious alliance against Napoleon, took a leading part in the congress of Vienna, brought Austria to the forefront of the European powers and stood as the resolute champion of conservative principles. He was born at Coblenz, in the electoral territory of Trier, on May 15, 1773, the son of Franz Georg Karl, Graf von Metternich-Winneburg (1746–1818) by his wife Beatrix, Gräfin Kagenegg. His father was then the Austrian envoy to the Electoral-Rhenish "circle" of the *Reich,* and Metternich spent his youth in the Rhine-Moselle region, for which he retained a lifelong affection. In 1788, with his brother Joseph, he entered the University of Strasbourg, where he attended Wilhelm Koch's famous school of diplomacy; but the spread of the French Revolution prompted him to leave Strasbourg in 1790. He performed a ceremonial function in the Holy Roman emperor Leopold II's coronation at Frankfurt am Main (Oct. 1790) and went on to Mainz university, where he was influenced particularly by Nikolaus Vogt, the historian of the law. In 1792 he witnessed the coronation of Francis II as Holy Roman emperor. Before the French Revolutionary troops entered Mainz, he went to Brussels in the Austrian Netherlands, where his father was then holding the chief ministerial appointment. In 1794 he undertook a diplomatic mission to England, whence he published a pamphlet calling for a general arming of the German people; but in October he rejoined his father, who had in the meantime fled to Vienna as the French advanced over the Netherlands. In Vienna he occupied himself with natural, scientific and medical studies, in which he always kept a lively interest and which he later did much to encourage: the medical theories of Johann Peter Frank made a particular impression on him, and their influence can be detected in his political system.

In Sept. 1795 Metternich married Eleonore, Gräfin Kaunitz, heiress and granddaughter of the former state chancellor Wenzel Anton von Kaunitz. This marriage gave him the link with the high nobility of Austria and the access to high office which he had long desired. Having represented the Catholic Westphalian counts of the empire at the end of the congress of Rastatt (from Dec. 1798), he was in 1801 appointed Austrian minister to the Saxon court at Dresden; and there he formed his friendship with Friedrich Gentz (*q.v.*). Austrian minister in Berlin from 1803, he failed to persuade Frederick William III of Prussia to join Austria in the war of 1805 against France, but gained a profound insight into the internal brittleness of the Prussian state, whose speedy ruin he predicted. Fichte and August Wilhelm von Schlegel, lecturing in Berlin at this time, made some impression on him.

**Metternich and Napoleon.**—In 1806 Metternich went as Austrian minister to France. In contact with Caroline Murat and other ladies of Parisian society, he won the reputation of a licentious man of pleasure; but he exploited these ladies and his relations with Talleyrand and with the Russian envoy Petr Aleksandrovich Tolstoi so as to obtain excellent reports on the state of affairs in France. Metternich's successes in the negotiations leading up to the Franco-Austrian treaty of Fontainebleau (Oct. 10, 1807) were insignificant; but he used his time to acquire a deep insight into the emperor Napoleon I's character. He overestimated the impact of the Spanish rising of 1808 on the Napoleonic system, and his optimistic reports did much to induce Austria to undertake the disastrous war of 1809 against France. After the battle of Wagram he tried to obtain favourable terms in the peace negotiations at Altenburg, but was rebuffed by Napoleon.

On Oct. 8, 1809, the emperor Francis (now Francis I of Austria but no longer Holy Roman emperor) appointed Metternich minister for foreign affairs. Six days later the oppressive peace treaty of Vienna (Schönbrunn) was concluded with France. Austria was now in urgent need of a respite; and to obtain this respite Metternich formed the project of a marriage between the archduchess Marie Louise, a daughter of the emperor, and Napoleon, whose vanity he cleverly exploited. It is not clear how far he expected that this marriage would restrain Napoleon from further campaigns of conquest, but at least he achieved a relationship between France and Austria loose enough to preserve his own freedom of action: Austria neither joined the Confederation of the Rhine nor became one of the client states of the Napoleonic system. Utterly exhausted and debt-ridden, Austria could hardly have resisted any further demands of Napoleon, but was then no longer the main object of Napoleon's hostility.

As early as 1811, in order to promote Austria's internal development, Metternich wanted the state to be reorganized on federal lines instead of the centralized system that the emperor Joseph II had imposed. Yet he could never overcome the objections of his strictly absolutist emperor. At the same time the enthusiasm for arming the nation and for national insurrection which he had still felt even in 1809 began to be superseded in Metternich's mind by a firm antipathy against all popular movements. Agreeing with the emperor on this, he now came to regard these manifestations as a menace to the multinational Habsburg state. He became the strictest exponent of the doctrine of the balance of power in Europe—a doctrine instilled into him originally by Koch, latterly by his friend Gentz.

When Napoleon launched his invasion of Russia in 1812, Metternich obtained the status of an independent formation for the Austrian forces under Schwarzenberg which accompanied the French army. The disaster that befell Napoleon's army came as a surprise to Metternich. On Jan. 30, 1813, Schwarzenberg concluded an armistice without any time limit with the Russians; but in view of the inadequacy of Austria's armaments Metternich could not make up his mind to change over to war on Russia's side against Napoleon. Resisting all ill-considered projects, in particular those of the archduke John (who was put under house arrest for planning a premature anti-French rising in the Alps), Metternich firmly adhered to neutrality while Austria secretly rearmed. He even drew Saxony into the neutral camp for a time. Then Saxony's return to the French side and Napoleon's victory over the Russians and Prussians at Bautzen (May 20–21, 1813) shook Metternich's will to make war and stiffened Napoleon's attitude. Metternich therefore mediated the armistice of Pläswitz (June 4) between France, Russia and Prussia. Even so, in the treaty of Reichenbach (June 27, 1813), between Austria, Prussia and Russia, he undertook to bring Austria into the war against France if Napoleon rejected the peace terms that he was offering.

Metternich dominated the negotiations with the French at Dresden (June 26–30, 1813) and, at the congress of Prague (July 12–Aug. 10), gained more time for rearming. At this point he was not interested in the annihilation of Napoleon's power, which Francis likewise, out of consideration for Marie Louise, was unwilling to destroy altogether. Metternich also distrusted the Russian emperor Alexander I and feared that, after the collapse of France, Europe would be at Russia's mercy. Napoleon's obstinacy frustrated the attempt at a settlement; but when on Aug. 12, 1813, Austria finally declared war on France, Metternich, by his superior conduct of negotiations, had won for his country the leadership both in the political and in the military field. In Oct. 1813 the hereditary title of prince was bestowed on him by the Austrian emperor (the principality of Winneburg in Swabia, bestowed on his father in 1803 in compensation for lost land on the left bank of the Rhine, had been mediatized in 1806).

In opposition to the plans of the Prussian minister Stein and of the Russian emperor, Metternich promised to the South German states of the Confederation of the Rhine that they should not forfeit the position they had achieved on Napoleon's side if they went over to the allies. This attitude alone was enough to show that he was striving for a solution compatible with the interests of all parties (though at the same time he wanted the South German states as allies against the Prussian-Russian designs of aggrandizement). Since he rejected as unrealistic the proposals of Stein and others for the resuscitation of the Holy Roman empire, the first peace of Paris (May 30, 1814) stipulated nothing more for Germany than a loose confederation of states.

**The Congress of Vienna.**—The congress of Vienna (Sept. 1814–June 1815) was the climax of Metternich's work of reconstruction. The very fact that it was held in Vienna was by itself a great success for him. He had precise ideas about the basis for a new order in Europe, but knew from the start that he would have to make far-reaching modifications of them if he was to save anything from the reaction of self-interested princes. He wanted to secure Austria's predominance by forming two confederations, one German and the other Italian, with Austria as the leading power in both. Within Germany, he wanted the creation of a hereditary German imperial title; and he thought that Austria and Prussia should share the task of protecting Germany's western frontier. Friendship with Prussia on the one hand and with Bavaria on the other thus seemed to him to be the prerequisite of success. Supported by the British foreign secretary, Lord Castlereagh, Metternich sought to prevent the elimination of France, as he saw France as a necessary counterweight against Russia. Likewise he resisted the territorial aggrandizement of Russia and Prussia and objected in particular to Prussia's designs for annexing all Saxony.

The congress became a splendid social event. By an unbroken chain of festivities Metternich kept the visiting monarchs in a mood that made them disinclined to interfere very persistently in the real work of the statesmen. Facile and not averse from amorous adventures, Metternich brilliantly mastered his dual role of social representation and political leadership. Yet he only partly succeeded in his plans: the German imperial project came to nothing because Francis steadfastly refused the title of German emperor; the Italian confederation did not materialize; and the German confederation, when it at last came into being in June 1815, was based only on a brief and noncommittal federal act derived from a Bavarian compromise proposal. In European affairs, however, Metternich was more successful: he achieved equality of status for France; he obtained a reduction of the Prussian demands on Saxony; and, in particular, he blocked the farther-reaching demands of Russia. Russia and Prussia, in fact, were held in check by the common front of Austria, England and France, which Metternich had created.

Metternich's moderation produced a long-lasting European order. This, however, must be ascribed to his diplomatic capability rather than to his political foresight. Austria's status in the German confederation had been fortified; but the emperor's refusal of the German crown meant that Prussia, with equal status in the confederation, would be able to counterbalance Austria.

**Austria and the German Confederation.**—Not even within the Austrian empire could Metternich prevail with the idea (already at the root of his plans of 1811) of overcoming the spirit of revolution by revitalizing the old historical regions and privileges of pre-absolutist times. His attempt to organize the newly acquired Italian provinces according to historical principles was brought to nothing by the emperor Francis, who, under the semblance of accepting Metternich's ideas, united two incompatible regions in a completely unhistorical "Lombardo-Venetian kingdom" and so destroyed Metternich's hopes of counteracting all-Italian nationalism. The reconstruction of Austria took shape entirely in the spirit of the emperor Joseph II, on centralist and absolutist lines, without regard to national differences and without the establishment of departmental ministries, which Metternich had demanded. After many futile remonstrances Metternich eventually yielded to the obstructionism of the emperor, who detested innovation and stood jealously on his dignity. The re-establishment of the ancient diets of Tirol and Galicia complied to some extent with Metternich's idea of resurrecting the provincial diets in order to conciliate liberal opinion without having to create a central parliament, but in practice the result disappointed him. He severely disapproved of the repressive measures taken by the chief of police, Joseph Graf Sedlnitzky.

The domestic affairs of Austria created difficulties for Metternich at the Frankfurt am Main federal diet (*Bundestag*), which opened in 1816. He had originally intended to use this assembly to carry through the fight against revolutionary thought all over Germany. Pointing to the examples of Tirol and Galicia, he attempted in 1817–18 to encourage the German states to introduce constitutions resurrecting the historical provinces and setting up provincial diets instead of a central parliament. In summer 1818, however, Bavaria and Baden promulgated constitutions that reflected, not Metternich's ideas, but the French democratic example; and in 1819, when revolutionary activity culminated in the murder of the dramatist August von Kotzebue and when the opening sessions of the Bavarian and Baden assemblies proved stormy, Metternich decided to stifle the liberal currents that he and his emperor could not contain. He managed to convince the Prussian chancellor Hardenberg that his prescription for provincial

diets was right. Then, assured that Prussia would not follow the South German example, he could quietly watch how parliaments created against his advice served to justify that advice and to discourage the liberal inclinations of German princes. Consequently, at the ministerial conferences of Carlsbad (*see* CARLSBAD DECREES) and Vienna in 1819–20, Metternich, to the surprise of the South German states, did not proceed against the new constitutions, but simply curtailed the activity of the federal assembly, which had become an inconvenience to him. Reorienting his German policy, he now relied, not on the assembly, but on the common interest of the princes, whom by personal contact he led to share his point of view: henceforth it was no longer the privileges of Austria as granted by the federal act, but Metternich's generally acknowledged personality that guaranteed Austria's predominance in the German confederation.

**Austria and Europe.**—Metternich had hoped that a system of congresses, at which the great powers would concert their actions, would maintain order and peace in Europe. At the congresses of Aix-la-Chapelle (1818), of Troppau (1820), of Laibach (1821) and of Verona (1822) his international reputation was at its zenith (*see* the separate articles on these congresses), but the disruption of the forum of great powers was evident when Great Britain abandoned the policy of intervention against revolutions in other countries: Castlereagh prepared the way for this change at Troppau, and George Canning, his successor as British foreign secretary, brought Metternich's influence on western Europe to an end by insisting on the right of national self-determination for the South American colonists in revolt against Spain and for the Greek insurgents against Turkey. With Alexander I's death (1825) it seemed likely that Metternich's influence on Russia would come likewise to an end; and Prussia's jealousy was causing further difficulties when in 1830 the July revolution in France, followed by insurrections in Belgium, in Poland and in Germany, appeared to justify again Metternich's dismal prognoses and served to convince the three eastern powers, Austria, Prussia and Russia, that they should stand together by his principles.

**The Decline of the Chancellor.**—Metternich had been appointed Austrian state chancellor on May 25, 1821, but his influence in Austria was decisively restricted by the appointment of Franz Anton, Graf Kolowrat, as minister of state and head of the cabinet conferences (1826). Kolowrat, for personal reasons, set himself against an orderly organization of the state and won great ascendancy over the emperor Francis. Metternich, as his influence dwindled, gave himself up to an ever more intolerable vanity and to a passion for theorizing which caused his utterances to become increasingly prolix and, at times, to verge on the ridiculous. For the sake of legitimacy and despite all apprehensions, he gave Francis the disastrous advice to recognize his feeble-minded eldest son, the archduke Ferdinand, as heir to the throne. In 1835, therefore, when Ferdinand succeeded his father, Metternich, at first together with the archduke Louis (Ludwig), took the chair at the "conference" or council of state which assumed the functions of a regency. In 1836 it seemed as if he would at last be able to carry out his idea of well-ordered government, but at the decisive moment Kolowrat managed to convert the archdukes John and Louis to his own theories, and thenceforth Metternich's authority was confined to external affairs. His vanity tempted him to disguise the waning of his influence by accepting responsibility for decrees which neither came from him nor accorded with his views. He thus became a hated symbol of repression and reaction, and eventually on March 13, 1848, had to resign, as the first victim of the revolution. He made his way with difficulty into exile to England, but returned to Vienna in 1851. Having taken no further direct part in politics, Metternich died in Vienna on June 11, 1859.

After his first wife's death (March 1825) Metternich had married Baroness Antoinette Leykam in Nov. 1827. After her death (Jan. 1829), he had married Melanie, Gräfin Zichy-Ferraris, in Jan. 1831 (she died in Dec. 1854). His son by his second marriage, Richard, Prince Metternich (1829–95), who was Austrian ambassador in Paris from 1859 to 1870 and one of the foremost diplomats of his time, published eight volumes of his father's papers, edited with the assistance of A. von Klinkowström, in 1880–84.

**Conclusions.**—Metternich's personality has long been the subject of dispute. His great merits cannot be denied. On the other hand, his failure to overhaul the government and administration of the Habsburg monarchy remained an omission that could never be compensated. He always went the way of least resistance and so allowed others to turn Austria into a prison in which free speech was impossible and any denunciation was enough to cut short a promising career. On several occasions he put before the emperor projects that show his insight into the growing difficulties, but he never drew the least consequence from the emperor's rejection of his plans. Even in the regency council he was content to play the part of the philosopher. The complaisance of his predominantly diplomatic talents prevented him from playing the part of the great Austrian statesman.

The rapid decline of Austria's institutions from 1826 sapped Metternich's international standing, but his vanity would not let him see how hollow the foundations of his prestige and system had become. He considered himself the "father confessor of cabinets" and the "physician of sick governments in the entire world." The "Metternich system," which he himself so often cited and of which so much has been written, postulated the existence of eternally valid maxims of supreme wisdom in statesmanship, the most important of them being the European balance of power, sole guarantee of international peace. For Metternich, the old cultural and political order of Europe was a living organism that he wanted to preserve against the destructive forces of the Revolution. His convictions were strengthened by the ease with which his statecraft could circumvent the liberals of the time, whose exaggerated way of expressing themselves often had an air of dilettantism and whose political immaturity seemed to him to threaten the delicate mechanism of the balance of power. He therefore founded his system on restraint of all those imponderable forces which could not be reconciled with the old-established art of statesmanship: imponderables such as the coming-of-age of peoples, the awakening of nations, the emergence of social problems, and so on. The struggle against the spirit of the time and against the political aspirations of the *bourgeoisie* was for Metternich also a struggle against a rising tide of political dilettantism. He hoped that economic affluence would keep the *bourgeoisie* away from politics, and the return to pre-absolutist conditions seemed to him the necessary basis for antirevolutionary action. Liberalism and the revolutionary spirit he merely regarded as a reaction—not entirely unjustified—against the absolutist anarchy for which the emperor Francis stood and which he, Metternich, condemned. In this absolutist anarchy he saw the root of all evil. It was his tragedy and also his guilt that he never built a foundation on which his system could really develop and prove its worth.

From the time of Joseph II there had been a discrepancy between the specific concerns of Austria and the old universalist tradition of the Holy Roman empire; and the same discrepancy is evident between Austria's internal policy and Metternich's foreign policy, which was devised to take responsibility for the whole of Europe. Whereas Francis II and his entourage thought on narrow Austrian lines, Metternich stood entirely in the tradition of the universal monarchy—not so much from devotion to the past glory of the emperors as from the conviction that the revolutionary spirit was an international disease which could be fought successfully only by disregarding national frontiers. For ten years after Napoleon's downfall Metternich, by sheer force of personality, made the world think of Austria as a real power: his failure came when the feet of clay could no longer be hidden. For Germany, the fatal effect of his influence was loss of contact with the liberal and progressive west. *See* also AUSTRIA, EMPIRE OF; and references under "Metternich, Clemens Lothar Wenzel" in the Index.

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(K. O. v. A.)

**METZ,** a city of France, capital of the *département* of Moselle and northern capital of Lorraine, on the Moselle river, 99 mi. (159 km.) N.W. of Strasbourg by rail. Pop. (1962) 101,496. The general appearance of the city is quaint and irregular, but there are several handsome modern streets. The Moselle, which is there joined by the Seille, flows through it in several arms and is crossed by many bridges. Of the ten city gates the most interesting are the Porte des Allemands on the east, a castellated structure built in 1445; and the Porte Serpenoise, flanked by turrets belonging to the old ramparts, on the south. The Cathedral of St. Étienne (13th to 16th centuries), with huge pointed windows, slender columns and numerous flying buttresses, belongs to the Gothic period. St. Vincent is 13th- and 14th-century Gothic with a classical façade and St. Eucaire (12th–15th-century restored) has a pilgrimage chapel. St. Pierre-aux-Nonnains (4th century) is the oldest church in France. The public library contains an extensive collection of works relating to the history of Lorraine, and the museum has important Gallo-Roman and Merovingian antiquities.

Metz is the seat of a bishopric, of a prefect, of the sixth military region, of tribunals of the first instance and of commerce, of a board of trade arbitrators and of a chamber of commerce. It is the centre of the iron-mining section of Lorraine and is near the coal mines of the Saar and Moselle. The chief industries are the manufacture of shoes and metal goods, printing, brewing and preserving of fruits and vegetables. There is a national tobacco factory. Trade is in Moselle wine, grain, cattle and garden produce.

Metz's location is of the utmost importance strategically. As a fortress, it has always been of the highest significance, and throughout its history, down to 1870 (*see* below), it had never succumbed to an enemy. The original town walls were replaced by ramparts in 1550, and the citadel was built a few years later. By 1674 the works had been reconstructed by Vauban. Under Napoleon III the fortress was strengthened by a circle of detached forts, which, after 1870, were modified and completed by the Germans, who treated the fortress as the pivot of operations against France.

Metz was the chief town of the Mediomatrici (called by the Romans Divodurum or Mediomatrica, of which Metz is a contracted form). The Romans fortified it and supplied it with water by an imposing aqueduct, the remains of which still exist. Under the emperors Metz was connected by military roads with Toul, Langres, Lyons, Strasbourg, Verdun, Reims and Trier. Christianity was introduced in the 3rd century. In the middle of the 5th century the town was plundered by the Huns under Attila; later it came into possession of the Franks and was made the capital of Austrasia. On the partition of the Carolingian realms in 843 Metz fell to the share of the emperor Lothair I as the capital of Lorraine. Its bishops, whose creation reaches back to the 4th century, now began to be very powerful. Metz became a free imperial town in the 13th century and soon became prosperous. Having partly adopted the Reformed doctrines in 1552 and 1553, it fell into the hands of the French and was defended against Charles V by the duc de Guise. At the peace of Westphalia in 1648 Metz, with Toul and Verdun, was formally ceded to France. It was taken by the Germans in 1870, ceded to them in 1871 and incorporated into Germany as part of Alsace-Lorraine. It was ceded again to France after World War I. From 1918 to 1939 Metz enjoyed an extraordinary revival. This was interrupted by the German occupation in World War II, during which the Germans expelled many of the inhabitants. The town was liberated by the U.S. army in Nov. 1944; it was damaged during the siege.

**Battles Around Metz, 1870.**—The area to the east of Metz saw three engagements of the Franco-German War (1870) and the city itself was under siege during all of September and most of October. Early in August, less than three weeks after war had been declared, the French force under Marshal M. E. de MacMahon had been defeated at the battle of Wörth. The Germans had then advanced from the Saar to the Moselle, passing south of Metz. By Aug. 14 the German 1st army under Gen. K. F. von Steinmetz had reached a position to the east of the French army under Marshal A. F. Bazaine in Metz. Bazaine decided to draw back to the west but in so doing encountered a German corps between Colombey and Borny in the afternoon of Aug. 14. A brief encounter brought no decisive results and both sides withdrew at nightfall. Neither army paid sufficient attention to scouting and patroling to learn the exact position and strength of its opponent. After resting and regrouping on Aug. 15, Bazaine resumed his retreat early on Aug. 16 but this time stumbled into contact with an isolated German corps in the area between Vionville and Mars-la-Tour. Though greatly outnumbered, the Germans attacked the French in a bold effort to conceal their own weakness. Amid much confusion on both sides there ensued an engagement that is often described as the hardest-fought battle of the war. The French chassepot rifle proved superior to the German needle gun, but the chief characteristic of the day's fighting was the effectiveness of the German artillery, which was handled in masses and not, as on the French side, by single batteries. The cavalry on both sides proved altogether incapable of affecting the outcome or providing adequate reconnaissance.

After this engagement the French fell back from Vionville to the area near Gravelotte and St. Privat. The Germans, too exhausted to attack on Aug. 17, renewed the fight on Aug. 18. Again the action was indecisive and was marked by considerable confusion. During the night following the battle the French army withdrew within the line of forts surrounding Metz. These forts, though insufficiently armed and still incomplete, were nevertheless too formidable for any field army to attack without the aid of a powerful siege train, which at the time was not available. The Germans therefore decided to starve out the French. The German forces, now under command of Prince Frederick Charles, fortified the encircling positions with a light outpost line behind which was drawn a main position on which every art of the engineer was expended. Meanwhile Bazaine in Metz planned to break out to the north, but he was irresolute and his attempt at the end of August resulted in failure. Marshal de MacMahon had meanwhile received word of Bazaine's plan to break out and felt obliged to march to his support. By Aug. 31 MacMahon's army was surrounded by the Germans at Sedan (*q.v.*), where it was forced to surrender two days later, the emperor, Napoleon III, himself being taken prisoner.

The investment of Metz then resumed its regular course and, as time wore on, conditions in the city and the surrounding camps became deplorable. Toward the end of September, rations had to be reduced and the troops began to slaughter cavalry horses for food. Two more attempts were made to break out of the city but both ended in failure. Negotiations for capitulation were begun on Oct. 13 and on the 28th the Army of the Rhine surrendered. The investment of Metz had lasted 54 days and the death roll of the civil population had risen to 3,587 against 1,200 in the corresponding period of a normal year. After he returned from captivity in Germany, Bazaine was brought to trial in 1873 before a military court for having surrendered too soon and was eventually sentenced to imprisonment. *See* also BAZAINE, ACHILLE FRANÇOIS; FRANCO-GERMAN WAR.

**MEUDON,** a town of northern France, in the *département* of Seine-et-Oise, 6 mi. (9½ km.) E. of Versailles by rail and about 7 mi. (11 km.) S.W. of Paris. Pop. (1962) 29,004. It forms a commune with Bellevue. Meudon is a residential town much in favour with artists. The painters Renoir and Manet; the sculptor Rodin; the composers Wagner, Alexandre Guilmant and Georges Enesco; and the organist Marcel Dupré have all lived there. Rodin's estate has been turned into a museum, housing his tomb and numerous works and studies. The remains of a castle (17th century, by J. H. Mansart) burned during the siege of Paris in 1871 have since been adapted as an observatory. In the 16th century the cardinal Charles de Lorraine built at Meudon a magnificent château; though this was destroyed in 1803, a fine terrace overlooking Paris and the Seine valley still remains.

**MEULEBROECK, JOSEPH,** BARON VAN DE (1876–1958), Belgian Liberal leader who as burgomaster of Brussels proved himself during World War II to be a courageous patriot, was born at Laeken, near Brussels, on Nov. 17, 1876. After graduating in medicine at the University of Brussels (1901) and spending one year on probation in the London hospitals, he became a Liberal town councilor at Laeken in 1907 and an alderman in 1912. During World War I he served as an army doctor. From 1920 to

1939 he was an alderman of Brussels in charge of the social services of the capital. In 1932, moreover, he was elected to the chamber of deputies; but he did not seek reelection in 1936. At the death of Adolphe Max (*q.v.*) he became burgomaster of Brussels on Nov. 28, 1939. During the German occupation of Belgium in World War II his refusal to countersign German regulations led to his suspension from office in July 1941 and to his confinement in his residence under military supervision. Van de Meulebroeck was reelected burgomaster of Brussels in 1947 and was created a baron on April 28, 1953. He relinquished his office on Feb. 10, 1956, and died in Brussels on Dec. 13, 1958. (JE. D.)

**MEULEN, ADAM FRANS VAN DER** (1632–1690), Flemish painter of battle scenes, was born at Brussels. He was a pupil of the battle painter Peter Snayers, and was called to Paris about 1666 by Jean Colbert, at the instance of Charles Le Brun, to fill the post of battle painter to Louis XIV. His paintings during the campaigns of Flanders (1667) so delighted Louis that from that date Van der Meulen was ordered to accompany him on all his expeditions. In 1673 he was received into the French Academy. He attained the grade of councilor in 1681, and died at Paris in 1690. He is best represented by the series of 20 paintings, executed for Louis XIV, now in the Louvre.

**MEUNIER, CONSTANTIN** (1831–1905), Belgian sculptor and painter who chose most of his subjects from the life and surroundings of farmers and workers, was born at Brussels on April 12, 1831. He was a pupil at the academy there. His first exhibit was a plaster sketch, "The Garland," at the Brussels Salon in 1851. Soon afterward, on the advice of the painter Charles de Groux, he gave up sculpture for painting. Influenced by Jean François Millet, he began to absorb socialistic ideals. About 1880 he was commissioned to illustrate those parts of Camille Lemonnier's description of Belgium in *Le Tour du Monde* which referred to mines and factories. After a visit in 1882 to Spain, where he painted "The Tobacco Factory at Seville" (Brussels gallery), he was appointed professor at the Louvain Academy of Fine Arts and in 1885 returned to sculpture, producing, among other works, "The Puddler," "The Hammerer" (1886), "The Mower" (1891), "The Glebe" (1892), the "Puddler at the Furnace" (1893) and "The Horse at the Pond." He collaborated with Charles van der Stappen in 1893, in the scheme for the decoration of the Botanic garden at Brussels. The "Monument to Labour," an unfinished work for the Brussels gallery, comprises four stone basreliefs, "Industry," "The Mine," "Harvest" and the "Harbour," four bronze statues, "The Sower," "The Smith," "The Miner" and "The Ancestor," and a bronze group, "Maternity." Meunier died at Brussels on April 4, 1905.

*See* C. Lemonnier, *Constantin Meunier* (1904); A. Fontaine, *Constantin Meunier* (1923). (A. K. McC.)

**MEURTHE-ET-MOSELLE,** a *département* of northeastern France, formed in 1871 from those parts of the former *départements* of Meurthe and Moselle that remained French after the loss of much of Lorraine to Germany following the Franco-German War. These *départements* had been constituted in 1790 from districts of the ancient duchy of Lorraine (*q.v.*) and of the bishoprics of Metz, Toul and Verdun. The *département* extends south from the frontier with Belgium and Luxembourg and is bounded by the *départements* of Moselle and Bas-Rhin to the east, Vosges to the south, and Meuse to the west. Pop. (1962) 678,078. Area 2,039 sq.mi.

The heart of the *département*, around Nancy, lies in the area of the converging valleys of the river Moselle and its tributary, the Meurthe, where they cross the clay *plaine* of Lorraine. Farther north the *département* extends over the dip slope of the oölitic limestone plateau of Briey and beyond its north-facing escarpment edge above Longwy. In the southeastward extension of the *département* beyond Lunéville the ground rises toward the Vosges and sandstone heights in the extreme southeast reach 2,000 ft. The winters are severe but the summers are warm and arable land is extensive, though there is considerable surviving woodland. The French school of forestry has its seat at Nancy. Cultivation in scattered strips of open fields has lingered late in Lorraine, and the farmland is devoted mainly to grain but fodder crops and potatoes have become important; use of pasture is increasing at the expense of arable land, especially on the clay soils of Vernois. The traditional agriculture is changing and, under the stimulus of the markets provided by the mining and industrial communities, livestock products have assumed increased importance. There is little viticulture, although vineyards were formerly extensive around Toul.

Most of the remaining reserves of iron ore in Lorraine underlie the Briey plateau in Meurthe-et-Moselle. The frontier that was drawn in 1871, now the eastern border of the *département*, gave Germany the most accessible and earlier developed part of the large iron ore field, but the great resources of buried ore beneath the limestone plateau farther west have been increasingly opened up since the 1890s. In the extreme north the *département* also includes an important outcrop section of the ore field in the Longwy area, and there is a small detached area in the south near Nancy. The iron and steel works keep to the valleys and in Meurthe-et-Moselle are concentrated on the restricted valley land about Longwy and Villerupt in the north; they are ranged along the Moselle valley north and south of Nancy, including works at Pompey, Pont-à-Mousson and Neuves-Maisons. These districts account respectively for about one-third and one-tenth of the Lorraine production of iron and steel. In the post-World War II modernization of the industry a large electric power station has been built at Herserange, a suburb of Longwy, to serve the local works. The *département* is traversed by the Marne-Rhine canal and by the Canal de l'Est but the traffic associated with the iron and steel industry is largely handled by rail. Around Dombasle, southeast of Nancy, there are important salt workings in the Triassic deposits which provide the basis for heavy chemical industries. Nancy's great breweries have also benefited from the gypsum content of the local water.

Nancy (*q.v.*), formerly capital of the ancient duchy of Lorraine, is the *préfecture* of the *département*, the seat of the bishopric which is co-extensive with it and the administrative centre for both justice and education. Nancy, Briey, Toul and Lunéville are the centres of the four constituent *arrondissements*. Nancy and Lunéville offer fine examples of 18th-century town planning in the grand manner carried out for the last dukes of Lorraine. The fortress city of Toul, compact within its 17th-century perimeter, has a fine medieval cathedral. (AR. E. S.)

**MEUSE,** a *département* of northeastern France, formed of part of the ancient provinces of Champagne and Lorraine (*qq.v.*). In the north it extends to the Belgian frontier and to the east is bounded by the *département* of Meurthe-et-Moselle, southeast by Vosges, south by Haute-Marne, and west by Marne and Ardennes. Pop. (1962) 215,985. Area 2,410 sq.mi.

The river Meuse crosses the *département* from south to north, its valley deeply entrenched in a plateau of Corallian limestone that rises above 1,300 ft. Its east-facing escarpment, known as the Côtes de Meuse, overlooks a clay vale, Woëvre, beyond which rises the backslope of the oölitic limestone plateau that is underlain farther east by the Lorraine iron ore field. The eastern boundary of Meuse, however, barely reaches the ore field. In the west, the *département* extends to the forested highland of the Argonne, composed of hard sandstone that has developed among the Lower Cretaceous rocks. The western part of the *département* is drained by headwaters of the Aisne and by the Ornain tributary of the Marne. Using the Ornain valley past Bar-le-Duc, the Marne-Rhine canal crosses the grain (*i.e.*, underlying geological structure) of the country from west to east in the south of the *département* and at Troussey links with the Meuse, which is canalized downstream as part of the north-south system of the Canal de l'Est. Important railways and roads also cross the *département* from Paris toward Strasbourg and Metz. The valley of the Meuse river is a natural barrier that forms part of the defenses on the approach to the heart of the Paris basin from the east. Its line has given great strategic importance to the fortress of Verdun and was the scene of heavy fighting in World War I.

Lying inland and for the most part more than 600 ft. above sea level, the *département* has a more severe climate than most of the Paris basin. The northern limit of viticulture crosses its centre

and the vine is restricted to a few localities with favoured aspects. There is a considerable amount of woodland left on the higher parts. Farmland is largely devoted to grain, fodder crops and potatoes; cattle are the principal livestock. The largest towns, Verdun and Bar-le-Duc, have fewer than 20,000 inhabitants and there is little manufacturing industry, although the working of man-made fibres is developing at Tronville.

The *département* is divided into three *arrondissements* centred upon Bar-le-Duc, Verdun and Commercy. Bar-le-Duc, once the capital of a medieval duchy (*see* BAR, COUNTS AND DUKES OF), is the *préfecture*, but the ancient fortress city of Verdun, with a Romanesque cathedral, is the seat of the bishopric and the *département* comes under Nancy for the administration of education and justice. (AR. E. S.)

**MEUSE RIVER** (Flemish MAES, Dutch MAAS), rises at Pouilly, on the Plateau de Langres, France, and flows generally northward for about 590 mi. through Belgium and the Netherlands to the North sea. It has cut a steep-sided and sometimes deep valley, through an area of Upper Jurassic rocks between St. Mihiel and Verdun. Beyond Mézières the river crosses the Lower Paleozoic of the Ardennes in a narrow valley with entrenched meanders. Entering Belgium at Givet it continues northward to Namur where it is joined on the left bank by the Sambre, and then turns eastward to Liège. The Meuse there forms a natural routeway and is a centre of industrial development. At Liège it is deep and narrow with the river about 450 ft. below the plateau tops. The river turns north and from Maastricht to Maeseyck (Maaseik) forms the frontier between the Netherlands and Belgium. From Venlo it curves gradually westward, reaches sea level and divides, one branch flowing into the Hollandsch Diep, another joining the Waal channel of the Rhine. Near Gorinchem the Waal divides, the southern branch entering the Hollandsch Diep, the northern (the Oude Maas), joining the Lek (Rhine).

From Troussey (France) to Givet, the Meuse is navigable to 300-ton barges and from Liège the Albert canal provides a route to Antwerp for Rhine barges and some seagoing vessels utilizing the Meuse for 10 mi. before diverging. The succeeding 4 mi. to Maastricht carry Rhine barges while beyond this the Juliana canal, open to 3,000-ton vessels, uses the Meuse to Mook and links with the Rhine between Mook and Nijmegen.

*See* also references under "Meuse River" in the Index.

(J. E. M.)

**MEW, CHARLOTTE MARY** (1869–1928), English minor poet whose verse is notable for its dramatic insight and feminine perceptiveness, was born in London on Nov. 15, 1869. She was educated privately and, apart from visiting France, spent most of a life made sad by illness and loss in Bloomsbury, London. She contributed short stories and poems to periodicals, and her first collection of poems, *The Farmer's Bride*, was published by the Poetry bookshop in 1916 (enlarged ed. 1921). She was extremely critical of her own work and may have destroyed much of it. Thomas Hardy admired her verse, which has some affinity with his own, and assisted in obtaining her a civil list pension in 1923. Her only other collection, *The Rambling Sailor* (1929), appeared after her death by suicide on March 24, 1928.

See *Collected Poems*, with a memoir by Alida Munro (1953).

**MEXICAN WAR,** a conflict that began in the last week of April 1846 with a series of skirmishes between troops of the United States and Mexican forces on the north bank of the Rio Grande. It came to an end 21 months later with the negotiation of the treaty of Guadalupe Hidalgo, signed in a suburb of Mexico City. The entire history of the war was closely associated with the expansionist movement in the United States. The war resulted in a decisive victory for the United States, and as a result the United States acquired a vast expanse of territory stretching from the Rio Grande to the Pacific ocean.

Relations between the two countries had been strained for at least 15 years before the outbreak of war. Unstable political conditions in Mexico created a continuing menace to the lives and property of foreigners. Before 1830 claims of U.S. citizens for losses incurred as a result of civil strife in Mexico had become a subject of diplomatic contention. The evasive tactics of the Mexican authorities caused increasing irritation in the United States; and the government of the United States several times considered the use of reprisals in an effort to compel Mexico to negotiate a settlement.

After a series of prolonged negotiations, beginning in 1839, Mexico agreed to pay claims in excess of $2,000,000; but after paying the accumulated interest on this sum early in 1843, it failed to continue the stipulated payments.

In the meantime, a revolt in the Mexican province of Texas, led by natives of the United States, resulted in the establishment of the independent Republic of Texas (1836). Almost immediately there began a move for the annexation of Texas by the United States. This proposal was favoured by a large majority in Texas, commanded widespread support in the United States, and introduced a highly explosive issue into the already tense relations between Mexico and the United States, for Mexico refused to accept the loss of Texas as a permanent fact. For six years the United States took no positive action respecting Texas, other than to recognize its independent status.

In 1843, Pres. John Tyler made the annexation of Texas a major objective of his administration. A treaty to accomplish this was rejected by the U.S. senate, and annexation became the principal issue in the presidential election of 1844. The candidate who was most outspoken in favour of annexation was James K. Polk. His victory was interpreted as a mandate for the early annexation of Texas, which was accomplished on March 2, 1845. By this action, the United States not only offended Mexico, which broke off diplomatic relations with the U.S., but also fell heir to a boundary dispute between Mexico and Texas. Mexico asserted that the boundary was the Nueces river, while Texas claimed to the Rio Grande, more than 100 mi. W. of the Nueces.

Polk hoped to settle the outstanding issues with Mexico by peaceable means. The situation was complicated, however, by his undisguised desire to acquire California, which was then a part of Mexico.

At the close of 1845, Polk sent John Slidell (*q.v.*) to Mexico City to negotiate a settlement of the questions in dispute and, if possible, to purchase California. Public opinion in Mexico was not favourable to compromise, and a shift in the government brought to power a party that appeared to favour war. The Mexican authorities refused to receive Slidell, and the situation appeared to have reached an impasse.

When Polk learned that the Slidell mission had failed, he ordered U.S. troops, under Gen. Zachary Taylor, into the disputed zone between the Nueces and the Rio Grande (Jan. 13, 1846). When, in April, Mexican troops were sent to the Rio Grande it appeared that hostilities could not be avoided. On April 24, a Mexican detachment crossed the Rio Grande. On the following day it fought a skirmish with a small party of U.S. troops, in which several Americans were killed. In the ensuing two weeks there was desultory fighting on the north bank of the Rio Grande, culminating in the battles of Palo Alto and Resaca de la Palma (May 8, 9, 1846).

On May 9, before news of the first skirmish on the Rio Grande reached Washington, Polk and his cabinet canvassed the tense situation. The president and a majority of his cabinet favoured a declaration of war on the grounds of the unsettled claims and the rejection of Slidell.

After the meeting adjourned, Polk learned that fighting had already begun, and he immediately prepared a message to be sent to congress recommending a declaration that war existed by action of Mexico in which U.S. blood had been shed on U.S. soil. Polk recognized that there would be opposition in congress and feared his recommendation would be rejected. Congress, however, quickly responded with the desired declaration.

The action of Polk in sending Taylor to the Rio Grande and his willingness to recommend war before he knew that Mexican troops had crossed that river caused some of his contemporaries to question his motives and has led historians to debate the justification of his policy. The conduct of Mexico was admittedly irritating, but Polk's determination to acquire California—an acquisition not possible of accomplishment by peaceable methods—

has been widely regarded as his true objective. The issue was obscured by the fact that Texas had entered the union as a slave state, and it was generally assumed that slavery might be extended into any territory taken from Mexico.

Polk was a southern slaveholder, and northern antislavery groups accused him of precipitating the war for the benefit of his fellow slaveholders. For more than half a century this view was commonly accepted by historians. Later research has indicated that Polk's action resulted partly from exasperation with the conduct of Mexico and partly from a desire to add California to the United States.

The original plans for the military conquest of Mexico were relatively simple. The army on the Rio Grande, under Taylor, was to invade the heart of Mexico, while a second force under Gen. Stephen Kearny was to occupy New Mexico and California. The navy was to blockade Mexico and to support the forces occupying California. The campaign into New Mexico and California encountered little effective opposition, and the residents of both provinces appeared to accept U.S. occupation with a minimum of resentment.

The plan to invade Mexico from the north was a disappointment. Taylor fought several engagements south of the Rio Grande, captured the important city of Monterrey, and defeated a major Mexican force at the bloody battle of Buena Vista (Feb. 22–23, 1847). He appeared to have no enthusiasm for a major invasion of Mexico and on several occasions he failed to pursue the Mexicans vigorously after defeating them. In disgust, Polk revised his war strategy.

Early in 1847, Polk ordered Gen. Winfield Scott to take an army by sea to Veracruz, capture that key seaport, and march inland to Mexico City. Scott took Veracruz after a siege of three weeks (March 9–26, 1847), and began the march toward Mexico City. He defeated the Mexicans in a battle at the mountain pass of Cerro Gordo (April 18) and continued inland. Despite some stiff resistance from the defenders, Scott's campaign was marked by an unbroken series of successes and he entered Mexico City on Sept. 14, 1847. This entry concluded the significant military operations of the war.

Polk had favoured a declaration of war; he was equally anxious to conclude peace whenever Mexico was willing to accept his terms. These included, as a minimum, the cession of New Mexico and California. To facilitate the early negotiation of a peace, Polk sent with Scott's army a special envoy, Nicholas Trist, who was authorized to conclude a peace as soon as Mexico would negotiate on Polk's terms. This negotiation was not easy, for despite the obvious military superiority of the United States, public opinion in Mexico was opposed to a cession of territory. In the meantime, expansionist elements in the United States were demanding that Mexico be required to yield more territory than Polk had originally contemplated.

After considerable delay, Trist and representatives of Mexico signed the treaty of Guadalupe Hidalgo on Feb. 2, 1848. By this treaty, Mexico ceded to the United States nearly all of the territory now included in the states of New Mexico, Colorado, Utah, Nevada, Arizona and California. The United States agreed to pay Mexico $15,000,000 and to assume the claims of U.S. citizens against Mexico. Polk was more interested in bringing the war to a close than in holding out for a cession of additional land, and he accepted the treaty.

The treaty was a political victory for Polk, but it satisfied few others. Antislavery groups opposed the acquisition of any territory as a result of a war that they regarded as unjust. Expansionists regretted that the President's terms had been so modest.

The treaty was ratified because it was the only practical means by which the war could be brought to a formal conclusion.

No foreign war of the United States except the War of 1812 with Great Britain so divided public opinion in the United States. The opposition to Polk's policies continued unabated throughout the war. In part, this was the product of partisan politics; but more significant was the attitude of the antislavery groups in the north. Antislavery congressmen repeatedly sought to force through congress a resolution excluding slavery from any area taken from Mexico. This question was unresolved at the close of the war, and became the principal issue in postwar politics. The prolonged and bitter debates over the organization of the territory ceded by Mexico gave slavery a greater political prominence than it had hitherto commanded, and set in motion a chain of crises which led a dozen years later to the American Civil War.

*See* also references under "Mexican War" in the Index.

BIBLIOGRAPHY.—The standard history of the Mexican War is Justin H. Smith, *The War with Mexico,* 2 vol. (1919), based on extensive research, but so argumentatively biased in favour of the United States as to be lacking in objectivity. A more recent useful account, also favourable to the United States and a strong defense of Polk, is Robert Selph Henry, *The Story of the Mexican War* (1950). An older but better balanced work is George L. Rives, *The United States and Mexico,* 2 vol. (1913). A well written brief account may be found in Nathaniel W. Stephenson, *Texas and the Mexican War,* in "Chronicles of America," xxiv (1921). J. S. Reeves, *American Diplomacy under Tyler and Polk* (1907), is critical of those presidents. (H. W. BY.)

**MEXICO,** a federal republic of North America, though belonging partly to Central America in the geographical sense, extending from the United States southward to Guatemala and British Honduras. Its northern boundary line follows the Rio Bravo del Norte (Rio Grande) from its mouth northwestward to latitude 31° 47′ N., thence on that parallel westward for 100 mi., thence south to latitude 31° 20′ N., thence due west to the 111th meridian, thence in a straight line, nearly west-northwest, to a point on the Colorado river 20 mi. below the mouth of the Gila river, thence northward to the mouth of the Gila, and thence nearly due west along the old line between upper and lower California, to a point on the Pacific coast one marine league south of the southernmost point of San Diego bay. This boundary is 1,550 mi. in length. The boundary line with Guatemala and British Honduras is even more arbitrary, beginning at the mouth of the Suchiate river on the Pacific coast, and following that stream to its source, thence determined by the peaks of Tacaná, Buenavista and Ixbul, from there following a parallel to the Salinas river, which is really the upper Usumacinta, to a point on the Usumacinta itself about 16 mi. S. of Tenosique (Tabasco), thence due east to the San Pedro Mártir river, thence north to latitude 17° 40′ N., which it follows eastward to the border between British Honduras and Guatemala, thence north to the Hondo river which it skirts to Chetumal bay. The length of this border line is approximately 550 mi.

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## I. PHYSICAL GEOGRAPHY

In its location, appearance and physical structure Mexico is a land of transition. It overlaps the juncture between the North American continent and the complex Central American segment of the Antillean-Central American structural system. Where the North American continent terminates depends on the criteria chosen. The two eligible limits are the Mexican volcanic axis (*see* Map in *Geographical Regions* below) and the Isthmus of Tehuantepec.

The physical characteristics of Mexico are somewhat complex but not difficult to understand. The core of the country is a high plateau rimmed by mountains on the east, west and south. Lowlands lie between the mountains and the sea on the east and west. In the south the low Isthmus of Tehuantepec ties the highlands of

Chiapas to the Sierra Madre del Sur. Two peninsulas complete the picture: Lower California, with a backbone of block mountains, and Yucatán, a limestone plain.

### A. Geology and Structure

Mexico's geologic heritage is both North American and Central American. It has been subjected to the periods of sedimentation and crustal unrest which shaped the continental areas to the north and south. A convenient line of separation between North American and Antillean structural characteristics may be made at latitude 19° N.

North American structural features that appear in Mexico and which are related to those of the United States include the plateau core of the Mexican highlands and the Gulf of Mexico coastal plain, the Sonora plains and most of the Lower California peninsula. The Gulf of California, east of the peninsula, occupies a depression which in the United States embraces the Salton sea.

The regions where structure appears to be related to the east-to-west pattern of the Greater Antilles and northern Central America include the Chiapas highlands, the Isthmus of Tehuantepec and the Sierra Madre del Sur. Perhaps the southern end of Lower California should also be included. The peninsula of Yucatán is considered the foreland of the elevated lands of Chiapas and Guatemala.

**1. Mexican Plateau.**—The Mexican plateau is composed largely of folded Mesozoic strata. Cretaceous and upper Jurassic formations predominate among exposed rocks, but middle or lower Jurassic and late Triassic sediments are widespread. The region's elevation, folding and faulting were contemporaneous with the uplift of the Rocky mountains. In the early Tertiary period great outpourings of lava terminated a long interval of weathering and erosion. Subsequently the large plateau block was uplifted, the displacement being greater to the south than to the north. Its margins have been dissected into the deeply gouged angular landscape of the Sierra Madre Occidental and the more rounded but rugged terrain of the Sierra Madre Oriental.

**2. Sierra Madre Occidental.**—Although the western fringe of the plateau, the Sierra Madre Occidental, was long assumed to have been a structurally simple feature consisting of the nearly horizontal lavas manteling Mesozoic sediments and old crystalline rocks, a complex structural history is becoming apparent. The underlying strata may have sustained great deformation because of folding and faulting during several periods, and there are numerous intrusive masses of large size. Paleozoic strata mostly of the Carboniferous and Permian periods overlie Ordovician and possibly Cambrian materials in the Sierra Madre and to the west. Whether pre-Cambrian crystallines have been identified for this or any region of Mexico is uncertain.

**3. Sierra Madre Oriental.**—The Sierra Madre Oriental, composed largely of folded sedimentary rocks of the late Mesozoic era, owes its present relief to late Pliocene and Pleistocene elevation and block faulting. Igneous intrusion forms are numerous.

**4. Volcanic Axis.**—Marking the southern edge of the Mexican plateau and spanning Mexico from coast to coast is a zone where volcanism developed during two episodes. In the early and middle Tertiary period immense quantities of lava were poured over the land. The second volcanic episode, which began in the Pliocene period and continues to the present time, is associated with the development of such spectacular peaks as Pico de Orizaba or Citlaltépetl (18,701 ft.), Popocatépetl (17,887 ft.), Ixtacihuatl (17,342 ft.), the Nevado de Toluca or Zinantecatl (14,433 ft.), and the Nevado de Colima and Volcán de Colima (14,219 and 13,110 ft.). In 1759 and 1943, respectively, the smaller volcanoes of Jorullo and Parícutin burst into existence. Additional peaks, cinder cones and other evidence of volcanism occur throughout the region.

**5. Sonora Plains.**—Between the Sierra Madre Occidental and the Gulf of California is a lowland region which in the north consists of broad basins and isolated mountain ranges and in the south appears to be a simpler coastal plain. The detached block ranges, which are aligned generally north to south, were elevated as a result of orogeny that occurred during the middle and late Tertiary period. Intrusions of granitic and other plutonic rocks accompanied this mountain building.

To the west of this region of basins and parallel ranges lies the down-faulted trough which is occupied by the Gulf of California. This depression may have occurred at the time that the peninsula of Lower California and the Sierra Madre Occidental were elevated. The Colorado river has carried immense amounts of debris into the gulf. Its delta has isolated the Salton sea basin.

**6. Lower California.**—The northern half of Lower California has as its core high, westward-tilted blocks of granite, along with metamorphosed (pre-Cretaceous and Cretaceous) and unmetamorphosed sediments (Cretaceous and Tertiary). The lower southern half of the peninsula is composed largely of marine sediments and Tertiary lava flows, although crystalline rocks occur in the Sebastián Vizcaíno and Cape San Lázaro areas. Pleistocene and later volcanism have produced a number of craters, cones and lava flows on the western side of the peninsula. There are several volcanic islands in the Gulf of California.

The cape area on the peninsula to the south of the town of La Paz, composed of granite and metamorphosed rocks, is distinct structurally. It may have closer affinity with the Central American-Antillean structure than with the North American.

**7. Gulf of Mexico Coastal Plain.**—To the east of the Sierra Madre Oriental and stretching to the limestone platform of Yucatán lies the coastal plain of the Gulf of Mexico. Its gradual uplift and erosion has resulted in the exposure inland of older strata in hilly belts that roughly parallel the coast. In the interior of the central and northern plain the older Cretaceous strata are exposed as a result of sharper lifting. Isolated hills in southern Tamaulipas and northern Veracruz and a cluster of hills in the San Andrés Tuxtla vicinity are volcanic.

**8. Yucatán Peninsula.**—The peninsula of Yucatán, the most recently formed region of Mexico, is a broad block of slightly warped marine strata, much of it Miocene and lower Pliocene limestone. Karst topography is general. Inland, the limestone shelf abuts the highlands of the Central American-Antillean structural system. This occurs in Guatemala and British Honduras as well as in Mexico. A submerged portion of the block juts into the Gulf of Mexico, and it is known as the Campeche bank. Transitory connections with Cuba were terminated in the late Pliocene by the depression of the block which now underlies the Yucatán channel.

**9. Chiapas Highlands.**—To the south of the Gulf of Mexico coastal plain and the Yucatán peninsula rise a number of blocks of limestone and sandstone, chief among them the Meseta Central de Chiapas. This region of more or less horizontal strata was elevated in the Pliocene period. Its plateau surface is broken by karst features, and in the northwest igneous rocks have resisted erosion well enough to stand out as low mountain ranges.

A large structural depression, the Valle de Chiapa, lies between the Meseta Central and the Sierra Madre de Chiapas. The Sierra was subjected to faulting on a grand scale, some folding and considerable lifting in the Pliocene period, yet it appears that orogenies may well have begun in pre-Cambrian times. Paleozoic and what may be pre-Cambrian crystalline rocks, Mesozoic sediments and recent eruptives form the range. The cone of Tacaná volcano (12,470 ft.) is outstanding among the latter features.

The major structural features of the Chiapas highlands are continued in Guatemala. To the west the continuity is preserved in the Sierra Madre del Sur region.

**10. Isthmus of Tehuantepec.**—The elevation of the Tehuantepec region to its present level occurred during the late Pliocene and in the Pleistocene. This low hilly area has been shaped from a core of old crystalline rock and overlying metamorphosed and unaltered sediments.

**11. Sierra Madre del Sur.**—To the west of Tehuantepec the great scarp of the Sierra Madre del Sur rises several thousand feet. This deeply dissected mountain mass reveals east to west folds in its base rocks of metamorphosed Cretaceous sediments and intrusives. An overburden, now largely removed by erosion, includes Mesozoic sediments capped with eruptives. The stratigraphy is a repeat of the Mexican plateau stratigraphy.

The Tlalpam expressway, one of the capital's principal traffic arteries

The Paseo de la Reforma, an important commercial thoroughfare

A section of the city's skyline

Makeshift housing, some of which remains despite large-scale urban renewal programs

Low-rent apartment building for government employees

## MEXICO CITY

PHOTOGRAPHS, (TOP LEFT) INTERPRENSA—P.I.P., (TOP RIGHT) HERBERT LANKS—PIX FROM PUBLIX, (CENTRE RIGHT) MANCHETE—P.I.P., (BOTTOM LEFT) UNITED PRESS INTERNATIONAL, (BOTTOM RIGHT) FRED LYON—RAPHO GUILLUMETTE

# MEXICO

Farm workers harvesting wheat in the valley of Santo Domingo, Lower California

A government-operated grain elevator in Tlalnepantla, a suburb of Mexico City

Plowing with oxen

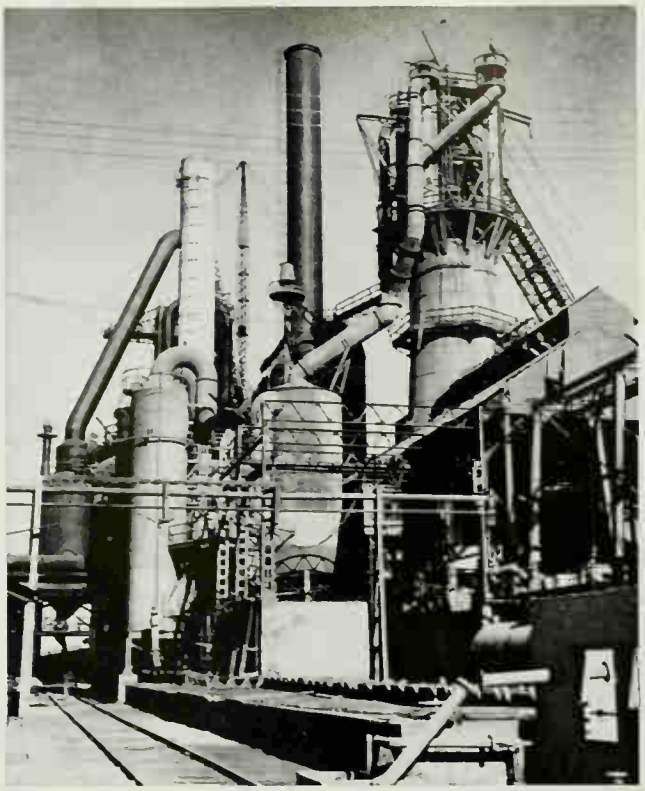
## CATTLE, AGRICULTURE AND FISHING

Fishing harbour in Guaymas, Sonora

Cattle roundup at a ranch near Pijijiápan, Chiapas

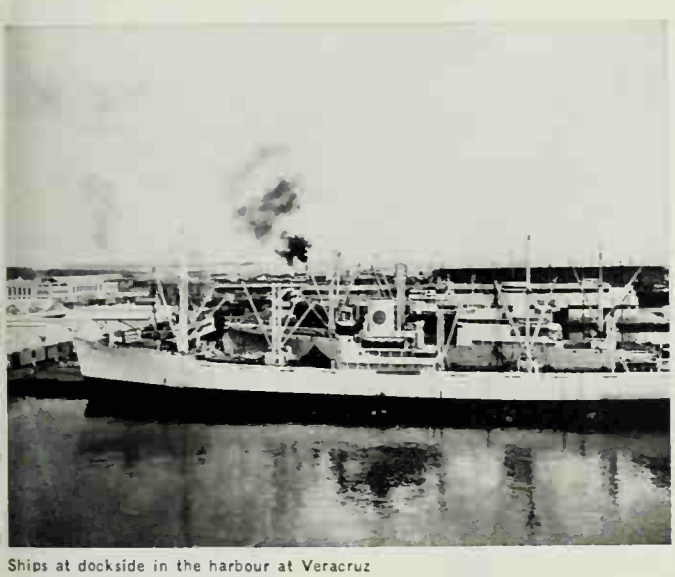
PHOTOGRAPHS: (TOP LEFT, TOP RIGHT) CARAGOLA; (CENTRE RIGHT) L. H. DEATHERAGE FROM BLACK STAR; (BOTTOM LEFT) DICK GREENING FROM BLACK STAR; (BOTTOM RIGHT) HERBERT LANKS FROM BLACK STAR

An automotive assembly line in Mexico City



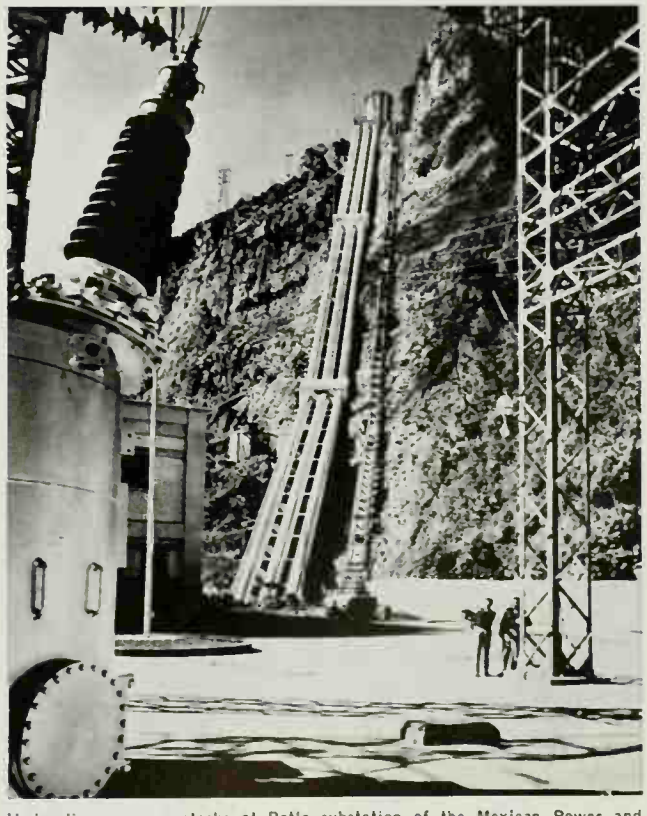
A steel mill in Monclova, Coahuila, one of the largest in the country

## POWER AND INDUSTRY



Ships at dockside in the harbour at Veracruz

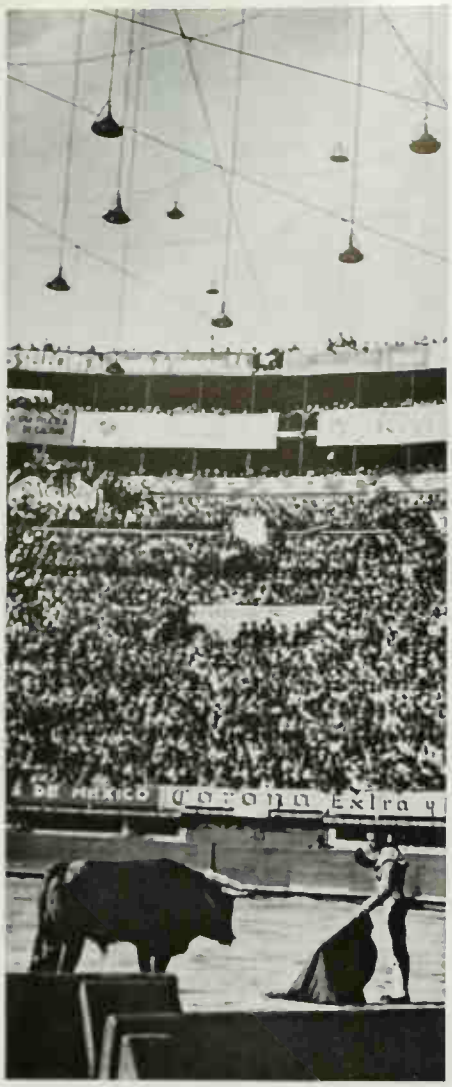
A petroleum refinery at Minatitlán, Veracruz



Hydraulic power penstocks at Patla substation of the Mexican Power and Light company. The water is conveyed to the substation through a tunnel three miles long

BY COURTESY OF (TOP LEFT) FORD MOTOR COMPANY; PHOTOGRAPHS, (TOP RIGHT, BOTTOM LEFT) CASASOLA, (CENTRE LEFT, BOTTOM RIGHT) EWING GALLOWAY

# MEXICO




A matador poised for the kill at a bullfight in Mexico City

Cathedral in Chihuahua city, built during the 18th century

Temple of the god Kukulcán at Chichén-Itzá, Yucatán, once capital of the second Mayan empire

Fishermen on Lake Pátzcuaro with butterfly nets across the bows of their canoes

Mt. Ixtaccihuatl, an extinct volcano near Amecameca, México state

A covered cart drawn by oxen in Oaxaca city

SCENES IN MEXICO

[illegible] EWING GALLOWAY (OTHERS) EWING GALLOWAY

**12. Revillagigedo Islands.**—About 450 mi. west of Manzanillo are the Revillagigedo Islands. They are the tops of volcanic peaks that are rooted in the floor of the Pacific ocean.

### B. Physiography

**1. Mexican Plateau.**—The major physiographic component of Mexico, the plateau extends more than 700 mi. southward from the frontier with the United States. Together with the flanking eastern and western ranges of the Sierra Madre it largely spans the country from coast to coast. The plateau surface is composed of broad basins and intervening mountain ranges. The average elevation of the basins increases from north to south, but relief is low compared to the relief displayed in the Sierra Madre Occidental, Sierra Madre Oriental and in the transverse axis of volcanoes. For convenience, the plateau proper may be divided into two components, northern and southern.

*Northern Plateau.*—Much of the lower northern plateau consists of broad bolson plains that are more or less continuous. The Bolsón de Mapimí and Bolsón de San Luis Potosí are the largest of such basins of interior drainage. A major exception to the bolson drainage pattern is provided by the Río Conchos and other right bank tributaries of the Río Bravo del Norte (Río Grande). Their system discharges into the Gulf of Mexico.

The broad alluvial basin floors are 3,000 or 4,000 ft. high to the north of latitude 25° N. Ephemeral lakes, sand dunes and patches of alkaline earth are common. Intermittently active washes lace the long slopes that rise from the basin floors to meet the mountain flanks.

In general, the mountains are 2,000 or 3,000 ft. higher than the desert basins. The ridges tend to be aligned from north to south or from northwest to southeast. Toward the west, flat-topped lava hills are more in evidence, while toward the east, narrow-ridged ranges are more common. In Coahuila the ridges of folded sedimentary rock include bituminous coal measures. This basic resource for northern industry is mined in the area from Piedras Negras to Monclova. Intrusives thread much of the uplands; associated with them are numerous deposits of such metallic minerals as silver, lead, zinc, mercury and gold. Near Durango is the iron ore deposit upon which the steel mills of Monterrey and Monclova depend.

Mountains in the northern plateau do not create barriers to communications. Railways and roads are general in distribution. They serve the region's oases and mining centres as well as providing links between the United States border and central Mexico. The oases are sustained by such streams as the Casas Grandes, Conchos, Nazas and Aguanaval, all of which arise in the Sierra Madre Occidental. The streams shrink appreciably once they enter the bolsons; irrigation, percolation and evaporation consume the water. Along with the bolson oases there are flood plain oases scattered along the depressions that have been carved by the Río Bravo and its tributaries. The oases at Ciudad Juárez and Ojinaga are representative of the latter; the Laguna district (Torreón) is the important bolson oasis watered by the Nazas and Aguanaval rivers.

*Southern Plateau and Volcanic Axis.*—In the higher southern plateau, volcanism has been more important in shaping the land. The features of the volcanic axis join with basin and range topography, and lava and ash accumulations have altered the contour of the basin floors. Further distinguishing the southern from the northern plateau is the nature of the drainage.

The heart of the southern plateau includes a series of broad alluvial surfaces, among which the Bajío, Toluca, Mexico and Puebla basins are notable. To the north of these basins (except for Puebla basin) are mountains that are similar to the ranges of the northern plateau. Separating the basins from each other, and to their south as well, are highlands that consist both of gentle knobs and rougher volcanic peaks. Within the basins lava has blocked drainage; ash and other rock waste have accumulated to considerable depths as well. Lakes and swamps are common.

Basins in the southern plateau usually are 5,000 to 8,500 ft. above sea level. The slopes above may be comparatively gentle. Rising to snow-cap elevations are the splendid volcanic peaks in the area that extends from Orizaba to Toluca. Westward from Toluca the massive volcanic boils are replaced by numerous cinder cones. Hot springs and lakes that result from volcanism are common in the high country south of the Río Lerma. The picturesque lakes, Cuitzeo and Pátzcuaro, are well known.

The southern plateau is drained by three of Mexico's major river systems. The Puebla basin is tributary to the Mexcala-Balsas system; the Río Lerma-Río Grande de Santiago watershed includes most of the plateau area west of the Basin of Mexico. Both river basins discharge into the Pacific. The Basin of Mexico had no exterior drainage until the 17th century when Spanish engineers opened the way to the Moctezuma-Pánuco system, which ends in the Gulf of Mexico. All of the rivers plunge through gorges of some magnitude as they leave the plateau.

In the southern plateau fertile soils support dense populations, whose farming heritage greatly predates the Spanish entry into the new world. One of the richest granaries is the Bajío, the district that lies along the Río Lerma between Acámbaro and La Piedad. The Puebla, Mexico and Toluca basins also have supported large numbers of village-dwelling farmers for centuries. The valley of Morelos, where the town of Cuernavaca stands, is another productive area of great age. It lies to the south of the main axis of the volcanoes.

The southern slopes of the volcanic axis present a very strong relief. The volcanic materials have been removed by headward erosion of the Río Balsas-Mexcala tributaries. Similar relief appears along the mountain bridge, the Sierra Mixteca (southeast of Puebla), which links the Mexican plateau and the Sierra Madre del Sur.

**2. Sierra Madre Occidental.**—The Sierra Madre Occidental extends approximately 700 mi. from northwest to southeast and is about 95 mi. in width. Summits mostly exceed 6,000 ft., and some peaks rise above 10,000 ft. From the east the mountains present relatively slight but broken relief; from the west they appear as formidable escarpments whose benched flanks drop into gigantic trenches. The great mountain ranges and trenches trend northwest to southeast, which is generally the trend of the folds in the Mesozoic and older basement strata. The local relief in the western *barranca* country may exceed 5,000 ft., and the canyons are sometimes considered to be as awesome as the Grand canyon of the Colorado river in the United States.

The rugged topography of the Sierra Madre Occidental has been a serious barrier to east-west communications. Because of the mountains, Spanish exploration, regional commercial evolution and the present road and railway systems developed independently on the plateau and in the lowlands of Sinaloa and Sonora states. No railroads cross the mountain barrier, although construction was begun many years ago on lines between Durango and Mazatlán and between Chihuahua and Topolobampo. The one federal highway to snake through the region links Durango with Mazatlán. The sparse settlement in this mountainous area is confined to mining centres or to farming and pastoral hamlets. Forest industries are most highly developed in the states of Chihuahua and Durango, but it may be that the long-term value of the forest-cover as watershed protection exceeds the timber's worth. The Sierra Madre Occidental is the source of waters which support the oases of the plateau and of the lowlands adjoining the Gulf of California. Oases that have been formed by water from the mountains include those along the Ríos del Carmen, Conchos, Nazas and Aguanaval, in the plateau. The westward flowing Yaqui, Mayo, Fuerte, Sinaloa and Culiacán rivers water important farming districts in the coastal lowlands.

**3. Sierra Madre Oriental.**—Extending southeastward from the "big bend" of the Río Bravo is a series of low mountains that are composed of folded sedimentary strata. South of Monterrey these mountains become a striking range, the Sierra Madre Oriental. Summit elevations are about 7,000 ft., but some peaks rise above 10,000 ft. (Cerro Peña Nevada). Steep-walled narrow valleys, a number of which are north to south in alignment, lie in the Sierra, and there are several gateways from the Gulf of Mexico lowlands to the plateau.

Among the substantial rivers which have watersheds that pene-

trate the eastern mountain flank of the Mexican plateau are the Ríos Moctezuma-Pánuco. This drainage system has captured a considerable area of the plateau. The process of capture was aided by the opening of a drainage canal in 1607 (amplified in 1900) to tap the Basin of Mexico. Numerous potential sources of hydroelectric development exist among the rivers that drain the eastern front of the mountains. Agricultural settlement is particularly dense in Veracruz.

**4. North Pacific Region.**—The North Pacific region consists of the parallel ranges and broad basins of Sonora state and the corridor of coastal plain, which all but end to the northwest of Tepic, the peninsular tilted blocks of Lower California and the Gulf of California trough.

*Sonora Plains.*—The basin and range topography of Sonora and Arizona are similar. The various basins, which diminish in elevation and which become broader from the northeast toward the Gulf of California, are flanked by great ramps of detritus and eroded bedrock. The ramps skirt block ranges, most of which are aligned from north to south. The mountains become more numerous and higher toward the northeast.

For the most part, the coast is straight, low and sandy, but there are bays of deep water surrounded by hills at Topolobampo and Guaymas. Intrusive rocks form the hills. Other sheltered bodies of water are lagoons enclosed by sandbars or sandy spits.

Between the Río Sonora and the Colorado river, streams rarely reach the sea. To the south are a number of fine oases where cotton, wheat, rice, sugar cane and vegetables are raised. They are served by a railway and road which parallel the coast. Mining centres, chiefly copper producers, are situated in the extreme northeast.

*Lower California.*—Lower California is a peninsula approximately 776 mi. long, averaging about 56 mi. in width. Its backbone of crystalline mountain blocks contains substantial areas where elevations exceed 5,000 ft., and there are peaks that reach 10,000 ft. The major ranges, the Sierra de Juárez and Sierra de San Pedro Mártir, present steep faces to the east and longer western slopes. To the south of latitude 30° N. the mountains usually are less than 5,000 ft. high. Tablelands are common. Diverging from the general mountain trend is the Sierra de Santa Clara, which lies to the south of the bay of Sebastián Vizcaíno. To the east and south of this range lie fairly broad areas of desert lowland.

There are some excellent natural bays on both coasts; Todos Santos and Magdalena on the Pacific side, and Santa Inés and La Paz on the Gulf of California side. Hinterlands are poor and small, although Ensenada is growing rapidly as a shipping port for the Mexicali valley.

At the head of the Gulf of California lies the delta of the Colorado river. The terrain that slopes toward the Salton sea, known as the Valle de Mexicali, becomes the Imperial valley in the United States. This land yields good crops of cotton, alfalfa and grain under irrigation. There are lesser oases scattered throughout the peninsula.

**5. Gulf of Mexico Coastal Plain and Yucatán Peninsula.**—To the east of the Mexican plateau and to the north of the mountainous region of Central American or Antillean Mexico lie the Gulf of Mexico coastal plain and the Yucatán peninsula. These lowlands of flat to slightly warped marine sediments are broadest at the extremities and narrowest between latitude 19° and 20° N.

*Gulf of Mexico Coastal Plain.*—The gradual tectonic rise of the Gulf of Mexico coastal plain developed in such a way that the greatest elevation and erosion occurred along the margin that abuts the Sierra Madre Oriental. There, low hills composed of sedimentary rock arise; elevations usually are below 650 ft. The hilly terrain is more common to the south of Tampico in the 175 mi.-long area known as La Huasteca. The coastal plain relief is almost featureless near the gulf. Wide beaches, sandbars, swamps and lagoons are characteristic. There are no good natural harbours along the northern gulf coast, but the Laguna Tamiahua affords sheltered water for coastal craft.

In central Veracruz state the usually broad coastal plain is pinched into a strip less than 10 mi. wide by spurs of the Sierra Madre Oriental. The plain is interrupted, and rocky coasts appear in conjunction with the hills clustered near San Andrés Tuxtla.

A number of Mexico's large rivers cross the coastal plain. In the north the Río Bravo del Norte and Tamesí-Pánuco systems are notable. South and east of the port of Veracruz the rivers Papaloapan, Coatzacoalcos, Grijalva and Usumacinta meander across the lowlands, forming extensive swamps as they near the sea. In this area the coast, consisting of sandbars and lagoons, affords little shelter for ships, and most ports are situated in the lower rivers. Although Veracruz developed in the lee of a small island, the natural qualities of its site are not as important in accounting for the city's growth as is its proximity to the economic heart of the country.

In Mexico it has been more important to have communications across the plain than along it, for the mineral, forest and farm products must be moved either into the densely populated highlands or seaward. All-weather roads serve the long-established cotton district of Reynosa-Matamoros, the petroleum fields and the fruit and livestock-raising districts near Tampico and Tuxpan, the farmlands of Veracruz and the sulfur and petroleum fields of Minatitlán. A railway connects Matamoros and Monterrey through the valley of the Río Bravo. There are two railways linking Tampico and the interior, and several lines fan to the west and south from the port of Veracruz. A railway link between Mérida-Campeche in the Yucatán peninsula, Minatitlán and the main network of the Mexican plateau follows the inland edge of the coastal plain.

*Yucatán Peninsula.*—The coastal lowlands attain their maximum breadth of approximately 275 mi. in the limestone platform of Yucatán. The flat to gently rolling terrain, much of it pitted, is highest in the centre of the peninsula and in northern Guatemala. Nevertheless, very little land is above 500 ft. in elevation. Surface drainage is almost absent because the precipitation percolates into the porous and soluble limestones. The accompanying subterranean solution has produced caverns and *cenotes,* the sinkholes that result when cavern roofs collapse.

On the west and north of the peninsula, the coast is marked by sandbars and lagoons. To the east lie reefs of coral. Mangrove swamps are common along the coasts and westward along the shores of Campeche gulf. Henequen production, forest industries and subsistence farming support the sparse population.

**6. South.**—The Mexican South is a mountainous region spanning 950 mi. from east to west and up to about 200 mi. from north to south. It extends from Cape Corrientes to the Guatemalan frontier, and lies to the south of the volcanic axis, the Gulf of Mexico coastal plain and the Yucatán peninsula. Included in the Mexican South are the Sierra Madre del Sur, the Isthmus of Tehuantepec and the Chiapas highlands.

*Sierra Madre del Sur.*—A labyrinth of narrow ridges and steep flanked valleys forms the Sierra Madre del Sur. Much of this broken country crests at elevations of about 6,500 ft., and a very few peaks exceed 10,000 ft. In general, the summit elevations are about the same as the basin floor elevations in the southern plateau region. Whereas the plateau's volcanic mantle is relatively free of dissection, the Sierra Madre del Sur has been stripped of much of its volcanic cover. The older basement rocks are exposed in what probably are the most highly dissected landscapes of Mexico. There is very little flat land in the region.

Abruptly terminating the region on the east is a magnificent scarp that overlooks the down-faulted block of Tehuantepec. The core of Sierra Madre del Sur is outlined by a narrow and discontinuous coastal plain to the southwest, and by the structural depression of the Balsas-Mexcala river on the north. To the east of this depression is the Sierra Mixteca, which forms a highland bridge between the volcanic axis and the Sierra Madre del Sur.

The Pacific shoreline corresponds with the trend of the Sierra Madre del Sur. Some sections are abrupt and rocky, and others are lagoon coasts. Natural harbours are superior to those on the Gulf of Mexico coast. The bays at Acapulco and Manzanillo are outstanding.

It has been very difficult to cross the Sierra Madre del Sur; no

railroad reaches the Pacific between Manzanillo and Salina Cruz. The highway to Acapulco from Mexico City is comparatively new. Other established routes to the sea from the north include the roads to Manzanillo, Navidad, Puerto Ángel and Salina Cruz.

The mountains contain iron ore, ferroalloy, lead, silver and gold deposits, some of which are being worked. Agriculture is largely for subsistence. The remoteness of the region has allowed Indian culture and languages to be preserved very well.

*Isthmus of Tehuantepec.*—Tehuantepec's rounded hills are topographically similar to the hills of the inner Gulf of Mexico coastal plain, but their geologic history is more closely related to that of the Sierra Madre del Sur and the Chiapas highlands. This hilly gap between major mountain regions is a communications corridor of considerable antiquity. Railway, road and pipeline cross it today; construction of a canal has been considered for many years.

*Chiapas Highlands.*—The Chiapas highlands region attains elevations of more than 5,000 ft. within 25 mi. of the Pacific coast, and there are several peaks, including Tacaná volcano, that exceed 10,000 ft. The southern mountain flanks are abrupt; their drainage feeds a number of short streams which have built up the lagoon-fringed coastal plain. Northeast from the summits the terrain descends more gradually into the structurally depressed valley of the Río Grijalva. Much of this broad depression is between 1,000 and 2,000 ft. elevation.

Fairly abrupt slopes outline the margin of a small plateau which overlooks the Chiapa depression from the northeast. The upland surfaces, most of them less than 6,000 ft. in elevation, are rather gentle. However, the faces of deeply faulted blocks of limestone create a difficult terrain between the plateau summit and the lowlands of Yucatán and the Gulf of Mexico coastal plain.

The region is pastoral and agricultural. Coffee is produced at intermediate elevations in the highlands. Mining, forest industries and manufacturing are undeveloped. Until the Inter-American highway was constructed through the highlands they were an isolated part of Mexico. The Pacific lowlands are served by a railway.

### C. Climate

Over almost all of Mexico the climate is either tropical or subtropical, and most of the country is deficient in moisture at least part of the year. The extent of tropical thermal conditions is less than the latitudinal position of the country might suggest because much of Mexico to the south of the Tropic of Cancer is highland. For each 1,000 ft. of elevation above the tropical lowlands the average annual temperature decreases about 3° F.

**1. Elevation and Climate.**—Elevation probably is more important in determining thermal characteristics of Mexican climate than is latitude. The decrease of temperature that occurs with increasing elevation permits the formalizing of vertical temperature zones: *tierra caliente* or hot land, *tierra templada* or temperate land and *tierra fría* or cold land. Unlike climatic areas farther from the equator, the seasonal variations in temperature are not marked at any elevation in the tropics.

The *tierra caliente* is restricted to tropical areas having elevations no higher than 2,500 or 3,000 ft. Mean annual temperatures are above 75° F. Seasonal and diurnal temperature ranges are slight. The *tierra templada*, which rises to about 6,000 ft., has mean temperatures of 65° to 75° F. Much of highland Mexico is in this thermal zone. It is the most pleasant of the zones insofar as human comfort is concerned. During winter frost may occur above elevations of 3,000 ft. In the cooler *tierra fría* the mean annual temperatures are between 55° and 65° F. Above 10,000 or 11,000 ft. the mean annual temperature is less than 50° F.; above 14,000 or 15,000 ft. the mean annual temperature is less than 32° F.

Mountain masses, besides creating islands of cooler climate within the tropics, play a major role in the incidence of clouds and precipitation. The mountains form barriers over which air may be raised, cooled and caused to condense. Within the mountains and in their lee there is a lower incidence of clouds and precipitation. Lee or descending air becomes warmer, and its capacity to retain moisture rises. Illustrating the effect of the mountains upon precipitation and cloudiness is the contrast between 80 in. of rain and 150 cloudy days per year for the eastern slopes of the Chiapas highlands and the Sierra Madre Oriental and the 40 in. of rain and 90 cloudy days per year that characterize much of the Pacific slope west of the Isthmus of Tehuantepec. The drier areas are in the "rainshadow" of the mountains.

**2. Prevailing Winds and Climate.**—In the summer and fall the inflow of warm Atlantic-Caribbean air with high relative humidity determines the character of weather in the Mexican highlands as far west as the Sierra Madre Occidental and to the crests of the Sierra Madre del Sur and the Chiapas highlands. Similar warm and humid air moves onshore from the Pacific during the summer. As a result of the air movement pattern, the seasonal precipitation exceeds 40 in. in the southeast. It diminishes to the north and northwest, dwindling to less than 5 in. in the extreme northwest. The rain usually falls in afternoon and evening convectional showers, but orographic and cyclonic lifting of air are also involved in producing rain.

During the winter, northern Mexico is dominated by the type of weather that marks the southwest of the United States in that season. Generally the atmospheric pressure is high and relative humidity is low. Temperatures are cool, and the skies tend to be clear. Rain occurs with the passage of occasional cyclonic disturbances. There is a pronounced temperature gradient between the northern and southern parts of the country. Occasionally between October and February a tongue of cold air will sweep from central Canada into Mexico and over the Gulf of Mexico. The north winds cause turbulence in the air and rough seas. Behind a squally front the chill air may penetrate across Yucatán and the Isthmus of Tehuantepec. During these northern storms, frost may occur in the coastal lowlands almost as far south as Tampico. Frosts affect the lowlands adjacent to the Gulf of California about as far south as latitude 28° N.

During the summer the north and northwest are hot and dry. The area adjacent to the head of the Gulf of California is particularly warm. On at least 15 days every year temperatures may reach 110° F. or over. This is the hottest part of Mexico. After June, especially, thundershowers arise from air that has flowed inland from the Gulf of Mexico or from the Gulf of California.

**3. Hurricanes.**—Hurricanes of Atlantic-Caribbean origin and of Pacific origin may strike Mexican coasts during the period from June to November. Generally speaking, the Pacific ocean hurricanes are smaller and less intense. In either case, substantial damage may result to farms, roads, urban centres and ports from excessive precipitation, winds and turbulent seas.

### D. Climatic Regions

The system of climatic classification used, a modification of the system devised by Wladimir Köppen (*q.v.*) recognizes three thermal regions: tropical, mesothermal and microthermal. It also distinguishes between constantly wet areas, areas with a short dry season and areas having a pronounced dry season in winter or in summer. Another important distinction is made between subhumid and humid climates.

**1. Tropical Climatic Regions.**—Among the tropical climates the humid ones are here classified as one (AF), although there are areas where a short dry season (Am) prevails. These are termed the tropical rain forest climates because of the predominant vegetation. Where a pronounced winter dry season occurs in the tropics (Aw), the region is said to have a tropical savanna climate. The rain forest and savanna climatic types coincide with the *tierra caliente*. The humid phase is largely oriented toward the east. The winter dry phase prevails over the Yucatán peninsula, a large part of the Gulf of Mexico coastal plain and the Pacific lowlands.

**2. Mesothermal Climatic Regions.**—In general, the mesothermal climates are either humid throughout the year or dry in the winter. However, a small northern segment of Lower California is dry in the summer (not shown on map). Typically the dry winter mesothermal climate (Cw) is the *tierra templada*. The humid mesothermal climate (Cf) is confined to a band along the eastern slope of the Sierra Madre Oriental and the Gulf of Mexico

coastal plain north of the Tropic of Cancer. Together, the mesothermal climates occupy about a quarter of Mexico.

**3. Microthermal Climatic Regions.**—Areas of microthermal and snowcap climate are too restricted in extent to be mapped. Most of these areas occur on the higher summits of the volcanic axis. The elevation of the snow line is about 14,500 to 15,000 ft.

**4. Subhumid Climatic Regions.**—The subhumid climatic regions cover about one-half of the area of Mexico. They are either arid (BW) or semiarid (BS). Most of the subhumid lands are subtropical. The arid or desert regions include parts of the northern plateau and lands adjacent to the Gulf of California. The semiarid or steppe areas tend to be transitional between desert and humid climates, but there are isolated semiarid intermontane pockets to the south of the volcanic axis. The northwestern corner of the Yucatán peninsula is a tropical semiarid area.

### E. Vegetation

Mexico's regional differences in vegetation reflect climatic differences. In the south and southeast the cover is tropical rain forest, woodland, chaparral or grassland, while in the north and northwest the vegetation is subtropical desert, steppe or chaparral. Within the tropics the effect of elevation is expressed in a gradual shift from lowland species through the more cold-tolerant species of the *tierra templada* and the *tierra fría*. Tundra or alpine vegetation occurs above about 13,000 ft. In the arid and subhumid north and northwest, precipitation as well as the thermal tolerance of plants is important in controlling vegetation distribution. Whatever the region, the diversity in detail of local cover may reflect variations in soil, exposure to wind and sun and the proximity of the water table underground. In all regions, too, the vegetation may show evidence of having been altered by man. Forests and brush have been cleared to prepare land for farming or to produce lumber, firewood and charcoal. Grazing or browsing livestock and the common herdsman's practice of burning off the old cover also have altered the vegetation. The extent of grasslands in the Gulf of Mexico coastal plain, the scrubby appearance of brush and forest in many tropical areas, and the bareness of slopes near Mexico City and close to archaeological and mining centres in the highlands can be attributed largely to man's activities. Many Mexican landscapes are denuded and scarred with erosion because of man's abuse of the natural cover.

**1. Tropical Forests.**—The vegetation of the tropical rain forest is notable for the diversity of plant species. Broadleaf evergreen forms are dominant. The exuberance of growth reflects prevailing high temperatures and abundant rainfall. Typically, straight-stemmed forest giants support a sombre green canopy of interlocking branches and vines. Below the canopy, which may be 100 ft. above the ground, palms, bamboo and the lesser broadleaf trees form an intermediate level of tree tops. Lianas are common; epiphytes and parasites are everywhere from forest canopy to floor. As a rule, shrubs and grasses are of minor importance because so little light reaches the ground.

Where the climate is dry seasonally, the forest develops a semideciduous character; trees, many of which are thorny types, are smaller and less dominant than in the rain forest. Cacti may be fairly common. The stands of small trees and the ground-cover frequently are thick enough to be called jungle. Tree forms become gnarled and scrubby, and their spacing more open in areas where the dry season is prolonged.

Around the coastal swamps and inland along the meandering rivers, forests of mangrove and other water-tolerant trees and palms occur. The fresh-water lakes and marshes that lie inland have a characteristic cover of grassland with clumps of trees interspersed. This may be a response to local soil conditions or to human activity.

Most of Mexico's tropical forests grow on the Gulf of Mexico coastal plain, on the southern part of the Yucatán peninsula and on the lower slopes of the adjacent highlands. Although not shown on the map, there are areas of forest on the lower, Pacific ocean flank of the Chiapas highlands. Other strips of tropical forest stand on the slopes above the eastern lowland areas.

Among the better-known economic trees of the wet tropical forests are the Spanish cedar, logwood, mahogany, lignum vitae, rosewood, sapodilla, copal and the silk-cotton tree. Lumber, cabinet wood, gums, resins, and dyes are collected. Plantation and subsistence agriculture are carried on.

**2. Tropical Savannas.**—Although tropical savannas are formed principally of coarse herbaceous plants, they may include scrub trees, shrubs and cacti to such a degree that an open woodland exists. Whether woodland or grassland, the savanna landscape is bleak, with brown and gray the dominant colours during the height of the dry season. Islands or strips of green vegetation may persist along stream courses or where the water table remains high. Wooded belts of this type are termed gallery forest. When the rainy season begins, the landscape of dormant trees and dead grass stems bursts into green.

Savanna areas of Mexico include northern and eastern Yucatán, the Gulf of Mexico coastal plain between latitude 18° and 24° N. and the Pacific slope plains and mountains from the Guatemala border to about latitude 26° N. The Balsas and Chiapa depressions are also savanna regions.

Northwestern Yucatán supports a chaparral and grassland cover that is patched with agaves and cactus. Henequen is the chief economic plant native to this area. The wooded savannas yield the same type of economic products as the more humid forests. Subsistence farming and cattle raising are practised in the savanna areas.

**3. Subtropical Woodland-Forests.**—In the heart of tropical Mexico there is a gradual vertical supplanting of tropical by subtropical plants. In the mountains at elevations between 1,200 and 2,000 ft. the tropical forms thin out rapidly. The subtropical or mountain woodland-forest contains many different varieties of oak and other broadleaf trees; epiphytes are common. The oaks remain abundant to about 4,500 ft. Pines may appear around 3,000 ft. elevation. They are most numerous at elevations of 5,900 to 7,000 ft.; nevertheless, the open forests usually include oaks. The mixed forests of conifers and hardwoods become woods only of pine and fir above 11,000 ft. The timber line is at about 12,500 to 13,000 ft. The ground cover in the mountain woodland-forest is predominantly grass. Nearer the snow line the vegetation consists of stunted woody plants, hardy grasses and flowering plants.

The lower Pacific flanks of the Sierra Madre Occidental bear a sparse cover of cactus, agave and mesquite. Oak, cedar and other small trees grow from about 3,000 to 5,000 ft. Yellow pine becomes common higher on the slopes. The open coniferous forest in the higher areas includes the pine, Douglas fir, aspen and spruce. This is Mexico's most important reserve of temperate woods.

**4. Subtropical Brush-Scrub Woodlands.**—There are elements of subtropical vegetation in northern Lower California and in northeastern Mexico, including scrub woodlands and brush, and annuals. In northern Lower California a limited area of scrub woodland and brush lies between the lowland steppe and the highland woods. The woody plants include the broadleaf, sclerophyllous evergreens which are associated with the chaparral cover of adjacent southern California. At higher elevations the vegetation is similar to the cover on the Sierra Madre Occidental.

In the northeast, north of the Rio Tamesí, a subtropical chaparral is the dominant cover inland from the strip of coastal swamps and dunes. Dense stands of mesquite are typical. Clumps of tropical trees and of palmetto occur in the brush toward the south; islands of grassland appear occasionally throughout the area. South of the Rio Tamesí, the cover becomes more tropical.

**5. Dry Subtropical Vegetation.**—The bulk of the area of the Mexican plateau is a subhumid to semiarid land where grasses and drought-resistant plants predominate. Pockets of this type of vegetation also occupy subhumid rainshadow areas in the mountain bridge between the volcanic axis and the Sierra Madre del Sur.

The transition from subhumid, or steppe, vegetation into arid, or desert, vegetation is gradual. Drought-resistant woody plants, cactus and agave may occur in either the steppe or desert, but the steppe has a more complete ground cover. Grasses occupy the ground between the scattered larger plants; in the southern plateau the grass cover becomes prairie-like.

Vegetation in the desert areas of the plateau lacks the diversity

of species and of plant numbers that the Sonora desert possesses; it is a more open and less attractive desert cover. There are extensive areas with little or no plant growth. Nevertheless, creosote bush, prickly pear and other cacti, the ocotillo, agaves, yuca, guayule and mesquite are widespread. After rainy periods the ground may become brilliant with flowers and fresh grass.

In the desert of Sonora grows what may be the greatest cactus garden in the world. Columnar and candelabra forms and barrel cacti down to pincushion size are common, and the bushy opuntias are very numerous. The desert is never dreary, but in spring it is most attractive. To the mosaic of cover may be added large patches of creosote bush and the scattered ocotillo. Cottonwood and mesquite appear along watercourses. The desert vegetation of Lower California is similar, although there are also plants peculiar to the region.

### F. Animal Life

Since Pliocene times—that is to say, since the two Americas were united—the animals of the two continents have merged, and the Mexican fauna of today includes animals from both South and North America, with a predominance of the latter. The high plateau attracted North American animals as the wolf, coyote, buffalo, bear and beaver, while the lowlands, on both sides and to the south, forced the South American fauna (jaguar, puma, five species of monkeys, etc.) toward and into the United States. Besides the above-mentioned, the Mexican fauna includes the *ocelotl*, a typical Aztec name, the lynx, badger, otter, raccoon, tapir, two species of peccary, the skunk, several species of opossum, the sloth, two species of ant bears, the armadillo, at least three species of deer, the Mexican big horn (still found in Chihuahua and Lower California), the fur-bearing seal and many different kinds of small rodents. Bats are numerous, among them the dangerous vampire, which makes it difficult to keep horses in some parts of Chiapas and Campeche.

Mexican birds are extremely numerous and comprise many beautiful species, while a few (notably the *zenzontle* or mockingbird) are songsters, the latter being identified with the cold and temperate zones. In the warm zone, on the other hand, as well as in the temperate, are found many varieties of parrots, parakeets and macaws, along with toucans, spoonbills, boatbills, ducks, pelicans, cormorants, sandpipers, curlews, grackles, chachalacas (*Ortalis vetula*), woodpeckers, jays, cuckoos, turkeys, partridges, quail and doves (sometimes seen in immense bevies), buzzards, especially the black zopilote which is protected by the Mexican laws as the scavenger of the country, and many hummingbirds (*chupaflor, chupamiel*). The gorgeous quetzal (*Pharomacrus mocino*) has almost disappeared from Mexico and is now rarely found even in Guatemala where its love of freedom has made it the emblem of the country. The turkey is the only important domestic animal of Mexican (and American) origin that was added to the European farmyard.

Reptiles of many species can be found throughout Mexico. All tropical rivers and lagoons abound in caymans, while the sea gives abode to enormous turtles and the swamps to tortoises and iguanas. One species of iguana, the black one, is largely arboreal. Lizards of many varieties are found everywhere; snakes are equally abundant, some, such as the *palanca* (fer-de-lance of Martinique), the *naoyaca* and 13 out of the 15 species of American rattlesnakes, being much dreaded. Many interesting varieties of amphibians are also to be found, as, for example, the remarkable tree-climbing frogs—toads and the famous axolotl.

Despite an abundance of fish, Mexico's commercial fishing industry has remained relatively undeveloped. Foreign fishing boats, especially those of U.S. registry, are active on the continental shelves beyond territorial limits. Shrimp and prawn fishing became a major enterprise in the 1950s.

In the tropical parts of Mexico man's greatest and most dangerous enemies are the insects, especially the many varieties of *garrapatas* or ticks, nigua or chigoe (*Tunga penetrans*), jején or gnat, mosquitoes and fleas. The ticks in some instances have wiped out cattle and horses from certain districts. Numerous species of ants are also found, the most famous being the leaf-cutting variety. The most destructive type of insect, however, is the so-called white ant or termite. (G. C. E.; H. J. Bx.)

## II. GEOGRAPHICAL REGIONS

If the physical geography of Mexico is clearly understood, it becomes relatively easy to visualize the generalized geographical regions into which the country may be divided. The plateau and associated mountain areas are divided into a northern and a southern region. The Sonora plains and Lower California may be grouped in a north Pacific region. Two regions located in the eastern lowlands are the Gulf of Mexico coastal plain and Yucatán. All of the Chiapas highlands, the Isthmus of Tehuantepec and the Sierra Madre del Sur may be considered the Mexican South.

**1. Northern Plateau.**—The northern plateau is a sparsely covered elevated land of basins and parallel ranges where irrigation farming, pastoral pursuits, mining and forest industries are among the chief activities. The population is clustered about oases, mining centres and the regional manufacturing, service, communications and administrative hubs. Important cities where these functions are concentrated include Monterrey, Saltillo and Monclova, all in the northeastern part of the region. Chihuahua, Torreón and Durango lie to the west.

**2. Southern Plateau.**—In the southern plateau the basin and range topography and the volcanic axis features are present. A densely populated area of village-dwelling farmers, this is the core region of Mexico. Its climate, scenery and cultural attraction draw much of the country's considerable tourist trade. In the southern plateau lies Mexico City, a vigorous metropolis which sets the tone for nearly all aspects of national life. It is the governmental, ecclesiastical, commercial and cultural capital of the country. Guadalajara, to the west, and Puebla, to the east, are centres of government, commerce, manufacturing and tourism.

**3. North Pacific Region.**—North Pacific Mexico is a land of block ranges, basins and narrow coastal lowlands where, because of the aridity, economic life is clustered along watercourses. Farming and livestock raising, fishing and mining are the major activities of the region.

**4. Gulf of Mexico Coastal Plain.**—The Gulf of Mexico coastal plain is Mexico's most important source of mineral wealth. Petroleum, natural gas and sulfur are produced. In the different segments of the region commercial agriculture embraces cotton, tropical fruit and vegetable and staple food crop production. Extensive areas of woodland and forest have been cleared to develop the agricultural as well as the pastoral potential of the region. Here, as in the northern plateau and north Pacific Mexico, the government has undertaken large-scale irrigation, flood control and hydroelectric power projects. Population concentrations are greatest about Veracruz, and La Huasteca, south of Tampico. Fishing is an important activity in the gulf.

**5. Yucatán Peninsula.**—Remote and sparsely populated ex-

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cept in the northwest, Yucatán is the wooded limestone shelf that forms a foreland to the Central American segment of the Antillean structural system. Near Mérida, henequen production has been the most important activity for many decades. The remainder of the peninsula supports various forest industries. Fishing is of considerable importance in the gulf ports of Progreso and Campeche.

**6. South.**—The Mexican South includes the sparsely populated Chiapas highlands and Isthmus of Tehuantepec and the more densely peopled Sierra Madre del Sur. The region has been removed from the stronger currents of change in national life. Subsistence farming is the chief pursuit of the largely Indian population. Mining and tourism are important in several parts of the region. (J. T.)

## III. THE PEOPLE

**1. Racial Types.**—The census of 1921 was the latest in which a racial classification of Mexico's population was attempted. At that time 10.3% of the people were classified as whites, 29.2% as Indians and 60.5% as mestizos (mixed bloods). Approximately the same proportions probably are to be found in the second half of the 20th century, although the percentage of the whites undoubtedly has increased somewhat and that of the Indians decreased. Culturally, however, there has been a great change, as increasing numbers of the people have given up their Indian ways of life. There are comparatively few Negroes and mulattoes, with estimates of their numbers ranging from about 15,000 to 120,000. The majority of them live along the Pacific coast in the state of Guerrero, but several thousand are found on the Yucatán peninsula adjacent to British Honduras and Guatemala, and a few hundred reside in Mexico City and the other large cities. There are some Chinese in the cities and along the Pacific coast in southern Mexico, but reliable estimates of their numbers are lacking.

Mexican anthropologists, led by Manuel Gamio and Alfonso Caso, have insisted that the census counts do not reflect the true importance of Indians in the population. For example, Gamio, writing in 1935, cited census data indicating that the number of Aztecs (a part of the Nahuatl linguistic group) was 516,410 in 1910 and 472,690 in 1930. He then gave estimates by explorers who recently had visited the Aztec areas that their numbers were "probably more than 1,500,000, including the Tlaxcaltecas"; more recently, Caso has written that almost all of those classified as bilingual in census tabulations in reality are persons who identify themselves with an Indian community, who speak one of the Indian languages as their native tongue and who know only a little Spanish. If the necessary allowances are made for these qualifications, it is probable that during the decade from 1960 to 1970 estimates of 10% white, 65% mestizo, and 25% Indian are about as accurate as can be obtained with respect to the relative importance of the racial types in Mexico's population.

**2. Languages.**—When Hernán Cortés and his followers reached Mexico in 1516, they found the inhabitants sharply differentiated into numerous linguistic groups. The conquering Spaniards maintained their native Castilian tongue, taught it to their children, and promoted its use by the mestizos and by the Indians with whom they came into contact. Throughout the long colonial period and during Mexico's history as an independent nation, the governmental and religious authorities continued to pursue the policy of fostering the use of Spanish by the masses of the Mexican population. Nevertheless, an extreme diversity of languages remains as one of Mexico's most distinctive characteristics.

Wherever the ruling groups use a tongue that is different from those employed by most of those whom they rule, census enumerations are almost sure to overemphasize the importance of the language used by the former and to under-emphasize the importance of the linguistic stocks of the latter. Certainly this has been true in Mexico ever since the censuses attempted to determine the linguistic affiliations of the population. The result is that the numbers and proportions of those whose mother tongue is one of the American Indian languages and not Spanish is considerably larger than would appear from the census data on the subject. Census returns classify 85% or more of the population of five years of age and over as speaking Spanish only, about 7–8% as bilingual (Spanish and one indigenous language), about 4% as speaking an indigenous language only and less than 1% as using other languages.

The degree to which the Indian languages have persisted as almost the sole means of communication varies widely from one part of the republic to another. Thus in the following state and territorial divisions of the nation more than 98% of the population speak only Spanish: Aguascalientes, Baja California Sur, Coahuila, Colima, Durango, Guanajuato, Jalisco, Nayarit, Nuevo León, Sinaloa, Tamaulipas and Zacatecas. Were it not for the fact that large numbers of foreigners are concentrated in Mexico City, the federal district also would be included in this category. At the other end of the scale is the state of Yucatán, where only about 36% of the population speak Spanish only, followed by Oaxaca (52%), Quintana Roo (53%), Campeche (68%), Chiapas (74%), Hidalgo (75%) and Puebla (78%).

Not only do large segments of the Mexican population speak exclusively or almost exclusively one of the Indian languages, but the diversity of the tongues which they use is very great. There is no one Indian language that is intelligible to all. Authorities differ, but the number of distinct linguistic families represented in Mexico seems to be at least 12, and these in turn are divided into between 50 and 100 different languages. Ordinarily the census enumerators must make use of about 50 separate and distinct languages, of which the majority belong to the Nahuatlan, Mayan, Otomian, Zapotecan and Totonacan linguistic families.

Nahuatl is the mother tongue of the largest number of those Mexicans reported as speaking exclusively one of the Indian languages and is also the one whose use is most widely distributed throughout the republic. Even so, however, the Nahuatl-speaking peoples are confined largely to the band of states extending across the central part of the nation from Guerrero on the Pacific coast to Veracruz on the Gulf of Mexico.

**3. Religion.**—Nearly all of the people of Mexico are Christians, and the vast majority of them are affiliated with the Roman Catholic Church. Census reports classify about 96.5% of the population as Roman Catholics, 1.7% as Protestants, about 0.3% as Jews, and about 0.4% as other religions.

It is quite unlikely that the millions of persons who can communicate only by means of one of the Indian languages, and who have retained most of the other features of their primitive cultures, have become thoroughly Christianized. Religion, as is well known, is a part of the cultural heritage to which a people clings tenaciously, and the many Indian groups in Mexico are no exception to this rule. As a result, throughout much of Mexico and especially in the southern portion of the nation, the religious beliefs and practices of the people are a combination of Christian and indigenous elements whose relative importance varies considerably from one place to another. The Christian features predominate in the northern states and in the major cities, whereas in much of the Yucatán peninsula, in Chiapas, in Oaxaca, and on into Veracruz, Puebla and Guerrero, Indian beliefs and practices form substantial parts of the religious complex.

**4. Customs and Culture.**—The customs and culture of the Mexican people vary greatly, ranging from the most ancient practices to the most modern patterns. They consist in large measure of the same native customs that Cortés found in 1516, although people of the upper and middle social classes maintain many of the cultural features and ways of life (such as the siesta and the rigid chaperonage of young women) that were brought from Spain. Influences from the United States and from western Europe are potent factors in the rapid social change taking place in Mexico, especially in the larger cities, during the second half of the 20th century. (*See* IBERO-AMERICAN ARCHITECTURE; IBERO-AMERICAN LITERATURE.)

In spite of the widespread changes associated with the revolution of 1910 and with the growing industrialization and urbanization during World War II, however, at mid-20th century (according to the 1950 census) 43% of the population of five years or more of age was unable to read or write any language; 106,272 or 1.1%

of those 25 years of age or more had completed more than 12 years of formal schooling; 46% of the population never ate bread made of wheat; and 54% of the population wore shoes.

Mexico's folk art is richly expressed in painting, sculpture, music, the dance, ceramics, weaving, needlecraft, basket making and metal working. The Palace of Fine Arts in Mexico City is symbolic of the concern of the upper classes with classical music, opera, painting, sculpture, drama and the ballet. Throughout Mexico are hundreds of small communities whose artists and artisans produce distinctive types of earthenware, sarapes, leatherwork, baskets, blouses and skirts, hats, lacquer ware and glassware; the hub of each of these communities is the ceremonial centre, in which music, regional dances and processions are attractions that result in frequent gatherings of the populace.

(T. L. Sh.)

## IV. HISTORY

For ancient Mexico before the Spanish conquest *see* the articles Aztec; Latin America: *The Pre-Columbian Period;* and Middle America.

### A. Colonial Period (1519–1821)

The conquest of the Aztecs by a Spanish force under Hernán Cortés between 1519 and 1521 inaugurated the colonial period of Mexican history. Mexico remained part of the Spanish empire until the establishment of independence in 1821. Along with neighbouring regions, it was officially known as New Spain.

**1. Expansion of Spanish Rule.**—After taking possession of the Aztec empire, the Spaniards quickly subjugated most of the other Indian tribes in southern Mexico, and by 1525 Spanish rule had been extended as far south as Guatemala and Honduras. Much of the remainder of Central America had already been occupied by expeditions moving northward from Panama. The only area of southern Mexico where effective Indian resistance was encountered was Yucatán, inhabited by the Maya tribes. Francisco de Montejo undertook the conquest of this region in 1526, but it was nearly 20 years before the Spaniards won control of the northern end of the peninsula, and some of the Indians in the interior retained their independence for another century and a half.

The occupation of northern Mexico, which was thinly populated and largely arid, proceeded more slowly than did that of central and southern Mexico. Spanish expansion in this area was motivated chiefly by the hope of discovering precious metals, the need for defense against nomadic Indian raiders and the desire to forestall the British and French.

Between 1530 and 1536 Jalisco and other Pacific coast regions were conquered by Nuño de Guzmán. The Indians of Jalisco rebelled in 1541 but were suppressed after hard fighting; this episode became known as the Mixton War. In order to complete the subjugation of the Indians, the Spaniards began to move into Zacatecas, where in 1546 they discovered immensely valuable silver mines. This was quickly followed by similar discoveries in Guanajuato and San Luis Potosí and by the occupation of most of this north-central region. Meanwhile Alvar Núñez Cabeza de Vaca, shipwrecked on the coast of Texas in 1528, had spent eight years making his way across northern Mexico before reaching a Spanish settlement on the Pacific coast and had brought back stories of rich Indian civilizations that supposedly existed somewhere in the north. During the years 1540–42 Francisco Vázquez de Coronado led an expedition northward to search for these mythical kingdoms, exploring as far as Kansas before turning back in disappointment. The effective occupation of northern Mexico occurred later in the century, and involved prolonged fighting with nomadic Indian tribes. Throughout much of the north the first Spanish settlers were Franciscans and Jesuits who established Indian missions. In all parts of Mexico, Indian tribes living in unattractive mountain, desert or forest country were left largely undisturbed.

Near the end of the 16th century the northern frontier of New Spain in most areas was close to the present Mexican-United States boundary line. Within the area that is now the United States a settlement had been made in Florida in 1565. In 1598 Juan de Oñate began the conquest of New Mexico, though the Indians of the region rebelled in 1680 and were not reconquered until 1694. Later northern expansion was undertaken mainly to check rival European powers. After the French had established colonies in Louisiana, Spanish settlements were made in Texas in 1716, while on the Pacific coast the threat of Russian expansion caused the Spaniards in 1769 to begin the occupation of upper California. Throughout the 18th century there were incessant boundary disputes between Spain, Britain, France and subsequently the United States, and some territories changed hands several times. Florida was ceded to Britain in 1763, restored to Spain in 1783 and sold to the United States in 1819. Louisiana became Spanish in 1763, but was regained by France in 1800 and sold to the United States three years later. The northern boundary of New Spain remained largely indeterminate until the Adams-Onís treaty of 1819, by which the United States acquired Florida but recognized Spanish sovereignty over Texas, New Mexico and California.

**2. Government.**—The supreme authority over the Spanish empire belonged to the king, assisted by the Council of the Indies. The chief purposes of Spanish administration were to maintain absolute royal authority, to extract wealth from the colonies and to protect and Christianize the Indians. The numerous humanitarian regulations included in the Laws of the Indies were, however, not effectively enforced owing to opposition from the Spanish settlers in the new world. In order to achieve these purposes all important positions in both state and church were normally reserved for natives of Spain, who became known in Mexico as *gachupines*. Persons born in the new world of Spanish descent, known as Creoles, ordinarily were admitted only to subordinate posts in the administrative hierarchy.

New Spain was placed under the rule of royal officials in 1523 and was organized as a viceroyalty in 1535. A series of viceroys, 62 in all, continued to rule the colony until independence. The viceroy was assisted by an *audiencia*, consisting of four or more *oidores*, which also acted as a court of appeals. A subordinate *audiencia*, with headquarters at Guadalajara, exercised jurisdiction over the northwestern area. The colony was divided into provinces ruled by governors, and these were subdivided into smaller units entrusted to *corregidores* or *alcaldes mayores*. The only institutions permitting any degree of self-government were the city councils (*cabildos* or *ayuntamientos*), composed of *alcaldes ordinarios* and *regidores*. These councils consisted largely of Creoles, but they were not allowed much authority.

The viceroyalty included the West Indies and Central America, though in practice these areas were mostly left under the control, respectively, of the *audiencia* of Santo Domingo and the captain-general of Guatemala. During part of the colonial period the viceroy of New Spain also had jurisdiction, at least in theory, over Venezuela and the Philippines.

Spanish control over the economic development of its colonies was rigid and comprehensive. In accordance with mercantilist theory, the colonies were expected to concentrate on producing raw materials and precious metals, little manufacturing being permitted. All goods shipped to and from the colonies were required to pass through Spain, direct trade with foreign countries being prohibited. The colonies were subject, moreover, to a wide variety of taxes, both direct and indirect. The produce and revenues of the colonies were shipped to Spain in the annual treasure fleet.

The organization of Spanish rule over New Spain was mainly the work of the first viceroy, Antonio de Mendoza (1535–50). His successor, Luis de Velasco (1551–64), was also an able administrator and is remembered as "the Liberator" because of his emancipation of numerous Indian slaves. Many of the succeeding viceroys during the later 16th and 17th centuries displayed less competence and integrity, and the whole system of administration became increasingly inefficient and corrupt. But the accession of the Bourbon dynasty in Spain in the 18th century brought reforms, especially during the reign of Charles III (1759–88). José Gálvez, dispatched to New Spain as *visitador general* in 1765, did much to improve conditions. The chief administrative change was the replacement of the governors and other lower officials by 12

intendants, who ruled much more efficiently. A liberalization of the economic regulations led to a rapid growth of prosperity. The later 18th century, especially during the viceroyalties of Antonio María Bucareli y Ursúa (1771–79) and Count Revilla Gigedo (1789–94), was the golden age of New Spain.

**3. The Church.**—The propagation of Christianity was one of the main purposes of Spanish imperialism, and church and state were closely connected. Roman Catholicism was the only form of religion that was permitted. The crown received from the papacy the right to make all ecclesiastical appointments and control ecclesiastical revenues. Systematic conversion of the Indians began in 1522 with the arrival of three Franciscan friars. The main organizer of the church in New Spain was Juan de Zumárraga, who became the first bishop of Mexico in 1528.

As a result of the efforts of the various orders of friars, almost all of the Indians were won to at least a nominal acceptance of Christianity. However, conversions were often superficial, and pagan ceremonials, especially religious dances, were transferred to the service of the church. After an area had been successfully Christianized, it was turned over to the secular clergy, though in some regions, especially in the north, friars continued to conduct missions until the 19th century. The conversion of the Indians was hastened by the belief that in 1531 the Virgin appeared to an Indian peasant at Guadalupe, ordering that a church be built at that place and imprinting her portrait on his blanket. The picture of the Virgin of Guadalupe became the most precious object in Mexico and was regarded as a symbol of divine care for the conquered Indian population.

The church had exclusive control over education and culture. During the early colonial period the clergy did much to educate the Indians and teach them new economic techniques, especially notable being the work of Vasco de Quiroga, the first bishop of Michoacán. Higher education, mainly for persons of Spanish descent, was conducted by the Royal and Pontifical University of Mexico, opened in 1553, the oldest university in the western hemisphere, and by a number of other colleges, those maintained by the Jesuits being of especially high quality. Members of the clergy made important contributions to learning, especially in the study of Indian antiquities and of the natural phenomena of the new world. They promoted the development of painting and architecture, more than 10,000 churches being built and decorated. The fusion of Spanish and Indian artistic traditions resulted in the early 18th century in the growth of a distinctive and highly ornate style of church building. The church also enforced intellectual and political orthodoxy through its powers of censorship. These were exercised by the Inquisition, which was established in New Spain in 1571.

During the later colonial period the clergy became richer and less conscientious. Tithes collected by the government and the receipt of baptism, marriage and funeral fees gave the Church a large revenue, and through gifts from the crown and from rich laymen it gradually acquired ownership of much property. By the early 19th century, according to the proclerical historian-statesman Lucas Alamán, its estimated holdings included half the real estate and capital of the country. As the church's wealth increased, its moral standards declined. This was probably hastened by the legal *fueros* (privileges) enjoyed by the clergy, especially that of being subject only to the clerical law courts. The church neglected its educational responsibilities, a large majority of the population remaining totally illiterate. The obvious need for reform caused the government to acquire anticlerical tendencies, evidenced particularly in the expulsion of the Jesuits in 1767.

By the end of the colonial period the church included one archbishopric, eight bishoprics and 1,703 parishes, while 254 convents were maintained by the different orders. While some of the lower clergy were receptive to liberal ideas, the leaders of the church used their immense influence to support conservative political principles as well as orthodox beliefs. This resulted in prolonged conflicts between the church and the liberals after Mexico became independent.

**4. Economic and Social Development.**—Spanish settlers in the new world generally hoped to acquire land and be supported by Indian or Negro labour. During the period of the conquests much of the cultivated land in New Spain became the property of Spaniards, while many of them also received *encomiendas*. The holder of an *encomienda* was entitled to exact labour from the Indians living in a specified area, and was expected, in return, to protect and Christianize them. Since the *encomiendas* often resulted in gross exploitation, the government tried to abolish them as early as 1542, when the so-called New Laws were adopted. Threats of rebellion by the colonists, however, deterred this attempt. The *encomiendas* were not finally ended until early in the 18th century. Outright enslavement of Indians, on the other hand, was mostly eliminated in the 16th century. A number of Negroes were imported into New Spain, mostly into the coastal regions, but they quickly intermarried with Indians and did not remain a distinct ethnic group. By the later colonial period chattel slavery had almost disappeared, although it was not formally abolished until 1829.

During the colonial period the hacienda, or large estate, normally owned either by a member of the Creole upper class or by the church, became the most important socioeconomic institution. The labourers on the haciendas nominally were free wage earners, but in practice were usually in debt to their employers and by this means were denied the right of mobility. Though there are no exact figures, it is probable that by the 19th century between one-third and one-half of the rural population were in this condition. Most of the remainder lived in village communities which continued to hold land by the traditional Indian system of collective ownership combined with individual use. The right of every village to a tract of common land, known as an *ejido*, was affirmed by the Spanish government. Thus, two forms of landownership, the hacienda and the *ejido*, were established in New Spain. Small farm properties were relatively inconsiderable, except in the north where there were few Indians.

Although agriculture was the occupation of a large majority of the population, the greatest source of wealth was the mining of silver. The mines remained the property of the crown, but concessions for their exploitation were given to individuals, on condition that a royalty on all minerals was paid to the government. The value of the total produce of the Mexican mines through the beginning of the 19th century was estimated at more than two billion pesos.

Manufacturing (except in the form of Indian handicrafts) was restricted by the Spanish government and remained primitive. Commerce, both wholesale and retail, was mostly controlled by Spanish mercantile houses. Thus New Spain failed to develop a strong middle class. Its native population mostly consisted, at one extreme, of wealthy Creole landowners and miners, and, at the other, of the mass of villagers and dependent labourers.

The most significant ethnic trend was the growth of the mestizo group, those of mixed Spanish and Indian descent. There was much intermingling between whites and Indians, especially during the period of the conquest when white women were scarce. Population estimates for the beginning of the 19th century give 3,000,000 Indians, 2,000,000 mestizos and 800,000 Creoles and *gachupines*. The mestizos, however, included many who were predominantly Indian in their ancestry and way of life, while a few belonged by wealth and education among the Creole upper class. Representing in their own persons the fusion of the Spanish and the Indian heritage, the mestizos have often been regarded as the truest representatives of the new Mexican nation. By the middle of the 20th century they comprised about 60% of the total population.

**5. The War of Independence.**—Despite authoritarian rule and heavy taxes, there were no rebellions of any consequence prior to the 19th century. Both the American and the French revolutions, however, had a wide influence upon the Creoles. Some of them, chiefly lawyers and the lower clergy, adopted liberal ideas; a larger number, while anxious to keep the Indians in subjection, favoured independence in the hope of ousting the *gachupines* and becoming a new ruling class.

Rebellion was made possible by Napoleon's occupation of Spain in 1808 and his attempt to establish his brother Joseph Bonaparte

as king. Creoles in Mexico City immediately began to demand self-government, though they continued to profess their loyalty to the legitimate Spanish king. The movement was quickly suppressed by the *gachupines*, and its leaders were imprisoned. But revolutionary ideas continued to spread, and in 1810 an insurrection was launched under the leadership of Miguel Hidalgo y Costilla, the priest of Dolores, who held strongly liberal ideas. Hidalgo called for the end of *gachupin* rule and also for racial equality and redistribution of the land in the big estates. This *grito de Dolores* ("cry of Dolores") occurred on Sept. 16, now celebrated as Mexico's Independence day. But while Hidalgo's revolutionary program appealed to the mestizos and Indians, it alarmed most of the Creoles and caused them to support *gachupin* authority. Thus the War of Independence became, in part, a civil war between different groups of Mexicans.

Gathering a mob rather than an army, Hidalgo quickly captured a number of towns; but when close to Mexico City, he decided to retreat, for unknown reasons, and his following then began to disintegrate. After suffering a crushing defeat in the battle of Calderon in Jan. 1811, he and his chief associates were captured by the *gachupin* authorities and put to death.

Leadership was then assumed by José María Morelos y Pavón, a parish priest of mestizo origin who had been a pupil of Hidalgo. Creating a small but effective army and displaying brilliant generalship, Morelos won control of much of southern Mexico. In 1813 and 1814 a congress meeting first at Chilpancingo and then at Apatzingán issued a declaration of independence and drafted a republican constitution. But in 1814 the expulsion of the French from Spain made it possible for Spanish troops to be shipped to Mexico to reinforce viceregal authority. Morelos was defeated at the end of the year, and in 1815 was captured, defrocked and executed. This was followed by a rapid disintegration of the whole independence movement, though a few chieftains, notably Vicente Guerrero, continued to lead guerrilla forces.

The final phase began in 1820 when a revolutionary movement brought liberalism into power in Spain. This alarmed many of the higher clergy and other conservative elements in Mexico and caused them to favour independence. Leadership of the movement was assumed by Agustín de Iturbide, a Creole landowner who had formerly been an officer in the Spanish army. The unsuspecting viceroy was persuaded to give him command of troops sent against Guerrero, and in Feb. 1821, Iturbide proclaimed the Plan of Iguala. Mexico was to be an independent monarchy under a European prince; the Roman Catholic Church was to retain its powers; Creoles and *gachupines* were to have equal rights; and there were to be no confiscations of property. Despite the conservative tendencies of the plan, Guerrero was persuaded to accept it. Within a few months Iturbide won the support of virtually every important element in the country, and in August the viceroy accepted Mexican independence. Thus, in contrast with the achievement of independence in South America where liberal elements predominated, in Mexico independence was gained by the efforts of social and economic groups determined to maintain the status quo.

Iturbide became president of a council of regents, and a congress was elected. Conflicts quickly developed, and in May 1822, Iturbide assumed the position of emperor, allegedly in response to popular demand. But he failed to retain the support of the army, and in March 1823 a military rebellion compelled him to reconvene congress and announce his abdication. He went into exile, returned in 1824 in the hope of regaining power, and was promptly arrested and shot. Meanwhile the congress had proclaimed Mexico a republic.

### B. Independent Mexico

**1. Early Republic.**—Republican government was not easily established among a people sharply divided by class and race differences, habituated only to authoritarian rule and at least 90% illiterate. The early years of independence were, in consequence, a period of anarchy. In effect, power belonged to the army, whose generals, especially the unscrupulous Antonio López de Santa Anna, quickly discovered that they could make and unmake presidents almost as they pleased. The disorder was intensified by incessant financial crises. The mining industry, the main source of wealth in Mexico, had been wrecked during the War of Independence, and despite investments of British capital it did not quickly recover. The national budget remained unbalanced every year until 1894, and the government subsisted largely on loans. Whenever the deficit was so high that the army officers went unpaid, there was likely to be a revolution.

A federal constitution, closely modeled after that of the United States and dividing Mexico into 19 states and four territories, was adopted in 1824. Guadalupe Victoria, one of the early leaders of the independence movement, then became president. He had the distinction of serving a full four-year term, the only president to do so before Benito Juárez, but his administration was devoid of constructive achievements. Meanwhile, two extremist political factions took shape. The liberals, often known as *puros*, supported the federal system, hoped to develop a strong middle class by means of agrarian reforms and the promotion of economic enterprise, and urged separation of church and state, secular education, and the abolition of the special legal privileges of the clergy and the army officers. The conservatives advocated centralized and authoritarian government and the maintenance of the powers of the clergy and the Creole upper class. Between these opposing groups an amorphous body of *moderados* struggled to maintain constitutional processes. The political conflict was intensified by international rivalries: the British, who regarded Mexico as a promising field for trade and investment, preferred the conservatives, while the first United States minister to Mexico, Joel Poinsett, became a partisan of the liberals.

A conservative victory in the elections of 1828 was followed by a successful liberal revolt, as a result of which Vicente Guerrero became Mexico's second president. In 1829 Guerrero was overthrown by General Anastasio Bustamante, who held power with conservative support until 1832. He was then ousted by Santa Anna, allied with the liberals, who became president in 1833. Pleading ill-health, Santa Anna allowed the liberal leader, Gómez Farías, to become acting president and launch a comprehensive attack on the powers of the clergy. The country was soon threatened with civil war, and in April 1834, Santa Anna took over the presidency, betrayed his liberal supporters, rescinded their anticlerical measures and assumed dictatorial powers. He retained these powers until 1836 when he was defeated in Texas.

The administration of Guadalupe Victoria had encouraged the entry of American immigrants into Texas, which was then almost uninhabited, and by 1830 they numbered close to 30,000. In that year the Mexican government, alarmed by the growth of American influence, prohibited further immigration from the United States and posted troops along the border. This was followed by numerous disputes, until the imposition of dictatorial government finally caused the Texans to resort to arms, initially on behalf of their rights under the Mexican constitution and later to maintain the independence that they had declared in March 1836. Attempting to crush the rebellion, Santa Anna captured the Alamo and slaughtered all its defenders, but he was decisively defeated at San Jacinto in April 1836.

The conservatives now assumed power in Mexico, adopting in Dec. 1836 a new centralist constitution, known as the Seven Laws, under which Bustamante again became president. In 1841 Santa Anna again seized power and held it for three years, governing dictatorially and extravagantly. Another centralist constitution, the Organic Bases, was adopted in 1843. In Dec. 1844, the treasury being empty, a military revolution brought to power a *moderado* administration headed by José Joaquín Herrera. In Jan. 1846, Herrera's apparent willingness to make concessions to the United States caused him to be overthrown by the conservative Mariano Paredes.

**2. War With the United States.**—The immediate cause of the war with the United States was the question of Texas. But the United States government was also interested in securing California, owned but not effectively controlled by Mexico. Possession of the California seaports would give the United States a strong commercial and strategic position on the Pacific. Rapid

action seemed desirable because of rumours (actually unfounded) of possible British purchase.

After the defeat at San Jacinto, Mexico made no further attempt to reconquer Texas but refused to recognize its independence. When the United States Congress voted for annexation early in 1845, the Mexican government broke off diplomatic relations. In annexing Texas the United States assumed claims to territory as far south as the Rio Grande, though the Texan republic had not exercised effective jurisdiction beyond the Nueces river. Polk, who became president in March 1845, dispatched John Slidell to Mexico with instructions to secure the Rio Grande boundary and discuss the purchase of California. But the advent of the Paredes administration made it plain that no agreement could be reached, whereupon Polk ordered troops to occupy the disputed region between the two rivers. This resulted, in April 1846, in a clash between American and Mexican patrols, and in May of that year the United States declared war.

During 1846 forces under General Zachary Taylor invaded northeastern Mexico, while smaller American detachments had little trouble in taking possession of New Mexico and California. Meanwhile a liberal revolution overthrew Paredes and brought back Santa Anna, who reassumed the presidency in September. He marched north against Taylor and was defeated by the American general in a hard-fought battle at Buena Vista in Feb. 1847.

In March a new American army under General Winfield Scott occupied Veracruz and advanced upon Mexico City, defeating Santa Anna at Cerro Gordo. The final phase of the war was marked by vigorous Mexican resistance, but the Americans had superior arms and equipment and abler leadership. After winning battles at Contreras, Churubusco and Chapultepec, Scott captured Mexico City on Sept. 14. Santa Anna then retired into exile, and a *moderado* government negotiated peace.

By the treaty of Guadalupe Hidalgo, concluded on Feb. 2, 1848, Mexico ceded all territory north of an irregular line extending along the Rio Grande and from El Paso, by way of the Gila river, to the Pacific. In return, the United States paid Mexico $15,000,000 and also assumed claims of U.S. citizens against Mexico amounting to some $3,000,000. The only subsequent major change in the Mexico-U.S. boundary was made in 1853 when, by the Gadsden treaty, the Mesilla valley (now southern Arizona) was sold to the United States by Mexico for $10,000,000.

**3. The Reform.**—The easy victory of the United States strengthened those extreme political groups who insisted that only drastic remedies could ensure the survival of Mexico as an independent nation. During the *moderado* administrations of Herrera (1848–51) and Mariano Arista (1851–53) both conservatism and liberalism assumed more extreme forms.

The conservatives seized power in 1853, but made the unpardonable mistake of inviting Santa Anna to become dictator, though many of them hoped that he would soon be replaced by a prince from a European royal family. In 1854 a liberal rebellion was initiated at Ayutla by Juan Álvarez, a mestizo landholder and an old hero of the War of Independence, and Ignacio Comonfort. Santa Anna's customary extravagance soon emptied the treasury; with no money to pay his troops, he retired into exile in 1855, his political career finally coming to a close. Álvarez, followed within a few months by Comonfort, assumed the presidency, initiating the social revolution known as the Reform.

The purpose of the Reform was to create a secular, progressive and democratic state. Its leaders proposed to abolish the privileges of the clergy and the army officers, to increase private landholdings by breaking up both the clerical haciendas and the Indian *ejidos*, and to promote industrial development and secular education. Such a program was unrealistic in its failure to take account of the specific needs and traditions of the Indian population. And though its main spokesmen were men of integrity and idealism, much of its support came from more self-seeking elements: from ambitious mestizos who coveted clerical wealth and land, and from provincial political bosses who disliked the strong central government favoured by the conservatives. While the Reform made possible political stability and economic progress, it failed to bring about democracy and led to a deterioration in the position of the Indians. It is ironical that its greatest figure, Benito Juárez, was himself a pure-blooded Indian, the son of Zapotec peasant parents, though he had acquired an education and become a lawyer.

The Reform program began in Nov. 1855, when Juárez, then minister of justice, issued a law (the *Ley Juárez*) abolishing the special jurisdiction of the military and ecclesiastic courts in civil cases. The *Ley Juárez* was followed in June 1856 by the *Ley Lerdo*, promulgated by the minister of finance, Miguel Lerdo de Tejada. This restricted the right of corporations to own land; all church lands not used for religious purposes were to be sold, and the Indian *ejidos* were to be distributed. Unfortunately the forced sale of church lands proved beneficial chiefly to speculators, many of them foreigners, while Indians who received *ejido* lands often failed to understand the concept of private ownership and were easily cheated out of their holdings. Meanwhile a convention was drafting a new federal constitution. This was completed in 1857 and differed from that of 1824 chiefly in giving more power to the central government and in the inclusion of a number of anticlerical clauses. Comonfort was then elected president.

The church refused to accept the constitution and excommunicated all officials who took the required oath to support it. The long-expected civil war began at the end of the year. Comonfort tried to work out a compromise settlement, but his proposals were not acceptable to either party, and in Jan. 1858 he went into exile. The conservatives took control of Mexico City, where they set up an administration headed first by Felix Zuloaga and then by Miguel Miramón. Juárez, now constitutional president in succession to Comonfort, established his headquarters at Veracruz and quickly began to display extraordinary powers of leadership. While European powers favoured the conservatives, the United States conceded diplomatic recognition to Juárez in 1859 and gave him moral and some material support.

In July 1859, convinced that the economic power of the church must be finally broken, Juárez issued a series of drastic reform laws. All real property held by the church, apart from buildings used for worship, was henceforth to be confiscated without compensation; all monastic orders were to be suppressed; and in order to end the obligation to pay marriage and burial fees to the church, civil marriage was instituted and the cemeteries were declared public property.

During the early phase of the civil war, the conservatives continued to win battles; but by controlling Veracruz, Mexico's main seaport, the liberals maintained an advantage which finally proved to be decisive. The tide began to turn in the summer of 1860. In December of that year the liberal army, commanded by González Ortega, captured Mexico City, and the surviving conservative leaders fled into exile.

**4. French Intervention.**—The pretext for intervention by the French was the failure of Mexico to meet its financial obligations. In 1861 its government ordered the suspension for two years of all payments on the foreign debt, which had been accumulating since independence and now exceeded $80,000,000. At the end of the year a joint British, French and Spanish expeditionary force landed in Mexico to enforce a debt settlement. But during the negotiations it became evident that the French did not wish to reach an agreement. In April 1862 the British and Spanish withdrew, while the French began to advance into the interior.

Napoleon III, the emperor of France, had been persuaded by the exiled Mexican conservatives that the majority of the people would welcome an intervention that would restore the rights of the church and establish a monarchy. France would gain in prestige; Mexican resources would be opened for development by French capital; and the growing power of the United States would be held in check. The outbreak of the Civil War in the United States meant that the Monroe Doctrine could not be enforced. After Juárez had been ousted by the French, Maximilian of Habsburg, younger brother of the Austrian emperor Francis Joseph, was to become emperor of Mexico.

Mexican resistance proved to be more effective than Napoleon had been led to expect, and on May 5, 1862, the French were defeated at Puebla. But they continued to hold the seacoast, and

early in 1863, strongly reinforced, they resumed their advance, defeating the ill-equipped Mexican armies and capturing Mexico City in June. While Juárez fled north, an assembly of conservatives voted to establish a monarchy. Maximilian, accompanied by his wife, the Belgian princess Carlota, arrived in the spring of 1864. Though Juárez continued to organize guerrilla resistance forces from his headquarters near the United States border, the French and conservative troops now controlled all the leading cities.

Maximilian proved to be a well-meaning but ineffectual emperor. He tried to win popular support and disappointed his clerical backers by refusing to restore the lands and privileges of the clergy and by appointing *moderados* to his administration. But the real authority remained with the French commander Achille Bazaine. On Oct. 3, 1865, Maximilian was induced to accept a decree ordering the summary execution of all persons captured while fighting against the intervention.

Meanwhile the Civil War in the United States had ended, and Secretary of State William H. Seward began to insist that Napoleon evacuate his troops from Mexico. Alarmed by the rising power of Prussia in Europe, Napoleon was forced to agree. In 1866 Carlota went to Europe to plead for help, but had no success either with Napoleon or with the pope, and became permanently insane. The French troops left Mexico in Jan. 1867, and the rapidly growing Juarist armies began to advance on the capital. Maximilian, however, refused to admit to failure and was persuaded by the conservatives that if he turned to them for support, he might still hope to save his empire. After being besieged in Querétaro, he and his leading associates were captured in May 1867. As vengeance for the decree of Oct. 3, 1865, he was then tried by a military court and executed.

**5. The Díaz Period.**—Juárez continued to serve as president until his death in 1872, being reelected in 1867 and 1871 amid accusations that he had become a dictator. He inaugurated the era of railroad building by contracting with British capitalists for a line linking Mexico City and Veracruz, promoted a school system based on the positivism of Auguste Comte and gave Mexico its first period of good government since viceregal times. He was succeeded by Sebastián Lerdo de Tejada, who pursued similar policies but lacked both Juárez's prestige and his force of character. In 1876 his announcement that he would seek a second term precipitated a rebellion headed by Porfirio Díaz. Winning support from a wide variety of discontented elements, Díaz took over the government in November.

A mestizo of humble origin, Díaz had become a leading Juarist general during the war with the French and had hitherto appeared to be a convinced liberal. But as president he adopted a "policy of conciliation," setting out to end political conflicts and inviting the adherence of all important elements, including the church and the landowning aristocracy. In 1880 he was succeeded by his friend, Manuel González. In 1884 Díaz returned to power and continued to govern Mexico until 1911, being reelected at the end of each term, usually without opposition. Constitutional processes were maintained in form, but in reality the government became a dictatorship. Díaz's rule, however, was relatively mild, at least by contrast with 20th-century totalitarianism, and speech and press were never systematically controlled. The army was reduced in size, order being maintained by an efficient police force. Until near the end Díaz seems to have retained the support of most literate Mexicans. Unfortunately, the benefits of his rule went mostly to the upper and middle classes. The mass of the population, especially in rural areas, remained illiterate and impoverished.

Díaz's main objective was to promote economic development by encouraging the entry of foreign capital, much of it from the United States. By 1910 the total American investment probably exceeded one billion dollars, while another three or four hundred millions were contributed by Europeans. About 15,000 miles of railroads were built; industries, especially textiles, were developed; a new impetus was given to mining, especially of silver and copper; and after 1900 Mexico became one of the world's leading oil producers. This economic growth resulted in a tenfold increase in the value per annum of foreign trade, which approached $250,000,000 by 1910, and in a similarly vast increase in the revenue of the government. Much of the success of Díaz's economic policies was due to the *científicos*, a small group of lawyers and officials who largely dominated the administration in its later years. Their leader, José Yves Limantour, served as secretary of finance after 1893.

Yet despite the impressive achievements of the dictatorship, popular discontent began to accumulate, leading finally to a revolutionary upheaval. This was partly a peasant and labour movement directed against the Mexican upper classes, and partly a nationalistic movement provoked by foreign ownership of much of the wealth of the country.

Díaz continued the Reform policy of breaking up the *ejidos*, but did not take adequate measures to protect the Indians from being deprived of their holdings by fraud or intimidation. By a law of 1894 he also allowed public lands to be transferred to private ownership at insignificant prices, and without any limit upon the acreage that an individual might acquire. The result was that by 1910 most of the land in Mexico had become the property of a few thousand large owners; and at least 95% of the rural population, totaling about 10,000,000, were without land of their own. Some 5,000 Indian communities, which had held land since before the Spanish conquest, were expropriated, and their inhabitants mostly became labourers on the haciendas. Díaz's agrarian policy was defended on the ground that private ownership would promote more efficient use of the land. But although there was a considerable increase in some commercial crops, production of basic foodstuffs remained inadequate. Although more than two-thirds of the total population were engaged in agriculture, Mexico during the later Díaz years had to import food.

The industrial workers fared better than the peasants but were denied the right to form unions, and on several occasions strikes were broken by government troops. In consequence, socialist and anarchist ideas began to spread. Meanwhile, Mexicans of the middle and business classes began to feel that Díaz had allowed foreigners to acquire too much economic power and privilege. Resentment was directed especially against the American and British oil companies, who had become owners of the country's most valuable resource.

**6. The Revolution.**—In the autumn of 1910 a revolutionary movement was initiated by Francisco Madero, an idealistic liberal from an upper-class family. Largely because of the support of Pancho Villa, a former bandit chieftain, the revolutionaries won victories in Chihuahua; when it became apparent that Díaz, now in his 81st year, was unable to suppress them, there were popular uprisings throughout the country. On May 25, 1911, Díaz retired into exile, and Madero was then elected president.

Madero proved to be a somewhat ineffectual chief executive, and he disappointed most of his followers by failing to recognize the need for economic changes. But he was a sincere believer in constitutional government, and labour and peasant groups were now free to demand reforms. The resultant disorders, which appeared to endanger the lives and properties of foreigners, caused the American minister, Henry Lane Wilson, to become an outspoken enemy of the administration. In Feb. 1913, part of the army in Mexico City rebelled, and on Feb. 18, after 10 days of fighting, the general commanding the government troops, Victoriano Huerta, joined forces with the rebels, compelled Madero to resign, and (with the aid and approval of Wilson) assumed the presidency himself. Madero was shot four days later, presumably by Huerta's orders. Huerta's rule was a military dictatorship and was both inefficient and severely repressive.

Civil war broke out almost immediately. Movements to restore constitutional government were launched in three northern states, the main leaders being Venustiano Carranza in Coahuila, Pancho Villa in Chihuahua and Alvaro Obregón in Sonora. Meanwhile in the mountains of the south Emiliano Zapata headed an Indian peasant rebellion aiming at land reform. The constitutionalist forces won the support of Woodrow Wilson, the new U.S. president. Wilson refused to recognize Huerta, tried to induce him to agree to a free election and in Feb. 1914 permitted the constitu-

tionalists to buy munitions in the United States while embargoing shipments for Huerta. When American marines landing at Tampico were temporarily arrested by Mexican officials and Huerta refused to make adequate apologies, Wilson intervened more directly; in April, in order to prevent Huerta from receiving an arms shipment from Germany, American naval forces seized Veracruz.

After a series of constitutionalist victories, Huerta went into exile in July 1914. Unfortunately the constitutionalist factions had never agreed on a common leadership and program, and a convention at Aguascalientes in November failed to settle their differences. Carranza won the support of Obregón, while Villa and Zapata formed a loose alliance, and in December civil war broke out again. By the end of 1915 Carranza had established control of most of Mexico, although Zapata continued resisting until he was murdered in 1918, and Villa did not come to terms until 1920. Carranza outbid his rivals for popular support by promising far-reaching land and labour reforms, though his real inclinations were decidedly conservative. He also owed his victory to the able generalship of Obregón and to the approval of the United States, which quickly accorded him *de facto* recognition. Relations, however, became severely strained in 1916 when Villa, angered by American policy, raided Columbus, N.M., killing 17 Americans. General John J. Pershing led a punitive expedition into Mexico in an unsuccessful effort to capture him.

The revolution, initially a movement against dictatorship, gradually assumed more specific social and economic objectives, and a convention assembled at Querétaro to make the necessary changes in the constitution. The resultant constitution of 1917 retained the federal framework set up in 1857, while limiting the president to a single four-year term, but included new articles providing for land and labour reform. In particular, article 27 stated that private ownership was subordinate to public interest, affirmed the right of every village community to an *ejido*, to be obtained, where necessary, by the expropriation of land from large owners and declared subsoil wealth to be inalienable national property. Article 123 was a comprehensive statement of the rights of labour. Other articles severely limited the rights of the church, which had evoked the hostility of the revolutionists by the support it had given to Díaz. A statement of aspirations rather than of immediate realities, the constitution was never fully enforced, but it served as a program for Mexican governments until 1940, and to a lesser extent after that date. As the earliest of the radical constitutions of the 20th century, moreover, it had a wide influence outside Mexico.

Carranza, who served as president until 1920, did not carry out his promises of reform, but was finally overthrown in an almost bloodless revolt headed by Obregón. Obregón was then elected president, taking office on Dec. 1, 1920. This marked the beginning of a new epoch of social reform and growing political stability.

**7. Obregón and Calles.**—The revolution had not brought democracy to Mexico. After 1920, as before, the president was virtually a dictator and usually chose his own successor, who was always elected by an overwhelming majority. The army continued to be politically powerful and absorbed an exorbitant share of the national budget. On the other hand, opposition groups usually enjoyed freedom of speech and press. The labouring masses, though still impoverished and largely illiterate, made economic and cultural gains, and there was increasing recognition of the value and importance of their Indian heritage. Probably the most important long-term trend was the growth of industry, much of it, in contrast with the Díaz era, being under native ownership and management.

The ablest statesman produced by the revolution, Obregón proceeded cautiously along the road of reform. Administrative machinery was set up for land distribution, although less than three million acres was actually restored to the villages. Organized labour represented by the *Confederación Regional Obrera Mexicana* (the CROM) received government support. The secretary of education, José Vasconcelos, launched an extensive school-building program, especially in rural areas, and gave government patronage to the rising group of revolutionary artists, including Diego Rivera and José Clemente Orozco. The United States, which had suspended diplomatic relations after the fall of Carranza, was placated by a debt settlement and by assurances that the constitutional provision declaring subsoil wealth to be national property would not be interpreted retroactively against the oil companies. Recognition was granted in Aug. 1923. At the end of the year when the question of the presidential succession provoked a right-wing military rising headed by Adolfo de la Huerta, the United States gave Obregón moral and material assistance in crushing the rebels. In 1924 Obregón's friend, Plutarco Elías Calles, was elected to succeed him.

Calles pursued the same policies with somewhat more vigour, distributing 8,000,000 ac. to the *ejidos* and continuing to support the CROM and to build schools. In Dec. 1925, he ordered the oil companies to exchange their titles of ownership for 50-year leases. This was followed by an acrimonious controversy with the United States, which was settled in 1927 after the appointment of Dwight Morrow as ambassador. After Morrow's skilful diplomacy had created a more friendly atmosphere, it was agreed that companies which had performed "positive acts" of exploitation before 1917 should not be disturbed, although Mexican ownership of the subsoil was reaffirmed in principle. Meanwhile Calles had also come into conflict with the church by ordering compliance with various anticlerical clauses in the constitution. The refusal of the clergy to obey led to an impasse; beginning in July 1926, no church services were held in Mexico for almost three years, although the church buildings remained open for individual worship. In 1929 the conflict was temporarily compromised through the mediation of Ambassador Morrow.

In 1928 Obregón was elected as Calles' successor but was assassinated by a religious fanatic before taking office. Congress then appointed Emilio Portes Gil as interim president, though Calles remained the real ruler of Mexico. Calles' leadership was exercised through his control of the National Revolutionary party (PNR), which was organized in 1929 and included all important figures in Mexican politics, its nomination being henceforth tantamount to election. It was renamed the Party of the Mexican Revolution (PRM) in 1938 and the Party of Revolutionary Institutions (PRI) in 1946. Also in 1929 another military rebellion headed by Gonzalo Escobar was suppressed, and Pascual Órtiz Rubio was then elected to fill the remainder of the presidential term, which had been extended to six years. In 1932 disputes with Calles led to his resignation, and he was succeeded by Abelardo Rodríguez.

Calles and his associates had now lost much of their enthusiasm for reform, and the period from 1928 to 1934 saw a swing to more conservative policies. Land distribution, though pushed vigorously under Portes Gil, was almost halted under Órtiz Rubio. The CROM, the leaders of which had evoked antagonism by abusing their powers, lost government support and rapidly disintegrated. The ruling group continued to display radical tendencies only in relation to religion. State governments imposed drastic limitations on the number of priests permitted within their borders, and many churches were closed.

**8. Cárdenas.**—Prior to the election of 1934 left-wing groups began to gain strength in the PNR, and Calles could retain control only by accepting a candidate whom they favoured. The result was the nomination and election to the presidency of Lázaro Cárdenas, a native of Michoacán who had displayed integrity and revolutionary principles in a series of military and administrative positions. In 1935 there was an open break between Cárdenas and Calles, who now lost all his influence in the administration and was driven into temporary exile.

Devoting himself tirelessly to the fulfillment of the ideals of the revolution, Cárdenas put new vigour into the land reforms. By 1940 he had distributed nearly 45,000,000 acres to the *ejidos*. Included were a number of plantations for the production of commercial crops, which were to be operated as units on a profit-sharing basis. Added to the land distributed between 1915 and 1934, this made a total of 75,000,000 acres. Although more than 200,000,000 acres remained in private hands, predominantly in

large haciendas, the area in *ejidos* now included almost half the land actually under cultivation. More than 40% of the agricultural population had become *ejidatarios*.

Labour unions, which were organized in 1936 into a new federation, the Confederacíon de Trabajadores Mexicanos (CTM), received strong support, and a number of enterprises, including especially the railroads in 1937, were nationalized and entrusted to the management of the workers. The boldest of these moves was the expropriation of foreign oil companies in March 1938, after they had declared themselves unable to comply with government orders to give their employees higher wages and other benefits. This led to a diplomatic controversy with the United States, which recognized the right of expropriation but asked for adequate compensation. By agreements concluded with the United States in 1942 and with Great Britain in 1947, Mexico agreed to pay the companies a total of nearly $175,000,000 in principal and interest.

The Cárdenas program appealed to national pride and brought real benefits to the peasants and workers, but it led to increasing economic difficulties, especially since many of the new co-operative enterprises were managed extravagantly and inefficiently. By 1940 there was strong popular pressure for a return to more conservative policies. Cárdenas recognized this trend by giving his support to the candidacy of General Manuel Ávila Camacho, a devout Roman Catholic and an advocate of moderation. His accession to the presidency in Dec. 1940 marked the beginning of a more conservative phase in Mexican politics.

**9. World War II and Postwar Period.**—The new administration was dominated by World War II. In domestic affairs its main purpose was to stimulate economic growth. There was little further land distribution; owners of haciendas were guaranteed against expropriation; many *ejidos* were parceled into individual holdings and emphasis was placed on more efficient use of the land. Labour benefited through the adoption of a social security system, but the more radical objectives of union leaders no longer received support, and private enterprise was encouraged. United States loans and purchases stimulated industrial development, much of the capital being contributed by an agency of the Mexican government, Nacional Financiera. Unfortunately war conditions caused a severe inflation, and while businessmen and speculators made large profits, wages lagged far behind prices.

In marked contrast with its neutrality in World War I, Mexico gave vigorous diplomatic and material support to the United States and declared war on the Axis powers in May 1942, after Mexican tankers had been sunk by German submarines. Although 300 Mexican fliers took part in campaigns in the Philippines and elsewhere in 1944–45, Mexico's main contributions were economic, large quantities of raw materials and manufactured goods being produced to meet American war needs. Mexico was one of the initial members of the United Nations Security council and continued after the war to play an active part in the United Nations and to work closely with the United States in support of democratic objectives. Communism, which had temporarily infiltrated some branches of the government during the Cárdenas administration, never acquired much popular strength and remained largely a movement of intellectuals. During World War II a fascist-type movement known as *Sinarquismo* ("with order") gained an alarming degree of strength, but dissension among its leaders and growing national prosperity soon caused it to decline.

In 1946 Miguel Alemán, a civilian from Veracruz, was elected president. Alemán pursued the same policies as his predecessor but with more vigour and on a larger scale. In agriculture he promoted technological improvements and an increase of the land available for cultivation by means of irrigation. Especially notable were two large-scale irrigation projects modeled after the Tennessee Valley Authority in the United States, in the Tepalcatepec and Papoloapan river basins. Food production increased, and by 1952, for the first time in half a century, Mexico was no longer importing corn. Meanwhile growth continued at a rapid pace in both the production of consumer goods and the development of new heavy industries, the total industrial investment more than doubling between 1940 and 1950. The business classes were the main beneficiaries of the expansion, but the increase in national wealth enabled almost all sections of the population to make economic gains. Unfortunately the achievements of the Alemán administration were marred by a marked growth of corruption in official circles.

Adolfo Ruiz Cortines, elected to succeed Alemán in 1952, made a vigourous attempt to enforce higher standards of official honesty and had a considerable measure of success. The chief innovation during his administration was the extension of the franchise in national elections to women in 1954. Economic progress continued, despite difficulties caused by a continuing inflation. Relations with the United States, while remaining generally friendly, were complicated by U.S. efforts to stop the illegal entry of seasonal farm labourers from Mexico (the "wetbacks"). Otherwise the period of Ruíz Cortines was remarkably uneventful. In 1958 he was peacefully succeeded by Adolfo López Mateos, who had previously served as secretary of labour.

Mexico in the 1960s still faced acute problems, and these were aggravated by the rise in population, which amounted to 15,000,000 in 1920 and had more than doubled, exceeding 34,500,000 in 1960. There was too little land for the needs of the expanding rural population, and industry did not grow rapidly enough to absorb all the surplus labour. The school-building program pursued since 1920 had failed to end illiteracy, which still amounted to nearly 40% (50% by unofficial estimates). But the stability achieved after 1940 contrasted remarkably with Mexico's earlier history. Despite the lack of effective opposition, the government undoubtedly reflected popular sentiment; relations with the church and with foreign investors no longer caused serious conflict, and violent revolution appeared to be a thing of the past. (H. B. P.)

## V. POPULATION

Mexico ranks third in population among the nations of the western hemisphere, behind the United States and Brazil. According to the census of 1960, the total population was 34,923,129, an increase of 9,132,112, or 35.4% over the 1950 census.

Population growth was slow until after 1920; since then it

*Population of Mexico, 1950 and 1960*

| Political units by regions | Area in square miles | Population 1950 | Population 1960 | Density 1960 |
|---|---|---|---|---|
| Total | 761,600 | 25,791,017* | 34,923,129 | 45.9 |
| *North Pacific* | 160,014 | 1,724,241 | 2,613,470 | 16.3 |
| Baja California | 27,071 | 226,965 | 520,165 | 19.2 |
| Baja California Sur | 28,447 | 60,864 | 81,594 | 2.9 |
| Nayarit | 10,664 | 290,124 | 389,929 | 36.6 |
| Sinaloa | 22,429 | 635,681 | 838,404 | 37.4 |
| Sonora | 71,403 | 510,607 | 783,378 | 11.0 |
| *Northern Plateau* | 309,103 | 5,176,855 | 6,864,521 | 22.2 |
| Chihuahua | 95,400 | 846,414 | 1,226,793 | 12.9 |
| Coahuila | 58,521 | 720,619 | 907,734 | 15.5 |
| Durango | 46,196 | 629,874 | 760,836 | 16.5 |
| Nuevo León | 24,925 | 740,191 | 1,078,848 | 43.3 |
| San Luis Potosí | 24,266 | 856,066 | 1,048,297 | 43.2 |
| Tamaulipas | 30,822 | 718,167 | 1,024,182 | 33.2 |
| Zacatecas | 28,973 | 665,524 | 817,831 | 28.2 |
| *Southern Plateau (Central)* | 106,049 | 12,449,201 | 17,099,160 | 161.2 |
| Aguascalientes | 2,158 | 188,075 | 243,363 | 112.8 |
| Federal District | 579 | 3,050,442 | 4,870,876 | 8,412.6 |
| Guanajuato | 11,510 | 1,328,712 | 1,735,490 | 147.0 |
| Hidalgo | 8,103 | 850,394 | 994,598 | 122.7 |
| Jalisco | 30,941 | 1,746,777 | 2,443,261 | 79.0 |
| México | 8,286 | 1,392,623 | 1,897,851 | 229.0 |
| Michoacán | 23,113 | 1,422,717 | 1,851,876 | 80.1 |
| Morelos | 1,908 | 272,842 | 386,264 | 202.4 |
| Puebla | 13,096 | 1,625,830 | 1,973,837 | 150.7 |
| Querétaro | 4,544 | 286,238 | 355,045 | 78.1 |
| Tlaxcala | 1,511 | 284,551 | 346,699 | 229.5 |
| *Gulf Coastal Plain and Yucatán* | 92,278 | 3,068,911 | 4,056,676 | 44.0 |
| Campeche | 21,666 | 122,098 | 168,219 | 7.8 |
| Quintana Roo | 16,228 | 26,967 | 50,169 | 3.1 |
| Tabasco | 9,521 | 362,716 | 496,340 | 52.1 |
| Veracruz | 28,114 | 2,040,231 | 2,727,899 | 97.0 |
| Yucatán | 16,749 | 516,899 | 614,049 | 36.7 |
| *South* | 92,085 | 3,360,046 | 4,289,302 | 46.6 |
| Chiapas | 28,528 | 907,026 | 1,210,870 | 42.4 |
| Colima | 2,106 | 112,321 | 164,450 | 78.1 |
| Guerrero | 24,631 | 919,386 | 1,186,716 | 48.2 |
| Oaxaca | 36,820 | 1,421,313 | 1,727,266 | 46.9 |
| Federal Islands | 2,071 | — | — | — |

*Includes 11,763 residents temporarily out of the country.

Sources: *Anuario Estadístico de los Estados Unidos Mexicanos*, 1960–61, p. 25; *Dirección General de Estadística: Censo de población*, 1960.

has accelerated greatly. During the 40-year period from 1920 to 1960, it increased 143.6% and was thus one of the fastest growing populations in the world. Because Mexico did not experience great waves of immigration, the growth has been almost entirely by natural increase (the excess of births over deaths).

**1. Distribution.**—The population is unevenly distributed geographically. For the country as a whole, there are 45.9 inhabitants per square mile. Almost half of the inhabitants, however, are crowded into the southern plateau region, which comprises less than one-seventh of the total land area and has a density of population of more than 100 persons per square mile. The north Pacific region has the lowest population density of any major region with only about 10 persons per square mile. In the decade 1950–60, however, the population of Baja California increased by 129.2% while that of Hidalgo increased only 17.0%. The table lists the populations for each of the regions and states.

A majority of Mexicans live in small rural villages, although urbanization began to increase markedly after 1940. In that year, 64.9% of the total population lived in rural communities having less than 2,500 inhabitants. By 1960 this percentage had declined to 49.3%. The urban population increased correspondingly during the same period. In 1940, there were only four cities having more than 100,000 inhabitants. By 1960 there were 17.

**2. Birth and Death Rates.**—Mexico has a high birth rate. The number of live births per 1,000 inhabitants has remained relatively constant since 1930 at about 45. Many infants, however, do not survive beyond the first year although the infant mortality rate declined from more than 130 in 1930 to about 75 in 1960. The comparable rate for the United States in 1960 was 26.

Both a high birth rate and a high death rate are reflected in the age composition of the population. There is a high ratio of children to adults, and this gives Mexico a relatively high dependency ratio. Despite the high infant mortality rate, children under 10 years of age constitute about 30% of the total population. On the other hand, the low proportion of the population in the older age groups reflects high death rates; comparatively few people survive beyond the age of 65. Although the general death rate is high (11.7 per 1,000 inhabitants in 1960), it has been declining consistently for several decades because of improvements in living conditions.

**3. Socioeconomic Classes.**—Class lines rather than blood lines tend to set one portion of the Mexican people apart from another. There is an enormous lower or "popular" class, a small but growing middle class and a tiny, unstable upper class that has changed its composition since the Mexican revolution. Each social class may be subdivided into rural and urban; differences between rural and urban people of any social class are probably about as significant as the thin lines between classes. Under the impact of urbanization and improved agrarian programs, both the urban and rural middle classes have been growing at the expense of the lower class, which embraces nearly all of the Indian and many of the mestizo groups. In 1960 it was estimated that about 25% of the Mexicans could be considered middle class. The rural middle class consists mainly of independent farmers, often termed rancheros, and small businessmen, while in the cities their counterparts are bureaucrats, professional people and various educated persons. The upper classes are ill defined, but include a few large landholders, large industrialists, important merchants, and prominent military and political families that rose to power because of their activities in the revolution. (N. L. W.)

## VI. ADMINISTRATION AND SOCIAL CONDITIONS

**1. Political Organization.**—Mexico is governed by the political constitution that resulted from the Mexican revolution of 1910. Promulgated on Feb. 5, 1917, its provisions have been borrowed in varying degree by almost every Latin American constitution subsequently drafted. Its dominant note is a strong political and economic nationalism; articles 27 and 123 outline a broad program of agrarian and labour reform in which individual rights relating to private property are subordinated to social welfare. Free and compulsory elementary education, from which religious organizations are excluded, is provided in article 3, as amended in 1942. The anticlerical tendencies, together with a long list of personal and civil liberties, were drawn from the earlier constitution of 1857. As a popular symbol of the 1910 revolution, the constitution has helped to systematize the social and economic changes within a democratic framework.

The constitution provides for national executive, legislative and judicial branches to govern the nation, and for a federal republic of sovereign states, each with a constitution modeled on the national one. Compared with the 1857 constitution or the U.S. constitution, the power of the national executive is greatly expanded, dwarfing the powers of the states and other organs. In addition the constitutional powers of the president have been expanded by the relative ease with which he, as leader of the dominant party, can effect amendments to the constitution. The amendment process requires only a two-thirds vote of a quorum in congress, supported by a majority of the state legislatures. In practice, the actual concentration of presidential power was achieved at first by the control of the armed forces and the use of emergency extraordinary powers in legislative matters. Most of the important legislation between 1920 and 1938 was enacted by executive decrees authorized by extraordinary powers, supported by a compliant congress and judiciary. Since the 1930s control of the dominant political party has been the mainstay of presidential power, and this has been reinforced by a broad power of appointment and removal and by the control of finance. A combination of these powers has made it possible for the president to replace state administrations of which he disapproves, and his control of the predominant party has allowed him to initiate and secure the passage of bills in congress. The president is also empowered to lay down basic rules (*reglamento*) which give effect to a more general provision of a statute. These rules have the same legal force as has the statute itself and are the form in which much of the Mexican law appears. The effect of his power to formulate these rules is to make the president the undisputed master of the administrative apparatus.

As with other republican constitutions, the president is accorded extensive control over foreign affairs, but his role as leader of the predominant party precludes the executive-legislative conflicts over treaty ratification and implementation that exist in the U.S. and western Europe. The president's judicial powers consist of appointing judges and seeking their removal by his party-controlled congress, together with granting pardons. In Mexico, where the symbol of the family is strong, the president is popularly regarded as the father of the national family. He must be a native-born citizen, the son of Mexicans by birth and at least 35 years old. The presidential term of office was increased from four to six years in 1928, and since 1933 no president under any circumstances may ever be reelected. Although the presidential powers can still be regarded as those of a temporary dictatorship, in the years since the revolution those powers have been exercised more subtly, relying less on coercive than persuasive controls, while party programs and a better-educated citizenry have been laying the basis for a popularly determined, issue-oriented government.

**2. Parties and Elections.**—The president's political position has been maintained by a single, monopolistic political party, organized in 1929 and renamed the Party of Revolutionary Institutions (P.R.I.) in 1946. Party control is located in the central executive committee (C.E.C.); its chief is selected by the president and is entrusted with the responsibility of approving party nominees for important elective positions except for the presidency. The incumbent president selects his own successor. The C.E.C. has been responsible for furthering a common understanding among state and national officials and among the various groups within the party.

The P.R.I. has sponsored emerging democratic processes. Its establishment under President Calles resulted in a shift of power from political-military chieftains to state party units and military, agrarian and labour sectors. President Cárdenas (1934–1940) enhanced the authority of the agrarian sector and balanced the existing groups with a popular sector. Civil servants have been the chief beneficiaries of the latter, although the popular sector

has been responsible for broadening representation of such disparate groups as small industrialists, small merchants, small farmers, artisans, youth and women. Women's suffrage was achieved for local elections in 1946 and for national elections in 1954. As a result, registered voters increased from 4,925,000 in the presidential election preceding the achievement of women's suffrage (1952) to 10,500,000 in the first presidential election in which women had the right to vote (1958).

In the early 1940's the military sector was disbanded and its members encouraged to join the popular sector. Since 1943, the popular sector has won a majority of seats in the chamber of deputies, while the labour and agriculture sectors have each claimed about 20% (the agricultural representation dropped from 30% to 20% in the 1952 election) of the representation in the lower house since 1952. All three sectors have their own national organization, which provides financial support for the party and selects its representatives for the party organization. The sectors have also influenced the president's selection of his successor; the popular sector spearheaded the nomination of Miguel Alemán (1946–52) and Adolfo Ruíz Cortines (1952–58) while the other two sectors launched the candidacy of Adolfo López Mateos for the 1958 election. Subordinate levels of the P.R.I. have been strengthened as the C.E.C. has endorsed their nominees for state and local governmental offices. The party organization at all levels has undertaken the responsibility for acting as a channel of communication and an agency of mediation between policy makers and the general public.

Most of the minority parties have been short-lived and oriented toward a personal leader. The revolutionary tradition of the official party has caused most of the opposition parties to be conservative, the strongest of them being the National Action party (P.A.N.). As a church-oriented, largely middle-class party, P.A.N.'s increased support since its establishment in 1939 may be attributed to Mexico's increased urbanization and industrialization as well as to the shortcomings of the P.R.I. Since 1946 P.A.N. has usually had 4 or 5 members in the chamber of deputies, and in 1958 it presented the only opposition candidate for the presidency. The Communist party grew in strength during the 1930s and 1940s, but its estimated 10,000 members have been insufficient to qualify the party's candidates for the ballot since 1952. Nevertheless, minor parties have received a share of the total vote: 7% in 1940, 21% in 1946, 26% in 1952 and 9.6% in 1958. Reform legislation in 1946 and 1952 reorganized electoral machinery by placing registration and polling supervision in the hands of technical boards on which congress, the executive and the parties are represented.

**3. Administration.**—Administrative efficiency is a critical need for the highly centralized Mexican government. The national budget and autonomous agencies account for 40% of the country's annual capital investment; the government has also assumed extensive responsibilities for social security and for the operation of certain nationalized industries. The state owns about half of the land, and national agencies furnish credit, advice and direction to the workers on these plots (*ejidos*). Major railways were nationalized in 1937, and all lines longer than 100 miles were later purchased by the government. Foreign concessions for international cable and telecommunications reverted to national control in 1949, while the telegraph service has been a government monopoly since 1865. Major petroleum producers were expropriated in 1938, and, as with the railways, the oil industry has since been administered by an autonomous government agency. In addition, the government has been actively engaged in an industrialization program since 1946.

Administrative responsibility is highly centralized; the president has complete freedom in appointing and removing the 12 ministers, 2 department heads and attorney general who form his cabinet. Both personally and through his personal secretary he intervenes frequently in the functioning of the various agencies. Cabinet meetings are infrequent and their decisions advisory. Administrative rationalization is not well developed; overlapping responsibilities and lack of co-ordination between the ministries and the autonomous agencies hinder governmental operations. The basic civil service law of 1948, as amended, granted base workers a limited right to strike, job tenure, and entrance and promotional examinations. However, low pay, overstaffing and lack of uniform job classifications have hindered the development of effective personnel programs. In the early 1960s there were about 200,000 employees in the federal government, twice as many as there were 20 years earlier. Large-scale corruption and graft in public life have plagued Mexico since the colonial period and did not improve substantially until 1953.

**4. Congress.**—A bicameral congress represents the people in the chamber of deputies and the states in the senate. Two senators from each state and from the Federal District are elected for six-year terms, concurrent with that of the president. The 162 deputies are elected every three years, one deputy representing 170,000 people. No state has fewer than two and no territory fewer than one deputy. Congressional candidates must be of Mexican birth and must have reached the age of 25 for deputies and 35 for senators. Congressmen may not be reelected for the immediately succeeding term. Each house is the final judge of the election of its own members, which has permitted the majority party to declare its own candidates elected, regardless of ballot results. Congress is in session annually from Sept. 1 to Dec. 31. A permanent committee of 15 deputies and 14 senators serves during the congressional recess and approves certain presidential requests, the most important of which may be the suspension of guarantees in times of emergency.

The legislative branch has declined in importance as compared with the executive. Annual changes in committee membership, low pay, infrequent meetings (often no more than two or three times weekly) and short sessions have discouraged the full development of congressional powers. The fact that the majority party leader in each house outranks the congressional presidents (who are selected at monthly intervals) further restricts congressional autonomy. Nevertheless the quality of congressional membership has been improving. Potentially, the chamber of deputies could exercise great power over the executive through its functions of verifying the presidential electoral returns, passing the budget and initiating tax bills.

**5. Judiciary.**—The judiciary has never challenged major executive policies, and its rulings never declare a law unconstitutional, but rather suspend the effectiveness of the law in the specific case being reviewed. The 21 judges of the supreme court are appointed for life (their terms were fixed at six years between 1934 and 1944, thereby permitting each new president to name his own court). Five judges are assigned to the court's four main divisions—penal, civil, administrative and labour—to which cases from the lower federal courts (there are 11 circuit court tribunals and 42 district courts) and separate administrative tribunals (fiscal, labour and civil service) are appealed, and in which new cases may originate.

The majority of federal court cases deal with the writ of *amparo* (literally, "protection"), regarded as Mexico's most important contribution to jurisprudence. The writ combines the Anglo-American writs of habeas corpus, mandamus and certiorari. *Amparo* is the means of enforcing the constitutional guarantees of individual rights, and it is also used in determining the superiority of conflicting state and federal statutes. Only after five consecutive decisions on a particular issue does the judgment of the supreme court bind all lower courts.

**6. State Government.**—The Mexican federal republic is divided into 29 states, each with a constitution modeled on the national one. The federal district, in which the national capital, Mexico City, is located, and two national territories are administered by the national government. Emerging state autonomy is evidenced in the less frequent removal of governors by the national government, and by the increasing willingness of an overburdened president to permit settlement of local issues by state authorities. The president's very strength has permitted this political decentralization; his ascendant position, reinforced by improved communications, has lessened the possibility that a state political machine can challenge the central government.

**7. Public Finance.**—The conception of financial management

as the focus of good administration was recognized in the budget law of 1935, although budgetary planning and control was not achieved by the ministry of finance until 1949, and its operations still do not account for the budgets of the independent agencies. The ministry of national properties and administrative inspection was created in 1946 to centralize the control of federal purchasing and contracts, make administrative improvement studies and direct the construction of public buildings. The fiscal system is characterized by excise taxes which impede interstate trade, multiple taxation by various governmental levels and a regressive tax system. However, yields from income taxes have been increasing; by the 1960s they accounted for about 30% of the total.

**8. Defense.**—The influence of the military in civil affairs has been steadily declining; no regime has been established by the military since 1920, and the last two military revolts, in 1929 and 1938, failed. Defense services have claimed about 12% of the national budget, as compared with 50% for economic development and 22% for social services. The military services were reorganized during World War II along the U.S. pattern. Compulsory military conscription was introduced in 1941 and has provided reserves totaling several hundred thousand. In addition to its function as an internal police force, the army is active in numerous civic tasks such as reforestation, road building and public health. The ministry of marine constructed navigational facilities, protected and promoted fishery resources and developed ports. The military services have fostered active literacy programs and maintain an array of advanced service schools.

**9. Social Welfare.**—There has been a growing disparity of income between the upper and lower classes. Between 1939 and 1960 labour's share of the national income fell from 30.8% to 24.19% (compared with the 70% wage earners received in the U.S.), while profits rose from 26.2% to 46.2%. An abundant supply of labour from rural areas and from natural population growth has prevented wages from rising, while inflation has lowered their real value. The cost of living index increased from 47 in 1945 to more than 160 in the 1960s (1953 = 100). Nevertheless, overall living standards improved as rural workers moved to more highly paid construction work in the cities and as urban workers qualified for positions with higher salaries.

In Mexico City the slums expanded rapidly, faster than housing projects could be built to replace them. In the second half of the 20th century one-third of Mexico City's families lived in one-room apartments, sharing a courtyard for their cooking, washing and toilet facilities. An additional 10% lived in shacks, often without electricity. Worker colonies sheltered 14% of the capital's inhabitants at the city's outskirts, but lacked water, electricity and sewage disposal facilities.

Medical care and hospital facilities can generally be afforded only by the economically favoured families; in the 1960s there were approximately 2,400 Mexicans for each physician and more than 800 inhabitants for each hospital bed. Social security benefits include health services but reach less than 5% of the population, and two-thirds of this favoured group live in the federal district. In the 1960s the Mexican masses were eating better, although cereals, starch foods and sugar made up much of their diet; and the average daily caloric deficiency was 8.8 per person (below Egypt and Japan). Inadequate living standards were reflected in the three most frequent causes for death: dysentery, pneumonia and malaria. However, the increasing national income brought about gradually improved living conditions. Per capita gross national product reached 3,500 pesos in the 1960s (12.5 pesos = $1); since 1946 it has grown twice as rapidly as the population.

**10. Education.**—As with social welfare, education has lagged behind industrial growth; since 1939 investments in schools have increased more than ten times while industrial investments have multiplied more than twentyfold. Gross expenditures for federal education have increased, and the proportion of the national budget set aside for education increased from 15% in 1943 to about 18% in the 1960s. Article 3 of the 1917 constitution declares that elementary education shall be free, compulsory and secular, a condition which still falls far short of attainment. Elementary school facilities do not yet exist for half of the nation's school age children. There are about 30,000 elementary schools with 100,000 teachers for about 5,000,000 students. One-quarter of the primary schools are located in urban centres, chiefly in the federal district, and the great majority of these provide for six grades each with a 190-day school year. The rural "action" primary school, developed since 1922, is the special creation and pride of the revolution. About 80% of these provide for no more than three grades.

Latin American teachers on government fellowships have been studying the Mexican rural school system at a regional centre established in 1951 at Pátzcuaro, Michoacán, under the joint auspices of the Mexican government, the Organization of American States and the United Nations. Where rural schools are not feasible, traveling culture brigades, or missions, of educational and vocational specialists make extended stays in rural places. In the main Indian areas, boarding schools which emphasize vocational preparation are maintained.

Secondary education may be of four types: general, preuniversity, prevocational or teacher-training. The general secondary schools, first authorized by the federal government in 1926, provide for a three-year program intended to prepare the student to fulfill his civic and social duties. There are about 700 such schools, employing about 10,000 teachers for about 100,000 students. Of these schools 35% are in the federal district. Student enrollment in teacher-training schools increased more than fourfold between 1945 and 1960 at which time there were about 100 normal schools with 40,000 students. More than 100 vocational, technical and special schools provide instruction for an estimated 100,000 students.

The formal educational system is culminated in the universities. In the 1960s there were 17 state universities. The National Autonomous University of Mexico in Mexico City, founded in 1551 as the Royal and Pontifical University of Mexico, has an average enrollment of 25,000 students. A new campus known as University City at the outskirts of Mexico City was created for it in 1952. The National Polytechnic institute in Mexico City has a student body of comparable size and supervises several state and municipal affiliates, notably in mining and industrial sections throughout the republic. Local businessmen founded (1943) and endowed the Institute of Technology and Higher Education of Monterrey, modeled on the pattern of the Massachusetts Institute of Technology.

The impetus given the educational system by the government was responsible for lowering the illiteracy rate from 78% of the adult population in 1910 to 51.6% in 1940. A crusade to obliterate adult illiteracy was inaugurated in 1944, whereby each literate person was required to instruct an illiterate one. Three years later the program was institutionalized with the establishment of permanent literacy centres. There were more than 14,000 of these with about 345,000 students by the 1960s. An official estimate of the illiteracy rate of 33% in the 1960s compared with unofficial estimates of 50%. Limited resources, high birth rates, rural lethargy and complex cultural patterns have handicapped the literacy program. (M. B. T.)

## VII. THE ECONOMY

Long dependent on extractive industries and plantation crops for commerce, Mexico in the 20th century proceeded rapidly in the direction of a more diversified economy. The percentage of workers employed in agriculture and related activities decreased from 83% in 1921 to about 55% in the early 1960s. Mining remained important but declined in comparison with the manufacturing industries, which experienced a period of rapid growth and development after World War II. Mexico's economically active population grew from 5,800,000 in 1940 to more than 10,000,000 in the early 1960s, and the national income increased from 6,000,000,000 pesos in 1939 to more than 100,000,000,000 pesos annually, U.S. $20,000,000,000 in 1962.

### A. Production

**1. Agriculture.**—The value of Mexican agricultural and livestock production represented slightly more than one-fifth of the

gross national product in the 1960s and approximately 6,000,000 people were engaged in agriculture and such related activities as livestock raising, forestry, hunting and fishing.

Corn (maize), beans and wheat make up about 90% of the crops raised for domestic use. Staple crops for subsistence have been corn (made into *tortillas*), beans, chili peppers and pulque (a weak alcoholic drink derived from the maguey or century plant). More than 50% of all land under cultivation is given to corn, and a large part of the rural population, especially in the poorer areas, is engaged in its cultivation. Wheat formerly was imported in considerable quantities but by 1960 the country had become self-sufficient in wheat production. Other crops grown principally for domestic consumption include rice, oats, sweet potatoes, barley, onions, lentils, beets, several varieties of bananas and tobacco.

Cotton, coffee, sugar cane, henequen, chickpeas, peanuts and tomatoes account for more than 90% of agricultural exports, with cotton the country's major export. The main cotton growing regions have been Matamoros, Sonora, Sinaloa, Mexicali and the area of La Laguna. Minor agricultural exports include garlic, cocoa, peas, chili peppers, green beans, vanilla, strawberries, cantaloupes, pineapples, watermelons, limes, oranges, and plantain bananas.

By 1950, *ejidos* (agrarian villages in which the land is legally held in common) occupied about one-half of all cultivated land in the country, but only about 27% of total farm properties. Most of the pasture, forest and unproductive land was in non-*ejido* holding. The *ejido* is a form of landholding roughly similar to that which existed in pre-Spanish Mexico. It was revived following the revolution of 1910–20. Under revolutionary land redistribution programs, much land was taken from large haciendas and redistributed to the Indian villages organized as *ejidos*. This program was especially active during the presidency of Lázaro Cárdenas between 1934 and 1940. By the 1960s the average holding of the individual *ejidatario* (*ejido* member) was 20 hectares (approximately 50 ac.), of which 4 hectares were cultivated. Each *ejido* is a legal entity but, except for several large, genuinely collectivized *ejidos* such as those in La Laguna, the land has been divided into family plots farmed on an individual basis. Holders of individual plots cannot sell or mortgage the land, but rights to the land may be passed to descendants by inheritance.

The small size of the individual plots has led to major difficulties with the program. Mechanization of farming methods on the small plots has proved very difficult. Also since much of the land, especially that comprising the corn-growing *ejidos* of the central plateau, has been exhausted or cultivated in a primitive manner, the plots have provided at best a mere subsistence for the families. Consequently, although the program has undoubtedly done much to improve human dignity, it has not solved the economic problem of effective production.

Efforts have been made to deal with these problems, including an attempt to open up new agricultural areas, such as the Papaloapan river valley in the state of Veracruz and the area along the eastern shore of the Gulf of California. Much dam building took place in connection with the various river valley development projects. Irrigated acreage grew from 2,000,000 ac. in 1946 to more than 6,500,000 ac. by 1960, and crops from this land were estimated to represent 33% of the total value of agricultural production. The use of hybrid corn also significantly helped to expand corn production.

Beef and dairy cattle are the most important products of the livestock industry, with the northern border states (Baja California, Sonora, Chihuahua, Coahuila, Nuevo León and Tamaulipas) and the northern part of Zacatecas producing primarily for export. Federally-inspected plants to pack meat for export were initiated in 1946. Hogs, goats, sheep, horses, asses, mules and chickens also are raised.

**2. Fisheries.**—Fishing is most highly developed in Baja California, Veracruz, Sinaloa, Sonora and Campeche. The most important products of the fisheries are tuna, shrimp, sardines, skipjack, red snapper, oysters and haddock.

**3. Forestry.**—Tropical hardwoods, temperate hardwoods and conifers are the most important types of timber found in Mexico. The principal producing area for tropical hardwoods is in southeastern Mexico in the region of the Isthmus of Tehuantepec, the territory of Quintana Roo, and the states of Tabasco, Chiapas, Campeche and Yucatán. Mahogany has been the principal wood marketed, but some cedar, logwood, primavera, ceiba (kapok) and fustic have also been exported. The sapodilla tree yields the sap called chicle, which is the chief ingredient in chewing gum.

**4. Mining.**—Mining has been an important activity in Mexico since pre-Spanish times. Mexico is the world's chief silver-producing country. The value of lead, zinc and copper production is, however, in each case greater than that of silver. Production of sulfur, primarily for export, rose to major proportions in the 1950s and 1960s. Iron ore, coal, gold, manganese, antimony, mercury, cadmium, bismuth, graphite, arsenic, molybdenum and tin also are mined. Nevertheless, the Mexican mining industry, which was once of major importance, has been in a state of relative decline as agricultural, livestock and industrial production have increased.

The Mexican government has legal title to minerals in the ground. Exploitation is by private companies operating under concessions from the government. Among the most important of these have been U.S. firms.

The commercial production of crude oil began in Mexico at Ebano, near Tampico, in 1901. In 1916, Doheny's Mexican Petroleum company brought in a well, Cerro Azul No. 4, with a production of 250,000 barrels a day, and during the first quarter of the 20th century Mexico produced nearly a quarter of the world's oil. Subsequent opening of vast fields in Texas, Venezuela and the middle east reduced its relative contribution by mid-century to less than 2%, though it remained as sixth or seventh largest producer with, in the 1960s, 100,000,000 bbl. a year.

The foreign oil companies had believed that they had obtained a status approximating fee simple titles to their properties from the government of Porfirio Díaz before 1910. Following 1910 the revolutionary government attempted to reassert the paramount title of the government to the oil in the ground. A prolonged controversy resulted in the expropriation of the foreign oil companies by the government of Lázaro Cárdenas in 1938. Compensation paid for the properties (U.S., British and Dutch) was about $164,000,000.

After 1938 a Mexican government company, Petróleos Mexicanos (Pemex) managed the Mexican oil industry. Some drilling was accomplished by foreign companies operating under contractual arrangements with Pemex. In 1957 Pemex installed the longest pipeline in Latin America, 300 mi., from Tampico to Monterrey.

**5. Manufactures.**—The textile industry and food processing have traditionally been the most important industrial activities in Mexico. The textile industry, centred in Puebla and Mexico City, attained considerable importance in the late 19th century, and the manufacture of cotton yarn and cloth has continued to be the leading industry, with woolen and synthetic fibre production also important. Principal food processing industries are meat production, flour milling, sugar and beer. The wood pulp industry (paper and cellulose) expanded during World War II and continued to grow. The more important chemical products are sulfuric acid, caustic soda, soda ash, superphosphates and nitrogenous fertilizers, and the main petroleum products are gasoline and residual fuel oil. Metals include iron and steel, copper, zinc and lead. Other products include cement, building bricks and roofing tiles, pharmaceuticals, tires, motor vehicles, beds and mattresses, light bulbs, electrical apparatus, corn and miscellaneous food products, agricultural machinery, razor blades, tin cans, shoes, refrigerators, aluminum foil, carpets, refractories, optical goods, asbestos products, paint, plastics, soap, detergents, office furniture, television sets and other items for domestic use.

There has been considerable industrial development in Mexico since World War II. The index number for industrial production rose from 63 in 1937 to 94 in 1950 and to 178 by 1960. Mexican governments have been sympathetic to this industrial development. They have tried to encourage it by such measures as protective tariffs, special tax exemptions, manipulation of currency

devaluation and subsidies. A governmental investment banking enterprise, Nacional Financiera, has provided capital and planning advice for new enterprises.

In many ways the most important new industrial development has been in steel. There have been steel mills at Monterrey since about 1900, operated by the Compañia Fundidora de Fierro y Acero de Monterrey. The chief steel producer in the country by 1958 was the government-sponsored Altos Hornos de Mexico, founded in 1942, at Monclova in the state of Coahuila. In 1957 Mexican steel ingot production for the first time exceeded 1,000,000 tons.

Electric power production in Mexico has long been inadequate. Between World War I and World War II the foreign-owned power companies objected to the low rates they were forced to charge. After World War II, however, there was considerable expansion of power facilities. Some of this expansion was in connection with the dam building program, which has been extensive. The Federal Electricity Commission supervised much of that development.

The importance of the tourist is indicated by a survey showing that during a ten-year period (1950–60) more than 5,500,000 tourists visited the country and provided foreign exchange income of more than $4,000,000,000.

### B. Trade and Finance

**1. Foreign Trade.**—Raw materials remain the basis of the export trade. Leading exports include cotton, coffee, sugar, frozen shrimp, lead, copper and zinc. Leading customers are the United States, Japan, the continental European countries, Latin America, Canada and the United Kingdom. Principal suppliers include the United States, western Europe, the United Kingdom and Canada.

**2. Banking and Currency.**—The monetary unit of Mexico is the peso, which is equal to 100 centavos. During colonial times and also during the 19th century the Mexican silver peso was one of the world's most respected coins. The exchange ratio between the peso and the dollar was for many decades two pesos to the United States dollar. The peso, however, was devalued twice during the 1930s, and also in 1948 and 1954. The exchange rate in the 1960s was 12.5 pesos to the U.S. dollar.

The central bank of the nation is the Banco de México. The government controls 51% of the bank's stock and appoints five of the nine members of the board of directors. The minister of finance has veto powers in all matters relating to banking and currency policy. The bank was originally established in 1925 and for a time operated also in the private commercial field. Following 1931, however, it withdrew from the private banking business. Credit control powers include those to fix reserve requirements, enforce qualitative as well as quantitative credit control and engage in open-market operations. The bank has financed much of the government's deficit spending.

Other government-sponsored banks include Nacional Financiera (planning and financing much of the industrialization program), the Banco Nacional de Crédito Ejidal (helping with the credit problems of the *ejidos* and also active in their management), the National Foreign Trade bank (with functions similar to those of the Export-Import bank in the U.S.) and several others.

The general banking law provides for six principal types of private banks: commercial banks, savings banks, industrial credit banks (financieras), capitalization banks, mortgage banks and trust companies. The commercial banks must associate with the Bank of Mexico and keep their reserves with that institution. Probably the most important of the commercial or deposit banks is the Banco Nacional de México.

**3. National Finance.**—The Mexican government has been reasonably successful in achieving a near balance between expenditures and revenues. The income tax provides about one fourth of the government revenue. Taxes on trade (chiefly import and export taxes) provide about 40% of the revenue.

### C. Transport and Communications

**1. Roads.**—By the 1960s Mexico had 25,000 mi. of paved and all-weather gravel roads. Mexico City was connected by highway with Nuevo Laredo, Ciudad Juárez and Nogales on the United States border. A fourth connection with the U.S. is the highway from Saltillo to the border town of Piedras Negras. The Pan-American highway was completed to the Guatemalan border at Ciudad Cuauhtémoc (El Ocotal).

**2. Railways.**—Most of Mexico's 15,000 miles of railroads were built in the last 20 years of the 19th century. The chief lines extended from Mexico City to Laredo, to Ciudad Juárez, Nogales, Veracruz and Suchiate on the border of Guatemala. About 75% of the trackage has been nationalized under the control of the National Railways of Mexico.

**3. Shipping.**—The Mexican government participates in ocean shipping activities through the tanker fleet of Pemex and to a limited extent through the Compañia Exportadora e Importadora Mexicana. Private ocean shipping under the Mexican flag is not extensive.

**4. Air Transport.**—Compañía Mexicana de Aviación (affiliated with Pan American World Airways) is the chief domestic airline. Mexico also is served by the major international airlines.

**5. Telecommunications.**—Teléfonos de México was formed in 1950 by a merger of the Ericsson and International Telephone and Telegraph interests. This private company provides virtually all of the telephone service in Mexico. Telegraph service is furnished by the government-owned Telégrafos Nacionales de México. Radio broadcasting is extensive, and television stations exist in Mexico City and several other cities. *See* also references under "Mexico" in the Index. (W. C. Gn.)

MAJOR CITIES, SURFACE FEATURES, HIGHWAYS AND RAILROADS OF MEXICO

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**MÉXICO,** a small interior state on the central plateau of Mexico. Pop. (1960) 1,897,851; area 8,286 sq.mi. Except on the south, the state surrounds the separately administered federal district and national capital, Mexico City. The general elevation is more than 10,000 ft. above sea level, standing some 2,500 ft. above the Mesa Central, of which it is a part. The extreme height ensures a cool, healthful climate, which with fertile lava-based soils and plentiful rainfall made the area a heavily populated one from aboriginal days; México's density of 229 persons per square mile is second only to that of neighbouring Tlaxcala (230).

Much of the northern part of the state lies in the Valley of México or Anáhuac, a circular lacustrine plain and intermontane basin from which most of the lakes have disappeared, leaving only swamps, sodden meadows and lagoons. Chief of these are Zumpango, San Cristóbal, Xaltocan, Xochimilco and Texcoco, the latter three lying partly in the federal district. The stream flow into this depression and beyond was altered greatly by opening of the Tequixquiac tunnel, conducting water eventually to the Gulf of Mexico, and by the system of tunnels and tubes completed in 1951 providing the state and the federal district with pure water and hydroelectric power.

Agriculture, mining and manufacturing are principal mainstays of the economy. Cereals, especially maize, have been principal crops, in addition to which maguey grown for pulque has long been a mainstay; coffee is also important, and in valley bottoms sugar cane and fruits grow. Manufacturing is concentrated chiefly at the edge of the federal district, where assembly plants, aluminum processing, cement fabrication, iron- and steelworks and many other industrial activities have been established. Mining dwindled in importance while dairying grew. Many communication lines traverse the state. Its capital is Toluca (*q.v.*); altitude 8,659 ft.; pop. (1960) 77,124.

The state contains many preconquest ruins, among them Tenayuca at Tlalnepantla and the great centre of San Juan Teotihuacán, about 30 mi. N.E. of Mexico City, which covers 8 sq.mi. Its Pyramid of the Sun, constructed around A.D. 200, is 211 ft. high, and 693 ft. by 693 ft. at the base. (J. A. Cw.)

**MEXICO, FEDERAL DISTRICT OF** (MÉXICO DISTRITO FEDERAL), seat of the national government of Mexico in a territory comprising Mexico City and its suburbs under the direct supervision of the president. Area, 579 sq.mi. Pop. (1950) 3,050,442; (1960) 4,870,876. Most of the population resides in the central department (metropolitan Mexico City), with the remainder in 12 subordinate jurisdictions (delegations), all under a presidentially appointed governor with cabinet rank.

The district occupies the southeastern corner of the Valley of Mexico, bounded on three sides by the state of México but touching Morelos at the south. An irregular polygon, the district lies between 19° 36′ (Cerro Sombrero) and 19° 05′ N. lat. (Cerro Chichinautzin), about 32 mi. N. to S., and between 98° 56′ and 99° 18′ W. long., about 27 mi. broad, with an average altitude of well over 8,000 ft. Its northern limits are the Sierra de Guadalupe, round topped and barren, which include the peaks of Sombrero, Gachupines and Tepeyac. The Sierra Nevada, including numerous volcanoes and especially Popocatépetl and Ixtacihuatl (*qq.v.*), together with the San Pablo range of cones, limits the district to the east; on the south are high ranges of Ajusco and Cuautzin, and to the west Las Cruces range, connected with Ajusco. Vestiges of an important lacustrine region, including Lakes Texcoco and Xochimilco remain in the southeastern portion of the district, while lava beds (*pedregales*) are extensive in its southern sections. Under the minister of hydraulic resources a commission of the valley is concerned with providing the district with drainage, sufficient and pure drinking and industrial water and hydroelectric power from the many streams, notably the Lerma, that traverse the district. Apart from the city of Mexico, there are eight distinctive ecological and physiographic subzones within the territory, which is divided into 13 political units. Largest and most important of these is the central department or Mexico City proper, together with municipalities it had annexed by 1931: Tacubaya, Tacuba and General Anaya, all later subdivided into residential and business districts blurring their original identities. Apart from this nucleus are the delegations, each of which has a complicated local history from aboriginal days as well as a special role as urban, semirural or agricultural suburb within the metropolitan district. The delegations include Guadalupe Hidalgo (Gustavo A. Madero), Atzcapotzalco, Ixtacalco, Ixtapalapa, Coyoacán, Tlalpan, Xochimilco, Tláhuac, Milpa Alta, Magdalena Contreras, Villa Obregón (San Angel) and Cuajimalpa. Both the central urban area and the delegations or fringes have grown during the 20th century, but the modern city at the centre (*see* MEXICO CITY) vastly overshadows its edges. Comparative populations, in thousands of people, indicate the growth and relationship:

| | 1900 | 1910 | 1921 | 1930 | 1940 | 1950 | 1960 |
|---|---|---|---|---|---|---|---|
| Mexico City | 369 | 471 | 615 | 1,029 | 1,448 | 2,234 | 2,832 |
| Federal District | 542 | 721 | 906 | 1,229 | 1,756 | 3,050 | 4,871 |

Thus, almost 14% of the nation's population is in the Federal District.

The governor, appointed by the president, administers by a congressionally approved organic statute which provides for appointment of local officials and others concerned with justice, public works and fiscal matters. Most of these are highly centralized, with the result that duties of the functionaries in the delegations and their lesser satellites are quite nominal.

Directly north of Mexico City is the delegation of Guadalupe Hidalgo, relatively barren, but famous as a religious shrine. Delegations in the extreme south—Milpa Alta, Tlalpan, Contreras—tend also to be more lightly populated and rural than the agriculturally and industrially richer jurisdictions of Cuajimalpa, Ixtapalapa, Xochimilco and the other suburbs on the outer ring. Atzcapotzalco, Coyoacán and Villa Obregón are highly urbanized. Crisscrossed by networks of bus, streetcar and railway lines terminating in the city, and containing about a third of the republic's automobiles, the district is knit together by communications, though these proved increasingly inadequate to care for its swelling numbers.

Numerous clusters of ruins and aboriginal remains of all sorts are still visible, side by side with colonial Spanish, 19th-century Mexican and ultramodern buildings. (Hd. C.; R. B. McCk.)

**MEXICO, GULF OF,** a partially landlocked body of water indenting the southeastern periphery of North America, connecting to the Atlantic ocean by the Straits of Florida between Florida and Cuba, and to the Caribbean sea by the Yucatán channel between the Yucatán peninsula and Cuba. Its northern boundary is the southern U.S. coast from Florida to Texas. In the southwestern part of the gulf a broad embayment is formed by the Gulf of Campeche west of the Yucatán peninsula.

Mexico and the United States share equally the shoreline of about 3,000 mi., not counting many small indentations. Western Cuba lies midway between Yucatán and Florida. The greatest length—Tampico, Mex., to Cape Sable, Fla.—is almost 1,100 mi.; the greatest width—Galveston, Tex., to Puerto México—is about 775 mi. The total area is about 615,000 sq.mi.

The continental shelf forms an almost continuous terrace around the margin of the Gulf of Mexico, varying in width from about 8 mi. beyond the southern pass of the Mississippi river and off the Mexican coast near Veracruz to 117 mi. off the west coast of Florida and 135 mi. off northern and western Yucatán. The shelf is important economically for its oil reserves (*see* Petroleum: *Production: Offshore Drilling*).

Although the shelf slopes somewhat regularly from the shoreline to the 100-fathom line, it is not a featureless plain. It has numerous minor knobs, ridges, depressions, escarpments and at least two submarine canyons. The most striking topographic features are two great limestone banks—one west of Florida and the other north of Yucatán—and the Mexican basin, deepest part of the gulf. The Mexican basin is a large triangular area near the center of the gulf, bounded by abrupt fault scarps toward Florida and Yucatán and by more gentle slopes to the north and west. Its bottom is nearly flat. The deepest place, Sigsbee deep, is 12,425 ft. below sea level. The gulf shores are mostly low, sandy and marshy, with barrier islands and lagoons extensive in most sections.

Tidal range in the Gulf of Mexico is small, averaging less than two feet at most places. A remarkable feature of most gulf tides is the daily occurrence of only one high water and one low water the greater part of the time. This diurnal tide contrasts with the semidaily type which is prevalent elsewhere. Current movement in the Gulf of Mexico, which feeds the Gulf stream (*q.v.*) consists essentially of a clockwise movement in the main body of the gulf and counterclockwise rotation in some of the larger coastal indentations. A significant portion of the current entering from the Caribbean through Yucatán channel moves directly eastward to the Straits of Florida. Surface currents through Yucatán channel range from one to three miles per hour.

Average surface temperatures in the Gulf of Mexico are very nearly uniform at 84° F. in the summertime. During the winter the temperature is between 65° and 70° F. along the U.S. coast and about 75° F. in the southern part of the gulf. The prevailing winds are the northeast trades, which are particularly strong during summer. The deflection of winds due to the rotational force of the earth causes considerable inflow of moist air from the gulf into southeastern United States. The relatively high temperature of the gulf in winter causes strong cyclonic inflows of air which are associated with the northers that affect the Mexican coast.

*See* U.S. Fish and Wildlife Service, *Gulf of Mexico* (1954).

(D. R. D.)

**MEXICO CITY** (Ciudad de México), capital and metropolis of the republic of Mexico. Pop. (1960) 2,832,133. Officially designated as the central department in 1945, Mexico City forms the core of the federal district which it dominates, the 12 other major political jurisdictions being metropolitan suburbs functionally connected to the central department and without major identity. The city proper, Ciudad de México, to which were annexed in 1930 the ancient municipalities of Tacubaya, San Pedro de los Pinos, Tacuba, Mixcoac, Portales, Popotla, Colonia del Valle and Pueblo de la Piedad, occupies about 53 sq.mi. of the total 579 sq.mi. in the federal district, giving the central department a density of 53,436 persons per square mile and the rest of the federal district a density of 3,876.

The capital is located at the southern margin of the Mesa Central. It is about 800 mi. S. of Laredo, Tex., on the international boundary, with which it is connected by rail and highways; about 200 mi. in direct line west by north of its major gulf port, Veracruz, to which it is joined by two railways and highways; and about 288 mi. N.N.E. by road of its nearest port on the Pacific, Acapulco, to which railways reach only part way, but which is reached by a well-developed highway net. With but few exceptions, trunk rail and highway lines terminate in Mexico City, making it the communications and economic as well as political head of the nation, despite numerous physical drawbacks inherent in its location.

**Physical Setting.**—Mexico City stands on a small lacustrine plain in the southwestern part of the Valley of Mexico or Anáhuac, at an altitude of 7,347 ft., nearly 1½ mi. above sea level. About 3 mi. W. of the city lies Lake Texcoco, and 8 mi. S. are Lake Chalco and Lake Xochimilco, whose combined waters at one time covered most of the oval valley floor, which varies in altitude from about 7,400 ft. to 8,000 ft., surrounded by spurs and chains of mountains and volcanoes which rise to 14,000 ft. above sea level.

Minor tremors are quite frequent, with occasionally violent earthquakes. Drainage works dating from early colonial times but completed in the 20th century nearly dried up these lakes, whose pulverized beds give rise to irritating dust storms (*tolaveras*) and whose spongy subsoils provide poor foundations. As a result until about 1940 Mexico City spread horizontally rather than rising vertically in the form of tall buildings. Completed in 1900, the Tequixquiac tunnel provided a discharge system for waste and sewage waters canalized and emptied into it, whence they pour into a tributary of the Pánuco river and then into the Gulf of Mexico. A series of aqueducts and tunnels from Toluca which cross the high Sierra de las Cruces divert waters of the Lerma river for use in the capital. As vestiges of the Aztec system of filling wicker baskets with earth to form *chinampas* ("floating gardens"), agriculturalists and horticulturalists around Lake Chalco and Lake

LANGE FROM MONKMEYER

LIBRARY OF THE NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO AT UNIVERSITY CITY, WITH STATUE IN FOREGROUND OF MIGUEL ALEMÁN VALDÉS, PRESIDENT OF MEXICO FROM 1946 TO 1952. THE EXTERIOR IS DECORATED WITH MOSAICS

Xochimilco raise vegetables and flowers for market.

Its altitude offsetting its tropical latitude, Mexico City has a temperate and healthful climate, divided into dry (October to March) and wet (April to September) seasons, with about 20–25 in. of annual rainfall, so that irrigation is necessary for any considerable cultivation. Temperatures average about 60° F., seldom rising above an average of 70° F. in the hottest months (June and July), or dropping below an average of 50° F. in the coolest month (December). Night frosts are frequent during winter months, and nights are always cool; there is a marked temperature contrast between sunny and shady places and between the heat of midday and the chill of mornings and evenings. Crops in the district cease growing when the sun sets. Of the mountains surrounding the city the twin volcanic peaks of the Sierra Nevada, Popocatépetl (17,887 ft.) and Ixtacihuatl (17,342 ft.) are perpetually snow-capped.

**History.**—With some justification Mexico City can claim to be one of the oldest metropolises in the new world. It was founded around A.D. 1300 and has been a principal theatre of Mexican history since. Its origins are wrapped in legend, the chief one being that an eagle landed on a cactus (nopal, called by the Indians *tenuch*), which itself was the child of a god, to show the Tenochca-Aztecs (also called Mexica) that a barren island in Lake Texcoco was their promised site. Indeed, after wandering around the valley as slaves and allies of more powerful tribes, the Aztecs were exiled to the middle of the lake for bad behaviour. The traditional founding date of their main city, Tenochtitlán, is placed at 1325; beside it grew a second city, Tlaltelolco. The Aztecs reclaimed the swampy island, and by the middle of the 15th century had grown strong enough to launch a conquest of its riparian neighbours; by the time of the Spaniards' arrival it was the centre of a loosely held confederation of Indian towns and principalities that rendered it tribute from an area westward to Michoacán, east and north to the gulf at about Tampico, southward to the Isthmus of Tehuantepec. The national seal and flag of Mexico retain the original legend in a representation of an eagle eating a snake while perched on a cactus growing out of a split rock. The main Aztec public buildings of Tenochtitlán were grouped around what is the modern Zócalo or La Plaza Mayor de la Constitución in the heart of Mexico City, which in Aztec times was connected to the mainland by causeways. The aboriginal population of the city is variously given from 250,000 to 500,000 people.

Cortés' siege of the city required filling in many of the causeways, and subsequent rebuilding by Spaniards obliterated the many canals used by Indians in lieu of streets. After Nov. 1521, Tenochtitlán was rebuilt as Mexico City to gain for the conquerors its prestige as a capital, since geographic logic pointed to Puebla as the preferable location. Northern and eastern parts of the city, including Tlaltelolco, were assigned to natives, while around its new main plaza the Spanish city was extended southward and westward as a grid of square blocks, divided into house lots and interspersed with parks according to a master plan. Under a long line of colonial viceroys consistent efforts were made to embellish this ancient seat of power, now capital of Spanish America down to Panama. In 1522 the city was chartered and its town council (*cabildo*) recognized, and a year later it was provided with a coat of arms that symbolized Spanish triumph over the natives. The Spanish crown (1535) gave Mexico City priority and leadership over other *cabildos* within New Spain, placing it in seniority on a par with Burgos, capital of Old Castile; the additional title of "very noble, great, and very loyal city" was added by Charles V in 1548. Local riots in 1692 destroyed some of the municipal buildings which were rearranged internally in their repair, especially the viceregal palace (originally built by Cortes for his residence and acquired by the crown in 1562). It is the modern national palace, covering nearly ten acres and containing the executive offices and national archives. There also is the liberty bell rung by Padre Miguel Hidalgo y Costilla on Sept. 16, 1810, Independence day. On this anniversary the president of the republic repeats Hidalgo's original *grito de Dolores*.

The city was a much sought prize during the wars of independence (1810–21) and in the many subsequent political upheavals during the first half of the 19th century. Foreign invaders occupied the city twice in this period. U.S. troops in 1847–48 and French forces, 1863–67. The latter supported the Habsburg emperor of Mexico, Archduke Maximilian, who laid out the Paseo de la Reforma to reach his palace in Chapultepec, now a beautiful park. Growth of population led to formation of new residential sections or *colonias*, first of which was Santa Maria de la Ribera (1862), followed by Guerrero (1880).

Under the long rule of Porfirio Díaz (1876–1911), Mexico City was transformed from an overgrown village into a modern metropolis by vast construction of public buildings, including the post office and Palace of Fine Arts, large business edifices and railway stations, while the introduction of streetcars, gas and electric lighting modified many old features. Architecture followed European styles. The completion of drainage works in 1907 notably improved public health.

With the outbreak of the Mexican revolution in 1910 the capital, as always, proved to be the main prize. Without it, possession of other parts of the nation was relatively meaningless. From Feb. 9 to Feb. 17, 1913, troops loyal to the successful revolutionary president, Francisco I. Madero, engaged in an artillery duel from the national palace with rebels in the nearby Ciudadela, during which numerous victims were killed and many buildings, including the U.S. consulate, damaged. A counterrevolution headed by Victoriano Huerta resulted in Madero's death and brought temporary peace and stability. Though ringed with enemies seeking to avenge Madero's murder and Huerta's usurpation, the latter by control of the capital was able to resist until 1914. In subsequent civil wars the metropolis frequently changed hands until 1920, when some coherence reappeared and the revolution passed into a more constructive phase. Troubled countrysides helped swell the tide of emigration to the capital that increased as new social and economic elements came into being. A new phase in Mexico City's evolution was marked in 1930 by suppression of many small municipalities within its limits and the planning activities detailed below.

The city's population at various years has been: 112,463 (1772); 131,000 (1790); 200,000 (1880); 331,781 (1895); 368,777 (1900); 470,659 (1910); 615,367 (1921); 1,029,068 (1930); 1,448,422 (1940); 2,233,914 (1950); 2,832,133 (1960).

**Metropolitan Growth.**—At the centre of the aboriginal city of Tenochtitlán, Spaniards created a preplanned town for themselves, placing the main public buildings around a square and utilizing materials and Indian sites, so that the great cathedral stands very nearly on the spot of the Aztec main temple, and the viceroy's palace (now national palace) was substituted for the palace of the Montezuma. The grid plan employed in laying out streets for the then small city of Mexico became standard for the whole Spanish empire. Until Mexico City reached a population of more than 1,000,000 in 1930, its growth and development was haphazard and unplanned, as it gradually broadened and enveloped various new nuclei (*colonias*) from 1862 onward. Suppression of numerous municipalities and annexation in 1930 set the stage for a series of planning commissions, first of which was founded in 1933, to reorganize and reform the metropolis. Between 1930 and 1950, the city more than doubled its population without significantly expanding its physical limits. For planning purposes, the city is divided into 19 zones, each of which has been assigned a function. As part of the reforms inaugurated in 1940, street names and numbers were unified, central railway cargo and passenger terminals constructed at the northern edges of the city, and an enormous University City built to house the National Autonomous University of Mexico at the south.

The central zone around the Zócalo remains the heart of the metropolis, and at it terminate most streetcar and city and national bus lines. Within a one-mile radius is the chief commercial and shopping district, chiefly to the south and west. Arterial avenues branch out toward the industrial and often slum-ridden areas to the east and north, while a principal avenue, Avenida de Francisco I. Madero, branches off to the west, broadens to become the Avenida Juárez as it passes the Alameda, the city's oldest park, and the Palace of Fine Arts, and near a colossal monument to the

revolution merges with the city's chief boulevard, the Paseo de la Reforma, which continues nearly 3 mi. to Chapultepec park. After 1940 a number of skyscrapers (offices, hotels and government buildings) sprang up along the Paseo, built on floating caisson foundations. Residential areas are in general south and west of the central zone, though at the extreme southwestern part of the city there is an industrial zone. One of the perennially fascinating aspects of Mexico City is the conjunction of old and new; as solid colonial Spanish constructions are still in use, many residences cling to the Moorish fashion of interior patios, while nearby are examples of modern functional architecture. Similarly, in the more native sections of the city, toward the east, the Aztec language is still spoken. The striking contrasts within the city have since early days provided an almost inexhaustible literary theme.

Especially noteworthy buildings are grouped around the Zócalo. These include the cathedral consecrated as the church of La Asunción de Maria Santisima and the largest in Latin America, started in 1573 but not completed until about 1810; the national pawnshop (Monte de Piedad) founded in 1775 and now a part of the public charities; the municipal palace or city hall; and the national palace, containing modern murals, ancient relics and most of the executive government apparatus, as well as libraries and archives. At Chapultepec castle and the surrounding park, reached by the impressive Paseo de la Reforma, are clustered numerous other points and items of interest and beauty, while each of the suburbs contains special features, such as the floating gardens at Xochimilco, the shrine at Guadalupe Hidalgo, University City, the Desert of the Lions and the archaeological ruins in the southern and western outskirts. The extensive City of Sports on the Avenida Insurgentes includes a bullring, a football stadium, a boxing arena, a *jai alai frontón* and a theatre.

**Education and Culture.**—As a direct dependency of the federal government, Mexico City's educational and cultural institutions are highly developed models for the rest of the nation. Within the national ministry of education a special department deals with the problem of primary and adult education for the federal district, which has about 1,200 elementary schools. About a quarter of the enrollment in secondary schools through the nation is concentrated in the federal district, specifically in Mexico City, with more than 100 schools (national and private). The National university was founded in 1553 as the Royal and Pontifical University of Mexico, interrupted during the 19th century and reopened in 1910; its several staffs train a student body of 30,000–40,000 annually in excellent schools ranging from architecture through law. Completion of University City in 1952 provided it with an impressive up-to-date plant. An interesting experiment in blending Mexican with American ways is represented by the privately run Mexico City college, founded in June 1940. Specialists of all sorts are trained at the huge and modern National Polytechnic institute, made autonomous in 1944, with 20,000 or more students. Near Mexico City at Chapingo is the National Agricultural school for advanced training. There are smaller schools of tropical medicine, health and hygiene and physical education, and a number of teacher-training schools. Most of the major centres of learning and teaching support extensive research and publication efforts; Mexican scholars connected with them and the diverse activities supported by government ministries in Mexico City have made notable contributions in astronomy, archaeology, chemistry, history, tropical medicine and all branches of the humanities. Mexico City is considered one of the great intellectual metropolises of the western hemisphere, a reputation gained and maintained in early colonial days. As compared with a national illiteracy rate of around 40% that of the federal district and Mexico City is close to 15%.

Popular museums supplement the great collections in the National Ethnological and Historical museum, just as local libraries parallel the National library. The Benjamin Franklin library was established by Americans for Mexicans as a good-will gesture in 1942. The Palace of Fine Arts at the east end of the Alameda houses the National theatre, art galleries and auditoriums.

**Industry.**—Mexico City's role as political and cultural head of the republic has traditionally been associated with its hegemony in fiscal and commercial matters; to this has been added the development of industry and manufacturing. It is the seat of the main sources of credit from private banking, national banks under the Banco de Mexico (founded in 1925 and later evolved into a central bank), and government-sponsored investments. With markets at hand, raw materials accessible and a vast labour pool, it is not surprising that Mexico City represents the single largest industrial aggregate in the republic. Much industrial expansion took place after 1944, when "new and necessary" industrial establishments within the federal district were given substantial tax exemptions and other aid in securing industrial sites at low cost by presidential decree. Dating from 1907 are iron and steel works (*La Consolidada*), leader among more than 30 foundries and fabricators in the district; other older industries include textiles, cigars and cigarettes, paper, shoes, bricks, glass, pottery, industrial chemicals and a wide range of food processing and household manufactures. There are numerous assembly plants established by large foreign producers, chiefly U.S., to finish their products in Mexico City. They include plants for automobiles and trucks, refrigerators, radio and television sets, electrical motors and appliances, pumps and miscellaneous consumer items. The total number of manufacturing establishments in and around Mexico City in the mid-1950s was estimated at 16,500, responsible for from 50% to 60% of the national manufacturing output.

**Communications and Transport.**—Mexico City's connections with the rest of the republic and the world are superior to its local facilities for moving people and goods from one part of the federal district to another, though neither are optimum. Rail, highway and air lines converge on the capital, a major terminal and transshipment point. Foreign-built and -owned railways were nationalized, so that by mid-20th century no road longer than 100 mi. remained in private hands. Under the National Railways of Mexico, a semiautonomous government agency, efforts were made to standardize gauges and rehabilitate trunk lines by replacing light with heavy rails and to improve terminal facilities in Mexico City. The several small, scattered and unsatisfactory passenger stations were sold, and the money applied to construction of a modern union station north of the Zócalo. The Nonoalco freight station in the congested business zone gave way to a modern housing unit for 38,000 people, with a modern cargo terminal substituted in the suburb of Gustavo A. Madero (Guadelupe Hidalgo) near the major industrial core of the city. Rail connections from the capital link it to Veracruz by two lines, the old Mexicano and the old Inter-Oceanic, with connections to the Isthmus of Tehuantepec and to Guatemala; a direct Mexico City-Tuxpán route was begun, while a link to the important gulf port of Tampico is maintained indirectly via San Luis Potosí, which also is a transfer point for the Pacific port of Manzanillo (via Guadalajara). Connections between Mexico City and Guadalajara, terminal of the Mexican South Pacific, tap the Pacific littoral and thence to the U.S. border at Nogales. A trunk line from Laredo, Tex., to Mexico City is a major economic artery. Mexico City is linked to the peninsula of Yucatán and its local network, while Mexicali, Lower California, was reached by national lines via Sonora. About 2 mi. N.E. of Mexico City is a large central airport capable of handling the largest civil aircraft on the numerous scheduled national and international routes which crisscross the country. Several broadcasting stations and television transmitters (one the first in Latin America), long-distance and telecommunication circuits to the United States and Europe make the capital a prime communications centre.

The rapid growth of Mexico City created a serious internal transportation problem. The 16th-century city was ill-adapted to the sudden traffic load created by extensive use of vehicles by its swollen population. At the turn of the 20th century, British capital provided streetcars that continued in service, without major maintenance or replacement. In the early 1960s within the city limits there were about 150,000 vehicles, including more than 100,000 private automobiles.

*See* also references under "Mexico City" in the Index.

(Hd. C.; R. B. McCk.)

**MEYER, ADOLF** (1866–1950), U.S. psychiatrist, whose teaching, called psychobiology (*see* PSYCHIATRY: *History: Psychobiological School*), was based on a concept of man as a psychologically integrated biological unit, was born Sept. 13, 1866, in Niederweningen, canton of Zürich, Switz., obtained his medical education in Zürich and went to the United States in 1892. Starting as pathologist in hospitals for the mentally ill, he found that he could not limit himself to the dead body but had to devise methods for the clinical study of the living patient. The outstanding scientific and practical quality of his work at Worcester, Mass. (1895–1902), led to his appointment as director of the pathological institute of the New York State hospitals (1902–10), where his leadership revolutionized methods of treatment. In 1910 he was called to Baltimore, Md., to the chair of psychiatry at the Johns Hopkins university, with the responsibility of creating and directing the Henry Phipps psychiatric clinic. He was among the first to stress psychological factors as medically pertinent, and his "reaction sets" pointed to the variety of causes responsible for mental illness. His emphas. was always on the concrete person. Prevention was a strong interest, and he served as adviser in the organization of the National Committee for Mental Hygiene. He retired in 1941 and died March 17, 1950. Meyer's *Collected Papers* were published in four volumes, 1950–52, and his *Psychobiology* posthumously in 1957. (E. E. W.)

**MEYER, CONRAD FERDINAND** (1825–1898), one of the most important of Swiss writers, ranking with Jeremias Gotthelf and Gottfried Keller. He belonged to an ancient aristocratic Zürich family and was born in Zürich on Oct. 11, 1825. After completing his schooling he began to study law, but the sensitive boy suffered from depression which compelled him to enter a mental home for a time. A long stay in French Switzerland, largely in Lausanne, gave him a thorough knowledge of French literature and culture and he took up history, studying abroad in Paris and Italy. Rome, and especially the work of Michelangelo, was one of the decisive experiences in his life, and Michelangelo's monumental style became an ideal which he attempted to realize in his own poetry. He passed the rest of his life in Zürich or nearby, where, with no settled profession and of independent means, he was able to devote himself to his writing; from 1877 he had a country house at Kilchberg, near Zürich. In 1892 depression once again forced him into a mental home for a year and afterward he did no more creative work. He died on Nov. 28, 1898, at Kilchberg.

Meyer began to write rather late and his total output was relatively slender. After two unimportant collections of poetry (*Zwanzig Balladen*, 1864; *Romanzen und Bilder*, 1870), he achieved his first success with a work of permanent importance, the powerful poem *Huttens letzte Tage* (1871). The narrative poem *Engelberg* (1872) was followed by his 11 *Novellen—Das Amulett* (1873), *Jürg Jenatsch* (1876), *Der Schuss von der Kanzel* (1878), *Der Heilige* (1880; Eng. trans. *The Saint*, 1930: on Thomas Becket), *Plautus im Nonnenkloster* (1881), *Gustav Adolfs Page* (1882), *Das Leiden eines Knaben* (1883), *Die Hochzeit des Mönchs* (1884; Eng. trans. *The Monk's Wedding*, 1887), *Die Richterin* (1885), *Die Versuchung des Pescara* (1887) and *Angela Borgia* (1891). His *Gedichte* were first collected in 1882.

Meyer's poetry contains no elements of the popular and is directed toward the educated and critical reader. He laid great stress on a polished form. In his *Gedichte*, his most personal and most original work, he created a new type of poem. It dispenses entirely with direct expressions of feeling and in an almost brittle tone presents a terse figurative *motif* (generally provided by history or by the mountains of his own countryside) to which he gives symbolic value. He was thus one of the first representatives of Symbolism. The material of his artistically constructed *Novellen*, which approach dramatic form, is taken exclusively from history, mainly from the Renaissance; but history is only the garment in which he clothes personal or general human problems: the meaning of destiny, the relationship of a man to death, the problems of justice, the power of conscience. The chief figures were passionate men of action whom the writer longingly admires, or innerly divided figures resembling himself. The stories are often lightly shot through with irony. This irony and Meyer's reserved and skeptical attitude to life set him somewhat outside the literary movements of his time and make him rather a precursor of the psychological writing of the 20th century.

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(A. Z.)

**MEYER, EDUARD** (1855–1930), German historian who established ancient Egyptian chronology, recognized the value to a historian of folklore, numismatics and historical monuments and did pioneer work in ancient history. Oswald Spengler was among those he influenced. Born in Hamburg, Jan. 25, 1855, he was educated at the excellent Johanneum school, where he began his classical and historical studies and learned Hebrew and Arabic, and at Bonn and Leipzig universities. He became professor of ancient history at Breslau (1885), Halle (1889) and Berlin (1902). Meyer's lifework was the *Geschichte des Altertums*, 5 vol. (1884–1902; new edition by E. Stier, 1953 *et seq.*), which he spent his later years revising. Other books, including *Ägyptische Chronologie* (1904), *Cäsars Monarchie und das Prinzipat des Pompejus* (1918) and *Ursprung und Anfänge des Christentums* (1921–23), were more detailed explorations into the universal history which was his goal. He died in Berlin on Aug. 31, 1930.

*See* H. Marohl, *E. Meyer Bibliographie*, with memoir (1941).

**MEYER, KUNO** (1858–1919), German Celtic scholar and editor whose fine translations made him the chief interpreter of Irish literature to English readers, was born at Hamburg on Dec. 20, 1858. After studying at Edinburgh and Leipzig, he became in 1884 lecturer in German at the University college, later the University, of Liverpool. An ardent propagandist, he founded the School of Irish Learning, Dublin (1903), and its journal *Ériu* (1904), as well as later establishing Celtic reviews in Germany. Meyer's many publications include *The Voyage of Bran* (1895) and *Selections From Ancient Irish Poetry* (2nd ed., 1911). In 1911 he became professor of Celtic at the University of Berlin. He died at Leipzig on Oct. 11, 1919. (Ms. D.)

**MEYER, (JULIUS) LOTHAR** (1830–1895), German chemist, was born on Aug. 19, 1830, at Varel in Oldenburg. His earliest work was on the chemistry of the blood, but his name is best known for the share he had in the development of the periodic classification of the elements (*see* PERIODIC LAW). He studied medicine at Zürich and Würzburg and then turned to physiological chemistry at Heidelberg and finally to mathematical physics at Königsberg. After lecturing on chemistry at Eberswalde and Karlsruhe, he became, in 1876, professor of chemistry at Tübingen, where he died on April 11, 1895.

Meyer noted, as did J. A. R. Newlands independently in England, that if the elements are arranged in the order of their atomic weights they fall into groups in which similar chemical and physical properties are repeated at periodic intervals. In particular he showed that if the atomic weights are plotted as ordinates and the atomic volumes as abscissas, the curve obtained presents a series of maxima and minima, the most electropositive elements appearing at the peaks of the curve in the order of their atomic weights. Other physical properties gave the same type of curve. His book on *Die modernen Theorien der Chemie*, which was first published in Breslau in 1864 and later translated into English, contains a discussion of relations between the atomic weights and the properties of the elements. In 1882 he, along with Dmitri Mendeléyev (*q.v.*), received from the Royal society the Davy medal in recognition of his work on the periodic law.

*See* K. Seubert, *Ber. dtsch. Chem. Ges.*, vol. 28, p. 1103, and B. Bedson, *J. Chem. Soc.*, p. 1403 (1896); also: P. Walden, essay in G. Bugge, *Buch der grossen Chemiker* (1929–30).

**MEYER, (MARIE) PAUL (HYACINTHE)** (1840–1917), French philologist, who ranks as a great modern authority on the French language, was born in Paris on Jan. 17, 1840. He was educated at the École des Chartes and in 1863 was attached to the manuscript department of the Bibliothèque Nationale. In 1876 he became professor of the languages and literatures of southern Europe at the Collège de France. In 1882 he was made director of the École des Chartes and in 1883 became a member of the Academy of Inscriptions. He was one of the founders of the *Revue Critique* and a founder and the chief contributor to *Romania* (1872). Meyer began with the study of old Provençal literature. He edited many old French texts for the *Société des anciens textes français*, and independently. He died on Sept. 7, 1917, at Paris.

**MEYER, VIKTOR** (1848–1897), German chemist who developed an important method for measuring the density of vapours, was born at Berlin on Sept. 8, 1848. He studied at Heidelberg under R. W. Bunsen (inorganic and analytical); E. Erlenmeyer (organic); H. Kopp (theoretical chemistry); G. R. Kirchhoff (physics); and he also worked under A. Baeyer in Berlin. In 1871 he was appointed extraordinary professor at Stuttgart polytechnic, and in 1872 succeeded J. Wislicenus at Zürich polytechnic. He was then only 24. In 1885 he obtained the chair of chemistry at Göttingen, and in 1889 he succeeded Bunsen at Heidelberg. He was awarded the Davy medal in 1891. Meyer proved to be not only a great investigator but also a stimulating teacher, with a wonderful command of language. He suffered from ill-health and committed suicide on Aug. 8, 1897. He is buried not far from Bunsen and Kopp in the Heidelberg cemetery.

Meyer's first papers dealt with the composition of a camphor, chloral hydrate, and the structure of benzene. In 1872 he discovered the nitro compounds (*q.v.*) of aliphatic hydrocarbons, and this led him on to the study of nitroso compounds and nitrols. In 1882 he discovered the oximes (*q.v.*) and showed that they can exist in stereoisomeric forms; he also investigated the chemistry of these compounds thoroughly. He invented the term stereochemistry. In 1871 he devised a method for determining vapour densities, and this led him on to a series of pyrochemical studies, in which the vapour densities of inorganic substances were determined at fairly high temperatures. The results of this work, with his brother, Carl Meyer, were collected in *Pyrochemische Untersuchungen* (1885). In the course of a lecture demonstration he made an observation which led him to the discovery of thiophene (*q.v.*) in 1883; he studied the substance and determined its structure; the results are published in *Die Thiophengruppe* (1888). In 1892 he discovered the iodoso compounds. He also studied "steric hindrance," a name coined by him. He and Paul Jacobson compiled the famous large *Lehrbuch der organischen Chemi*, 2 vol. (1893–96; 2nd ed., 1922–29).

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**MEYERBEER, GIACOMO** (1791–1864), German opera composer who established in Paris a vogue for spectacular romantic opera. He was born at Tasdorf, near Berlin, on Sept. 5, 1791, of a wealthy Jewish family, his real name being Jakob Liebmann Meyer Beer. He studied composition with C. F. Zelter and Bernard Weber in Berlin and from 1810 with G. J. Vogler at Darmstadt, where he formed a friendship with C. M. von Weber. His early German operas, produced at Munich, Stuttgart and Vienna, were failures, and after a journey to Paris and London he settled in 1816 in Italy, where he produced five operas in the style of Rossini. The best of these was *Il Crociato* (Venice, 1824), given the following year in London and Paris. His first French opera, written in association with Eugène Scribe, was *Robert le Diable* (Paris, 1831), produced on an extremely lavish scale and calculated to appeal to the current romantic taste for medievalism, the supernatural and the macabre. Its success was immediate, establishing this work as the model of French grand opera. *Les Huguenots* was similarly successful in 1836. In 1842 Meyerbeer temporarily returned to Berlin, where he became music director to the king of Prussia and where he promoted the production of Wagner's *Der fliegende Holländer*. From this period date his German opera *Ein Feldlager in Schlesien* (1844), in which Jenny Lind took the principal part, and the incidental music he wrote for the play *Struensee* by his brother Michael Beer. His third romantic opera on a libretto of Scribe, *Le Prophète*, was given in Paris in 1849. He then turned to a lighter style and produced two works in the tradition of the *opéra comique*, *L'Etoile du Nord* (1854) and *Le Pardon de Ploërmel* (1859). Meyerbeer died in Paris on May 2, 1864. His last opera, *L'Africaine*, was in rehearsal at the time and was not given until the following year.

Meyerbeer enjoyed an enormous vogue in his day but later generations judged his music to be superficial and his reputation, based on his four Paris operas, did not survive long. Yet he had a considerable influence on the development of opera. This influence derived from his conception of big character scenes, his dramatic style of vocal writing and his original sense of the orchestra, particularly his novel use of the bass clarinet, the saxophone and the bassoon. Berlioz came under his influence and operas such as Verdi's *Don Carlos* and Puccini's *Turandot* owe to Meyerbeer not only their spectacular element but also their effective manipulation of ensembles and arias.

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**MEYERHOF, OTTO** (1884–1951), German biochemist, was awarded the Nobel prize in physiology and medicine, jointly with A. V. Hill (*q.v.*), in 1922 "for his discovery of the fixed relationship between consumption of oxygen and the metabolism of lactic acid in muscle." Meyerhof was born at Hanover, Ger., on April 12, 1884. He studied medicine at the universities of Freiburg, Berlin, Strasbourg and Heidelberg (M.D., 1909).

Meyerhof's early interests were in psychology and philosophy, but under the influence of Otto Warburg he turned to the study of physiology and physical chemistry. He held positions at Kiel and at other German universities, and became well known in England and the United States as a visiting lecturer and as the author of a book on *The Chemical Dynamics of Life Phenomena* (1924). In 1929 he became head of the department of physiology of the Institute for Medical Research in Heidelberg, but in 1938 he was forced to leave Germany. He continued his work in Paris, and, after the German invasion of France in 1940, escaped to the United States, where he was appointed research professor in the department of physiological chemistry at the University of Pennsylvania. Although Meyerhof's work was greatly revised and extended as a result of later research it remained a basic contribution to the knowledge of the very complex processes involved in muscular action. He died in Philadelphia, Pa., Oct. 6, 1951. (W. J. Bp.)

**MEYERHOLD, VSEVOLOD EMILIEVICH** (1874–1942), Russian theatrical producer who was head of the Communist theatre throughout the U.S.S.R., received his early training (1898–1905) in Stanislavski's Moscow Art theatre. His stylistic experiments conflicted, however, with Stanislavski's emphasis on naturalism. Subsequently Meyerhold developed his highly individualistic theories in a theatre with no proscenium, no curtain and a bare stage with the action projected on a forestage against constructivist and scenic abstractions.

During the Russian Revolution he became head of the theatre section of the Commissariat of Education, responsible for all Bolshevik theatre activities including a new form of political propaganda theatre for the masses. His productions developed a more allegorical and symbolical style and in the 1930s was criticized as too individualistic; *Camille* in 1936 and Tchaikovsky's *Queen of Spades* were said to reflect a bourgeois, formalistic departure from the revolutionary pattern. *Pravda* denounced him for his persistent production of "anti-Soviet" plays and he came under the fire of Communist party officials. His theatre was liquidated. In June 1939, as a principal speaker before the first

national convention of theatre directors in Moscow, he clarified his own views on the art of the theatre. The following day he was arrested and he was not heard of again in the west until 1958, when the *Great Soviet Encyclopaedia* reported his death in 1942. Meyerhold wrote *On the Theatre* (1913) and *Reconstruction of the Theatre* (1930). (D. M. O.; X.)

**MEYER-LÜBKE, WILHELM** (1861–1936), Swiss philologist, a central figure of Romance linguistics, was born in Dübendorf, Switz., on Jan. 30, 1861, and taught at Zürich, Jena, Vienna (1890–1915) and Bonn. Meyer-Lübke established his reputation as a comparativist with his *Grammatik der romanischen Sprachen* (4 vol., 1890–1902; French trans., 1890–1906), which revolutionized the discipline and with his less influential *Romanisches etymologisches Wörterbuch* (1911–20; 3rd ed., 1930–35). He published manuals and monographs on Old Sardinian (1903), Old Portuguese (1904–17), Catalan (1925) and Rumanian; his *Italienische Grammatik* (1891), revised and translated into Italian, became widely accepted. The *Historische Grammatik der französischen Sprache* represents for phonology (1908), chronological sequences and for derivation (1921) a novel patterning around functional nuclei. Most successful in methodology, Meyer-Lübke reached his peak in the *Einführung in das Studium der romanischen Sprachwissenschaft* (1901; 3rd ed., 1920; Spanish trans. and rev. by R. Castro, 1926). He died Oct. 4, 1936, at Bonn, Ger. (Y. M.)

**MEYNELL, ALICE CHRISTINA GERTRUDE** (1847–1922), English poet and essayist whose verse, though limited in scope, recaptures something of the spirituality and simplicity of language of 17th-century religious poetry, was born at Barnes, near London, on Sept. 22, 1847. Her father, Thomas James Thompson, a man of culture and a friend of Charles Dickens, himself superintended his daughter's education and much of her childhood was spent in Italy. In about 1872 she was converted to Roman Catholicism. Encouraged by Tennyson and Coventry Patmore she published her first volume of poems, *Preludes*, in 1875. One sonnet, "My Heart Shall be Thy Garden," brought her the friendship of Wilfrid Meynell (1852–1948), whom she married in 1877. Although they had eight children, her literary activities continued to flourish. She helped her husband, who edited the *Weekly Register*, and in 1883 launched *Merry England* (1883–95), a monthly magazine to which she contributed many essays. His contributions to it led to the discovery of Francis Thompson (*q.v.*), who was rescued and befriended by the Meynells.

In 1889 she began contributing essays to the *Scots* (later the *National*) *Observer*. These were subsequently reprinted in *The Rhythm of Life* (1893), the first of several collections of essays. In the same year she published *Poems* and was hailed as a genius by Patmore, whose work she in turn greatly admired. Her weekly articles in the *Pall Mall Gazette*, reprinted in *The Colour of Life* (1896), attracted the praise and friendship of George Meredith. In 1901 she visited the United States on a lecture tour and on her return resumed her indefatigable literary industry, writing art criticism, light journalism, literary reviews and still more essays. The popularity of her poetry led her to be mentioned as a possible poet laureate, and she continued to produce verse until her death. She died in London on Nov. 27, 1922.

Her prose has fallen out of fashion with the change in attitude to the essay, but her essays, on many subjects—literature (including a first-rate essay on Dickens, in *Hearts of Controversy*, 1917), women, landscape and children—testify both to the delicate charm of her personality and to the independence of her judgments. Her admiration of 17th-century poetry was unusual for her time, and her own verse, with its religious sincerity, simple vocabulary, gentle mournfulness and sense of the passing of time, has in it many of the qualities she valued.

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**MÉZIÈRES, PHILIPPE DE** (*c.* 1327–1405), French knight, chancellor of Cyprus and writer, the unfaltering champion of the lost cause of the crusades (*q.v.*), was born at Mézières in Picardy. From the canons of Notre Dame at Amiens he learned the idealism of the medieval romances of chivalry; and in 1345 he was in Italy, serving first Lucchino Visconti, lord of Milan, then Andrew of Hungary in Naples. Having joined the crusade led by Humbert II of Viennois against the Turks in Anatolia in 1346, he was knighted soon after the battle of Smyrna. He then made a pilgrimage to Jerusalem (1347), where a vision inspired him to plan a new order of knighthood for the recovery of the Holy Places from the Muslims. On his way home he spent about a year in Cyprus, where he found a fervent sympathizer in the count of Tripoli, later Peter I of Cyprus. He was at Avignon, the seat of the papacy, in 1349 and in Normandy fighting the English in 1354.

Peter became king of Cyprus in 1358; and by the end of 1361 Mézières was chancellor of the kingdom. Encouraged by the papal legate Peter Thomas (Petrus Thomasius), king and chancellor then set off to Europe to win support for a crusade. In 1363–64, while Peter I was visiting France and England, Mézières was in Italy negotiating between Milan and the papacy; but he may have rejoined Peter I in Germany and he was with him in Venice between Nov. 1364 and June 1365. The crusade, finally launched against Egypt, culminated in the sack of Alexandria (Oct. 1365) but came to nothing more. Two further missions, to Venice and Avignon (1366–67) and to Italy with Peter I again (1367–68), were unsuccessful. When Peter I, back in Cyprus, was assassinated in Jan. 1369, Mézières was still in Venice. He never returned to Cyprus.

After a short visit to Avignon (1372), Mézières went to Paris where Charles V of France made him a member of the royal council (May 1373) and preceptor to his son, the future Charles VI. On Charles V's death (1380) Mézières retired to the Celestine monastery in Paris. When Charles V's former ministers were in power again (1388–92) he exercised some further influence on affairs. Later he was a protégé of Louis, duc d'Orléans. He died in Paris on May 29, 1405.

What part Mézières had in composing the *Somnium viridarii* (*Le Songe du vergier; see* CHARLES V) is controversial. Apart from this, his major writings are: his life of the legate Peter Thomas (1366); his prospectus for his "New Order of the Chivalry of the Passion" (drafted first in 1367–68 and re-elaborated in 1384 and in 1396); *Le Songe du vieil pèlerin* ("The Old Pilgrim's Dream"; 1389), an allegory in which Queen Vérité, or Truth, visits the countries of the known world, containing autobiographical elements and a plea for peace between France and England in the interests of the crusade; the *Oracio tragedica* (1389–90), dedicating his old age to "spiritual" instead of practical crusading; and the *Epistre lamentable et consolatoire* (1397), on the defeat of the Balkan crusade at Nicopolis on the Danube in 1396.

*See* N. Jorga, *Philippe de Mézières . . .* (1896); D. M. Bell, *Études sur le Songe du vieil pèlerin* (1955).

**MEZZO-SOPRANO:** *see* SINGING.

**MEZZOTINT** is a process of engraving in which a plate that has been prepared to produce a black impression in paper is burnished in such a way that it will produce a picture in tonal values. A copper or steel plate is first pricked with innumerable small holes which will hold ink. The pricking of the plate was originally done with a roulette or small wheel covered with sharp points, but later an instrument called a cradle or rocker was used. This resembles a small spade with a toothed edge and with it a copper or soft steel plate can be roughened all over. Nevertheless, this is a tedious and laborious procedure. The rocking process not only punctures the plate to hold ink, but also produces a burr on the metal's surface, which, cutting into the paper while in the press, causes a deeper absorption of ink, and produces that velvety effect characteristic of the mezzotint in an early impression. A simpler (20th century) method of preparing a plate is to work over it in several directions with a carborundum stone.

After the surface of the plate has been prepared, the high lights in the picture are obtained by scraping away and burnishing parts of the plate, thus reducing or obliterating the small holes, according to the effect desired. The surface of the roughened plate is left undisturbed where the deepest black is required, and by a graduated scraping of the plate, which removes both burr and punctures so that ink is held in lesser degrees, middle and light

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"THE STANDARD BEARER" BY PRINCE RUPERT (1619–1682). DUTCH IN THE ART INSTITUTE OF CHICAGO

tones are obtained when an impression is taken from it. In mezzotint, as in all other forms of printmaking, the ink used is a thick ink which does not run.

**History.**—About the middle of the 17th century, Ludwig van Siegen (1609–76), a Dutch officer in Hessian service, who was also an amateur artist, applied the old device of dotted work to a metal plate by means of a small roulette, and succeeded in producing an excellent print entirely by its use. His portrait of Amelia Elizabeth of Hesse (1642) is the earliest dated mezzotint. In 1654, Van Siegen met Prince Rupert, count palatine of the Rhine and grandson of James I of England, at Brussels. Prince Rupert, a skilled amateur artist, became deeply interested in Van Siegen's invention, which he at once tried. In a short time he produced a very fine piece of rouletting in a print of "The Large Executioner," after José Ribera. William Sherwin, the English engraver and a friend of Prince Rupert, learned the new art from him and made mezzotint portraits of Charles II and his queen in 1669, dedicating them to Rupert.

The early mezzotinters were Dutchmen who, curiously enough, did most of their work in England. Their productions are not particularly distinguished until the arrival in 1673 of Abraham Blooteling who did splendid work, especially after Van Dyck, Sir Godfrey Kneller and Sir Peter Lely. However, his greatest contributions to the method were his improvements in technique. Instead of using only a roulette to produce dark space, he began by roughening the plate all over, so that if printed from, it would show simply a black space, and then he cut away the roughness with a scraper to render the high lights as required. It was Blooteling who invented the tool called the rocker, which is described above, and substituted it for the roulette.

**The 18th Century.**—After Blooteling, and during the 18th century, a remarkable school of English mezzotinters became prominent, and did such distinguished work that abroad the process became known as *la manière anglaise*. This pre-eminence was due not only to their remarkable skill and the beauty of their work but also to the fact that there were in England at that time portrait painters of the very first rank for them to interpret. The existence of the finest mezzotints ever made is due to the inspiration of men like Lely, Reynolds, Lawrence, Romney, Hoppner, Constable and several others of lesser reputations. It was in England that J. C. Le Blon (1667–1741) made the earliest attempts to produce multicolour mezzotints.

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SIR JOSHUA REYNOLDS BY VALENTINE GREEN (1739–1813). ENGLISH, 18TH CENTURY. IN THE ART INSTITUTE OF CHICAGO

Early in the 18th century an Irishman, Thomas Frye (1710–62), who had tried several other byways of art before specializing in mezzotint, ended by "scraping" a series of large portrait heads from his own drawings. Another Irishman, James MacArdell (1729–65), became one of the greatest mezzotinters. Sir Joshua Reynolds had so high an estimation of MacArdell's work that he declared he would be immortalized by his engravings, a statement which may prove true because the paintings have in many cases deteriorated badly and the mezzotints of MacArdell are lasting records of their original qualities. Richard Earlom (1743–1822) used only the roulette where he wanted shadows. His most famous work is the "Liber Veritatis" after the drawings of Claude Lorrain which suggested to J. M. W. Turner, in the next century, his "Liber Studiorum."

The numerous mezzotints by Valentine Green (1739–1813) are of the highest quality. He frequently printed his plates in brown ink, a practice which became very popular, and he was especially successful in his renderings of the full length female portraits by Sir Joshua Reynolds. John Raphael Smith (1752–1812) began his artistic career as a miniature painter, but eventually became one of the foremost mezzotint engravers. He worked mainly after Reynolds but was very successful in his interpretations of Romney. S. W. Reynolds (1773–1835), who made 357 plates of portraits after Sir Joshua Reynolds, was much more successful in his larger plates. He was an accomplished artist and produced many plates after his own work. Later he did mezzotinting on some of the plates in Turner's "Liber Studiorum."

**The 19th Century.**—The use of steel plates for mezzotint was introduced by William Say (1768–1834), who sought to substitute a more durable metal for copper which, because of its softness, produced only a small number of impressions of high quality. He used a hard steel and the results were not as satisfactory as those of T. G. Lupton (1791–1873), who employed a softer quality of the same metal. Instead of being able to print only about 50 proofs of excellence from copper, it was found possible to print about 1,500 from steel, without the appearance of deterioration.

Both Samuel Cousins (1801–87) and David Lucas (1802–81), apprentices to S. W. Reynolds, used etching and engraving freely with mezzotint, so much indeed that their method is known as the "mixed" style. Cousins' plate of "Bolton Abbey in the Olden Time" after Sir Edwin Landseer, published in 1837, is said to have killed the art of line engraving in England by proving that paintings could be much more effectively reproduced by mezzotint. With equal justification, the same claim might be made for Lucas' wonderful series of plates after John Constable.

**The 20th Century.**—Despite its inimitable charms and individual qualities, mezzotint had always been practised principally as a reproductive medium and the introduction of photogravure and a myriad of photomechanical processes has made it almost obsolete. During the latter part of the 19th and the first half of the 20th centuries it had its practitioners, although it had lost much of its purpose and vitality. Sir Frank Short, C. W. Campbell, John D. Miller, Gerald P. Robinson, William Strang and S. Arlent Edwards produced work which had success with amateurs and collectors but was looked upon as old-fashioned by the following generation. The once highly popular medium has been rarely used since, although Georges Rouault and S. W. Hayter each made several plates. Its most distinguished and almost solitary advocate afterward was Yozo Hamaguchi, a Japanese artist living in Paris. *See* also ENGRAVING, LINE; ETCHING; STIPPLE AND CRAYON ENGRAVING.

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**MIAMI,** an Algonkian-speaking Indian tribe, first encountered by Europeans in the 17th century in the Great Lakes region of the U.S. Traditionally they had patrilineal clans and subsisted on hunting and agriculture. They were estimated to number not more than 1,750 in historical times; about 150 Miami were reported to live in California and Oklahoma in the 1960s. *See* also ALGONKIAN TRIBES; WEA INDIANS.

*See* W. V. Kinietz, *Indians of the Western Great Lakes, 1615–1760* (1940), C. Godfroy, *Miami Indian Stories* (1961). (H. B. Cs.; X.)

**MIAMI,** the metropolis of southeastern Florida, U.S., the transportation and business hub of greater Miami and the administrative and political centre of Dade county. The city is located

on Biscayne bay at the mouth of the Miami river. The climate and vegetation are subtropical, with generally wet summers and dry winters. Average monthly mean temperature ranges from 66.5° F. in January to 81.4° in August, with recorded extremes of 27° and 97°. The warmth of the north-flowing Gulf stream and the prevailing southeasterly winds help to make an ideal winter climate for tropical fruits and vegetables and a favoured tourist centre.

Greater Miami, which is co-extensive with the Miami standard metropolitan statistical area, comprises all of Dade county and includes several smaller cities, each with its own personality. Only Miami Beach (*q.v.*), across Biscayne bay on the Atlantic ocean, is older than the real-estate boom of the 1920s. Until 1912 a mangrove swamp on which coconuts and avocados had been planted, Miami Beach became the tourist, hotel and convention centre of greater Miami with housing for 120,000 visitors. West of Miami, Coral Gables (*q.v.*), born of the real-estate boom and chartered in 1925, is almost exclusively a middle and upper middle-class residential city with many winter homes and apartments rather than hotels. Hialeah (*q.v.*) grew from a ranch in 1911 to a real-estate development in 1917 to incorporation in 1925. Hialeah is characterized by its industries and the workers who live there and by Hialeah Park, the leader of Miami's three horse-racing tracks. North Miami (*q.v.*) represents the northern reach of Miami.

Other smaller municipalities are: North Miami Beach, Miami Springs, Opa-Locka, Miami Shores and South Miami. Yet another group of 13 municipalities range in population up to 5,000; seven of them are under 1,000. The population of the city of Miami in 1960 was 291,688; of the metropolitan area, 935,047. (For comparative population figures *see* table in FLORIDA: *Population.*)

**History.**—Spaniards in the 16th century found a village of Tequesta Indians at the mouth of the river, estimated to have been there for perhaps 2,000 years, subsisting chiefly on the bounties of nature. The name "Mayaimi" seems to have belonged to a large inland lake, probably Okeechobee, and to a nearby Indian group who may have been in contact with Biscayne bay by way of the watery Everglades. In 1567 the Spaniards planted a mission among the Tequesta tribe in a futile effort to pacify the hostile Indians, protect the route of the treasure fleets from America and provide a refuge for victims of storms and wrecks on the Florida reef.

The British made the first recorded land grant in 1774 during their 20-year control of Florida, but nothing came of it. The Spaniards returned (1784–1821) and made five grants in the city area. Richard Fitzpatrick acquired the lands early in the American period and came with slaves to establish a plantation of cotton and tropical fruits. The Seminole War in 1835 made the slave property insecure and Fitzpatrick moved to Key West. U.S. armed forces occupied the plantation and named it Fort Dallas. Naval and military expeditions into the interior by way of the Miami river and the nearby Everglades sought out the Indians to punish them for raids and to remove them to Indian territory.

After passing through several hands the lands north of the river came to Mrs. Julia D. Tuttle, "mother of Miami." South of the river, William B. Brickell established a home, a post office and a trading post frequented by Seminole Indians who brought in skins, hides and feathers. A few settlers drifted in around the 1890s. Usually homesteaders, they lived by gardening, hunting, fishing, beachcombing and some fruit and vegetable farming for the Key West market, from which some of the produce reached New York by the Mallory line steamers. Boat owners often engaged in "wrecking," the salvaging of ship and cargo from wrecks on the Florida reef, the most lucrative business until about 1900.

In 1896, induced in part by Mrs. Tuttle, Henry M. Flagler pushed his Florida East Coast railroad to Miami and started the Royal Palm hotel. Miami was incorporated in the same year. Two years later the Spanish-American War made Miamians conscious for the first time of their all-important geographical relationship to Cuba and other Latin-American lands. The Royal Palm hotel was filled with people on war business, and the 7,500 troops who came to protect the 1,500 Miamians completely overwhelmed them during their brief stay.

Miami slowly grew to almost 30,000 people by 1920. It then became the focus of the Florida land boom and by 1925 had almost 85,000 inhabitants. By the end of 1926 the boom had come and gone, reaching its highest point in 1925 when building permits in the area totaled over $100,000,000. The *Miami Herald* for a time led the nation in the amount of newspaper advertising linage sold and the *Miami Daily News* put out an edition of 504 pages in 32 sections. In Sept. 1926 a severe hurricane, the first in 20 years, destroyed any hope that the boom might be revived and made a shambles of flimsy boomtime construction. Many tangible benefits remained, however, such as streets and sidewalks cut into the wilderness that would be developed after World War II, highways, a second railroad, a 27-story courthouse and a downtown skyline that would not be altered until the new surge of building in the 1950s.

The expansive 1920s led to the growth of older communities and some new ones around Miami. The central city grew from 13 to 43 sq.mi. in 1925 by annexing Allapattah, Buena Vista, Coconut Grove, Lemon City, Little River and Silver Bluff, all of which remain clearly identifiable sections of the city. Coconut Grove, oldest and most unique, several miles down the bay, had once been better known than Miami, with the Peacock inn, the first tourist hotel in the region, the Biscayne Bay Yacht club, the Coconut Grove Subscription library and the Housekeepers' club. This area still allows for individuality in architecture and attracts many artists and writers as residents.

Pan American World airways based its overseas operations on the Miami waterfront until overwater flights became land-based. The old terminal became the Miami city hall; one large hangar was converted into a 12,000-seat meeting hall; and other buildings house various city administrative departments. The U.S. coast guard maintains a base there.

Though Miami annexed no other territory and population growth in satellite communities was more rapid in the mid-20th century, the city tripled its 1930 population in the next 30 years. More significant was the appearance after World War II of new skyscraper hotels and business buildings and the expansion of the mercantile, financial and professional services in the downtown area. Miami responded to the competition of outlying areas with greater attention to traffic problems, advertising and specializations of its offerings.

**Metropolitan Government.**—Mid-20th century political and governmental developments are of revolutionary importance. Miami adopted a commission-manager plan of government in 1921, but since 1957 some municipal functions have been taken over by a county-wide government with broad powers over municipal affairs. This metropolitan government could absorb the municipalities. Otherwise, since Miami is completely surrounded by incorporated areas that show no interest in annexation, any integration with the central city is difficult. The county board of commissioners, known as the Metro commission, is made up of nine members elected by the county as a whole (district seats and municipal seats for Miami, Miami Beach and Hialeah were abolished by amendment in 1963); one of the members runs as mayor and is permanent chairman. The commission appoints the county manager and directs policy. The county sheriff was restored to elective status, also in 1963. Judges for the Metropolitan court are selected by a modified "Missouri plan." The board of county commissioners also functions as a port authority, makes policy and appoints a director for the Miami International airport and the port of Miami. Public schools of the county, consolidated in 1945, are administered by an elected board of public instruction.

**The Economy.**—The great debate in the Miami area is tourism versus a diversified economy. In the 1960s tourism led, but industry was growing more rapidly (*see* also FLORIDA). Miami's industries are selective, being limited mostly to clothing, plastics, electronics, contract construction and allied industries, with cement plants west of the city utilizing the native limestone. Manufacturing ranks third after wholesale and retail trade and services, including hotel services. The effort is to increasingly

attract visitors the year around, and conventions play a larger role in the economy. Miami and Miami Beach, with private and public facilities, are most active.

Greater Miami is served by railroads to the north and south; the Dixie highway, Tamiami trail, Sunshine State parkway and other highways lead to the north, south and west. The port of Miami, an ocean harbour on Biscayne bay near the downtown business district, is being replaced by a new port facility under construction on a nearby island. Miami International airport handles both passengers and freight cargo; most of the volume of international cargo goes to Latin-American destinations. A new airport costing $80,000,000 and a $26,000,000 terminal opened in 1959. In the 3,000-ac. airport area are numerous aircraft overhaul and outfitting plants.

**Education and Cultural Activities.**—The University of Miami in Coral Gables, Barry college, a Catholic school for women in North Miami and public, private, and parochial elementary and secondary schools attract people interested in educational opportunity. The Jackson Memorial hospital is the centre of a complex of medical services which, together with the University of Miami school of medicine, make this a growing health centre. The Miami public library, with branches and bookmobile services, together with the libraries of some of the older municipalities, provide books for every age and interest group. Other cultural activities include the University of Miami Symphony orchestra, the Miami Beach Summer Pops orchestra, the Miami Opera guild, two subscription concert series, the Coconut Grove playhouse, the drama, music and art activities of the university and college, experimental play groups, Vizcaya (the estate of James Deering, a palatial villa of Italian type, now a county museum), the Historical Association of Southern Florida, the Museum of Science and Natural History and the Fairchild Tropical gardens.

**Recreation.**—Recreational facilities abound with yacht clubs, docking facilities and boat services, boat liveries and charter boats for the water-minded, and public and private golf courses. Horse tracks, greyhound tracks and a jai alai fronton operate in the winter and permit pari-mutuel wagering. The Orange Bowl stadium is in Miami. (C. W. Te.)

**MIAMI BEACH,** the hotel, tourist and convention city of southeastern Florida, U.S., in Dade county, lies on the oceanfront with 9 mi. of natural sandy beach; it is separated from the mainland and the city of Miami by Biscayne bay. Until 1912 this 7.4-sq.mi. island was a mangrove swamp. Henry B. Lum and his son had planted 38,000 coconuts, and John S. Collins, another nurseryman from Morristown, N.J., had planted a large acreage of avocados. In 1912 the reclamation and development of the island began. Collins and his son-in-law, Thomas J. Pancoast, started a wooden bridge across the bay. The brothers J. N. and J. E. Lummus, Miami bankers, refinanced the bridge and began to take an active part in the development. In the same year Carl Graham Fisher became interested in the project, to which he brought youthful energy and ample means, and as a result of their combined efforts Miami Beach was incorporated in 1915, with J. N. Lummus the first mayor. In 1920 the first of four causeways across the bay was built in Dade county, this one carrying street railway tracks. In 1921 Pancoast headed the first chamber of commerce and started an extensive advertising campaign to attract visitors. Growth was slow, the population being only 6,494 in 1930. The 1926 collapse of the Florida land boom stopped all activity; the national depression followed and World War II halted a wave of recovery and hotel building. The war ended the tourist business but served to advertise the city widely when the U.S. government took over three-fourths of the hotels to house trainees in the armed services. Thousands of men spent six or more weeks on the beach and the families of many visited them. After the war the hotels along the beachfront grew northward, highlighted by the plush Fontainbleau, the Eden Roc and the Americana. Behind the hotels were apartments and homes. Many of the more exclusive homes are on 28 man-made islands in the bay, connected to each other and to roadways by bridge and causeway.

The size of the city's resident population (63,145 in 1960) is no measure of its relative importance. Its hotels, motels and apartments provide housing for 120,000 visitors. There are one-third more telephones than permanent residents. Miami Beach is becoming a year-round resort and convention city. Many of the larger hotels provide meeting facilities for 450 to 5,000-persons. The city auditorium seats 3,500 and the adjoining exhibition hall 15,000. Recreation and entertainment are big business. The beach (much of it private for beachfront hotels), private and public golf clubs, boating and fishing services, nightclubs and restaurants, the Miami Beach Kennel club, and specialty shops on Lincoln road and in the largest hotels cater to the visitors. The city has no industries, no railroads and no airports. It receives its visitors by way of Miami and the multiple transportation services there, as well as by yacht and automobile. It has a council-manager form of government, in effect since 1923; some municipal functions were being turned over to the metropolitan Miami government (*see* also Miami).

For comparative population figures *see* table in Florida: *Population.* (C. W. Te.)

**MIAO** (Miao-tse), a group of peoples calling themselves A Hmao, and living mainly in Kweichow and Yünnan, China. The name is often indiscriminately applied to hill tribes of southwest China. Miao live in self-contained colonies interspersed with Chinese, whose culture they have largely adopted; their own language has affinities with the Mon-Khmer group of the Austroasiatic languages (*q.v.*). Such subtypes as Pei Miao, Ch'uan Miao and Hua Miao indicate mainly regional differences of costume. The whole group numbered more than 2,500,000 in the 1960s.

Maize, buckwheat and potatoes are the principal cultivated crops. Most Miao communities had a servile status and village headmen were the appointees of Nosu (Lolo; *see* Yi) landlords. Like the Chinese, Miao are organized in patrilineal, exogamous, surname groups. A few religious practices are Chinese in style but the ancestor cult entails animal sacrifice (chickens, sows, oxen) on a scale that is quite alien to modern Chinese practice. Each patrilineal clan has its own hereditary priesthood. Hua Miao are reported to be peculiarly sensitive to the disapproval of their fellows; suicide by hanging seems to be an institutionalized response to such situations.

In pre-Communist days the term *miao-tse* had a contemptuous connotation, the English equivalent being "savage" or "barbarian." Under the Communist administration, much research has been done on Miao legends, which have been translated and published in Chinese; educational facilities have been extended and a phonetic method of writing Miao introduced. By the 1960s, in both Kweichow and Yünnan, the Miao had been formed into communes. *See* also China: *The People;* Man Languages.

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**MIAOULIS, ANDREAS VOKOS** (1769–1835), a successful Greek naval commander during the War of Greek Independence (*q.v.*), was born on the island of Evvoia (Euboea). He settled on the island of Hydra (Idhra), whose shipping, like that of Spetsai and Psara, increased considerably during the Napoleonic Wars. These islands joined the Greek revolt, providing on occasions 80 armed ships. Miaoulis spent his fortune on the Greek cause. His most outstanding actions were his victories off Modon (Methoni), Cape Matapan and Suda (May–June 1825) and his running of supplies into Missolonghi (Aug. 1825 and Jan. 1826). In 1825 he signed the Greek demand for British protection. He approved of the appointment of Lord Cochrane (*see* Dundonald, Thomas Cochrane, 10th Earl of) as naval commander in April 1827 and, at Cochrane's request, commanded the U.S.-built frigate "Hellas." He accepted Count Kapodistrias as president of Greece, but later defied him and, at Poros in July 1831, blew up government ships, including the "Hellas." He died in Athens on June 24, 1835. (D. Dn.)

**MICA,** an important group of common rock-forming minerals characterized by their highly perfect cleavage yielding thin laminae

(sheets or flakes). The name is the Latin *mica*, "a grain." The principal members of the group are muscovite, biotite and lepidolite. These are aluminosilicates with potassium, magnesium, iron or lithium, as well as hydroxyl or fluorine. The micas as a group are highly variable in chemical composition, physical and optical properties and occurrence; however, they are all based on a simple crystal-structure unit (see *Crystal Structure*, below).

The different kinds of mica vary greatly in colour and are frequently zoned. Muscovite is commonly colourless and may be gray, brown, light green, lavender or ruby red. The biotites are commonly black, brown, green, yellow and occasionally colourless. Pink, violet, yellow, gray, red, brown and green are the colours displayed by the lepidolites. The lustre varies from pearly, as in muscovite, to submetallic, as in lepidomelane.

**Occurrence.**—The micas as a group are of wide occurrence in all rock types—igneous, metamorphic and sedimentary. Members of the group are found under the entire range of geological conditions: in lavas, schists, granites, marbles, soils and deep-sea sediments; in veins, pegmatites, alteration zones; and as weathering products of other minerals. The largest crystals are found in veins and pegmatites; the largest book (block of laminae) of mica discovered was 14 ft. in diameter and 33 ft. long. A characteristic occurrence is in granite where both muscovite and biotite usually form, not uncommonly in parallel intergrowth. Phlogopite is common both in ultrabasic rocks such as dunites and periodotites and in dolomitic marbles. Fine-grained white micas, or sericite, particularly muscovite, form in the early stages of metamorphism of sediments and are joined closely by biotite. During retrograde metamorphism the aluminous silicates are altered to sericite; these silicates include andalusite, kyanite, sillimanite, cordierite, staurolite, as well as the feldspars. The illites, composed in part of a mica, are a common constituent of soils and deep-sea sediments. The glauconites are found characteristically in marine deposits. Celadonite is an alteration product of some basic igneous rocks. Lepidolite is mainly found in veins and pegmatites, often in parallel growths with muscovite.

**Synthesis.**—Micas very closely approaching the properties of those found in nature have been synthesized in the laboratory; these include phlogopite, muscovite, paragonite, margarite, clintonite, annite and eastonite. Some of the fluorine analogues of these micas, such as fluorophlogopite, fluoromuscovite and fluoroparagonite, as well as polylithionite, have been made. In addition, other compounds having the mica structure, but not found in nature, have been prepared for special commercial applications. Examples of successful synthesis include: $BaMg_3Al_2Si_2O_{10}F_2$, $KMg_3BSi_3O_{10}F_2$, $KNi_3AlSi_3O_{10}F_2$ and $KMg_2MnAlSi_3O_{10}F_2$. The hydrous micas are grown in steel pressure vessels capable of withstanding high water pressures and the fluoromicas are grown from melts in platinum, graphite or bonded silicon carbide crucibles at approximately atmospheric pressure. Crystals in excess of four inches square and one-eighth inch thick have been produced from fluoride melts. Smaller synthetic fluoromica crystals have been bonded into large sheets and other forms.

**Mining.**—Mica mining is difficult because the mica books are readily damaged by rough handling. The methods of extraction are therefore primitive and necessarily wasteful. The veins and pegmatites are usually worked by quarrying; however, underground stoping (*see* MINING, METAL) may be economical. The books are split and trimmed by hand, sorted according to size, transparency, colour and freedom from spots or strains, and the scrap is ground. The production of sheets seldom exceeds 10% of the total mine output. Mining is carried on primarily in the United States (North Carolina, New Hampshire, South Dakota), India, South Africa, U.S.S.R., Brazil, Argentina, Canada and Madagascar.

**Uses.**—Because some micas are poor electrical conductors, they are used in the construction of electrical equipment. Some micas are also poor heat conductors, transparent and relatively resistant to water corrosion, and have been useful as stove windows and boiler gauge packings. Ground mica is commonly employed as a filler, lubricant, absorbent, dusting powder and packing material. It is used in the manufacture of wallpaper, roofing paper and paints. It is employed for special effects by decorators and toy manufacturers, for example as "frosting" or Christmas tree "snow." Sheets of mica are used to make quarter-wave plates, used in the analysis of polarized light. Lepidolite is an important source of lithium and rubidium (*qq.v.*) salts. Some of the synthetic micas are used as electrical insulators and in special delicate electronic instruments. The high infrared transmission of synthetic fluorophlogopite has important applications as a window material in spectral transmission equipment.

BENJAMIN M. SHAUB

FIG. 1.—MUSCOVITE CRYSTALS, SHOWING HEXAGONAL STRUCTURE: TIGER BILL MINE, OXFORD COUNTY, MAINE

**Crystal Structure.**—The unit of structure of the micas has been deduced by X-ray analysis (*see* MINERALOGY) of single crystals. The fundamental unit consists of two sheets of oxygen tetrahedra containing silicon and usually some aluminum. Each sheet consists of tetrahedra linked at each of three corners to form a hexagonal or pseudohexagonal array with all the bases parallel and all the vertexes pointing the same way. The two sheets are parallel and have opposing vertexes. These sheets are held together by magnesium or other ions co-ordinated with two apical oxygens and one hydroxyl from one sheet and two apical oxygens and one hydroxyl from the opposing sheet, forming an octahedron. The hydroxyls occupy the centres of the hexagonal or pseudohexagonal arrays of apical oxygens. The structure is a succession of such double sheets with alkali atoms, potassium for example, between them, the alkali atoms sitting between the hexagonal or pseudohexagonal arrays formed by the basal oxygens of the adjoining double sheets. The alkali atoms are thereby in twelvefold co-ordination, occupying the centre of a hexagonal prism formed by six basal oxygens from each of the adjoining sheets. The general structure may be represented by the formula $XY_{2-3}Z_4O_{10}(OH,F)_2$ where X in twelvefold co-ordination may be K, Na, Ca, or Ba; Y in sixfold co-ordination may be Mg, $Fe^{+2}$, $Fe^{+3}$, Al, Li, Mn and rarely Cr, V and Ti; and Z in fourfold co-ordination may be Si and Al.

**Polymorphism.**—Minerals having the same chemical composition and different structures are called polymorphs. The simple structure unit described above has monoclinic symmetry. If successive units are stacked on top of each other with precisely the same orientation the repeating unit of the mica is described as having a one-layer monoclinic structure (1M). If successive units are stacked with different orientations in a regular way, different structures (polymorphs) result. The symmetry of the surface of the unit restricts the number of ways in which successive units may be stacked. The structures resulting from the various types of stacking may be described by the number of layers involved and the symmetry produced. The following structures have been observed in addition to the 1M: two-layer monoclinic, type one ($2M_1$); two-layer monoclinic, type two ($2M_2$); three-layer trigonal (3T); eight-layer triclinic (8Tr); twelve-layer monoclinic

TABLE—*Principal End Members of the Mica Group*

(General Formula $XY_{2-3}Z_4O_{10}(OH,F)_2$)

| Name | X | Y | Z | $O_{10}$ | $(OH,F)_2$ |
|---|---|---|---|---|---|
| **Dioctahedral** | | | | | |
| Muscovite | K | $Al_2$ | $AlSi_3$ | $O_{10}$ | $(OH)_2$ |
| Paragonite | Na | $Al_2$ | $AlSi_3$ | $O_{10}$ | $(OH)_2$ |
| Margarite | Ca | $Al_2$ | $Al_2Si_2$ | $O_{10}$ | $(OH)_2$ |
| Celadonite | K | $MgFe^{+3}$ | $Si_4$ | $O_{10}$ | $(OH)_2$ |
| Al-celadonite | K | MgAl | $Si_4$ | $O_{10}$ | $(OH)_2$ |
| **Trioctahedral** | | | | | |
| Phlogopite | K | $Mg_3$ | $AlSi_3$ | $O_{10}$ | $(OH)_2$ |
| Annite | K | $Fe^{+2}_3$ | $AlSi_3$ | $O_{10}$ | $(OH)_2$ |
| Clintonite | Ca | $Mg_3$ | $Al_2Si_2$ | $O_{10}$ | $(OH)_2$ |
| Eastonite | $K_2$ | $Mg_5Al$ | $Al_4Si_4$ | $O_{20}$ | $(OH)_4$ |
| Iron-eastonite | $K_2$ | $Fe^{+2}_5Al$ | $Al_4Si_4$ | $O_{20}$ | $(OH)_4$ |
| Polylithionite | K | $Li_2Al$ | $Si_4$ | $O_{10}$ | $F_2$ |
| **Intermediate** | | | | | |
| Siderophyllite | K | $Fe^{+2}_{1.66}Al$ | $Al_{1.33}Si_{2.67}$ | $O_{10}$ | $(OH)_2$ |
| Lepidomelane | K | $Fe_{1.66}Fe^{+3}$ | $Al_{1.33}Si_{2.67}$ | $O_{10}$ | $(OH)_2$ |

(12M); and eighteen-layer monoclinic (18M). Other more complex structures may exist. A structure in which the units are randomly stacked (1Md) has also been found. In addition, two more polymorphs, two-layer orthorhombic (2O) and six-layer hexagonal (6H), have been predicted but not found in nature. A single hand specimen may contain several polymorphs; however, the biotites usually are 1M, the muscovites $2M_1$ and the lepidolites $2M_2$.

**Chemical Composition.**—The various species of the mica group may be described for the most part as consisting of variable proportions of ideal end members. Actual compositions are complex due to substitutions. The group may be divided into those micas which have two atoms in octahedral co-ordination (Y position), the dioctahedral micas; three atoms in octahedral co-ordination, the trioctahedral micas; and between two and three atoms in octahedral co-ordination, the intermediate micas. The ideal end members are listed in the table: The various atoms are arranged according to their structural position. Broadly speaking, the white micas, commonly referred to as sericite when fine grained, consist of muscovite, paragonite or both. These form a limited series of solid solutions. Common glauconite consists of about two-thirds celadonite and one-third muscovite. It is not known whether glauconite is a true compound or a random mixed-layer structure, a structure consisting of discrete structural units of both muscovite and celadonite. Illite, a field term for some sedimentary micas, is a mixed-layer mineral usually consisting of muscovite and montmorillonite. Common biotite is widely variable in composition and incorporates in solid solution various proportions of phlogopite, annite, eastonite, iron-eastonite, siderophyllite and lepidomelane. The biotites do not form solid solutions with muscovite. Lepidolite consists mainly of polylithionite and

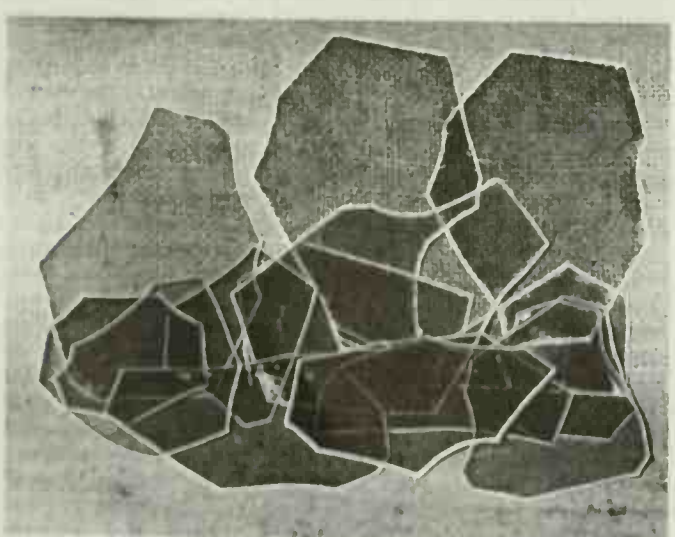

FIG. 2.—MUSCOVITE MICA TRIMMED FOR USE IN ELECTRICAL INDUSTRY. CLEAN AND TRANSPARENT NATURE OF SHEETS INDICATES FINE QUALITY MICA

forms limited solid solutions with muscovite and paragonite. There is no known complete series of solid solutions between a dioctahedral and a trioctahedral mica. The rare micas include: a vanadium-rich mica, roscoelite, $K(V,Al)_2(AlSi_3)O_{10}(OH)_2$; a chromium-rich mica, fuchsite, $K(Cr,Al)_2(AlSi_3)O_{10}(OH)_2$; the manganese-bearing mānganophyllite, $K(Mg_2Mn)(AlSi_3)O_{10}(OH)_2$; and taeniolite, $K(Mg_2Li)Si_4O_{10}F_2$, one of the aluminum-free micas, and zinnwaldite, $K(LiFe^{+2}Al)(AlSi_3)O_{10}(OH)_2$, the lithium-iron mica. Some mica samples yield more water on chemical analysis than that indicated by the formula. These are erroneously referred to as hydromica, and are mixtures or mixed-layered minerals of mica and a more hydrous mineral such as montmorillonite. A true hydromica in which the hydronium ion, $H_3O^+$, replaces potassium has not as yet been described.

**Mineralogical Properties.**—The crystals are usually tabular with hexagonal or pseudohexagonal outline; commonly six-sided prisms; often massive lamellar. The perfect basal cleavage yields thin laminae which are usually elastic. Some varieties, margarite for example, have brittle laminae. The perfect basal cleavage reveals the layered character of the crystal structure. The weakest bonds in the structure are those about the alkali atoms in twelve-fold co-ordination, and it is these bonds which break first, yielding laminae parallel to the principal double sheets in the crystal structure. The cleavage laminae are not equal in thickness throughout, but may have a series of steps. Each step is exactly equal to, or a multiple of, a crystal structure unit. When a cleavage flake is struck a sharp blow with a blunt needle point, a six-rayed star of cracks, or percussion figure, develops. A similar set of cracks develops 30° from the percussion set when a blunt punch is pressed against the crystal; these cracks, the pressure figure, coincide with the secondary parting planes in the crystal. The marked hexagonal or pseudohexagonal character of many of the features of the micas attests to the symmetry of the crystal structure.

The hardness of the micas ranges from 2.5 to 4.5; the specific gravity, from 2.8 to 3.4; and the indexes of refraction from 1.535 to 1.705. The birefringence (double refraction) is strong in all the micas. The dark-coloured micas exhibit strong pleochroism, that is, exhibit different colours in different directions. Inclusions are common in the micas and sometimes produce pleochroic halos. The micas often enclose flattened crystals of garnet, tourmaline, quartz and magnetite in thin plates between the sheets. Minute acicular inclusions arranged parallel to the rays of the percussion figure, particularly in phlogopite, give rise to asterism similar to that observed in rubies and sapphires.

The muscovites are relatively insoluble in acids, and the biotites and lepidolites are attacked by acids leaving a residue of silica. Most micas yield water on ignition. The structure of muscovite can be completely destroyed by prolonged grinding. Alteration of muscovite usually results in a loss of alkalies and hydration, producing a mixed-layer mineral with the clay mineral montmorillonite. Strong alteration may produce kaolinite or gibbsite with quartz. The biotites on alteration are converted into chlorite. Potash feldspar, rutile, hematite, magnetite or serpentine may also be produced. Weathering of biotite usually changes it to a soft, brown or yellow mineral with a bronze lustre, vermiculite (*q.v.*).

More detailed information on mineralogical and crystallographical concepts used in this article is given under CRYSTALLOGRAPHY and MINERALOGY. *See* also the separate articles on BIOTITE; MUSCOVITE; OTTRELITE; PARAGONITE; PHLOGOPITE. *See* also references under "Mica" in the Index. (H. S. Y.)

**MICAH, BOOK OF** (MICHEAS, PROPHECY OF), in the Old Testament, part of the collection known as the "Minor Prophets" or the "Twelve." The author was a contemporary of the prophet Isaiah. The same historical background is reflected in both, the Assyrian invasions of the last part of the 8th century B.C. Similar themes occur, especially the holiness of Yahweh (Isa. vi, 3 ff.; Mic. i, 2) and the promise of the Messiah (Isa. vii, 13–14; Mic. v, 2 ff.). Micah ("Who is like God?"; ancient Greek and Latin versions, Micheas) is to be distinguished from the 9th-century prophet Micaiah, in I Kings xxii, 8 ff., who left no writings.

**Contents.**—The book falls into three well-marked parts. In

ch. i-iii Micah, reflecting on the destruction of the capital of the northern kingdom of Israel (Samaria was taken by Sargon in 721), ascribes its ruin to the Lord advancing in judgment "from his holy temple" (i, 2). A like doom threatens the southern kingdom, Judah, and its capital, Jerusalem. While false prophets, relying on the hope of the great "day of the Lord" (*cf.* Mic. iii, 6 and Amos v, 20), condone oppression of the poor and encourage illusions by proclaiming "Is not the Lord in the midst of us? No evil shall come upon us" (iii, 11), the true prophet declares "to Jacob his transgression" and foretells that, for its sins, "Zion shall be plowed as a field; Jerusalem shall become a heap of ruins" (iii, 8, 12). In ch. iv–v there is a sudden, indeed harsh, change of perspective. An ideal Jerusalem is proclaimed as the focus of the religion of mankind; thither the peoples stream to learn the law of God, and from it God gives peace to the world. This happy age is foreseen against a confused background of tribulation. Israel suffers dispersion, exile, onslaughts and siege before the final triumph, which is granted through a ruler who is to come from Bethlehem. The section ends with a threat against military installations and superstitious objects, which is perhaps merely a promise of a purified faith. In ch. vi–vii a number of loosely connected oracles denounce Israel's ingratitude, the persistence of social injustice and fraud, the disappearance of godliness and the collapse of human loyalties. A day of punishment is foretold (vii, 4), but the prophecy concludes with hope in the ultimate salvation of Israel and a psalmlike prayer for mercy and for the fulfillment of the promises made to Abraham and the fathers.

**Message.**—The Book of Micah voices in a distinctively forceful way the message of the early prophets: that the ethical demands of Yahweh are inexorable, that the promises do not work automatically but demand a sincere religious response, that Yahweh is lord of the universe and of history. Micah gives a strong impulse to individual piety in vi, 8, where he rejects a grandiose ritual which is not inspired by justice, love of kindness and humility. The prophet Jeremiah, a century later, appealed to the acknowledged inspiration of Micah to justify his own right, as a prophet, to pronounce sentence of chastisement. Micah's promise of the Davidic Messiah from Bethlehem sustained Israel's hopes in the dark times after the exile, and it became one of the most cherished prophecies of Christians when the evangelist Matthew (Matt. ii, 5–6) applied it to Jesus. Mic. vii, 6 is used in the New Testament (*e.g.*, Matt. x, 21, 35–36) to describe the divisions called forth by the challenge of the gospel.

**Literary History.**—That Micah was the prophet of the first three chapters is not questioned. But the attribution of ch. iv–v to Micah has raised widespread doubts, partly on account of the contrast between their message of hope and the gloomy outlook of the first chapters, partly because of their references to exile and the loss of dominion, which seem to presuppose the fall of Jerusalem and the royal house (587). These reasons are serious, especially the naming of Babylon in iv, 10, but they are not decisive against the section as a whole. The ministry of Micah saw mass transportations of Israelites from the north between 734 and 721, and the capture of every Judaean town but Jerusalem by the Assyrians in 701 (*cf.* II Kings xviii and the Assyrian annals). These losses could explain the promises of restoration, especially if one remembers Micah's interest in the fate of the northern kingdom (Mic. i, 5 ff.; vi, 16). Ch. vi–vii may also be read in the light of the Assyrian attack of 701. Critical opinion has renounced its former general skepticism about these chapters. The poem in Mic. iv, 1–5, on the ideal Jerusalem, one of the loftiest concepts of Hebrew prophecy, raises special difficulties, as it occurs again almost verbatim at Isa. ii, 2–4. Its authorship remains uncertain, as does its date, since many critics place it after the exile of 587, on account of its worldwide religious outlook. But the vision may have been as old as King David, and its religious value is not affected by its precise dating.

Textual criticism offers no major problems. Many commentators think that in the famous prophecy "But you, O Bethlehem Ephrathah . . . from you shall come forth for me one who is to be ruler in Israel," the word Bethlehem is a gloss, for the ancient Greek version has an extra "house of" (translating *Beth*) before "Ephrathah." But "Bethlehem" is in the Hebrew text, as in all versions, and there is no sufficient reason to doubt it. (The Greek adds "house of" elsewhere—*e.g.*, i, 5; iii, 1.)

**Interpretation.**—Patristic interpretation was chiefly concerned with the Bethlehem prophecy, and saw in the words "whose origin is from of old, from ancient days" an indication of the eternal generation of Christ. Some moderns agree that there is question of some marvelous origin for the Messiah, but most hold that only the antiquity of the Davidic line is emphasized. Many moderns treat Micah as merely the prophet of doom, appealing to the way he is invoked by Jeremiah. But Jeremiah's peculiar position made that element uniquely relevant, and it cannot be decisive in refusing ch. iv–vii to Micah. *See* also BIBLE.

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**MICA SCHIST,** a metamorphic rock composed essentially of mica and quartz (*qq.v.*), and possessing a foliated or schistose structure due to the parallel arrangement of the mica flakes. Mica schists differ from gneisses principally by the absence of conspicuous alternations of schistose and granular bands characteristic of the latter rocks, and by the paucity of feldspar minerals. Between phyllite (*q.v.*) and mica schist there are all gradations. Mica schists possess a greater variety of constituent minerals and are more coarsely crystallized. The mica may be muscovite or biotite; both are often present. Paragonite and fuchsite (chrome mica) are rare. In addition to quartz, minor quantities of albite or oligoclase feldspar are frequently found. A great number of accessory minerals are known in mica schists, and when these are conspicuous they may be regarded as constituting special varieties receiving distinctive names. These minerals include almandine garnet, staurolite, kyanite, andalusite and sillimanite. Many of them are indicators of a special grade of metamorphism. Accessories include rutile, hematite, ilmenite, tourmaline and zircon.

In nearly all cases mica schists are metamorphosed sedimentary rocks of the composition of clays, shales and slates, though examples are known which are clearly transmuted acid igneous rocks, such as rhyolites and porphyries. The origin of these latter types, if not decipherable by their field relations, is usually indicated by their bulk chemical composition.

The common associates of mica schist are quartzites, quartz schists and limestones, representing sediments of a siliceous and calcareous nature interstratified with clays and mudstones from which the mica schists are derived.

Like most metamorphic rocks mica schists are found in areas of Pre-Cambrian rocks. In the mountain chains of the Alps, the Himalayas, etc., mica schists of Paleozoic and Mesozoic eras are known as they are seen to pass into sediments containing recognizable fossils. At Bergen, in Norway, Paleozoic fossils have been found in mica schists, and some of the Mesozoic schists of the Alps retain identifiable organic remains. Mica schists are rarely of economic value, being too fissile for building stones and too brittle for roofing slates. *See* also SCHIST. (C. E. T.)

ARCHIVES PHOTOGRAPHIQUES, PARIS

"ST. MICHAEL VANQUISHING SATAN." BY RAPHAEL, 1518. IN THE LOUVRE, PARIS

**MICHAEL** (Heb. "Who is like God?", synonymous with Micaiah or Micah; Arabic MIKA'IL or MIKAL), one of the archangels, mentioned four times

in Scripture, more often in the Apocrypha and once (by name) in the Koran. He is repeatedly shown as the "great captain," leader of the heavenly hosts, the warrior helping the children of Israel (Dan. x and xii; Jude i, 9; Rev. xii, 7–9), and early in the history of the Christian church he came to be regarded as helper of the church's armies against the heathen. He holds the secret of the mighty "word" by which God created heaven and earth (Enoch lxix, 14), and was "the angel who spoke to [Moses] on Mount Sinai" (Acts vii, 38). The numerous representations of Michael in art reflect his character as a warrior: he is shown with a sword, in combat with or triumph over a dragon, from the story in the Book of Revelation (Apocalypse).

The feast of St. Michael, which originated in Phrygia, is kept in both East and West on Sept. 29. In the Roman Catholic Church the feast of the Appearing (or Apparition) of St. Michael the Archangel is kept on May 8. According to legend, this appearance took place on Mt. Gargano, in Apulia, *c.* 492, and the mountain became an important medieval pilgrimage site.

In the Koran it is said (Sura ii, 98), "Whoever is an enemy to God . . . , to Gabriel and Michael,—Lo! God is an enemy to those who reject Faith."

**MICHAEL,** the name of nine Byzantine emperors.

MICHAEL I (Michael Rangabe), emperor from 811 to 813, son-in-law of Nicephorus I, was proclaimed emperor by a *coup d'état* in face of the claims of Stauricius, the mortally wounded son of Nicephorus. Michael supported the iconodules and was under the influence of Theodore Studites, who proved a poor adviser in secular matters. Extravagant at home and ineffective abroad, in 812 Michael recognized Charlemagne's claim to the imperial title of basileus. He failed to subdue the Bulgars advancing under Krum and in 813 was defeated at Versinikia near Adrianople, being deserted by the Asia Minor troops, whose leader shortly afterward came to the throne as Leo V the Armenian. Michael retired to a monastery on one of the Princes Islands.

MICHAEL II (d. 829), emperor from 820 to 829, a native of Amorium in Phrygia, founded the dynasty of this name. Rising from humble origins he became a commander. Incurring the suspicions of his former comrade-in-arms Leo V, he was imprisoned for alleged conspiracy. His partisans assassinated Leo and proclaimed Michael emperor (820). Michael maintained a moderate attitude toward the use of icons, favouring neither party. With the help of the Bulgar Khan, by the end of 823 Michael had defeated a dangerous revolt led by a fellow soldier, Thomas. He had insufficient naval resources to check Muslim attack in the Mediterranean, and during his reign Crete was lost, while from 827 onward Arab raids on Sicily began. Michael died in Oct. 829.

MICHAEL III the Amorian or Phrygian (*c.* 836–867), son of Theophilus, was emperor from 842 to 867. He used to be known as "the drunkard," but this view of his character has in some respects been modified. His reign saw the beginning of the successful foreign policy and cultural efflorescence which characterized the middle Byzantine period. This was mainly due to the work of the regents, the dowager-empress Theodora and her chief minister Theoctistus, and then of Michael's gifted uncle Caesar Bardas. At the outset orthodoxy was restored (843) while a moderate ecclesiastical policy attempted to conciliate the former iconoclasts. Campaigns against the Arabs in the Aegean and in Asia Minor were undertaken, and also against the Slavs ravaging Greece. In 856 Michael III, supported by Caesar Bardas, forcibly took control of the government; Theoctistus was murdered and the dowager-empress Theodora was eventually relegated to a convent. Under the new regime, Bardas was the moving spirit; a university was organized in Constantinople, and the scholar Photius (*q.v.*) became patriarch. In Asia Minor counterattacks were launched against the Arabs. But the Byzantines failed to strengthen their diminishing hold on Sicily. The Russians, who unsuccessfully attacked Constantinople in 860, were from this time onward brought within the orbit of Byzantine civilization. Michael III himself was an unstable young ruler. He fell under the influence of his favourite, Basil "the Macedonian," and in 866 made him co-emperor after he had treacherously murdered Bardas Caesar (865). On Sept. 23/24, 867, he himself was in turn assassinated by the ambitious Basil.

MICHAEL IV the Paphlagonian (d. 1041), emperor from 1034 to 1041, of humble origin, owed his elevation to his brother John the Orphanotrophus, an influential and capable eunuch who brought him to court where the old Macedonian empress Zoe fell in love with him and married him on the untimely death of her husband, Romanus III. Michael, though subject to epilepsy, proved a vigorous emperor, and with the help of his brothers, particularly John, he attempted to check the landed aristocracy and to strengthen the frontiers. Some headway was made against the Muslims in Sicily, though only temporarily. In the Balkans Michael failed to subdue the ruler of Zeta, but quelled the rebellious Bulgarian provinces which had revolted under Peter Deljan. He returned from his victorious campaign mortally ill, and died in the monastic habit on Dec. 10, 1041.

MICHAEL V Calaphates or "the Caulker" (d. after 1042), so named after his father's occupation, emperor from 1041 to 1042, the nephew of Michael IV the Paphlagonian, was adopted by the elderly Macedonian empress Zoe, and crowned on Michael's death. This attempt to keep the throne in the hands of the Paphlagonian family failed, owing to Michael V's foolish policy. On his accession he exiled his uncle John. He also banished his benefactress Zoe to a convent, which led to an uprising in Constantinople. Though Michael hurriedly recalled Zoe, his political opponents had him deposed and blinded.

MICHAEL VI Stratioticus, emperor from 1056 to 1057, was an elderly official chosen by the last Macedonian ruler, the empress Theodora, shortly before her death. A representative of the court party, he was incapable of controlling the military aristocracy who deposed him in favour of the commander Isaac Comnenus.

MICHAEL VII Ducas or "Parapinaces," emperor from 1071 to 1078, the eldest son of Constantine X Ducas, was a minor on his father's death (1067) and his mother, the regent, married the military commander Romanus IV Diogenes (*q.v.*). On Romanus' defeat by the Seljuk Turks in 1071 Michael VII was proclaimed sole emperor by the court party led by his tutor, the scholar Michael Psellus. Michael VII was a bookish youth who proved incapable of providing the necessary military leadership. When he came under the influence of an official, Nicephoritzes, Psellus fell into disfavour. A corn shortage and increase in prices precipitated a rising in the capital, while two rival commanders, Nicephorus Bryennius and Nicephorus Botaneiates, marched on Constantinople to claim the throne. Michael abdicated and became a monk, while Botaneiates entered the capital to be crowned Nicephorus III (1078). (J. M. Hy.)

MICHAEL VIII Palaeologus (*c.* 1225–1282), emperor from 1259 to 1282, was the son of Andronicus Palaeologus and Theodora Palaeologina, a granddaughter of Alexius III. When Theodore II Lascaris died in 1258 the regent whom he had appointed for his son John IV (*q.v.*) was murdered, and Michael assumed the regency first as grand duke, then as despot; and about Jan. 1, 1259, he was crowned emperor with John at Nicaea. At Pelagonia in 1259 he eliminated his Greek rival, Michael of Epirus, who had allied himself with Manfred of Sicily and the Frankish prince of Achaea. Two years later Constantinople was liberated from the Latins by his general Strategopulus, and in Sept. 1261 Michael was crowned sole emperor. John IV was banished and blinded.

This act of cruelty, by which Michael founded the dynasty of Palaeologus, earned him excommunication by his patriarch and the hatred of many of his subjects, but he heaped further odium upon himself by the policy that he pursued to save Constantinople from reconquest by the western powers. The rulers of Sicily, first Manfred and then Charles of Anjou, organized campaigns to this end. Michael exerted all his diplomatic skill to prevent his other enemies, the Serbs, the Bulgars and the separatist Greek rulers of Epirus and Thessaly, from co-operating with Charles of Anjou, thwarted the Venetians by favouring the Genoese, and made alliances with the Mongols and the Mamelukes of Egypt. To bring moral pressure to bear on Charles he made repeated overtures to the papacy; and in 1274, at the second Council of Lyons, Pope Gregory X received the submission of the Greek Church in the name of the emperor and all his clergy and people. The opposition to this policy in Constantinople was fanatical, and Michael met it

with ruthless persecution. But the popes grew increasingly skeptical, and Charles strained at the papal leash. An army that he sent into Albania was defeated by Michael's generals at Berat in 1281; and in the same year Pope Martin IV repudiated the union of Lyons, and gave Charles his blessing for a crusade against Byzantium. Michael, however, scored his last diplomatic triumph by underwriting the rebellion in Sicily, which in 1282 brought Charles's kingdom to ruins in the Sicilian Vespers. Michael died in Thrace on Dec. 11 of the same year, more despised for the betrayal of his church than honoured for the salvation of his empire.

MICHAEL IX Palaeologus (*c.* 1277–1320), was the son of Andronicus II, by whom he was made co-emperor in 1295, but whom he predeceased. He commanded mercenary troops against the Turks in two unsuccessful engagements (1302, 1310) and in 1305 was instrumental in the murder of Roger de Flor, leader of the Catalan mercenaries, who then rebelled. Michael's lingering death at Thessalonica on Oct. 12, 1320, was hastened by the misdemeanours of his son Andronicus III (*q.v.*). (D. M. N.)

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*Michael VII:* G. Ostrogorsky, *History of the Byzantine State* (1956); J. M. Hussey in *Cambridge Medieval History*, vol. iv, ch. 4, new ed. (1963). (J. M. Hy.)

*Michael VIII: See* his "autobiography," ed. by H. Grégoire, *Byzantion*, vol. xxix–xxx (1959–60). *See* also C. Chapman, *Michel Paléologue, restaurateur de l'empire byzantin* (1926), which contains extracts from the "autobiography"; S. Runciman, *The Sicilian Vespers* (1958); D. J. Geanakoplos, *Emperor Michael Palaeologus and the West* (1959); G. Ostrogorsky, *History of the Byzantine State* (1956). (D. M. N.)

**MICHAEL** (MIHAI) (1921– ), king of Rumania from 1927 to 1930 and from 1940 to 1947, was born at Sinaia on Oct. 25, 1921, the son of the future king Carol II (*q.v.*) and his consort Princess Helena of Greece. With his father's exclusion from the succession by an act of Jan. 4, 1926, Prince Michael became heir apparent to his grandfather King Ferdinand; and on Ferdinand's death on July 20, 1927, he was proclaimed king under a regency of three. With the return of Carol in June 1930, Michael once more became crown prince, with the title of grand voivode of Alba Iulia. His mother, who divorced King Carol in 1928, left Rumania. Michael became king again on Sept. 6, 1940, when Carol abdicated. Queen Helena returned to Bucharest and remained with her son for the years of his reign. During the dictatorship of Gen. Ion Antonescu, who brought his country into World War II as the ally of Germany against the U.S.S.R., the king enjoyed great popularity and acted as a focus of discontent with the regime and for opposition to Rumania's continuance in the war after the reconquest of Bessarabia. Michael approved the attempts of the democratic leaders, Iuliu Maniu and Dinu Brătianu, to bring Rumania out of the war and played a big part in the *coup d'état* of Aug. 23, 1944, whereby Antonescu was dismissed and Rumania joined the Allied cause. Michael courageously tried to maintain a democratic government in the face of Soviet pressure. On Dec. 30, 1947, however, he was forced to abdicate. He then went into exile. On June 10, 1948, in Athens, he married the princess Anne of Bourbon-Parma. *See* also RUMANIA: *History.* (B. Br.)

**MICHAEL** (MIKHAIL FEDOROVICH ROMANOV) (1596–1645), tsar of Russia from 1613, the first ruler of the Romanov dynasty. He was the son of Fedor Nikitich Romanov, later patriarch under the name Philaret (*q.v.*), and his wife Ksenia Ivanovna Shestova. Toward the end of the "Time of Troubles" (*see* RUSSIA: *History*) he was in hiding with his mother at a monastery near Kostroma when a national assembly or *zemski sobor* elected him tsar on March 3 (new style; Feb. 21, old style), 1613. The 17-year-old Michael and his mother at first rejected the offer of the crown, brought by emissaries from Moscow, on the grounds that the royal properties had been despoiled and that the country was in a condition of anarchy. Eventually, however, they consented, and on June 21 (N.S.; 11, O.S.), Michael was crowned in the Church of the Assumption. In the first years of his reign actual power seems to have been wielded by his mother and a coterie of influential magnates; but in 1619, with the return of Michael's father from captivity in Poland, the monarchy's grip tightened. Elected patriarch, Philaret in this capacity served as formal co-tsar with his son in a dyarchy that has no exact parallel in Russian history. Until his death in 1633, Philaret seems to have controlled much of the administration.

Throughout his reign, Michael and his government were preoccupied with problems bequeathed by the "Time of Troubles." The country had to be cleared of Cossacks and robbers who continued to ravage it with impunity; the royal domains had to be reassembled and the treasury replenished; the gentry and tax-paying classes had to be registered. Close co-operation between the monarchy and the various estates, exhausted by long disorder, permitted a comparatively sound solution of most of these problems. Much effort was also exerted to secure foreign recognition of Michael's title to the crown in the face of Polish and Swedish claims. This aim was achieved in the treaties of Stolbovo (1617) and Polyanovka (1634) with Sweden and Poland respectively, the second of which ended a long period of wars on the western frontier. Good relations with England and Holland induced the Russian government to grant merchants from these countries favourable commercial and industrial concessions.

Michael appears to have been weak in character as well as body. During his reign the government was run either by his parents or by boyars who controlled the main administrative organs of the monarchy, the *prikazy*. However, statements by early Russian and foreign sources that Michael's authority was limited by a constitutional charter have not been substantiated. Michael died in Moscow, on July 23 (N.S.; 13, O.S.), 1645. He had been married twice and left a son, Alexis, by his second wife, Evdokia Lukyanovna Streshneva. (R. E. Pi.)

**MICHAEL** (MIHAILO OBRENOVICH III) (1823–1868), prince of Serbia, was born at Kragujevac on Sept. 16 (new style; 4, old style), 1823, the second son of Milosh Obrenovich I. On his father's abdication in June 1839 his elder brother Milan Obrenovich II became prince; but Milan died on July 8 (N.S.), 1839, whereupon the young Michael succeeded him. Sent into exile by a revolt (Sept. 1842), he lived chiefly in Austria, but visited many other European countries. When his father was recalled to the Serbian throne (1858), Michael was appointed commander in chief of the army; and when Milosh died (Sept. 26, 1860), Michael became prince again.

Michael proclaimed the supremacy of the law, limited the power of the council and increased the power of the *skupshtina* (parliament). The following institutions date from his reign: a regular national army (1861), the state mortgage bank (1862), the Serbian Learned society (1864), a reformed judicature, the Cross of Takovo (1865; the first Serbian order), a new law on municipalities (1866), the first Serbian coinage since medieval times (1868) and the national theatre (1868). With Iliya Garashanin (*q.v.*), he conducted an active foreign policy; and he patriotically devoted the major part of his inherited wealth to armaments. He was an exemplary ruler for his time, even if his government gradually developed into enlightened absolutism. He was assassinated at Kosutnjak, near Belgrade, on June 10 (N.S.; May 29, O.S.), 1868. He left no heir by his wife Julia Hunyadi (1831–1919; daughter of Count Ferenc Hunyadi), whom he had married in Aug. 1853 but from whom he was separated in Nov. 1865.

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**MICHAEL** (MIHAI, called VITEAZUL OR THE BRAVE) (1558–1601), prince of Walachia whose success in bringing Transylvania and Moldavia also under his rule was an early but short-lived fulfillment of Rumanian national aspirations, was the son of Petrascu, ban of Craiova. Invested prince of Walachia by the

Turkish government in 1593, he proceeded to conclude an anti-Turkish alliance in 1594 with Aaron, prince of Moldavia, and Sigismund Báthory, prince of Transylvania. War began in Nov. 1594, and Michael's forces took the fortress of Ruse (Ruschuk) and Silistra on the right bank of the Danube. After a victory at Călugăreni (Aug. 23, 1595), Michael retreated to the mountains before a new Turkish army; but with Sigismund Báthory's help he resumed his offensive and defeated the Turks at Giurgiu (Oct. 25–27). In May 1598 he made an alliance with the Holy Roman Emperor Rudolf II against the Turks; but in October the Turks signed a peace with him, recognizing the Danube as the Walachian-Turkish frontier.

In 1599, when Sigismund Báthory abdicated, Michael, supported by Rudolf, invaded Transylvania, defeated Sigismund's son Andreas at Selimbăr (Oct. 18) and proclaimed himself prince of Transylvania. Next, in May 1600, Michael invaded Moldavia, deposed its prince, Jeremy Mohila, a protégé of Poland, and assumed the title of "prince of Walachia, Transylvania and Moldavia."

Austria and Poland resented this unification of the Rumanian lands. Rudolf ordered his Albanian general, Giorgio Basta, to uphold the Magyar noblemen's rising in Transylvania: the defeat of Michael's army at Mirăslău (Sept. 18, 1600) followed. The Poles invaded Moldavia, defeated the Walachians at Bucov (Oct. 19, 1600), restored Jeremy as prince of Moldavia and put his brother Simon on the throne of Walachia. At this juncture Rudolf reverted to support of Michael, whose army, together with Basta's, defeated the Magyar rebels at Goráslău (Aug. 3, 1601); but six days later, on Basta's order, Michael was murdered at Turda.

**MICHAEL CERULARIUS** (*c.* 1000–1058), patriarch of Constantinople from 1043 to 1058, is principally associated with the schism between the Roman and Byzantine churches (1054) and with his claims, partly satisfied, to the autonomy of the church in matters of ecclesiastical administration against imperial absolutism. The former event, wholly ignored by Byzantine historiographers, is regarded by modern scholarship as of less decisive significance than was afterward attributed to it by the Roman Catholic Church: the bold stroke of the Latin Cardinal Humbert in anathematizing the patriarch in his own cathedral (1054) was an incident, rather than a turning point, in papal-Byzantine relations, which were more or less permanently estranged during the whole period between the iconoclastic dispute and the fourth crusade (*see* BYZANTINE EMPIRE). In vindicating ecclesiastical claims against the crown, Cerularius was following in the footsteps of Photius (*q.v.*), in his second patriarchate, though Cerularius, with all his predecessor's administrative skill and despotic arrogance, had little or none of his genius and learning.

Born into a bureaucratic family, Cerularius had, while still a layman, been concerned in a plot against the emperor Michael IV (1040), and was for this exiled and made a monk. The weak emperor Constantine IX made him patriarch, and he steadily increased his temporal influence during the reigns of Constantine, Theodora and Michael VI. Isaac Comnenus, however, whom his intrigues had brought to the throne in 1057, saw that there was room for only one emperor at a time in Byzantium, and in Dec. 1058 dethroned Cerularius, who died soon afterward.

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**MICHAELIS, GEORG** (1857–1936), chancellor of the German empire for 15 weeks in World War I, was born at Haynau on Sept. 8, 1857. Having worked in the Prussian administrative service from 1879, he went to Japan in 1885 to teach in the school of German law at Tokyo till 1889. Returning to Prussia, he was public prosecutor before re-entering the administrative service in 1892. He became undersecretary of state in the Prussian ministry of finance in 1909, director of the wartime imperial department for cereals in 1915 and Prussian state commissioner for the food supply early in 1917. Then, when the imperial chancellor Bethmann Hollweg resigned, Ludendorff and the military high command on July 13, 1917, secured the appointment of the colourless Michaelis as his successor. When the majority in the *Reichstag* called for his assent to its "Peace resolution" of July 19 (indicating that Germany desired no annexations), Michaelis evasively agreed to it "as I understand it," thus not committing himself further than the military might decide; and in September, when he acknowledged Pope Benedict XV's peace proposals of Aug. 16, he likewise avoided any specific statement of Germany's territorial aims. Then, by supporting allegations that the Independent Socialist leaders were to blame for a mutiny in the navy, he lost the favour of the *Reichstag* and so became useless to Ludendorff; and his resignation was announced on Oct. 31, 1917. From March 1918 to April 1919 he was head of the administration in Pomerania. His autobiography, *Für Staat und Volk*, appeared in 1922. His later life was mainly devoted to Protestant church organizations and to student welfare. He died at Bad Saarow on July 24, 1936.

**MICHAELIS, JOHANN DAVID** (1717–1791), German Protestant biblical scholar and theologian, important for work in Hebrew and Arabic studies and on early versions of the Bible, was born at Halle on Feb. 27, 1717, a member of a family which included several good biblical scholars. He qualified as university lecturer at Halle in 1739–40, but he did not feel at home in the pietistic atmosphere of the university at that time, and was glad to accept a position as *Privatdozent* at Göttingen. He became full professor in 1750, and remained there until his death on Aug. 22, 1791. Michaelis' works include *Einleitung in das Neue Testament* (1750); an annotated translation of the Old Testament, 13 vol. (1769–91); and *Mosäisches Recht*, 6 vol. (1770–75), which typified his rationalist approach and greatly influenced later German biblical criticism. He edited the *Orientalische und exegetische Bibliothek* (24 vol., 1771–79; new series, 8 vol., 1786–91).

*See* his autobiography, *Lebens beschreibung* (1793); and correspondence, ed. by J. G. Buhle, 3 vol. (1794–96).

**MICHAUX, ANDRÉ** (1746–1802), French botanist whose work on the flora of North America was a valuable contribution to American botany, was born at Versailles, March 7, 1746. In 1779 he spent some time botanizing in England, and in 1780 explored Auvergne, the Pyrenees and the north of Spain. In 1782 he was sent by the French government on a botanical mission to Persia. After two years he returned with a fine herbarium, and also introduced numerous eastern plants into France. In 1785 he was sent to North America, but on his return in 1797 he was shipwrecked and lost most of his collections. In 1800 he went to Madagascar, where he died on Nov. 16, 1802.

**MICHEAS, PROPHECY OF:** *see* MICAH, BOOK OF.

**MICHEL, CLAUDE:** *see* CLODION.

**MICHEL, LOUISE** (1830–1905), revolutionary French socialist, called *la Vierge rouge de Montmartre* ("the Red Virgin of Montmartre"), was born at the château de Vroncourt (Haute-Marne) on May 29, 1830, the daughter of a servant, Marianne Michel, and of the son of the house, Etienne Charles Demahis. Brought up by her father's parents, she received a liberal education and, after her grandfather's death in 1850, was trained as a teacher; but her refusal to take the oath of loyalty to Napoleon III prevented her from teaching in a state school. She obtained a post in 1866 in a school at Montmartre, in Paris, and interested herself in social work, developing her revolutionary ideas at the same time. During the siege of Paris by the Germans (1870–71) she worked in the ambulance service. On the establishment of the Commune (of Paris; *q.v.*) in March 1871 she joined the national guard and fought with great ardour, being one of the last groups of Communards to resist the troops from Versailles. At her court-martial in Dec. 1871 she defended the Commune. She was condemned to deportation and sent to New Caledonia. Among her companions was Henri Rochefort, who remained her friend until her death.

The amnesty of 1880 did nothing to diminish Louise Michel's extreme socialistic fervour, and she traveled throughout France preaching her gospel of revolution. She was sentenced to six years' imprisonment in 1883 for inciting a mob to rob the bakeries during a hunger march, but was released in 1886. She then lived in London till 1896. Returning to France, she lectured on revolutionary themes till her death at Marseilles on Jan. 10, 1905.

In addition to her *Mémoires* (1886), she published numerous works on social themes, some in verse and some in novel form.

*See* I. Boyer, *Louise Michel* (1927); A. L. Zévaès, *Louise Michel* (1936).

**MICHELANGELO** (MICHELAGNIOLO DI LODOVICO BUONARROTI-SIMONI) (1475–1564), the greatest monumental painter of the Renaissance and certainly the most famous of all sculptors since the time of the Greeks.

**Childhood and Early Training.**—Michelangelo was born on March 6, 1475, at Caprese in Tuscany, where at that time his father, Lodovico Buonarroti, held for six months the appointment of resident magistrate (podesta). When Michelangelo was only a few weeks old, his father's term of office expired and the family returned to Florence. Michelangelo was placed in the care of a marble-worker's wife at Settignano. Michelangelo's mother, Francesca di Neri, died when he was six. In 1485 his father married again, and probably only in that year Michelangelo was brought back to Florence, to live there with his father, his stepmother, brothers and an uncle in a gloomy house near the church Sta. Croce. Three years later he made friends with a young painter, Francesco Granacci, who was working with the brothers Ghirlandajo. On April 1, 1488, Michelangelo was articled as an apprentice in the same workshop, after a sharp struggle with his father, who thought it an unfit occupation for the son of an old and noble family. Domenico Ghirlandajo was working at the time on the frescoes of Sta. Maria Novella, and Michelangelo, at the age of 13, was perhaps allowed to paint a few of the minor figures. In the Ghirlandajo workshop he certainly learned the technique of fresco and of panel painting and was instructed to copy in pen and ink groups of figures from the frescoes of Giotto and Masaccio in Florentine churches. But Michelangelo was much more inclined to sculpture; he had sucked in this passion, as he used to say, with his foster-mother's milk in the marble quarries of Settignano.

In 1489 he went to the "school of sculpture" in the Medici gardens, where Lorenzo de' Medici, the ruler of Florence, allowed young sculptors to study his collection of antique sculptures under the tutorship of Bertoldo di Giovanni, a pupil of Donatello. There Michelangelo studied Greek and Roman marbles, making, among other copies, a marble head of an old faun (now lost). His talents were brought to the attention of Lorenzo, who invited him to stay in his palace, where the young artist listened to the discourses on Neoplatonism and the philosophical conversations of Angelo Poliziano, Marsilio Ficino, Pico della Mirandola and other humanists. Their influence was profound and Michelangelo remained a Christian Platonist to the end of his days. In the Medici palace the artist also met Cristoforo Landino, the commentator of Dante, and became an ardent student of the *Divine Comedy*.

Two works of this early period (both now in the Casa Buonarroti, Florence) are small marble reliefs; the earlier one (*c.* 1491), the "Madonna of the Stairs," is influenced by the monumental style of Donatello; the other, somewhat larger, relief, "The Battle of the Centaurs," follows the style of Roman sarcophagus fronts.

**Florence Under Savonarola: Flight to Bologna.**—In the spring of 1492 Lorenzo died; his son, Piero de' Medici, invited Michelangelo to remain as a guest in the palace but as he gave him no serious commissions Michelangelo returned home. Piero inherited his father's position, but not his talents or the love of the people. War was drawing near, the French army marched toward Florence, and it became apparent that disaster was imminent. In Oct. 1494 Michelangelo fled; six weeks later the French entered Florence, the Medici were expelled and for the next four years (1494–98) Savonarola, the preacher and religious reformer whose sermons Michelangelo had heard and admired, governed the town (*see* FLORENCE: *History*). Michelangelo's flight took him first to Bologna, and then to Venice, where he ran short of money and was compelled to return to Bologna. There he was kindly received by a member of the Aldovrandi family, on whose commission he carved three marble statuettes which were still wanting on the shrine of S. Domenico, in the church of that name. The three small figures, two saints and an angel, were apparently executed in a great hurry; they are not as brilliant as his two early reliefs, but they show a new influence, that of the great sculptor Jacopo della Quercia, whose work at the west door of S. Petronio Michelangelo must have studied carefully.

After a year in Bologna Michelangelo returned to Florence, where he carved a youthful "St. John" for Lorenzo di Pierfrancesco de' Medici, a cousin of Lorenzo de' Medici and patron of Botticelli. This "St. John" is lost, and so are three other early works: a marble "Hercules," a wooden "Christ on the Cross" and a "Sleeping Cupid." The "Sleeping Cupid" was sold by a dishonest dealer to a Roman collector, the cardinal Raffaello Riario di San Giorgio, as a genuine antique, but when the fraud was discovered the cardinal could not but admire Michelangelo's skill.

**First Visit to Rome, 1496–1501.**—In June 1496 Michelangelo went to Rome, perhaps in the hope of finding a patron in the cardinal of San Giorgio. He received no countenance from him, but Jacopo Galli, another collector of antique sculpture, commissioned him to make a life-size marble statue of a standing "Cupid" (sometimes described as "Apollo"). This, too, has disappeared. Jacopo Galli's second commission was for a "Bacchus" (1497; now in the Bargello, Florence). This life-size sculpture was intended as a decoration in the garden of the Casa Galli; it is composed as a free-standing group and must be viewed from every angle in order to have a proper view of the Bacchus and also of the little Pan behind him. Galli also obtained for Michelangelo a contract (dated Aug. 27, 1498) from the French cardinal Jean de Villiers de la Groslaye for a "Pietà" (the Virgin holding the dead Christ) and guaranteed that it would be "the finest marble work of today in Rome, such as no living master could do better." Michelangelo fulfilled the promise. In the spring of 1499, a few months before the cardinal's death, the "Pietà" was installed in a chapel of St. Peter's (San Pietro in Vaticano); it is the only sculpture that Michelangelo signed with his name. Despite this great achievement he received no further commissions in Rome, and in the spring of 1501 he returned to Florence.

**In Florence Under the Republic (1501–05).**—During the five years of Michelangelo's absence from his native town many political changes had occurred, both under Savonarola's dictatorship and after his death in 1498. Michelangelo found on his return a democratic regime. A few months later Pietro Soderini, an admirer of his work, was elected *gonfaloniere*, or head of the Signoria, and soon the artist was entrusted with more commissions than he could deal with. On Aug. 16, 1501, he made a contract for a gigantic marble "David"; before he had finished it a bronze "David" was commissioned; and before this second statue was cast he had signed another contract (1503) for 12 marble statues of the apostles for the cathedral. At the same time he worked on a commission he had accepted from Francesco Cardinal Piccolomini for 15 marble statues for the altar built by Andrea Bregno in Siena cathedral.

The marble "David," a statue almost 17 ft. high, was commissioned by the Operai del Duomo, the building administration of Florence cathedral. The figure was carved out of a huge block of marble which had been partially worked and then abandoned by an earlier sculptor. Michelangelo started his work on Sept. 13, 1501, and finished it in Jan. 1504. At the artist's request a commission was invited to choose the best place for it. This conference of about 30 men included the best artists of Florence, among them Leonardo da Vinci, Botticelli, Piero di Cosimo and Filippino Lippi. It was decided that Donatello's "Judith" should be removed from the entrance to the Palazzo Vecchio, the town hall of Florence, to make room for the "David." The installation took place on Sept. 8, 1504, and the statue remained there until 1873 when it was removed to the Accademia di Belle Arti (Academy of Fine Arts). In 1910 a marble copy was placed in the original position. The "David" is a herculean figure, completely nude, poised with his sling-shot and waiting quietly for the approach of Goliath, the enemy of his people. The style is rather in the spirit of Hellenistic sculpture than of the early cinquecento (16th century).

Attempts have been made to find antique prototypes for Michelangelo's marble "David," and also to ascribe a political meaning to the statue. The fact is that a "Hercules" was planned as a companion piece of the "David" and C. de Tolnay (1947) has pointed out that there are some representations of Hercules on Roman

sarcophagus reliefs showing a similar stance to the "David." The point is, however, that Michelangelo's "David" is not only a herculean figure but also a figure of colossal size. For this reason J. W. Pope-Hennessy (1963) believes that Michelangelo's source of inspiration was the antique "Horse Tamers" on the Quirinal in Rome, which are of the same enormous height.

According to Vasari, Michelangelo represented "David" "holding the sling to show that Florence should be boldly defended and righteously governed, following David's example." Giovanni Papini (1949) thinks that this is one of the cases where "good old Vasari has not understood the master, who had no allegory in mind but only a gigantic naked figure." It is true that at the same time Michelangelo's bronze "David" was delivered to France, where it certainly was not regarded as a political symbol but as a statue in the spirit of antiquity.

While working on the "David," Michelangelo neglected the commission for the 15 figures for Siena cathedral and at last, with the help of assistants, he finished only four, two popes and two saints. Probably also intended for the Bregno altar is a "Madonna and Child," almost completely by his own hand. This was executed in the same years (1501–04) but was then sold to a merchant family in Bruges, Belg., who placed it in the church of Notre Dame, where it still can be seen. Of the 12 apostles for Florence cathedral Michelangelo began only one, the unfinished "St. Matthew," which is in the Bargello at Florence. The bronze "David," commissioned by the *maréchal* Pierre de Rohan in 1502, was finished six years later, sent to France and is now lost.

Between 1503 and 1505 Michelangelo executed three *tondi* (circular representations) of the Madonna, two of them sculptures and one a painting. The earliest of these, a circular marble relief of the Madonna with the Christ child and St. John the Baptist, was carved for Taddeo Taddei, but was not quite finished. In 1823 it was bought by Sir George Beaumont and later presented to the Royal Academy of Arts in London. The other marble relief, a little smaller and not perfectly round, was made by Michelangelo for Bartolommeo Pitti in Florence; it is now in the Bargello. The third Madonna *tondo* was painted in tempera on a circular wooden panel for Angelo Doni, who also patronized Raphael during the young artist's stay in Florence. The "Madonna Doni" (now in the Uffizi gallery, Florence) is the only extant easel painting by Michelangelo; it is recorded by Giorgio Vasari and Ascanio Condivi (see *Bibliography*, below).

Two other panel paintings, the so-called "Manchester Madonna" and the "Entombment of Christ," are sometimes, and very doubtfully, attributed to Michelangelo. They are both in the National gallery, London. The National gallery in its catalogues of 1929 and 1948 regarded both pictures as by Michelangelo himself; in the catalogue of 1962 only the "Entombment" is given to the master, whereas the "Manchester Madonna" is catalogued as "ascribed to Michelangelo." The old attribution to Antonio Mini is rightly discarded: no documented paintings by Mini are known.

*The Cartoon of the Battle of Cascina (1504–06).*—While Michelangelo was working on the *tondi*, Leonardo da Vinci was designing a historical painting for the east wall in the Sala del Gran Consiglio (Chamber of the Great Council) in the Palazzo Vecchio of Florence. Leonardo's theme was the "Battle of Anghiari" (contract dated May 4, 1504). A few months later Pietro Soderini procured for Michelangelo the commission to execute a companion painting (measuring about 24 by 60 ft.) on the left half of the same wall. Michelangelo chose an incident at the battle of Cascina, during the Pisan War of 1364, when Florentine soldiers bathing in the Arno were roused by an alarm announcing the approach of the enemy. Since Florence was again at war with Pisa (1496–1509) the subject was politically significant, a warning to the citizens of Florence that they should always be on the alert.

Michelangelo designed the cartoon between Dec. 1504 and spring 1505, and perhaps did some further work on it in 1506; but the execution in fresco was never begun. The cartoon was, according to Benvenuto Cellini, Michelangelo's best work, even superior to the Sistine frescoes; Cellini called it "the drawing academy of the world," and in fact scores of artists made drawings after this cartoon, among them Raphael, Andrea del Sarto, Berruguete, Perino del Vaga, Rosso, Pontormo and other Mannerists. The most comprehensive copy of the main scene, "The Bathers," is the grisaille painting in Lord Leicester's collection, Holkham hall, Norfolk. Other parts of the cartoon showed, as we know from Vasari, "innumerable soldiers on horseback, beginning the fight." The cartoon, executed in black chalk, charcoal and white lead, was cut up during Michelangelo's lifetime. Cellini brought one fragment of it back from France to Florence and other portions were preserved in Mantua and Turin until the early years of the 17th century, but all the fragments have disappeared.

This cartoon was the foundation of Michelangelo's reputation as a painter. By means of perspective foreshortening, it represented nude human beings twisting in every possible attitude. This perfect knowledge of the human body—a knowledge based on observation of nature and of Hellenistic sculpture—had already been proclaimed in the "Bacchus," the dead Christ of the "Pietà" of St. Peter's, and the gigantic figure of "David." The fidelity to nature shown in these sculptures and in the cartoon by far surpassed anything produced in the quattrocento; a direct link had been forged with antique art, the presentation of the nude, thus fulfilling one of the great aspirations of the Renaissance. Michelangelo, at the age of 30, became the most famous artist in Italy.

**Second Visit to Rome (1505–06).**—In March 1505 Pope Julius II called Michelangelo to Rome and entrusted to him the task of executing his tomb. When the design had been approved, Michelangelo went in April 1505 for eight months into the quarries of Carrara, superintending the breaking and shipping of the marble blocks, the first of which arrived in Rome in Jan. 1506. Michelangelo established a large workshop at the Piazza di San Pietro, hired assistants and masons and began work enthusiastically. For a while the pope followed his progress eagerly and even had a drawbridge made which connected the Vatican with the artist's studio. But soon Michelangelo felt that the pope's interest was waning and he was giving undue attention to Bramante and his plan for rebuilding St. Peter's, in which the tomb was to be placed. On April 17, 1506, the day before the pope laid the foundation stone of the new church, Michelangelo fled on horseback from Rome, and before the pope's messengers could overtake him, he was safe on Florentine territory. In Florence he resumed work on the "Battle of Cascina" and on the statue of "St. Matthew."

**The Bronze Statue of Pope Julius at Bologna (1506–08).**—The pope meanwhile was engaged in a military campaign against Bologna, which he entered in triumph on Nov. 10, 1506. At once he summoned Michelangelo to join him there, promising him safe conduct and renewed favours. The artist arrived in Bologna by the end of November, was kindly received and commissioned to make a bronze portrait of the pope, about 10 ft. high, showing him seated, with the key in his left hand, his right hand raised in benediction. Michelangelo set up a workshop, hired several bronze founders, and made small and full-sized models. The statue had to be cast twice as the first pouring of metal was unsuccessful. Installed in Feb. 1508 on the facade of S. Petronio, the portrait survived only until 1511 when the people of Bologna rose against the pope, and it was hurled down and shattered to pieces. From the fragments Duke Alfonso d'Este cast a mighty cannon, which he ironically christened "La Giulia" (Julia), and used against the papal army. The head was exhibited in the duke's gallery, at Ferrara, but has since disappeared.

**The Ceiling Frescoes in the Sistine Chapel (1508–12).**—Early in March 1508 Michelangelo was back in Florence and had rented a workshop in the Borgo Pinti; a few weeks later he was called again to Rome by Julius II to paint the ceiling of the Sistine chapel, the pope's private chapel. The contract was concluded on March 10, 1508, and on that day Michelangelo received the first payment.

The project of repainting the ceiling of the chapel had been mentioned by the pope two years before. At the time the shallow barrel-vaulted ceiling was painted to symbolize the heavens, a blue background being ornamented with golden stars. According to the first plan for its redecoration, the central portion was to be filled by Michelangelo with grotesques, and the twelve apostles were to be painted in the pendentives. Gradually the plan was

extended until the final version also included the spandrels and lunettes. Prophets and sibyls replaced the apostles, and instead of grotesques there were nine biblical histories; 300 figures were painted as against the 12 of the first project.

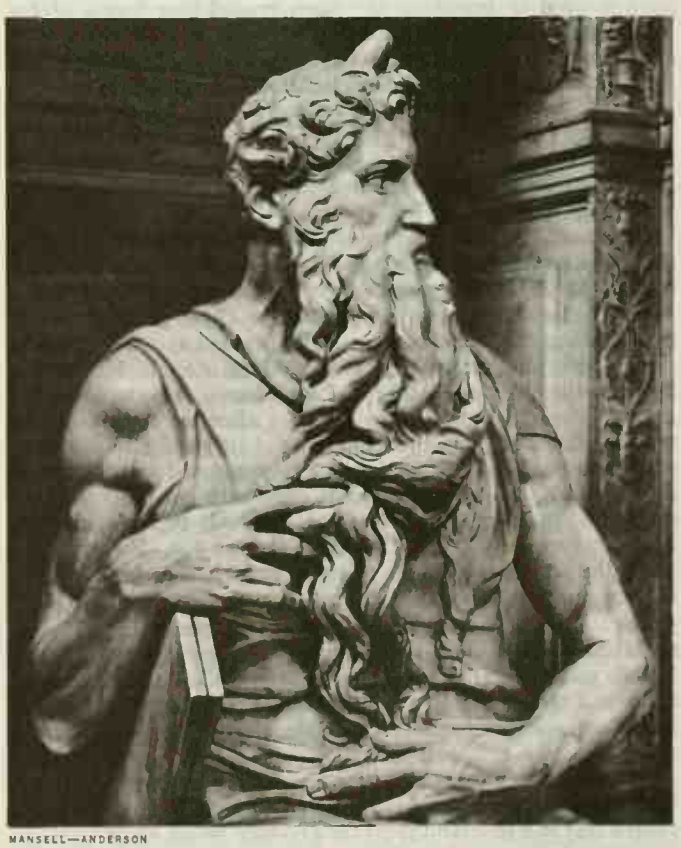
The main field of the ceiling shows four larger panels alternating with five smaller ones, divided up by painted architecture. The larger panels measure about 10 by 18 ft., the smaller ones about 6 by 9 ft. These nine pictures tell the story of Genesis from the Creation to the time of Noah, demonstrating the history of mankind, created by God, falling into sin, living in sin and awaiting redemption. The first triad depicts the origin of the world: (1) the division of light from darkness; (2) the creation of sun, moon and stars; (3) the separation of water from land, and the creations of plants and animals. The second triad shows the origin of mankind and of sin: (1) the creation of man; (2) the creation of woman; (3) the fall of man and the expulsion from the Garden of Eden into the wilderness of this world. The third triad shows the perpetuation of sin in the world: (1) Noah's offering and the everlasting covenant between God and every living creature; (2) the great flood, the punishment and purging of sin; (3) the drunkenness of Noah and the continuation of sin.

Each of the smaller panels is surrounded with two seated pairs of nude youths, commonly known as "slaves." There are altogether 20 nude figures (one of them almost completely destroyed). The "slaves" (also called *ignudi* or *genii*), with their vigorous and contorted movements, signify the strivings of mankind awaiting redemption. Along the lateral spaces, between the crown of the shallow vault and the walls of either side, are the gigantic seated figures of five prophets and five sibyls; two further prophets are introduced at the narrow ends of the ceiling, over the altar wall and over the entrance wall. These 12 figures are by far the largest in the whole composition: standing they would be about 12 ft. high. This chorus of seers points the way of salvation. The subjects in the triangular spaces at the four corners deal with temporal salvation: the miraculous deliverances of the people chosen by God. The victories of a boy and of two women demonstrate the victory of weakness over strength and the grace of God over brutal power: we see the triumphs of David, Judith and Esther. But the most significant of these spandrel pictures is the fourth, the Brazen Serpent. "And as Moses lifted up the serpent in the wilderness, so must the Son of man be lifted up, that whoever believes in him may have eternal life" (John iii, 14, 15). This prefiguration of the Redeemer's coming is linked with the pictures of the ancestors of Christ, as enumerated in Matt. i, 1–17, which are shown in the 16 lunettes (two since destroyed; see *The Last Judgment,* below) and the 8 triangles above them.

The preparations for the Sistine ceiling frescoes began in May 1508. The erection of the scaffolding was finished in July. In September some assistants arrived from Florence and probably worked on the layout of the ceiling paintings, the architectural framework, the tracing of outlines on the rough mortar. The actual work of painting, carried out by Michelangelo himself, started at the latest in Jan. 1509. He began near the entrance, progressing toward the altar; the histories last in chronological order (the great flood, the sacrifice of Noah, and the drunkenness of Noah) were painted first. In Sept. 1509 these three histories were finished, a year later two more, and again a year later all nine histories were complete, together with the surrounding figures of "slaves" and "seers," and also the four histories in the corner spandrels.

On Aug. 14, 1511, the eve of the feast of the Assumption of the Blessed Virgin, the ceiling frescoes were unveiled; then, until the end of Sept. 1512, Michelangelo painted the "Ancestry of Christ" in the lunettes; and on Oct. 31, 1512, the first Mass was celebrated in the Sistine chapel. The impression produced on Michelangelo's contemporaries by the monumental paintings was profound and they have maintained their influence to the present day.

**The Julius Monument.**—Toward the end of Sept. 1512 Michelangelo wrote to his father: "I have finished painting the chapel; the pope is very pleased with my work. But my other undertakings do not move so well as I hoped, and for that I can only blame the bad times which are unfavourable for the arts." About a month later he wrote to his father again: "I am still doing no work and am waiting for the pope to tell me what to do." Michelangelo was waiting to continue work on the Julius monument, for which he had concluded a contract in 1505. According to the first designs, it was to be a free-standing monument, rectangular in shape and decorated with about 40 marble figures, but later the plans were modified. On Feb. 21, 1513, Pope Julius II died and on May 6 a second contract was drawn up by the executors of his will. Michelangelo undertook to complete the monument in seven years and not to accept any other work in the meantime. He submitted a revised design. Between 1513 and 1516 the "Moses" and two "Captives" (commonly called "Slaves") were carved. Michelangelo had a workshop at the Macello de'Corvi in Rome and employed Florentine stonemasons. In July 1516 a third contract was concluded and a modified design submitted; but there was fresh interruption because of Michelangelo's work for the façade of S. Lorenzo. The following years were spent on unproductive work in Florence for the Medici and in journeys to the marble quarries of Carrara, Pietrasanta and Seravezza. In 1520 the contract for the façade of S. Lorenzo was cancelled, but work on the Medici tombs (see *In the Service of Pope Clement VII,* below) was begun. In 1525 Michelangelo had the idea of completing the Julius monument as a wall-tomb, but no decision was reached although he submitted a new design in Oct. 1526 and meanwhile he went on working on the Medici chapel. On April 29, 1532, after prolonged negotiations, a fourth contract was drawn up, but then Michelangelo was commissioned to paint the "Last Judgment" in the Sistine chapel. When this large fresco was finished in 1541 the work on the Julius monument, which had long been relegated to assistants, was entrusted entirely to Raffaello da Montelupo and Pietro Urbano, two undistinguished sculptors. In the fifth contract, dated Aug. 20, 1542, it was stipulated that Michelangelo should use for the monument the statue of "Moses" (described as "almost finished") but not the two "Captives," which would not fit into the much reduced scale of the design. He undertook to make two other statues, to stand on either side of the "Moses," namely "Rachel" and "Leah" (or, as they are called in the fifth con-



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MICHELANGELO'S "MOSES," A PART OF THE MONUMENT COMMISSIONED BY POPE JULIUS II. CHURCH OF S. PIETRO IN VINCOLI, ROME

tract, "Contemplative Life" and "Active Life"). Michelangelo was allowed to leave the completion to the hands of minor masters. The two more than life-size "Captives" are now in the Louvre museum, Paris; four more, begun about 1530, but only hewn out in rough, stand in the Accademia, Florence. The "Moses," originally intended as a subsidiary figure for one of the angles of the upper story, is now placed at eye level in the centre of the final and miserably reduced version of the monument, which, 40 years after the first contract, was erected in 1545 in the church of S. Pietro in Vincoli. "Rachel" and "Leah" are almost completely by Michelangelo's own hand; the others—the statue of the pope, a prophet and a sibyl, a Madonna and child—are the work of assistants. The sculptured decorations were designed by Michelangelo but carried out by various minor sculptors.

It is the statue of Moses which gives incomparable value to the monument. "When Michelangelo had finished the Moses," wrote Vasari in 1568, "there was no other work to be seen, antique or modern, which could rival it." It is still the most famous statue in the whole of Rome.

**In the Service of Pope Leo X.**—In 1513, when Cardinal Giovanni de' Medici, a son of Lorenzo Magnifico, succeeded Julius II on the papal throne (as Leo X, 1513–21), the Medici family regained full power in Florence, where six months earlier their government had been reinstalled with the help of Spanish troops. Giuliano de' Medici, duke of Nemours and a brother of Pope Leo X, was master of the city; when he was called to Rome as general of the papal army, his nephew Lorenzo de' Medici, duke of Urbino, became ruler of Florence. Pope Leo X employed Michelangelo not as a painter, not even as a sculptor, but as an architect. Michelangelo designed for him the front of a small chapel in Castel Sant'Angelo in Rome (1514). This chapel is dedicated to Cosmas and Damian, the patron saints of the Medici; the emblems of the Medici family and of Leo X form part of the decoration. In 1516 Michelangelo returned to Florence and worked there on two commissions which were intended to bring honour to the Medici. For the façade of the church of S. Lorenzo he made several designs and models; but this magnificent plan came to nothing. Then the pope decided to transform the open ground-floor loggia of the Medici palace into a hall, and Michelangelo was entrusted with the construction of the façade. The two windows he designed for the bays of the former loggia are original and well balanced.

**In the Service of Pope Clement VII: the Medici Chapel.**—In 1523 Cardinal Giulio de' Medici became pope, taking the name of Clement VII. Already as a cardinal he had planned a great group of monuments to members of the Medici family, which was to be set up in a new sacristy in S. Lorenzo. From 1520 onward Michelangelo made designs for the completion of this chapel, following the style of the old sacristy (designed by Brunelleschi 1421–25). His cupola, crowned with its lantern, polyhedric copper ball and cross, was in position in 1524. The sepulchral monument in the chapel was originally planned as a free-standing edifice with four tombs for Lorenzo Magnifico, for his brother Giuliano the elder, the father of Pope Clement VII, and also for the two Medici who had ruled Florence after the collapse of the republic, Giuliano, duke of Nemours (d. 1516) and Lorenzo, duke of Urbino (d. 1519). The plan was soon reduced and the monument was planned as a mural decoration with two sarcophagi on each wall; for a time the addition of a double tomb for the two Medici popes, Leo X and Clement VII, was considered. Eventually the project was limited to two separate tombs for the dukes of Nemours and Urbino.

The statues of the Medici monument rank beside the "Moses" as Michelangelo's greatest achievement in sculpture. The two famous monumental groups are each composed of a seated armed figure in a niche, with an allegorical figure reclining on either side of the sarcophagus below. The seated figures, representing the two dukes, are not treated as portraits but as types. To the Florentines who missed a portraitlike fidelity in the statues and were puzzled by the purely idealistic conception, Michelangelo answered that in a thousand years time nobody would know what the two dukes had really looked like. Lorenzo, whose face is shaded by a helmet, personifies the reflective man; Giuliano, who is holding the baton of an army commander, portrays the man dedicated to heroic deeds. The one represents contemplative life, the other active life. At the feet of Duke Giuliano recline the figures of "Night" and "Day." "Night," a giantess, is twisting in uneasy slumber; "Day," a herculean figure, looks wrathfully over his shoulder, but his face is indistinct, merely blocked out of the stone. As grand, but far less violent, are the two companion figures which recline between sleep and waking on the sarcophagus of Duke Lorenzo. The male figure is known as "Evening" (or "Dusk"), the female figure as "Aurora" (or "Dawn").

Lorenzo Magnifico and his brother Giuliano were buried at the entrance wall, and over them was set up a marble group of a "Madonna and Child," flanked by the Medici patron saints Cosmas and Damian. The Madonna is a work of imposing majesty, completely by Michelangelo's own hand; the saints are the work of pupils after models by the master. After 14 years of work (1520–34), Michelangelo left the monument unfinished and pupils completed it as well as they could.

The four "River-gods," which were to recline on the broad bases at the sides of the sarcophagi, were never executed in marble. They were intended to be of an enormous size, as one can see from the one damaged clay model which is still extant (Florence, Accademia); from the knees to the neck it measures almost 6 ft.; head and arms are missing. A few small-sized models for statues in the Medici chapel have also been preserved. A wax model for "Evening" is in the British museum; clay models for "Dawn" and "Night" are in the collection of Alejandro Pietri, Caracas, Venez., and in the Casa Buonarroti, Florence, there is a clay model for an allegorical female figure, probably the "Earth," which was to stand in a niche next to "Giuliano." (A figure of "Heaven" was to stand on the other side, but neither figure was executed.) Frescoes, too, were intended for the lunettes in the chapel, but were never painted.

Various attempts have been made to interpret the allegorical meaning of the monument: K. Borinski saw in it allusions to Dante; E. Steinmann, to a carnival song; H. Brockhaus, to Ambrosian hymns. Tolnay gives an elaborate explanation, according to which the whole chapel was a synthesized representation of the universe, divided into its three zones: hell, earth and the heavenly spheres. There are some other Neoplatonic and some political interpretations, none of them convincing.

**Other Works, 1519–34.**—*Sculpture.*—A life-size marble statue of the "Risen Christ" (commissioned in 1514 by three citizens of Rome) was carved by Michelangelo between January 1519 and April 1520. It was sent to Rome and there finished and polished by two assistants. It now stands in the church of Sta. Maria sopra Minerva, Rome. A "Crouching Boy," hewn out of a marble cube with maximum utilization of the volume, was probably intended for the entablature of the tomb of Lorenzo in the Medici chapel, but was not used. Michelangelo left it unfinished and some pupil tried to continue it. It is now in the Hermitage, Leningrad. Also unfinished and partly the work of assistants are the four "Captives" (also called "Slaves," or "Giants") which until 1908 were inserted in a grotto of the Boboli gardens in Florence, and are now in the Accademia there. They were carved for the Julius monument from models which Michelangelo made. One of his small wax sketches, that for the "Young Slave," who is covering his face with his left arm, is now in the Victoria and Albert museum, London. Three small clay models for "Slaves" are in the Casa Buonarroti, Florence, and one is in the British museum, London. Six small clay sketches are in the LeBrooy collection in Montreal, Que.; another one, for a "Victory group," sometimes called "Hercules and Cacus" (now in the Casa Buonarroti), is usually regarded as a model for two figures of the Julius monument as conceived in about 1525. The greater than life-size marble "Victory," representing a youthful conqueror, standing upright and naked and crushing down a bearded enemy, was also sculptured for the Julius monument, but was then left behind in Florence. It is now in the Palazzo Vecchio.

While Michelangelo was still labouring on the Medici tombs and the Julius monument the war between the pope and the emperor came to a climax. In 1527 Rome was occupied and sacked by the

imperial troops under the connétable de Bourbon, and the pope was besieged in Castel Sant'Angelo (*see* ITALY: *History*). The Florentines seized the occasion to expel their Medici rulers, two illegitimate minors, Ippolito and Alessandro, who governed with the help of the cardinal of Cortona, and again set up a free republican government. The emperor and the pope soon became reconciled and agreed to restore the rule of the Medici in Florence. In 1529 Michelangelo was employed as military engineer, fortifying Florence against the expected attacks. He lent the city money, went on diplomatic missions to Ferrara and Venice, and negotiated pessimistically for a future residence in France. He was declared a traitor and threatened with confiscation of his property; whereupon he returned to Florence while the siege was still in progress. On Aug. 12, 1530, Florence capitulated and the imperial troops entered the city, which was then handed over to the pope. Baccio Valori was appointed commissary for the pope and the other members of the Medici family and no mercy was shown to those who had taken part in the defense of the republican government. Michelangelo went into hiding, but at the intervention of Valori was promised immunity by Pope Clement on the condition that he should resume work on the Medici chapel. "When Michelangelo felt himself thus reassured," relates Vasari, "he sought first to win the favour of Baccio Valori. He made for him from a block three ells high a figure representing Apollo who is drawing an arrow from his quiver. This statue is not quite finished." This "Apollo," sometimes described as a "David," is now in the Bargello, Florence.

*Painting.*—Another work Michelangelo executed to show his gratitude was a tempera painting of "Leda and the Swan," which he had promised to Alfonso I d'Este, duke of Ferrara, whom he visited during the siege of Florence to obtain advice concerning the best system of fortification. He finished the picture in autumn 1530 but refused to deliver it to the duke's ambassador, who had offended him. Instead he presented it to his favourite pupil, Antonio Mini, who took it to France; it is now lost. The National gallery and the Royal Academy of Arts in London own copies of the painting, both by Rosso, the one in oil, the other a monochrome cartoon.

*Architecture (in Florence, 1524–34).*—The Biblioteca Medicea-Laurenziana, adjoining the cloisters of S. Lorenzo, was commissioned by Pope Clement. Michelangelo made the first drawings for it in Jan. 1524. The carved ceiling was designed in the same year, but finished ten years later by two indifferent craftsmen. The mosaic floor, which repeats the design of the ceiling, and the carved benches were made by various assistants from sketches of the master. Michelangelo also made designs for the staircase of the library; his model for this was finished by Bartolomeo Ammanati and Vasari in 1559 and the library was opened in 1571. Another architectural work ordered by Pope Clement from Michelangelo is the "Pergamo" of S. Lorenzo, a sacrarium (or reliquary loggia) which was erected over the main entrance inside the church, to store the relics collected by Lorenzo de' Medici. Over the left pilaster appear the three Medici rings, the emblem of Lorenzo de' Medici, and under the tribune the coat of arms of Pope Clement VII. Michelangelo made the first designs in Feb. 1526, but the work was only finished in winter 1532–33.

**Later Life in Rome.**—The later part of the winter 1532–33, and the following spring, Michelangelo spent in Rome. He formed a lifelong friendship with Tommaso de'Cavalieri, to whom he dedicated many poems and drawings, and he decided to settle in Rome. In June 1533 he returned for four months to Florence and made arrangements with his assistants as to how they should finish the Medici chapel and the Biblioteca Medicea-Laurenziana.

*The Last Judgment.*—In Nov. 1533 Michelangelo went once more to Rome to work on the Julius monument, but Pope Clement insisted that he must complete the decoration of the Sistine chapel by painting the wall above the back of the altar; the subject chosen was the "Last Judgment." The artist dissolved his workshop and household in Florence and moved to Rome, where he remained for the rest of his life. He was almost 60 years old and had another 30 years to live; but he never saw Florence again.

Two days after his arrival, on Sept. 25, 1534, Pope Clement VII died and was succeeded by Alessandro Farnese, who took the name of Pope Paul III. The new pope confirmed at once the order for the painting of the "Last Judgment." In autumn 1535 the cartoon was finished; then the wall had to be prepared for fresco. First of all the paintings which decorated the wall over the altar were removed, three frescoes by Perugino and two lunettes by Michelangelo, and the two windows were blocked up. An inner wall of dried bricks was erected, overhanging at the top by about one foot, preventing the accumulation of dust on the painted surface. The actual work of painting was begun in summer 1536. Michelangelo executed the whole work personally, being assisted only by one colour grinder. The fresco was unveiled on Nov. 1, 1541, almost 30 years after the unveiling of the ceiling frescoes.

MANSELL—ANDERSON

ONE OF THE DAMNED DESCENDING INTO HELL, A DETAIL OF MICHELANGELO'S "LAST JUDGMENT," SISTINE CHAPEL, ROME

The "Last Judgment" is probably the most famous painting in Rome; it certainly is the largest, covering an area of 48 by 44 ft. It is arranged in three zones. At the top is the kingdom of heaven, with Christ as judge of the world enthroned in the centre and the Virgin next to him. Around him is an inner circle of apostles and patriarchs. In the outer circle are the prophets and martyrs, Hebrew women, virgin saints and sibyls. Above, in the lunettes are hosts of angels with the instruments of Christ's Passion, the pillar at which he was scourged and the cross. The angels have no wings, the saints no halos; they are gigantic figures, moving vehemently like leaves in a storm. The middle zone is the realm of those who have been judged: on the left the ascent of the elect, on the right the fall of the damned; while in the centre the messengers of the Lord blow their trumpets. The book of the elect is small and light and a young angel is holding it; but the book of the damned is so large and heavy that it has to be carried by two strong angels. On the right of the lowest zone is the realm of Charon and the demons; on the left is the resurrection of the dead. Christ, rising from his seat of clouds, looks down on the arrival of the damned in hell; his right arm, lifted in an awesome gesture, seems to condemn them; his left hand, lightly raised, points at the wound in his side and at the same time at the elect. We are told that the pope, overcome by the sight, broke into prayer with the words: "Lord, charge me not with my sins when Thou shalt come on the day of judgment."

The painting had an enormous influence on artists of the period; it created a new style whose ideal was timelessness, spatial universality and spiritual pathos. In contrast to its impression on contemporary painters "The Last Judgment" aroused the hostility of theologians and men of letters, who were filled with the spirit of the Counter-Reformation. Most of the nudities in the fresco were painted over, first by Michelangelo's pupil Daniele da Volterra, and then by various other artists. Under Pius V (1572) further draperies were added, and a few years later the young El Greco offered to replace the painting with one of his own, which would be "decent, pious, and no less well painted." It was to be hoped that a time would come when Michelangelo's fresco would be cleaned and freed of the disturbing overpaintings.

Also at this period—Michelangelo's religious period, which lasted to the end of his life—he came in contact with Cardinal Reginald Pole and the circle of the "spirituali," orthodox Catholics aiming to purify the Roman Church. To this religious circle belonged also the widow Vittoria Colonna, marchesa of Pescara. Michelangelo met her in 1538 when he was 63, became her friend, and dedicated to her many poems and religious drawings. Another of his friends, Donato Giannotti, who was once secretary of state in Florence and after the downfall of the republic lived in Rome as a political exile, persuaded Michelangelo to execute a larger than life-size marble bust of "Brutus," as a symbol of love of liberty and hatred of tyranny. Michelangelo gave the unfinished bust to his pupil Tiberio Calcagni, who completed it in parts. It can be seen in the Bargello, Florence.

*The Frescoes in the Cappella Paolina, 1542–50.*—The erection of the Pauline chapel, at the south end of the Sala regia, which is adjacent to the Sistine chapel in the Vatican, was finished in 1540 and the stucco decorations of the ceiling (after drawings by Michelangelo) in 1542. Pope Paul III commissioned Michelangelo to paint in fresco the two centre panels between pilasters on the longitudinal walls. On Nov. 15, 1545, the pope saw the finished fresco on the left wall, the "Conversion of St. Paul." In the same year a fire destroyed the ceiling and the stuccos of the chapel, but only damaged the painting slightly. Michelangelo finished the fresco on the right wall, the "Crucifixion of St. Peter," in 1550 when he was 75 years of age. The Pauline frescoes had a great reputation in the late 16th century and were repeatedly reproduced in engravings. Later generations lost interest in them; in the 19th century they were blamed for their "unqualified energy and violence of action." In 1933 they were cleaned, restored and published in detail, and appreciation for them has revived. They are in fact paintings of great importance: in their abandonment of scientific perspective, their use of abstract space and their simplification of natural forms they are rather near to trends of modern art.

**The Last Phase.**—*Architecture in Rome.*—In 1546 when Antonio da Sangallo died, leaving the building of the Palazzo Farnese unfinished, Michelangelo was appointed by Pope Paul III to continue this work. Michelangelo is responsible for the balcony, the large coat of arms, the windows of the upper story and the cornice; and also for the upper story of the courtyard. At the same time he made his first designs for the rebuilding of the Capitol square. He designed the outside steps of the Palazzo del Senatore. The Palazzo de'Conservatori (on the right when facing the Palazzo del Senatore) was rebuilt to his designs and finished in 1568. Opposite it, and its exact replica, is the Museo Capitolino, which was founded in 1603 and completed in 1654. The elliptical pavement of the Capitol square, designed by Michelangelo in the shape of a rosette in 1546, was laid down only in 1940.

Michelangelo also succeeded Antonio da Sangallo as chief architect of St. Peter's. He remodeled all the designs, returned on the whole to Bramante's plan and removed as much as possible of what Sangallo had constructed. He lived long enough to see some of the main features carried out, including the drum of the dome. After his death, Giacomo della Porta and other architects completed the dome, using a large wooden model which Michelangelo had left (now in the Museo Petriano at the Vatican). The present dome is his noblest monument, although the architects did not keep strictly to his design but elongated the shape of the cupola. The body of the church was completed in a manner quite different from his devising.

Other architectural tasks on which Michelangelo was engaged were the Gran Nicchione del Belvedere ("Large Niche of the Belvedere") in the Vatican; the outside of the Porta Pia; the conversion of a part of the baths of Diocletian into the church of Sta. Maria degli Angeli; and of the Sforza chapel in Sta. Maria Maggiore. The last-named two buildings have been altered so much by later architects that they cannot be counted any longer among Michelangelo's works.

*Sculpture: The Three Pietàs.*—The "Florentine Pietà," destined by Michelangelo for his own tomb (but now standing in Florence cathedral), was begun before 1550; in 1556 he was still labouring on it, according to Vasari. After many years of work, Michelangelo one day lost patience and smashed the sculpture; the left leg of Christ is missing, his left arm is considerably damaged. Michelangelo's pupil Tiberio Calcagni tried to repair and finish it. The group consists of four figures; the Magdalen is much reworked by Calcagni—some of his chisel work can be distinguished on the arms and the chest of Christ—but the Virgin and Nicodemus are completely by Michelangelo's hand. The latter is a self-portrait of the artist. The "Palestrina Pietà," a group of three figures, formerly in the chapel of Santa Rosalia in Palestrina but now in the Accademia, Florence, is only partly by Michelangelo: the head, right arm and legs of Christ are his work; everything else was carved by a pupil. The "Rondanini Pietà" is an infinitely pathetic unfinished work; it looks as if it were an ecstatic improvization, but Michelangelo worked on it for very many years. He probably began this work before the "Florentine Pietà" and then revised it again about ten years later. The legs of Christ and the detached right arm are relics of the first version. It is a group of two figures, nearly abstract and at the same time vehemently expressive by means of distortions, towering upright like a carved Gothic column. Formerly in the Palazzo Rondanini in Rome, since 1952 it has been in the Castello Sforzesco in Milan.

*Michelangelo's Death.*—On Feb. 12, 1564, Daniele da Volterra watched his master all day long working on a "Pietà." Two days later Michelangelo fell ill and, though feverish, wandered about in the open air. After only two days in bed he died on Feb. 18, 1564, in the presence of a number of friends and doctors. The pope wished him to be buried in St. Peter's; but Michelangelo's nephew and heir, Leonardo Buonarroti, removed coffin and body to Florence, and there Michelangelo was buried, in Sta. Croce.

**Drawings.**—For nearly all his great works preparatory sketches and studies by the master's hand exist. Michelangelo was one of the most inspired and daring draftsmen and from boyhood to extreme old age never ceased to practise with pen and with black or red chalk. There are some 400 sheets scattered among various collections, chiefly public ones. Of these England owns about 200, shared between the Royal library, Windsor castle, the British museum, the Ashmolean museum and Christchurch at Oxford, the Fitzwilliam museum, Cambridge, and several private collections; about ten are in America. From 1530 to 1542 Michelangelo produced a number of highly finished and fully shaded drawings of classic or symbolic subjects in red or black chalk for presentation to Gherardo Perini, Tommaso de'Cavalieri, Vittoria Colonna and other friends. The most famous of these are the "Archers Shooting at a Herm," the "Tityus," the "Bacchanal of Children," drawn for Cavalieri (Windsor castle), and the "Christ on the Cross" for Vittoria Colonna (British museum). The ardent religious feeling of Michelangelo's last years found its strongest expression in six Crucifixion drawings, two at Windsor castle, two in the British museum, one in Oxford and one in the Louvre. Only two original cartoons have been preserved: one for three figures of the fresco "Crucifixion of St. Peter" is in the Galleria Nazionale di Capodimonte, Naples; and the other, for an "Epiphany," is in the British museum and was made for his pupil and biographer, Ascanio Condivi, who used it for an oil painting.

**Poetry.**—About 250 poems, and some fragments, by Michelangelo are known. His poetical style is strenuous and concentrated. He wrote with labour and much self-correction; he seems to fling himself on the substance of language with the same overwhelming

energy and vehemence as on the substance of marble and the same impetuosity of temperament combined with the same fierce desire for perfection but with far less instinct for the material or trained mastery over its difficulties. His most passioned sonnets are addressed to Febo di Poggio, Tommaso de'Cavalieri and Vittoria Colonna. In many ways he remains the most compelling poet Italy has ever produced. Michelangelo, to quote from a letter by Francesco Berni to Sebastiano del Piombo, "says things, while others speak words."

**Reputation.**—From his very beginnings Michelangelo found admiration. Whatever he did—every sketch, every drawing, every piece of marble touched by his chisel and carved in the rough—amazed everybody. But most admired by his contemporaries were his Sistine frescoes.

In these paintings all human standards seem to have been surpassed both in aim and in form. What has filled the minds of all the thinkers of all times—the beginning and the end of the world—here assumes visible shape. The creation of light, the birth of life, the origin of sin, the day of judgment: all this is expressed through movements of the human body.

The vast expanse of the Sistine ceiling is covered with human bodies; and their movements, rising and falling like the notes of a stormy melody, respond in an unmistakable manner to the movements of their souls. And movement, made visible in human bodies, pervades the "Last Judgment" fresco on the altar wall: in the souls of the saved flying upwards, and in the damned souls thrown headlong down into the depths.

In sculpture, too, Michelangelo showed how the movements of bones and flesh can express spiritual urges. According to Condivi, Michelangelo knew Dürer's treatise on the proportions of the human figure, but found it unsatisfactory: "He deals only with the proportions of the human body; of its movements and gestures, which are more important, he says nothing." Leonardo, Dürer and Raphael were concerned with the proportions of the figures and the equilibrium of space. Michelangelo, furiously striving for expression, did not mind overcrowding parts of his paintings and ignored the relations between figures and background; in his late paintings and sculptures the anatomical proportions of the body are willfully distorted, as already Michelangelo's contemporaries observed. Dürer and Raphael worked in the spirit of the Renaissance; Michelangelo's style opened new vistas, toward Mannerism and the baroque. (*See* MANNERISM.)

In the last 22 years of his life Michelangelo finished none of his sculptures, in the last 14 no painting; but his fame continued to grow until the end. Even Pietro Aretino and Lodovico Dolci, who attacked him—the one for moral reasons, the other for his "exaggerated foreshortenings, the striving to achieve the gigantic at all cost"—admired him nonetheless. Aretino begged him in vain for a drawing; Dolci admitted in one of his last letters that Michelangelo "has led sculpture back to the excellence of the antique."

But soon after Michelangelo's death, and from then to the time of the French Revolution, Michelangelo's reputation was subjected to every kind of attack. El Greco, though he learned much from Michelangelo's works, failed to appreciate the "Last Judgment." Jonathan Richardson, 150 years later, called this great fresco "black, harsh and disagreeable"; and he thought the "Moses" of the Julius monument had much of the "air of a goat."

Full and fair understanding of Michelangelo came only with Sir Joshua Reynolds. In his *Fifth Discourse,* a speech delivered on Dec. 10, 1772, at the Royal Academy in London, he contended that art would not recover unless the esteem for Michelangelo's work had recovered first: "It is remarkable that the reputation of this truly great man has been continually declining as the art itself has declined." Even before this, in a letter to James Barry (1769), he had described Michelangelo as "the greatest genius that ever was employed in the arts," and in his last academy speech (1790) he called him: "This exalted Founder and Father of modern Art."

Since then, the voices in praise of Michelangelo have never been silent. From Walter Pater to the comte de Gobineau, from J. A. Symonds to Karl Justi, from H. Wölfflin to Bernard Berenson, from Auguste Rodin to Romain Rolland, from Henry Thode to C. de Tolnay, there runs a constant stream of admiration for the master.

*See* also references under "Michelangelo" in the Index.

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**MICHELET, JULES** (1798–1874), one of the first, and greatest of the nationalist and romantic historians of France, was born in Paris on Aug. 21, 1798. His father, a modest printer whose business was closed by imperial decree in 1812, managed to give him an education. A brilliant and a laborious student, Michelet was at 29 teaching history and philosophy at the École Normale Supérieure. He had already published various textbooks and a translation (1827) of Giambattista Vico's *Scienza nuova.* The revolution of 1830 confirmed Vico's influence on Michelet in stressing man's own part in the making of history, conceived as a continuous struggle of human freedom against fatality. This is the main theme of the *Introduction à l'histoire universelle* (1831); and it underlies all Michelet's later writings.

After the *Histoire romaine* (two volumes, 1831), Michelet devoted himself to medieval and modern history; his appointment as head of the historical section of the record office in the same year provided him with unique resources for carrying out his monumental life's work, the *Histoire de France.* The first six volumes (1833–43) stop at the end of the middle ages; they include the "Tableau de la France," in which the emergence of France as a nation is seen as a victory over racial and geographical determinism; they also include his treatment of Joan of Arc as the very soul of France and the living symbol of his own patriotic and democratic ideals. Michelet deliberately threw his intimate self into his narrative, convinced as he was that this was the way to achieve the historian's ultimate aim: the resurrection (or recreation) of the past. Such a resurrection must be integral: all the elements of the past—artistic, religious, economic, as well as political—must be brought back, intertwined, as they once were, in a living synthesis. Arbitrary and overambitious as the undertaking seems, Michelet's compassionate genius and romantic imagi-

nation enabled him to conjure up an effective evocation, unsurpassed for poetic and dramatic power.

Toward the end of this period of his life, which was marked by private crises reflected in his work (the death of his first wife, in 1839, and the death of his friend, Mme Dumesnil, in 1842, cast their shadows over whole periods of his *Histoire de France*), Michelet turned away from Christianity and began to profess a messianic belief in democratic progress. His increasing hostility to the church, expressed in his lectures at the Collège de France (where he had held the chair of history since 1838) and in *Du prêtre, de la femme et de la famille* (1845), brought him into conflict with the Jesuits, and caused his lectures to be suspended in Jan. 1848. A month later the revolution which he had heralded in *Le Peuple* (1846) seemed to bring about the realization of his dreams. They were soon shattered: in 1852 Michelet, having refused allegiance to the second empire, was deprived of his posts. In 1847 he had interrupted the sequence of the *Histoire de France* to write the *Histoire de la Révolution française*, (seven volumes, 1847–53). He visualized the French Revolution as a climax, as the triumph of *"la Justice"* over *"la Grâce"* (by which he meant both Christian dogma and the arbitrary power of the monarchy). These volumes, written at a feverish pace, are a vivid and impassioned chronicle.

Michelet then resumed the *Histoire de France* from the Renaissance to the eve of the Revolution (11 volumes, 1855–67). Unfortunately, his hatred of priests and kings, his hasty or abusive treatment of documents, his mania for symbolic interpretation, continually distort these volumes into hallucinations or nightmares. Also thus distorted is *La Sorcière* (1862), an apology for witches considered as God-forsaken souls, victims of the anti-natural interdictions of the church. A new and happier inspiration produced a series of books on nature: *L'Oiseau* (1856); *L'Insecte* (1858); *La Mer* (1861); *La Montagne* (1868). They reflect the influence of his second marriage to Athénaïs Mialaret, 30 years his junior, in 1849; written in a lyrical vein, they contain some of the most beautiful pages of a supreme prose-writer. *L'Amour* (1858) and *La Femme* (1859), written under the same influence, are, however, erotic and didactic divagations. *La Bible de l'humanité* (1864) is the story of man's quest for God, a story immensely enriched by the 19th-century philological and archaeological discoveries in the oriental field.

The Franco-German War of 1870 shattered Michelet's idealism and his illusions about Germany. He died at Hyères on Feb. 9, 1874. His widow tampered with his diaries and their publication as a whole was only begun in 1959 (*Journal*, volume one, 1959; volume two, 1962; *Écrits de jeunesse*, 1959). They record his travels through Europe; and, above all, they give the key to his personality and illuminate the relationship between his intimate experiences and his work.

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**MICHELIN, ANDRÉ** (1853–1931) and **ÉDOUARD** (1859–1940), French industrialists, were the first to use demountable pneumatic tires on automobiles and the first to market them successfully. André was born in Paris on Jan. 16, 1853, and his brother Édouard in Clermont-Ferrand, June 23, 1859. The brothers established the Michelin Tire company in 1888 to manufacture bicycle tires. To show that demountable pneumatic tires could be employed successfully on motor vehicles, they entered and drove a car in the 1895 Paris-Bordeaux road race, equipping their entry with pneumatic tires held on the rims by bolts. Although they did not win the race, they created popular interest in pneumatic tires. Their company became a leading producer of tires in Europe and also operated a plant at New Brunswick, N.J., from 1908 to 1931. The Michelin firm became well known to travelers in Europe because of its maps and guide books. André died in Paris on April 4, 1931, and Édouard in Orcines, Aug. 25, 1940.

(M. J. BI.)

**MICHELL, JOHN** (1724–1793), English natural philosopher, astronomer and geologist, who has been called the founder of seismology, was born in 1724. He was educated at Queens' college, Cambridge. He was a fellow of his college and was appointed Woodwardian professor of geology in 1762, and in 1767 rector of Thornhill in Yorkshire. He was elected a fellow of the Royal society in 1760. Michell made signal contributions in the fields of physics, geology and astronomy, but it was not until after he left Cambridge that his eminence in natural philosophy was displayed in the successive papers which he communicated in the *Philosophical Transactions*. In 1750 he published at Cambridge a work on artificial magnets containing a lucid exposition of the nature of magnetic induction. Michell was the original inventor of the torsion balance, afterward made famous in the hands of its second inventor, Charles Augustin de Coulomb. Michell described it in his proposal of a method for obtaining the mean density of the earth. He did not live to put his method into practice; but this was done by Henry Cavendish. Michell died at Thornhill, Yorkshire, on April 21, 1793.

His most important geological essay was "Conjectures Concerning the Cause, and Observations Upon the Phaenomena of Earthquakes" (*Philosophical Transactions of the Royal Society*, vol. 51, 1760), including a contribution to seismology containing the first attempt to suggest a natural cause of earthquakes and to explain the nature of seismic movements.

*See* A. Geikie, *Memoir of John Michell* (1918); C. Davison, *The Founders of Seismology* (1927). (C. E. T.)

**MICHEL OF NORTHGATE, DAN** (fl. 1340), English monk who was the author of the *Ayenbite of Inwyt*, which is philologically valuable as an authenticated and dated example of the Kentish dialect. The *Ayenbite of Inwyt* ("Remorse of Conscience") is a literal translation of a French treatise, *Le Somme des vices et des vertues* (also known as *Le Miroir du monde* or *Le Livre des commandemens*, etc.), written in 1279 by Laurentius Gallus, a Dominican monk and confessor to Philip III of France. This was translated into Flemish, Catalonian, Spanish and Italian, and appears in six English translations. Dan Michel's autograph manuscript, preserved in Arundel manuscript 57 in the British museum, London, states that the work was completed in 1340 on the vigil of the feast of the apostles Simon and Jude by Dan Michel of Northgate, a brother of St. Augustine's abbey, Canterbury. More than 25 books in the medieval library of this house are known to have been owned by him. The *Ayenbite of Inwyt* was edited by J. Stevenson for the Roxburghe club (1855) and, more completely, by R. Morris for the Early English Text society (1866).

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**MICHELOZZO** (MICHELOZZI) **DI BARTOLOMMEO** (1396–1472), Florentine architect and sculptor, an important figure in the development of Renaissance art, was born in Florence in 1396. Michelozzo collaborated with Ghiberti, Donatello and Luca della Robbia and after 1438 worked independently, chiefly as an architect, succeeding Brunelleschi as architect for the cathedral of Florence in 1446.

Michelozzo assisted Ghiberti on the north doors for the Florentine baptistery until the beginning of his partnership with Donatello, which lasted from 1423 to 1438. Michelozzo was mainly responsible for the architecture and for some of the decorative sculpture in their joint work: the tabernacle of St. Louis, Or San Michele, Florence; sculpture for the baptismal font, Siena cathedral; tombs for the schismatic pope John XXIII (baptistery, Florence); Cardinal Brancacci (S. Angelo a Nilo, Naples) and Bartolommeo Aragazzi (cathedral, Montepulciano, and Victoria and Albert museum, London); and the pulpit outside the cathedral of Prato. In 1445 Michelozzo and Luca della Robbia contracted for the bronze doors of the sacristy of San Lorenzo.

Michelozzo's design for the tabernacle of Donatello's St. Louis was more classical in style than anything then built by Brunelleschi. A similar classicizing restraint is found in his sculpture. The Aragazzi monument reveals Michelozzo's independent style in

marble: severe, formal arrangement of figures, uniform surface and firm contours clearly and sharply defined. A somewhat warmer and softer treatment is found in Michelozzo's work in other mediums, notably the silver statuette of St. John the Baptist (1452, Museo dell'opera del duomo, Florence).

Michelozzo's major works in architecture were executed for his friend and patron the elder Cosimo de' Medici. His masterpiece, the Medici palace in Florence (1444–59, later enlarged as the Riccardi palace) was essentially a systematization of earlier palaces and consists of a large block around a central arcaded court. It is three stories high, with each story distinguished by graduated rustication and by bands of classical modillions, the whole crowned with an enormous, strongly projecting cornice. For Cosimo, Michelozzo also rebuilt the Convent of S. Marco, built villas at Careggi and Caffagiolo and remodeled the Medici palace and bank in Milan. In the fidelity with which Michelozzo followed an ancient prototype in the tribune of SS. Annunziata (1455) and the thoughtful and rational approach to architecture throughout his career, Michelozzo may be considered a distinguished precursor of Alberti. He died in 1472.

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**MICHELSEN, CHRISTIAN** (1857–1925), Norwegian statesman who as prime minister proclaimed his country's separation from Sweden in 1905, was born at Bergen on March 15, 1857. He was educated for the law, practised for some years and also started his own shipping firm, which became one of the biggest in Norway. A member of the *storting* from 1891, he adhered at first to the "Pure" Left party, but broke with it and in 1903 was returned to the *storting* as a member of the Coalition party (conservatives and moderate liberals). Shortly afterward he joined the coalition ministry of G. F. Hagerup, but in Feb. 1905 he abandoned it in protest against Hagerup's extremely moderate policy in the growing conflict with Sweden (*see* NORWAY: *History*); and on March 2 he was appointed prime minister in a new coalition. Thenceforward Michelsen was the unquestioned leader of the Norwegians in the conflict that led to the dissolution of the union with Sweden and the establishment of the new kingdom of Norway. He soon met with some opposition, however, because of his willingness to compromise with the Swedes in the Karlstad negotiations in Sept. 1905 and because of his definite stand for monarchy against republicanism. Trying to preserve the unity of the coalition, he remained in office until Oct. 28, 1907, but then retired because of illness. He took part in the organization of the moderately conservative Liberal Left party in 1909, but refused to be leader. After 1910 he retired from political life. Michelsen died at Fjösanger, near Bergen, on June 28, 1925. (D. MA.)

**MICHELSON, ALBERT ABRAHAM** (1852–1931), U.S. physicist, who was awarded the 1907 Nobel prize in physics for his spectroscopic and metrological investigations, was born in Strelno, Ger., Dec. 19, 1852. His parents came to the U.S. in 1854 and resided at Virginia City, Nev., and San Francisco. He graduated from the U.S. Naval academy in 1873, and was instructor in physics and chemistry there (1875–79). From 1880 to 1882 he studied in Berlin, Heidelberg and at the Collège de France and École Polytechnique in Paris. He resigned from the navy in 1881. In 1883 he was appointed professor of physics at the Case School of Applied Science, Cleveland, O., and six years later accepted a similar position at Clark university, Worcester, Mass. In 1892 he was appointed professor and the first head of the department of physics at the newly organized University of Chicago.

Michelson early directed his researches to the velocity of light, and in 1881 invented his interferometer (*q.v.*) for the purpose of discovering the effect of the earth's motion on the observed velocity of light. This was employed by Michelson and Edward W. Morley in a celebrated experiment (1887), presenting evidence that light travels at a constant speed in all inertial systems of reference. (*See* ETHER [IN PHYSICS]; MICHELSON-MORLEY EXPERIMENT.) This instrument also enabled him to measure distances with great accuracy by means of the length of light waves (*see* SPECTROSCOPY).

He standardized the metre in terms of the wave length of cadmium light for the Paris Bureau International des Poids et Mesures. He received the Rumford, Mattencci, Elliott Cresson, Draper and Copley medals, and Grand Prix at the 1900 Paris exposition. During World War I he rejoined the naval service, devoting considerable time to new devices for naval use. His range finder was adopted as part of the U.S. navy equipment. In 1920 he was able to demonstrate by means of light interference that the diameter of Betelgeuse was 240,000,000 mi.; this was the first substantially accurate determination of the size of a star. He published *Velocity of Light* (1902); *Light Waves and Their Uses* (1899; 1903); *Studies in Optics* (1927); and numerous papers in scientific journals. He was the first to be appointed distinguished service professor at The University of Chicago (1925). (For the bearing of the Michelson-Morley experiment on the Einstein special theory of relativity, *see* RELATIVITY.) Michelson died at Pasadena, Calif., on May 9, 1931.

*See* B. Jaffe, *Michelson and the Speed of Light* (1960).

**MICHELSON-MORLEY EXPERIMENT,** a celebrated experiment carried out by A. A. Michelson and E. W. Morley to attempt to measure a velocity of the earth through a theoretical "ether" by the effect which such a velocity might be anticipated to have on the velocity of light (*see* ETHER [IN PHYSICS]). Had such a velocity been established, axes fixed in the "ether" could have been taken as standards of fixed position, to which all velocities could be referred, and in this sense it would have been possible to talk of the absolute velocity of a body, as distinct from the relative velocity of two bodies. The failure to detect any influence of the earth's motion on the velocity of light really formed the starting point of Albert Einstein's theory of relativity (*see* RELATIVITY), and it is because of its importance for this theory that the experiment is so fundamental, and has been so often repeated.

In the experiment light is sent along two paths at right angles to one another. If the luminiferous "ether" were a fixed medium, obeying the laws of such a wave-carrying medium as an elastic solid (or of a medium obeying the laws represented by J. C. Maxwell's original equations) then the time of the passage of the light should be greater for a to-and-fro path in the direction of the earth's motion than for a to-and-fro path, of equal length, at right angles to the direction of motion. More precisely, when light goes from a source to a mirror at distance $l$ and back, and both source and mirror are moving with the same velocity $v$, the time taken is

$$\frac{l}{c-v}+\frac{l}{c+v}$$

when the motion is in the direction of the rays, and is

$$\frac{2l}{c}\Big/\sqrt{\left(1-\frac{v^2}{c^2}\right)}$$

when it is crosswise, $c$ being velocity of light. These expressions are approximately $\frac{2l}{c}\left(1+\frac{v^2}{c^2}\right)$ and $\frac{2l}{c}\left(1+\frac{1}{2}\frac{v^2}{c^2}\right)$ respectively, so that the difference depends on $\left(\frac{v}{c}\right)^2$ which, because of the low terrestrial velocities relative to the velocity of light, is very small and requires the greatest refinement of experimental skill for its detection (*see* LIGHT, VELOCITY OF).

If, therefore, the apparatus can be set so that one path lies in the direction of motion, and can then be turned through a right angle, the two beams of light will interchange their roles, the one which in the first position traveled the faster traveling the slower in the second position. If, further, a system of interference fringes is formed by the two beams, as is done in the Michelson interferometer (*see* INTERFEROMETER), then it follows that this fringe system will shift when the apparatus is slowly rotated, so that it must pass through the two positions just specified twice per revolution. Michelson and Morley looked for, but failed to find, any shift of fringes of the order of magnitude to be expected on the hypothesis of a fixed "ether."

Preliminary experiments were carried out by Michelson alone

in 1881; the experiment with Morley, of a superior order of accuracy, was performed in 1887. In the experiment of 1887 the interferometer was on a heavy block of stone mounted on a disc of wood floating in a tank of mercury; this allowed the apparatus to be rotated smoothly. To increase the light path, and enhance the theoretical effect sought, each of the interfering beams was reflected several times backward and forward: four mirrors were used to replace each of the single mirrors in the simple form of interferometer, and their supplementary mirrors. The total length of the path of either beam was about 1,100 cm. With such a path length the difference of times to be expected on the fixed "ether" hypothesis, though only about 1 in 100,000,000, should give rise to a displacement of 0.4 of a fringe. But the actual displacement measured was at most $\frac{1}{40}$ of this value. In carrying out the experiment the orbital motion of the earth alone was considered; the sun was taken to be at rest. (The rotational motion of the earth produces a velocity which is, of course, negligibly small compared to the orbital motion.) Readings were made for 16 different directions, the stone being kept slowly turning and the observations taken by the experimenter as he walked around with it. The experiment was carried out at midday, when the velocity relative to the sun is in the plane of the apparatus, and at 6 P.M., when the velocity is normal to the plane of the apparatus. To see if there was a velocity of the solar system as a whole through the "ether," which might, by a remote chance, have canceled out the orbital motion at the particular month of the experiment, it was proposed to repeat the experiment every three months. Later experiments failed to verify this possible explanation of the negative effect.

The experiment is of such fundamental importance that it has been often repeated, with a view both to increasing the accuracy and to investigating suggested explanations of the negative effect other than that offered by the theory of relativity. In 1904, a year before Einstein first put forward his theory, Morley and D. C. Miller carried out new measurements. It had been suggested that the contraction in the direction of motion demanded by the Fitzgerald-Lorentz hypothesis might be a property of particular materials only, and that it would be desirable to try the effect of replacing the stone on which the interferometer parts were mounted by other substances. Morley and Miller used both a wooden and a steel framework to support the apparatus, which again was floated on mercury. The path length was increased to 3,224 cm., which is 55,000,000 wave lengths of yellow (sodium) light, so that the fringe displacement should, on the hypothesis of a stationary "ether," be 1.1 fringes in place of the 0.4 fringes of 1887. In the cellar at Cleveland, Ohio, where the apparatus was mounted the effect was less than $\frac{1}{100}$ of this amount; in other words these results show that the velocity of the earth with reference to a hypothetical stationary "ether" is at most 3 km. (say 2 mi.) per second. (The shift is, of course, proportional to the square of the velocity, and the earth's orbital velocity is about 30 km. per second.) Morley and Miller took into account the motion of the solar system toward a fixed point in the heavens, and compounded this with the velocity of the earth in the solar system when computing the velocity vector of the apparatus.

In 1905 and 1906 Morley and Miller removed their apparatus from the cellar and installed it in a shed at an elevation of 300 ft. above Lake Erie, to see if the immediate surroundings, whether massive or not, affected the "ether wind" the experiment was designed to detect. A possible effect of about $\frac{1}{10}$ of the calculated value was detected, but it was not clear whether this was a spurious effect of temperature. It would be a result of the first importance, constituting a grave blow to the theory of relativity, if an actual effect, which varied with elevation or with the surroundings, could be definitely established, and therefore in 1921 and again in 1925 Miller carried out experiments of the Michelson and Morley type at Mt. Wilson, about 1,800 m. (6,000 ft.) above sea level. To avoid possible magnetic effects the steel frame used in the earlier experiments was later replaced by concrete. Miller, as a result of several thousand readings, arrived at the conclusion that there was a small positive effect, about 9 km /sec., as against the full orbital velocity of 30 km./sec., and also considered that the experiments in the cellar at Cleveland showed a still smaller positive result. He attempted to explain his results by a drift of the solar system in a direction nearly normal to the plane of the ecliptic. These experiments of Miller naturally attracted much attention, but it appears almost certain that the positive effect must be due to unrecognized sources of error, possibly to temperature effects. This is the conclusion of an analysis (1955) by R. S. Shankland *et al.* Further, it has been pointed out, notably by H. Thirring, that the measurements of Miller are not consistent among themselves, from the point of view of his explanation.

To check Miller's results R. J. Kennedy repeated the experiment, using an ingenious modification of the interferometer, produced by making a small step, only $\frac{1}{20}$ of a wave length in height, on one of the totally reflecting mirrors. This produces two fringe systems bordering on one another, which allows a very slight displacement of the interference patterns, of the order of 0.004 of a fringe, to be detected. Kennedy's apparatus was comparatively small, the light path being only 4 m., and sealed in a case containing helium, the refractivity of which is only $\frac{1}{8}$ that of air, at atmospheric pressure. The experiments were carried out at times of day when Miller's effect should be greatest, but no positive effect was ever found, although a shift $\frac{1}{4}$ as great as that measured by Miller would have been detected. K. K. Illingworth repeated Kennedy's experiments, likewise finding no positive result (1927). Both Kennedy's and Illingworth's experiments were carried out at constant temperature in a basement at Pasadena, Calif., which gives defenders of the reality of Miller's effect a possible line of criticism, namely that while no positive result can be found in a sheltered spot, where massive surroundings check the "ether wind," this does not prove that a small positive effect does not exist at a height, in a free situation. This last possibility is, however, removed by the experiments of A. Piccard and E. Stahel, carried out at intervals from 1926 to 1928. These workers placed the apparatus in a free balloon, the chief measurements being made at a height of 2,500 m. The apparatus was a small interferometer of Michelson-Morley pattern, with multiple reflections. The fringes were registered photographically on a moving film, and the balloon was kept in steady rotation by small air screws. No trace of an effect was ever found.

In 1929 Michelson published a short account of a repetition of the Michelson-Morley experiment he carried out in collaboration with F. G. Pease and F. Pearson, with new refinements: the results, in contradiction to Miller's, were negative.

In 1955 L. Essen, using short radio waves in place of light (*see* ELECTROMAGNETIC WAVES: *Generation and Propagation of Electric Waves*), measured the change of frequency produced by rotating the axis of a cylindrical cavity resonator. This change could be measured with extraordinary precision and was found to be no more than $\frac{1}{10}$ of that reported by Miller. Essen suggested that Miller's result must be ascribed to some systematic error. In 1958 J. P. Cedarholm, G. F. Bland, B. L. Havens and C. H. Townes also used short radio waves, produced by two masers (*see* MASER) having their beams traveling in opposite directions. They found that any effect must be smaller by a factor of at least 1,000 than would be the result of the earth's motion through a supposititious ether—or not more than $\frac{1}{200}$ of the effect found by Miller.

It seems certain, then, that no motion of the earth through something that might be called the "ether" can be detected by the agency of electromagnetic waves, either light or radio waves.

*See* also LIGHT.

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**MICHIGAN,** known as the "Wolverine state," is one of the north-central group of the United States of America. It consists of two peninsulas, the upper, or northern, and the lower, or southern. The upper peninsula is bounded north by Lake Superior; east by Whitefish bay and St. Mary's river, which separates it from Ontario; south by Lake Huron and Lake Michigan, the Straits of Mackinac and Wisconsin; and west by Wisconsin. The lower peninsula is bounded north by Lake Huron and Lake Michigan and the Straits of Mackinac; east by Lakes Huron, St. Clair and Erie and the Detroit and St. Clair rivers, through all of which runs the international boundary; south by Ohio and Indiana; and west by Lake Michigan. The census bureau, omitting from its statistics that part of the Great Lakes over which Michigan has undisputed jurisdiction (38,504 sq.mi.), ranks the state 23rd in size, with an area of 58,216 sq.mi., of which 1,197 sq.mi. are inland water. The Michigan legislature, however, in 1945 passed an act declaring the area of the state to be 96,720 sq.mi., consisting of 57,022 sq.mi. of land and 39,698 sq.mi. of inland water, and requiring official publications to use those figures. With similar adjustments for the seven other lake states, Michigan would rank eleventh nationally in area and be first instead of third among states east of the Mississippi river. Michigan was admitted to the union in 1837 as the 26th state. The official tree is the white pine, the official flower the apple blossom and the state bird the robin. The name Michigan is derived from the Indian words *michi,* "great," and *gami,* "water." The capital is Lansing (*q.v.*).

## PHYSICAL GEOGRAPHY

**Physical Features.**—The northern part of the state (which lies within lat. 41° 41′ and 48° 18′ N. and long. 82° 7′ and 90° 25′ W.) is rugged, mountainous old land, not completely worn down by erosion; and the southern part is a portion of the old coastal plain, whose layers contain salt, gypsum, oil and bituminous coal. Lake Huron on the east and Lake Michigan on the west of the lower peninsula are each 581 ft. above mean tide at New York city, and Lake Superior on the north of the upper peninsula is 602 ft. above. The surface of the state is in general gently undulating and at a slight elevation above the lakes, but low marshlands are common to many sections; the north part of the lower peninsula is occupied by a plateau of considerable dimensions, and the northwest part of the upper peninsula is rugged with hills and mountains. Crossing the lower peninsula from Saginaw bay west by south, through the valleys of the Saginaw, Maple and Grand rivers, is a depression—the former channel of an old glacial river—in which elevations for a considerable area are less than 100 ft. above the lakes. To the southeast of this depression a water parting, with summits varying from about 400 to 600 ft. above the lakes, extends from a point between Saginaw bay and Lake Huron, south by west, to the southern border of the state and beyond. The eastern slope descends quite rapidly to a low flat belt from 5 to 40 mi. wide along the eastern border of the state south of the outlet of Lake Huron. East and southeast of Saginaw bay is the portion known as the "Thumb" of the mitten-shaped peninsula; the southern part of its beaches is wide and sandy, followed northward by precipitous shores abounding in rocks and bluffs. Western Michigan, south of Grand Traverse bay, is drained by five major rivers, which empty into Lake Michigan among sand dunes; these dunes, formed by prevailing westerly winds and as much as 600 ft. high, line the lake shore from the Indiana border to Grand Traverse bay.

The surface of the upper peninsula is more irregular. Eastward from Green bay are two ranges of hills; one lines the southern shore and ranges from 100 to 300 ft. in height; the other is close to or touches the north shore and in places is 1,200 ft. above sea level. The famous Pictured rocks on the Lake Superior shore, east of Munising, display wide diversity of shapes and hues.

The most rugged portion of the state is farther west. South and southeast of Keweenaw bay, in the Marquette iron district, is an irregular area of mountains, hills, swamps and lakes; some of the peaks of the Huron mountains (Marquette county) and Porcupine mountains (Ontonagon county) rise to more than 1,400 ft. above Lake Superior. A peak in Baraga county is the state's highest point (1,980 ft. above the sea). South of this is the Menominee iron district, marked somewhat regularly by east-west ridges. Extending in a general northeast-southwest direction through the Keweenaw peninsula to the Wisconsin border, and beyond, is the middle of three approximately parallel ridges. The northern portion of these contains Michigan's famous copper-bearing rocks, as does Isle Royale (209.1 sq.mi.), farther north in Lake Superior, a wilderness archipelago that was designated a national park in 1931 and dedicated as such in 1940. To the south, on the Wisconsin border, is the Gogebic iron district.

The numerous rivers are of clear water. In the interior of the upper peninsula, and in the Saginaw valley and the southeast, they are rather sluggish; but many of the larger rivers in the lower peninsula have sufficient fall to furnish a large amount of water power, while many of the small streams that flow into Lake Superior have in places high banks, rapids and falls. Tahquamenon falls, the largest, has an arc of 200 ft. and a drop of 40. Most of the larger rivers—the Muskegon, Grand, St. Joseph, Manistee and Kalamazoo—are in the western portion of the lower peninsula.

Glacial action formed more than 11,000 lakes and ponds, about 6,500 of them large enough to be called lakes. The largest of these, in order, are Houghton, Torch, Burt, Mullett, Charlevoix, Gogebic and Manistique, the latter two in the upper peninsula. Also numerous are the islands dotting all Michigan shores.

**Climate.**—Although the temperature of the entire lower peninsula is considerably influenced by the lakes, it is in the western portion of that peninsula that the moderation is greatest, both the summer and winter isotherms being there deflected more than half the length of the peninsula, since the prevailing winds are westerly. In the upper peninsula, on the other hand, since the prevailing winds are northwesterly, the lakes have less effect on the temperature, and so, while in the southwest the extremes are not great, in the rest of the state they have ranged within two years from 108° F. to 48° F. below zero. The mean annual temperature is about 45° F. The mean annual precipitation is approximately 31 in., a little more than one-half of which falls during the five growing months from May to October; the rain is evenly distributed over all parts of the state, but the snow is exceptionally heavy along the north shore of the upper peninsula.

**Soil.**—The soil of southwestern and southeastern Michigan is for the most part a dark clay loam; in the north-central part of the lower peninsula it is a light sandy loam; along the Huron shore it is heavy with blue clay; in the mining districts of the northwest the rocks are usually either barren or very thinly covered; and elsewhere in the state the soil is generally rich in a variety of mineral elements.

**Vegetation.**—The area now included in Michigan was originally a forest, except in the southwest, where there were a few small open areas, possibly cleared by the Indians. The remainder of the southern part of this area, for about 60 mi. along the southern boundary, was a part of the great hardwood forest of the Ohio basin, with woods varying with soil and drainage: on the drier gravel lands were oak forests, consisting of red, black and white oak, hickory, ash, cherry, basswood and walnut; in depressions there were maple, elm, ash, beech, sycamore, poplar and willow; in the southeast there were also a few chestnuts and tulip trees. North of this southern hardwood forest there were pine forests on the sandier land, mixed hardwoods and conifers on the loam and clay, and tamaracks and cedar in the swamps. The sandy lands were in part burned over by Indians, and there was a growth of scrub oak, aspens and huckleberry bushes. The tamarack and cedar swamps now have a growth, especially on their edges, of spruce, birch, balsam, white pine, ash and aspens.

**Animal Life.**—Mammals include black bears, moose, deer, lynx, wolves, coyotes, wildcats, porcupines, foxes, squirrels, hares, rabbits, muskrats, opossums, minks, weasels, skunks, raccoons and woodchucks. The last native woodland caribou in conterminous United States disappeared from Isle Royale between 1927 and 1929. Among the game birds are quail, grouse, ducks, geese, coots, brant, woodcocks, snipe and plover, as well as imported Chinese ring-necked pheasants. Of songbirds the favourites are the robin, thrush, bobolink, oriole, chickadee, meadow lark, catbird, bluebird,

wren and warbler. Among fish, whitefish, walleyes, lake trout, perch, herring, sunfish, bass, smelts, sturgeons, pike, chub, suckers, mullets, sheepshead and carp abound in the lakes. Speckled, brown and rainbow trout thrive in many of the streams.

**Parks and Recreation.**—Nearly 100 state parks and recreation areas with 7,500 camp sites make Michigan the leading state in providing accommodations for families. Swimming, boating and fishing are easily accessible. Mackinac Island State park is interesting for its natural setting and for the historic associations of the old fort, which contains an attractive museum. Isle Royale National park, in Lake Superior, is noted for its fishing, hiking trails and copper pits dug by prehistoric miners. It is estimated that more than 10,000,000 tourists visit Michigan annually. There is excellent hunting, especially for deer and game birds. Skiing is a popular winter sport, for which there are facilities at many areas in both peninsulas.

## HISTORY

From 1622 to 1760 the territory now within the borders of Michigan formed a part of New France, and the first Europeans to found missions and settlements within those borders were Frenchmen. Two Jesuits, Charles Raymbault and Isaac Jogues, visited the site of Sault Ste. Marie (*q.v.*) as early as 1641 for the conversion of the Chippewas. In 1668 Père Jacques Marquette founded there the first permanent settlement within the state, and three years later he founded a mission among the Hurons at St. Ignace. René Robert Cavelier, sieur de la Salle, built a fort at the mouth of the St. Joseph in 1679, the sieur de Courtemanche constructed Ft. St. Joseph up the river (at Niles) in 1691, and in 1701 Antoine Cadillac founded Detroit (*q.v.*) as an important point for the French control of the fur trade. In 1715 the French built a fort called Michilimackinac, now Mackinaw City, to replace the one at St. Ignace, which had been abandoned. No other settlements were made, and there was little growth in those already established.

During the last war between the English and the French in America, the Michigan settlements passed into the possession of the English, Detroit in 1760 and the others in 1761. The white inhabitants, mostly French, were subjected to an English rule that, until the Quebec act of 1774, was chiefly military, and as a consequence many of the more thrifty sought homes elsewhere. The Indians, most of whom had been allies of the French, were so ill-treated, both by the English officers and traders, that Pontiac, chief of the Ottawas, attacked Detroit. The fort was besieged for 155 days, and, aroused by Pontiac's example, local Indians took Michilimackinac and Ft. Saint Joseph (Niles).

**Michigan Territory.**—At the conclusion of the American Revolution, title to what is now Michigan passed to the United States, and in 1787 the region became part of the Northwest Territory; it was not until 1796, however, that Detroit and Mackinac were surrendered by Great Britain. In 1803 the entire area of the present state became a part of the newly established Indiana territory. In 1805 Michigan territory was organized, consisting of the lower peninsula and a strip at the east end of the upper peninsula. During the War of 1812, Gen. William Hull, first territorial governor, although not greatly outnumbered, surrendered Detroit to the British without a struggle; in the same year Mackinac was taken and Michigan again passed under British rule. However, soon after Commodore Oliver H. Perry's victory on Lake Erie (Sept. 10, 1813), Detroit and the rest of Michigan, except the Mackinac area, were finally taken into U.S. possession. Mackinac was reoccupied in 1815, but not until Nov. 14, 1828, did the British garrison quit Drummond island. They were the last British troops to leave the United States.

Up to about 1815 the territory had remained for the most part a wilderness in which the fur trade brought the largest profits. The few small settlements were confined to the borders, and the inaccurate reports of the surveyors sent out by the U.S. government described the interior as a vast swamp with only a little land here and there fit for cultivation. The large number of hostile Indians was also a factor in making the territory unattractive. But during the efficient administration of Lewis Cass (*q.v.*), governor of the territory from 1813 to 1831, the interference of the British was checked and many of the Indians were removed to west of the Mississippi. Printing presses, established during the same period at Detroit, Ann Arbor, Monroe and Pontiac (*qq.v.*), became instrumental in making the country better known. The first steamboat on the upper Great Lakes, the "Walk-in-the-Water," appeared at Detroit in 1818, the Erie canal was opened in 1825 and by 1830 a daily boat line ran between Detroit and Buffalo. The population of Michigan, which was only 4,762 in 1810 and 8,096 in 1820, increased to 31,639 in 1830 and to 212,267 in 1840.

**Statehood.**—In 1819 the territory was empowered to send a delegate to congress. In 1835 the people elected state officers and applied for admission to the union, but a dispute with Ohio over the boundary between the two delayed admission until Jan. 26, 1837. The bloodless "Toledo War" resulted in Ohio's being awarded the strip from Lake Erie westward, at the latitude of Toledo; as compensation Michigan received the entire upper peninsula.

During the first half century under the U.S. flag, farming supplanted the fur trade as the chief occupation, but opening of the canal at Sault Ste. Marie in 1855 provided for cheap transportation of the iron and copper ores, of which exploitation had begun a decade earlier, and Michigan became a mining state. In the 1870s and 1880s it was the nation's leading lumber producer.

The frontier disappeared with rapid extension of railroads and expansion of industry, and in the 50 years after 1880 the population changed from predominantly rural to principally urban. Automobile manufacturing began, and with it came the vast social and economic changes incident to a regional trend from agriculture to industry.

The Republican party was organized July 6, 1854, in an oak grove near Jackson, and the first Republican governor was elected in that year. Thereafter, the state usually gave majorities to that party, though after 1932 the industrial areas were commonly Democratic.

Closing of all the banks in the state precipitated the national banking crisis of 1933. Financial depression was severe in the state, but its industries emerged to prosperity and record production, accelerated by World War II.

After World War II the political complexion of Michigan gradually changed. Democrats, with the aid of organized labour, elected G. Mennen Williams governor six times (1948–58) and in 1960 elected another Democrat, John B. Swainson, as his successor. Although the legislature had a majority of Republicans, Democrats in 1957 held all the elective administrative offices. The election of Philip A. Hart in Nov. 1958 gave Michigan two Democratic senators for the first time since 1856. In presidential elections since 1900 the state generally has voted Republican, although it supported Progressive candidate Theodore Roosevelt in 1912 and Democratic candidates Franklin D. Roosevelt in 1932, 1936 and 1944 and John F. Kennedy in 1960. As a result of the increase in population shown by the 1960 census, congress awarded Michigan a 19th representative.

**State Constitution.**—The constitution adopted in 1850, when it was felt that the powers conferred upon the executive and the legislature by the constitution of 1835 were too broad, was revised in 1908. In the April 1961 election a majority voted to call a convention to write a new constitution. One hundred forty-four delegates, one from each senate and house district, were elected, of whom 99 were Republicans. Meeting in Lansing from Oct. 3, 1961, until May 11, 1962, the convention produced a new constitution which the voters ratified on April 1, 1963, by a majority of 7,829.

In the Nov. 1962 election, George Romney, Republican, who had been a prominent delegate to the constitutional convention, was chosen governor. The Republicans again returned majorities to the state house and senate.

## GOVERNMENT

The 1963 constitution conferred greater authority upon the governor, permitted more latitude to the legislature in implementing constitutional provisions, and defined more clearly the position of

BY COURTESY OF (TOP RIGHT) CRANBROOK INSTITUTIONS; (CENTRE) CITY OF DETROIT DEPARTMENT OF REPORT AND INFORMATION; (BOTTOM LEFT) "THE HOLLAND EVENING SENTINEL"; PHOTOGRAPHS (TOP LEFT) JOHN GAUDA, (TOP RIGHT) HARVEY CRAZE, (BOTTOM RIGHT) BENJAMIN OF MACKINAC ISLAND

## URBAN AND RURAL VIEWS OF MICHIGAN

*Top left:* Port scene at the fishing town of Leland in the northwestern part of the state

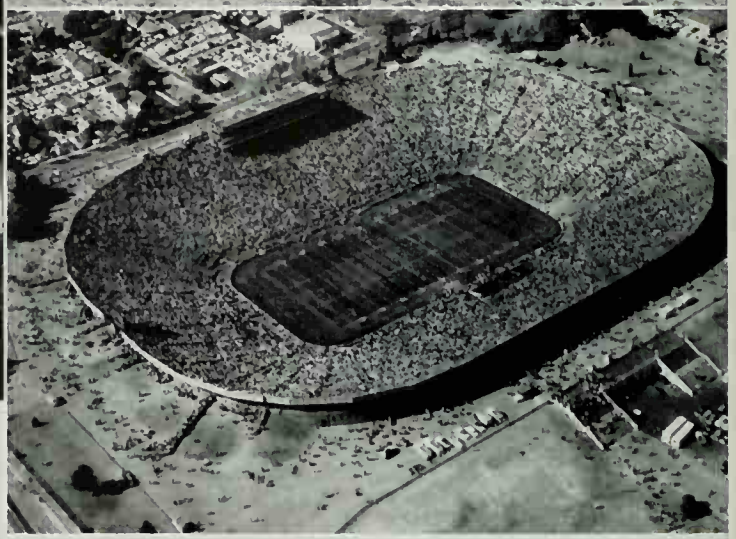
*Top right:* Fountain in the centre of the main quadrangle at the Cranbrook institutions, Bloomfield Hills. There are a variety of schools at Cranbrook, from kindergarten to the college of arts and sciences

*Centre:* View of the Detroit River with Detroit in the background (left). The Ambassador Bridge connects the U.S. and Canada

*Bottom left:* Descendants of the Dutch washing streets during the annual tulip festival at Holland, southwestern Michigan

*Bottom right:* Sailboats at Mackinac Island between races on Lake Michigan

# MICHIGAN



BY COURTESY OF (TOP RIGHT) THE DETROIT NEWS, (CENTRE RIGHT) UNIVERSITY OF MICHIGAN, (BOTTOM LEFT) MICHIGAN TOURIST COUNCIL, (BOTTOM RIGHT) FORD MOTOR CO.; FOR COLLEGE, (TOP LEFT) DAVID GORDON FROM A. DEVANEY, INC.

## SCENES IN MICHIGAN

*Top left:* Carriage at Greenfield village, Dearborn museum built by Henry Ford. In the background can be seen the replica of Independence hall

*Top right:* Ore boats frozen in the ice at Whitefish bay, near Sault Ste. Marie, keep up their steam while waiting for icebreakers to free them

*Centre right:* The University of Michigan's football stadium at Ann Arbor seats over 100,000 persons

*Bottom left:* The pictured rocks along the Lake Superior shore in Michigan's upper peninsula

*Bottom right:* Aerial view of the Ford Motor company's River Rouge plant near Detroit

the supreme court as the ruler of the judicial system than did the constitution of 1908. The first election of state officers for four-year terms under the new document was designated as that of Nov. 1966.

An amendment to the constitution may originate in either house of the legislature and, by a two-thirds vote of both houses, be referred to the people; or it may be initiated by a petition signed by registered electors numbering at least 10% of the total vote cast for all candidates for governor at the last preceding general election. An amendment to become effective must be approved by a majority of the qualified electors voting thereon. The question of general revision must be submitted to the voters in 1978 and each 16th year thereafter, and at such other times as may be provided by law.

The constitution confers suffrage upon every citizen of the United States who is 21 years of age or over, has resided in the state six months, and has acquired local residence "as provided by law." Elections for national, state, county and township officers are held on the first Tuesday after the first Monday in November of even-numbered years.

Voters may participate directly in legislation by use of the initiative and the referendum. They may recall any elected officers except judges.

A bipartisan civil rights commission has the duty to investigate alleged discrimination against any person because of religion, race, colour or national origin and to secure for him equal protection of his civil rights.

**Executive.**—The executive power is vested in the governor, who is elected for four years. At the time of his election he must have attained the age of 30 years, and have been a registered voter in Michigan for the four years next preceding his election. A lieutenant governor, for whom the same qualifications are prescribed, is elected on a joint ticket for the same term. He is president of the senate and succeeds the governor in case of vacancy. A secretary of state and an attorney general are elected for four years; a treasurer is appointed by the governor; and an auditor-general is chosen by the legislature for an eight-year term. A highway director is appointed by a four member bipartisan commission named by the governor with the advice and consent of the senate, and a superintendent of public instruction is appointed by the state board of education, consisting of eight members elected for eight-year terms. Broad powers over departments, commissions, institutions and officers of the state are lodged in an administrative board consisting of the governor and the seven other officials named above. Further concentration of authority is provided by a department of administration. Its duties include budgeting, accounting and purchasing. An appointive controller is its executive head.

The constitution requires that 20 principal departments shall contain all the executive agencies of the state.

**Legislature.**—The legislature, consisting of a senate of 38 members elected for four years and a house of 110 members elected for two years, meets annually in January. Senatorial districts were laid out on a basis of 80% population and 20% area. House districts were drawn on a population basis. An eight-member bipartisan commission selected by the major political parties was charged with carrying into effect provisions to reapportion both houses after the adoption of the constitution and after each federal census. If the commission is unable to agree on a plan, the supreme court is empowered to designate a plan, as it did in 1964.

No bill can pass either house except by an affirmative vote of a majority of the members elected to and serving in that house, and on its third reading the ayes and noes must be taken and recorded. No act can take effect until the expiration of 90 days from the end of the session, but the legislature may give immediate effect to acts by a two-thirds vote. When the legislature is convened in special session, no bill may be passed on any subjects other than those stated in the governor's proclamation or submitted by special message. The governor has 14 days in which to exercise his veto power, and a two-thirds vote is required to pass the bill over his veto.

The legislature is prohibited from authorizing any lottery, levying an income tax graduated as to base or rate, and passing a law providing for the penalty of death.

**Judiciary.**—Justice is administered through two U.S. district courts and the state courts. The latter consist of a supreme court, court of appeals, circuit courts, probate courts and courts of limited jurisdiction. The supreme court consists of seven justices elected for a term of eight years. It has general superintending control over all other state courts and is given rule-making power as to judicial practices and administration. The court of appeals consists of nine judges elected for six-year terms. The legislature divides the state into judicial circuits and determines the number of circuit judges in each. A presiding judge is empowered to distribute the fluctuating case load among judges of the various circuits. Under the pretrial process, attorneys evaluate opportunities for settlement to save the time of litigants and courts. There is one probate court in each county. Probate courts, although mainly concerned with estates, have original jurisdiction in all cases of juvenile delinquents and dependents. The 1963 constitution provided for the replacement, within five years, of justices of the peace by courts of limited jurisdiction. Cities may have municipal courts.

**Local Government.**—The state is divided into 83 counties, and the counties into a total of 1,262 townships. Township officers are a supervisor, clerk, treasurer, justices of the peace and trustees. The supervisor (who functions also as assessor), trustees and clerk constitute the township board, with local legislative and administrative powers. So-called urbanized townships are permitted to provide additional services.

The business of the county, including levying of taxes, is conducted by a board consisting of township and municipal supervisors. Officers of the county are a clerk, sheriff, treasurer, register of deeds and a prosecuting attorney, all elected for four years. The new constitution continued the existing form of county government and contains provisions for county home rule such as those previously available to cities and villages. To help solve the numerous problems of metropolitan areas, in the new constitution provision is made for co-operation by various governmental units. In addition, power is given to cities, villages and home rule counties to levy taxes other than those on property.

**Finance.**—In the late 1950s the state government experienced a severe financial crisis. Expenditures in 1958–59 exceeded general revenues; on June 30, 1959, there was a deficit of $110,000,000. The recession of 1957–58 had reduced income and increased welfare costs. New tax money was needed. The legislature rejected the recommendations of a tax study commission that provided for a revision of the tax structure. Rejecting Gov. G. Mennen Williams' proposal of a personal income tax and a corporations profit tax, the legislature increased the rates of "nuisance" taxes and put on the Nov. 1960 ballot a proposal for an increase of the sales tax from 3% to 4%. The voters approved the proposal and the new rate took effect on Jan. 1, 1963. A treasury surplus resulted.

## POPULATION

The population of Michigan in 1810 was 4,762; in 1850 it was 397,654; in 1900, 2,420,982; in 1940, 5,256,106; in 1950, 6,371,766; and in 1960, 7,823,194. This last figure represented an increase of 22.8% over the population in 1950. The population per square mile in 1960 was 134.4, as compared with 109.5 in 1950, and with 49.6 for the U.S. in 1960.

Of the 1960 population, 4,915,082 or 62.8% lived in incorporated places of 2,500 or more, as compared with 64.3% in 1950. The entire urban population amounted to 4,899,150 or 73.4% of the state total. The state has ten standard metropolitan statistical areas, which are Ann Arbor, Bay City, Detroit, Flint, Grand Rapids, Jackson, Kalamazoo, Lansing, Muskegon-Muskegon Heights and Saginaw. These areas had a total population of 5,720,692 or 73.1% of the total population of the state in 1960. Area adjustments in Oct. 1963 brought the total population of the ten standard metropolitan statistical areas to 5,861,337. The number of households in 1960 was 2,238,650, as compared with 1,791,639 in 1950. The average population per household had declined from 3.6 in 1950 to 3.4 in 1960.

The population of the state was distributed by colour and nativity in 1960 as follows: 92.5% native white; 7.3% foreign-born white; and 9.3% nonwhite, practically all Negro. There were

*Michigan: Places of 5,000 or More Population (1960 census)**

| Place | Population | | | | |
|---|---|---|---|---|---|
| | 1960 | 1950 | 1940 | 1920 | 1900 |
| Total state | 7,823,194 | 6,371,766 | 5,256,106 | 3,668,412 | 2,420,982 |
| Adrian | 20,347 | 18,393 | 14,230 | 11,878 | 9,654 |
| Albion | 12,749 | 10,406 | 8,345 | 8,354 | 4,519 |
| Allen Park | 37,052 | 12,329 | 3,487 | — | — |
| Alma | 8,978 | 8,341 | 7,202 | 7,542 | 2,047 |
| Alpena | 14,682 | 13,135 | 12,808 | 11,101 | 11,802 |
| Ann Arbor | 67,340 | 48,251 | 29,815 | 19,516 | 14,509 |
| Battle Creek | 44,169 | 48,666 | 43,453 | 36,164 | 18,563 |
| Bay City | 53,604 | 52,523 | 47,956 | 47,554 | 27,628 |
| Benton Harbor | 19,136 | 18,769 | 16,668 | 12,233 | 6,562 |
| Benton Heights | 6,112 | 6,160 | — | — | — |
| Berkley | 23,275 | 17,931 | 6,406 | — | — |
| Beverly Hills | 8,633 | — | — | — | — |
| Big Rapids | 8,686 | 6,736 | 4,987 | 4,558 | 4,686 |
| Birmingham | 25,525 | 15,467 | 11,196 | 3,694 | 1,170 |
| Buchanan | 5,341 | 5,224 | 4,056 | 3,187 | 1,708 |
| Cadillac | 10,112 | 10,425 | 9,855 | 9,750 | 5,997 |
| Center Line | 10,164 | 7,659 | 3,198 | — | — |
| Charlotte | 7,657 | 6,606 | 5,544 | 5,126 | 4,092 |
| Cheboygan | 5,859 | 5,687 | 5,673 | 5,642 | 6,489 |
| Clawson | 14,795 | 5,196 | 4,006 | — | — |
| Coldwater | 8,880 | 8,594 | 7,343 | 6,114 | 6,216 |
| Dearborn | 112,007 | 94,994 | 63,584 | 2,470 | 844 |
| Detroit | 1,670,144 | 1,849,568 | 1,623,452 | 993,678 | 285,704 |
| Dowagiac | 7,208 | 6,542 | 5,007 | 5,440 | 4,151 |
| East Detroit | 45,756 | 21,461 | 8,584 | — | — |
| East Grand Rapids | 10,924 | 6,403 | 4,899 | 1,310 | 466 |
| East Lansing | 30,198 | 20,325 | 5,839 | 1,889 | — |
| Eastlawn | 17,652 | 4,127 | — | — | — |
| Ecorse | 17,328 | 17,948 | 13,209 | 4,394 | — |
| Escanaba | 15,391 | 15,170 | 14,830 | 13,103 | 9,549 |
| Fair Plain | 7,998 | 4,134 | — | — | — |
| Farmington | 6,881 | 2,325 | 1,510 | 853 | 530 |
| Fenton | 6,142 | 4,226 | 3,377 | 2,507 | 2,408 |
| Ferndale | 31,347 | 29,675 | 22,523 | 2,640 | — |
| Flint | 196,940 | 163,143 | 151,543 | 91,599 | 13,103 |
| Fraser | 7,027 | 1,379 | 747 | 247 | 252 |
| Garden City | 38,017 | 9,012 | 4,096 | — | — |
| Gladstone | 5,267 | 4,831 | 4,972 | 4,953 | 3,380 |
| Grand Haven | 11,066 | 9,536 | 8,799 | 7,205 | 4,743 |
| Grand Ledge | 5,165 | 4,506 | 3,899 | 3,043 | 2,161 |
| Grand Rapids | 177,313 | 176,515 | 164,292 | 137,634 | 87,565 |
| Grandville | 7,975 | 2,022 | 1,566 | 799 | 457 |
| Greenville | 7,440 | 6,668 | 5,321 | 4,304 | 3,381 |
| Grosse Pointe | 6,631 | 6,283 | 6,179 | 2,084 | 343 |
| Grosse Pointe Farms | 12,172 | 9,410 | 7,217 | 1,649 | 817 |
| Grosse Pointe Park | 15,457 | 13,075 | 12,646 | 1,355 | — |
| Grosse Pointe Woods | 18,580 | 10,381 | 2,805 | — | — |
| Hamtramck | 34,137 | 43,355 | 49,839 | 48,615 | — |
| Hancock | 5,022 | 5,223 | 5,554 | 7,527 | 4,050 |
| Harper Woods | 19,995 | 9,148 | 858 | — | — |
| Hastings | 6,375 | 6,096 | 5,175 | 5,132 | 3,172 |
| Hazel Park | 25,631 | 17,770 | — | — | — |
| Highland Park | 38,063 | 46,393 | 50,810 | 46,499 | 427 |
| Hillsdale | 7,629 | 7,297 | 6,381 | 5,476 | 4,151 |
| Holland | 24,777 | 15,858 | 14,616 | 12,183 | 7,790 |
| Huntingtoo Woods | 8,746 | 4,949 | 1,705 | — | — |
| Inkster | 39,097 | 16,728 | 7,044 | — | — |
| Ionia | 6,754 | 6,412 | 6,392 | 6,935 | 5,209 |
| Iron Mountain | 9,299 | 9,679 | 11,080 | 8,251 | 9,242 |
| Ironwood | 10,265 | 11,466 | 13,369 | 15,739 | 9,705 |
| Ishpeming | 8,857 | 8,962 | 9,491 | 10,500 | 13,255 |
| Jackson | 50,720 | 51,088 | 49,656 | 48,374 | 25,180 |
| Kalamazoo | 82,089 | 57,704 | 54,097 | 48,487 | 24,404 |
| Kingsford | 5,084 | 5,038 | 5,771 | — | — |
| Lakeview | 10,384 | — | — | — | — |
| Lansing | 107,807 | 92,129 | 78,753 | 57,327 | 16,485 |
| Lapeer | 6,160 | 6,143 | 5,365 | 4,723 | 3,297 |
| Lincoln Park | 53,933 | 29,310 | 15,236 | — | — |
| Livonia† | 66,702 | 17,534 | 8,728 | 1,608 | 1,460 |
| Ludington | 9,421 | 9,506 | 8,701 | 8,810 | 7,166 |
| Madison Heights | 33,343 | — | — | — | — |
| Manistee | 8,324 | 8,642 | 8,694 | 9,694 | 14,260 |
| Marquette | 19,824 | 17,202 | 15,928 | 12,718 | 10,058 |
| Marshall | 6,736 | 5,777 | 5,253 | 4,270 | 4,370 |
| Melvindale | 13,089 | 9,483 | 4,764 | — | — |
| Menominee | 11,289 | 11,151 | 10,230 | 8,907 | 12,818 |
| Midland | 27,779 | 14,285 | 10,329 | 5,483 | 2,363 |
| Monroe | 22,968 | 21,467 | 18,478 | 11,573 | 5,043 |
| Mount Clemens | 21,016 | 17,027 | 14,389 | 9,488 | 6,576 |
| Mount Pleasant | 14,875 | 11,393 | 8,413 | 4,819 | 3,662 |
| Muskegon | 46,485 | 48,429 | 47,697 | 36,570 | 20,818 |
| Muskegon Heights | 19,552 | 18,828 | 16,047 | 9,514 | 1,012 |
| Negaunee | 6,126 | 6,472 | 6,813 | 7,419 | 6,935 |
| Niles | 13,842 | 13,145 | 11,328 | 7,311 | 4,287 |
| Novi‡ | 6,390 | 4,086 | 2,428 | 1,227 | 1,245 |
| Oak Park | 36,632 | 5,267 | 1,169 | — | — |
| Owosso | 17,006 | 15,948 | 14,424 | 12,575 | 8,696 |
| Petoskey | 6,138 | 6,468 | 6,019 | 5,064 | 5,285 |
| Plymouth | 8,766 | 6,637 | 5,360 | 2,857 | 1,474 |
| Pontiac | 82,233 | 73,681 | 66,626 | 34,273 | 9,769 |
| Port Huron | 36,084 | 35,725 | 32,759 | 25,944 | 19,158 |
| River Rouge | 18,147 | 20,549 | 17,008 | 9,822 | 1,748 |
| Riverview | 7,237 | 1,432 | 804 | — | — |
| Rochester | 5,431 | 4,279 | 3,759 | 2,549 | 1,535 |
| Roseville | 50,195 | 15,816 | 9,023 | — | — |
| Royal Oak | 80,612 | 46,898 | 25,087 | 6,007 | 468 |
| Saginaw | 98,265 | 92,918 | 82,794 | 61,903 | 42,345 |
| St. Clair Shores | 76,657 | 19,823 | 10,405 | — | — |
| St. Johns | 5,629 | 4,954 | 4,422 | 3,925 | 3,388 |
| St. Joseph | 11,755 | 10,223 | 8,963 | 7,251 | 5,155 |
| Sault Ste. Marie | 18,722 | 17,912 | 15,847 | 12,096 | 10,538 |
| Southfield | 31,501 | — | — | — | — |
| Southgate | 29,404 | — | — | — | — |
| South Haven | 6,149 | 5,629 | 4,745 | 3,829 | 4,009 |
| Springfield Place | 5,136 | 13,161 | — | — | — |
| Sturgis | 8,915 | 7,786 | 7,214 | 5,995 | 2,465 |
| Tecumseh | 7,045 | 4,020 | 2,921 | 2,432 | 2,400 |
| Three Rivers | 7,092 | 6,785 | 6,710 | 5,209 | 3,550 |
| Traverse City | 18,432 | 16,974 | 14,455 | 10,925 | 9,407 |
| Trenton | 18,439 | 6,222 | 5,284 | 1,682 | 1,167 |
| Troy | 19,058 | — | — | — | — |
| Warren | 89,246 | 727 | 582 | 326 | 350 |
| Wayne | 16,034 | 9,409 | 4,223 | 1,899 | 1,361 |
| Wyandotte | 43,519 | 36,846 | 30,618 | 13,851 | 5,183 |
| Wyoming | 45,829 | — | — | — | — |
| Ypsilanti | 20,957 | 18,302 | 12,121 | 7,413 | 7,378 |

*Populations are reported as constituted at date of each census. †Formerly township; incorporated as city in 1950 census. ‡Formerly township; reported as city in 1960 census.
Note: Dash indicates place did not exist during the reported census, or data not available.

98.4 males per 100 females in the 1960 population, as compared with 101.7 in 1950. 8.2% of the population was 65 years old or over, and 55.0% of the population 14 years old and over was in the labour force. Of the total number of employed persons, 3.4% was engaged in agriculture; 4.6% in construction; 38.0% in manufacturing; 5.7% in transportation, communication and other public utilities; 15.0% in wholesale and retail trade; and 21.1% in service activities of all kinds, including public administration.

## EDUCATION

**Public Schools.**—Though committed to an aggressive program of public education in territorial days, it was on admission to the union in 1837 that Michigan pioneered in the development of what was to become the typical U.S. pattern of free, nonsectarian, tax-supported and state-controlled schools. Not, however, until the legislature acted to make teacher training adequate (1849–50) and attendance mandatory (1871) was the system fully effective. Local initiative and control through elective township school inspectors and school district boards were features borrowed from New England, but a state superintendent of public instruction as the appointed head of the system was a novel adaptation of European ministries of education (the office was made elective by the constitution of 1850 and appointive again by the constitution of 1963). County school commissioners were added later, as was also a state board of education, which is responsible for issuance of teacher's licences and certificates, though it functions chiefly through the state superintendent, an ex officio member.

After 1900 the tendency was toward consolidated schools in the interests of efficiency and economy. School districts (of which there are seven types) declined in number from more than 6,500 in 1935 to slightly over 3,000 in the early 1960s, influenced by increasing financial dependence on the state and desire for equality of educational service, as well as by good roads and free transportation. In 1949 every county became by law a school district, and county boards of education, elected by representatives of district boards, took over the function of township officials relative to school districts. Their executives became employed county school superintendents, superseding elective commissioners, and receiving part or all of their compensation from the state. Two or more counties of less than 15,000 population may combine to form a single district. Special education, including training of handicapped children, is of long standing and highly developed.

Enrollment in the public schools in the early 1960s approximated 1,500,000, including about 1,000,000 in elementary grades (kindergarten through sixth grade) and 500,000 in secondary (grades 7–12). Michigan annually budgets nearly $800,000,000 for public-school expenditures. Nearly 20,000 students were enrolled in junior colleges. About 18% of the school population was enrolled in parochial schools.

**Higher Education.**—*University of Michigan.*—The University of Michigan was established in Detroit in 1817 by the territorial legislature. Because a local land company offered a 40-ac. tract, it was moved to Ann Arbor in 1837. This original campus was greatly extended, and a transfer began of research and graduate work to the north campus, an area of about 660 ac. outside the

city. Facilities there include the Cooley Memorial laboratory (engineering research), the Phoenix Memorial laboratory (peacetime uses of atomic energy), the Ford nuclear reactor, the automotive laboratory and the aeronautics research laboratory.

Besides maintaining extension service centres in several cities of the state, the university opened Flint college in the Mott Memorial building in 1956. In the same year the Ford Motor company gave the university 210 ac. and $6,500,000 to establish a college in Dearborn.

The university is governed by a board of regents provided for in the state constitution. Two of the eight members are elected biennially for eight-year terms.

The university consists of the following schools and colleges: literature, science and the arts; medicine; law; dentistry; pharmacy; engineering; architecture and design; education; business administration; natural resources; music; public health; nursing; and social work.

Notable buildings include the Clements library, the law quadrangle, Hill auditorium, the Horace H. Rackham School of Graduate Studies, the Michigan league, the Michigan union, the Burton Memorial tower, the undergraduate library, the intramural sports building and the Michigan stadium. There are also a number of large residence halls for students.

The university library has more than 2,000,000 printed volumes. Manuscripts include Greek papyri and Arabic writings. Housed in the Clements library are many rare books relating to American history. The manuscript collection is especially rich for the period of the American Revolution. The 270,000 volumes in the law library comprise one of the largest collections in the world. The archives of the university are in the Rackham building, administered by the Michigan Historical Collections, which also contain research materials relating to the state.

Natural science collections are in the Museums building, archaeological materials are in the Kelsey museum, art collections are in Alumni Memorial hall, and the Stearns collection of musical instruments is in Hill auditorium. There are three astronomical observatories. The one in Ann Arbor was built in 1854. The others are at Portage lake and at Lake Angelus.

The university hospital has more than 1,000 beds. In addition to the main building there are: the neuropsychiatric institute, the veterans' adjustment centre, the women's hospital, the Alice Crocker Lloyd radiation therapy centre, the outpatient clinic, the children's psychiatric hospital, the Kresge medical research building and the Simpson Memorial institute. The hospital serves the medical school and the school of nursing training programs.

Enrollment in the 1960s exceeded 25,000 full-time students annually, making the University of Michigan one of the largest in the United States. The faculty numbered more than 2,000.

*Other State Institutions.*—Michigan State university (at East Lansing) had its beginning in 1855 as Michigan Agricultural college, the first state college of agriculture in the United States. It is governed by the elected eight-member board of trustees. After the addition of curricula in applied science and liberal arts, the name was changed in 1925 to Michigan State College of Agriculture and Applied Science; in 1955 the legislature substituted university for college in the title. Enrollment is approximately 20,000 each year, with faculty numbering about 1,200. In 1959 it opened the Oakland branch near Rochester.

Wayne State university was established in 1868. By 1934 the Detroit school board had acquired several local colleges, organized new ones and combined them to form Wayne university as a unit of the Detroit school system. Rapid growth strained the financial resources of the city, and in 1956 the legislature made the university a part of the state system. It is under an elected eight-member board. Annual enrollment is over 20,000, including part-time students, and the faculty totals about 1,000. Grand Valley State college was established at Allendale in 1960.

The four teacher-training schools are Eastern Michigan university, at Ypsilanti, the first west of the Appalachians when it was established in 1849 as Michigan State Normal school; Central Michigan university, at Mt. Pleasant (1892); Northern Michigan university, at Marquette (1899); and Western Michigan university, at Kalamazoo (1903). Other state educational institutions are Michigan College of Mining and Technology, at Houghton (1885), Ferris State college, at Big Rapids (1884) and Grand Valley college near Grand Rapids (1960). These seven institutions are governed by eight-member boards appointed by the governor with the advice and consent of the senate for eight-year overlapping terms.

*Private Institutions.*—Long-established denominational institutions, of which the University of Detroit (Roman Catholic; 1877) is largest, include Adrian (Methodist; 1845), Albion (Methodist; 1835), Alma (Presbyterian; 1886), Calvin, at Grand Rapids (Christian Reformed; 1876), Hillsdale (Baptist; 1844), Olivet (Congregational; 1844), Hope, at Holland (Reformed; 1851) and Kalamazoo (Baptist; 1833) colleges, all coeducational. Major nonpublic technical and professional schools are Detroit and Lawrence institutes of technology, General Motors institute, Chrysler Institute of Engineering, Detroit College of Law and Cranbrook Academy of Art. There are also 16 community colleges.

## ECONOMY

**Agriculture.**—By the 1960s the acreage in farms had been reduced to less than 15,000,000 (about half in conservation reserves), as compared with more than 19,000,000 in 1920. Farms numbered about 110,000, half of them ranging in size from 50 to 180 ac. Their value totaled nearly $2,200,000,000, and cash farm income was around $700,000,000 annually. About 250,000 persons were employed in agriculture.

Michigan is known as a fruit-producing state, and principal fruits are grown in vast quantities, especially in the fruit belt along the shore of Lake Michigan. Melon and berry crops also are large. Michigan generally leads all the states in the production of tart red cherries and dry edible beans, and it ranks high also in production of apples, peaches, celery, cantaloupes, plums, strawberries, tomatoes, cucumbers and onions.

Chief livestock industry is dairying. Michigan was the first state to require pasteurization of all milk sold to the public, and all cows are tested for tuberculosis. Livestock and livestock products account for about two-thirds of all farm income.

**Industry.**—Products of the state's more than 13,000 establishments in the second half of the 20th century have had a value added by manufacture of about $10,000,000,000 annually (compared with $5,000,000,000 in 1947). Industrial employees number about 1,000,000.

The dominant automobile industry, concentrated in southeastern Michigan (Detroit, Lansing, Pontiac, Dearborn, Hamtramck and Flint [*qq.v.*]), produces about 50% of the total value added by manufacture in the U.S. of motor vehicles and equipment.

The diversity of Michigan manufacturing is revealed by the fact that of the approximately 425 separate industrial groups defined in the U.S. census of manufactures, more than 350 are represented in the state. In 21 industrial groups it normally ranks first in value added by manufacture, in 11 second and in 13 third. It leads in motor vehicles and parts; boatbuilding and repair; internal-combustion engines; metalworking machinery; conveyors; industrial patterns and molds; machine shops; hardware; metal stampings; wirework and steel springs; gray iron and malleable-iron foundries; cereal preparations; salt; public-building fixtures; industrial leather belting; padding and upholstery filling; and sporting and athletic goods.

**Minerals.**—Michigan's mineral products are valued at more than $400,000,000. Its diversified output includes iron ore, limestone, gypsum, salt, sand and gravel, cement and copper. Michigan leads all other states in quantity of salt produced and ranks high in gypsum, iron ore, bromine, sand and gravel, portland cement and copper.

In 1844 iron ore was discovered by a surveying party on the site of the present Negaunee. In 1846 mining began, and operations in the three upper peninsula ranges placed Michigan in the front rank of iron-producing states. It held first place from 1890 until 1900, when it was outstripped by Minnesota. Annual production averages about 10,000,000 tons of ore.

Prehistoric miners separated native copper from the rocks on

Isle Royale and in the upper peninsula. Modern digging began in 1844, and two years later 27,000 lb. were shipped. Total production during the first 100 years was 9,700,000,000 lb. The record year was 1916, when the output was nearly 270,000,000 lb. Michigan stood first in copper production from 1847 to 1887, but because Michigan mines were deep, some a mile below the surface, Arizona and Montana, with open-pit mines, gradually took the lead.

A low-grade coal was mined from 1835 until 1952, when the last mine closed.

The presence of oil and gas in Michigan was known as early as 1834. Sporadic operations after 1886 produced some oil, but the petroleum industry had its real beginning in the 1920s. All the wells are in the lower peninsula. By 1948 Michigan ranked third among the states east of the Mississippi in oil production, but during the 1950s there was a gradual decline. Natural-gas production increased to more than 25,000,000,000 cu.ft. yearly in the 1960s, placing Michigan high among the gas-producing states. To meet the great demand of industries and homeowners, however, quantities of gas are received by pipeline from mid-continent fields.

Michigan has for many years been first in the nation in salt production, with nearly one-fourth of the total U.S. product. The Michigan chemical industry, sixth largest employer in the state, uses more than half the salt. Most of the remainder is utilized in soda ash plants and in the production of chlorine and other chemicals.

**Forestry.**—In the late 1950s the forested area totaled 19,300,000 ac. (53% of the state land area); of this, nearly 7,000,000 ac. were publicly owned, including 23 state forests, 5 national forests, Isle Royale National park and 54 state parks and 14 recreation areas. There were four state nurseries, and 50,000,000 trees were transplanted each year from state, federal and private nurseries. Michigan leads all other states in acreage planted, principal varieties being red, jack, Scotch and white pine, and white spruce. Forest fires are a continuing problem in spite of annual expenditures of about $1,500,000 for forest fire protection. Annual sawmill production fell steadily, while pulpwood production rose. Standing timber was estimated at about 63,000,000,000 bd.ft. The forests and waters of Michigan provide the basis for the state's tourist and recreation business.

**Transportation.**—In 1836 the first trains in Michigan began running between Adrian and Toledo, O. The next year the state began building two railroads. The Central reached Kalamazoo from Detroit, and the Southern reached Hillsdale from Monroe, in 1846. In the same year they were sold to private companies, and both entered Chicago in 1852. Railway mileage increased until 1910, when it was 9,021 mi.; a gradual decline reduced it to about 6,500 in the 1960s.

With a shore line of 3,100 mi. on four of the five Great Lakes, Michigan has always enjoyed excellent water transportation. Completion of the St. Mary's Falls canal (Soo canal) in 1855 permitted vast quantities of iron ore and copper to be shipped cheaply to cities near the coal supply. Later, wheat from the western plains moved from Lake Superior ports to elevators and mills on the lower lakes. The annual tonnage (more than 100,000,000) that passes through the canal is considerably larger than that of the Suez and the Panama canals combined. Foreign, as well as U.S., freighters call at ports around the lakes, their number having increased greatly after the opening of the St. Lawrence seaway.

Chief projects in a major road and bridge construction program undertaken after World War II included expressways from the Ohio line to Mackinaw City and Sault Ste. Marie, from Detroit to the Indiana line and from Toledo through Detroit to Port Huron. In Nov. 1957 a bridge, with a total span of 8,344 ft., was opened across the Straits of Mackinac, and during its first year nearly 500,000 vehicles crossed the bridge. In 1960 a lift bridge carrying automobile, rail and pedestrian traffic over the Keweenaw waterway between Houghton and Hancock was opened. The Sault Ste. Marie International bridge, to carry automobile traffic across the ship canals and the St. Mary's river, was dedicated in 1963.

*See* also references under "Michigan" in the Index.

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Current statistics on production, employment, industry, etc., may be obtained from the pertinent state departments; the principal figures are summarized annually in the *Britannica Book of the Year,* American edition. (L. A. W.; F. Cl. B.)

**MICHIGAN, LAKE,** named from the Algonkian Indian term for large body of water, "Michigami" or "Misschiganin," is the third largest of the Great Lakes of North America and the only one located wholly within the boundaries of the United States. It is bordered on the east and north by the state of Michigan, on the west by Wisconsin and Illinois, and on the southeast by Indiana. It is 321 mi. long between its northern and southern shores and its greatest width is 118 mi. The surface area is 22,400 sq.mi. and the area of its drainage basin, exclusive of lake area, is 45,460 sq.mi. The mean height of the lake above sea level is 581 ft., being the same as that of Lake Huron, to which it is joined at its northeastern extremity by the Straits of Mackinac (*q.v.*). The maximum depth of the lake is 923 ft. Lake level varies with the season, generally about 1.5 ft. from February to July, and also from year to year. In the 100 years from 1860 to 1959 the difference between the highest (583.7) and the lowest (577.4) monthly mean stages of the whole period was 6.3 ft. The mean annual precipitation is 31 in. Currents in the lake are slight; there generally is a southward drift along the western side and a northward drift along the eastern side, and at times a counterclockwise swirl in the major southern basin and a similar swirl around the Beaver island group in the north. (For comparisons with the other Great Lakes, a discussion of their origins, connections, utilization, etc., *see* GREAT LAKES, THE.)

**Exploration.**—Jean Nicolet, sent west by Samuel de Champlain in 1634, skirted the northern shore of Lake Michigan to Green bay, by canoe. Father Claude Allouez began missionary work among Indians of Green bay and the Fox river, in 1668. Louis Jolliet and Father Jacques Marquette mapped the western shore of Lake Michigan from Green bay to the site of Chicago in 1673, and Jolliet made further explorations of the lake in 1674–75. René Robert Cavelier, sieur de la Salle, brought the first sailing ship, the "Griffin," to Lake Michigan in 1679. Sent eastward with a cargo of furs, the ship was lost in a storm. La Salle later established posts near St. Joseph, Michigan, and on the Illinois river.

**Physiography.**—Approximately 100 streams flow into the lake, only a few of which are of appreciable size. The principal rivers on the east side, from north to south, are the Manistee, the Pere Marquette, the White, the Muskegon, the Grand, the Kalamazoo, and the St. Joseph; on the west side the two major rivers enter Green bay, the Fox at its south end and the Menominee on its west shore where it is the boundary between Wisconsin and the northern peninsula of Michigan. (The Chicago river flows away from the lake, *see* below.) The north end of the lake contains all of the islands, the largest of which is Beaver, 13 mi. long. The discharge of the lake, through the Straits of Mackinac, has not been measured.

Lake Michigan lies within an area of Paleozoic sedimentary rock formations in a zone of relatively weak rocks which were eroded by preglacial rivers to form a lowland which was further deepened by the scouring action of glacial ice. More resistant Niagaran dolomite rock forms the western and northern rims of the lake basin. The eastern shore is underlain in part by other relatively resistant rock strata and in part by great thicknesses of unconsolidated glacial deposits. Sandy beaches are nearly continuous around the lake. The adjacent land generally is low and gently rolling, but wave-cut bluffs of rock or of unconsolidated material occur in many places. Sand dunes are common along the eastern shore, where the prevailing westerly winds blow sand from the beach and move it inland.

Abandoned shorelines indicate that the lake once stood 60 ft. higher and drained southwestward to the Illinois river while glacial ice occupied the northern part of the lake basin, and other evidence shows that the lake surface was 350 ft. below the present level after the ice melted and before upwarp of the land to the northeast raised the outlet area.

The principal mineral resources of the region are iron ore, in northern Michigan; petroleum and salt in the southern peninsula of Michigan; and limestone, sand and gravel.

The prevailing westerly winds produce a climate in western Michigan, in a belt extending 15 mi. inland from the lake, which is suitable for fruit growing. Michigan is the leading producer of sour cherries and an important producer of peaches and apples. Several national and state forests in the surrounding districts provide for timber growth and recreation.

**Harbours and Commerce.**—Shipping on Lake Michigan includes long-distance hauls from the other Great Lakes and vessels from Europe. Accumulation of ice in the connecting waters and harbours in the winter season restricts navigation to a period from mid-April to mid-December. The open lake rarely freezes over, however, and railway-car ferry service across the lake is maintained between several ports throughout the year. By the second half of the 20th century the service on Lake Michigan, by far the most extensive of its kind in the world, consisted of two ferries operated between Grand Haven and Milwaukee by the Grand Trunk railway; seven between Ludington and Milwaukee, Manitowoc and Kewaunee, by the Chesapeake and Ohio railway; four between Frankfort and Menominee and Manistique, and between Frankfort and Manitowoc and Kewaunee, by the Ann Arbor railroad. Many harbours are situated at the mouths of rivers, where piers and breakwaters have been built to afford protection from waves and to maintain adequate depth of water. The large outer harbours at Milwaukee, Wis., Chicago and South Chicago (Calumet harbour), Ill., are artificial. The harbours of Port Washington, Wis., Waukegan, Ill., and Indiana harbour and Gary, Ind., are entirely artificial, consisting of dredged channels and basins protected by piers and breakwaters.

The water supplies of the Chicago district and of several other lake cities are drawn mainly from Lake Michigan.

The Chicago district at the south end of the lake is a great industrial centre, consuming large quantities of water-borne raw materials, principally iron ore, coal and limestone, which are handled through the ports of Calumet harbour, Indiana harbour and Gary. Most of the iron ore is brought to Lake Michigan from Lake Superior, but some of it is loaded at Escanaba, Mich., on the north shore of Lake Michigan. Milwaukee and Green Bay, Wis., are centres of distribution of coal from Lake Erie ports. Calumet harbour, Chicago and Milwaukee are grain-shipping ports.

**Fisheries.**—For many years the important commercial fish included lake trout, whitefish, perch, suckers and chub, taken by gill nets and pound nets. The annual catch of lake trout amounted to more than 6,000,000 lb. for several years through 1945. A species of sea lamprey, invading from the lower lakes, eliminated the trout as a commercial fish and seriously reduced the whitefish catch. (*See* also CYCLOSTOME.)

**Connections with Illinois River.**—The Illinois river watershed is separated from Lake Michigan by a low divide. In 1848 the Illinois and Michigan canal was constructed from the Chicago river across the divide to the Illinois river at a point just below La Salle, thus permitting through navigation. In 1900 the sanitary district of Chicago completed a drainage canal from the south branch of the Chicago river to the Des Plaines river at Joliet. This, combined with work in the Chicago river, reversed the flow of the latter and permitted water from Lake Michigan to flow through the canal into the Des Plaines and thence to the Illinois. A discharge of 8,500 cu.ft. per second from Lake Michigan was permitted in the years 1925–30, and of 1,500 cu.ft. per second thereafter. The drainage canal also provided a navigable channel 21 ft. deep, with a minimum bottom width of 200 ft., from the lake to a point between Lockport and Joliet, where a power plant was constructed.

A Great Lakes-to-Mississippi river waterway was completed with federal aid and was officially opened in 1933. The minimum depth, between Lockport and the mouth of the Illinois river, was 9 ft. and the minimum channel width was 200 ft. A branch of the canal system, extending from the Sag junction of the Calumet Sag channel with the Des Plaines river, about 10 mi. north of Lockport, eastward to Lake Calumet and connecting with Calumet harbour, was enlarged in 1958 as part of a program of expansion of port facilities in that area.

See *Great Lakes Pilot*, and charts, U.S. Lake Survey, Detroit (annual); M. M. Quaife, *Lake Michigan* (1944). (J. L. HIL.)

**MICHIGAN, UNIVERSITY OF,** at Ann Arbor, Mich., is one of the largest educational institutions of the U.S. and is one of the oldest state universities, having been founded in 1817. *See* MICHIGAN: *Education.*

**MICHIGAN CITY,** a city of La Porte county, northwestern Indiana, U.S., on Lake Michigan 50 mi. E.S.E. of Chicago across the tip of the lake. It was planned and founded by Maj. Isaac C. Elston, who in 1831 purchased land from the government on which he plotted a townsite, incorporated as Michigan City in 1836. It was chartered as a city in 1867. Michigan City has many diversified businesses and industries. It is widely famed for its excellent beach, boating and recreational facilities, and beautiful residential areas in the famed Indiana sand dunes. It is a favourite vacation spot for thousands of visitors yearly, being readily accessible by water, rail, highway and air transportation. Development of the St. Lawrence seaway was a stimulus to the economy of the city. For comparative population figures *see* table in INDIANA: *Population.* (E. P. KI.)

**MICHOACÁN,** a central agricultural and mining state of Mexico. Pop. (1960), 1,851,876, chiefly mestizos and Tarascan Indians. Area 23,113 sq.mi., bisected by the Sierra Madre Occidental running southeasterly from the high central Mexican plateau, of which the state forms a part. Michoacán lies in an area of fertile valleys, lakes and great volcanic activity; in 1759 Mt. Jorullo suddenly arose after an eruption in the midst of an agricultural area, and in 1943 Paricutin similarly appeared near Uruapan. Nearby stands the highest peak in Michoacán, Tancitaro (12,605 ft.). The rivers drain to the Pacific; the Lerma, on the northwestern frontier, and the Balsas-Tepalcatepec at the south, are the most important. Each is the scene of large-scale irrigation projects. The federal government began a long-term development of hydroelectric power, drainage, communication facilities and of new industrial-agricultural communities on the underpopulated Pacific slopes.

The mountain valleys of Michoacán are cool and healthful, but the Pacific coastal plain is hot and insalubrious. The state has two large lakes: Chapala, bordering Jalisco, and Pátzcuaro, a popular

resort where fishermen use butterfly nets. In the 1530s the Dominican Vasco de Quiroga established the first successful missions among the Tarascan Indians around Lake Pátzcuaro on the site of Quiroga and the pre-Columbian town of Tzintzuntzán. Influenced by Thomas More's *Utopia*, Quiroga sought to organize a cooperative commonwealth among the natives. Crafts taught then survive today, and Quiroga's name is still venerated in this region.

In 1951 the United Nations Educational, Scientific and Cultural Organization and the Organization of American States jointly established on Lake Pátzcuaro a regional educational centre, Crefal, to train rural teachers for Latin America. Former Pres. Lázaro Cárdenas of Mexico donated his home there as the school plant.

Michoacán produces a wide range of forest products, tropical crops, grains, gold, lead, silver, cinnabar, copper, coal, oil and sulfur. It is well supplied with highway, air and rail connections. Important cities of the state are Morelia (*q.v.*), the capital, Uruapan (*q.v.*), Zamora and Pátzcuaro. (J. A. Cw.)

**MICHURINSK** (formerly KOZLOV), a town of Tambov *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., stands on the small river Lesnoi Voronezh, a headstream of the Voronezh, 45 mi. N.W. of Tambov city. Pop. (1959) 80,653. The town, which was founded as a frontier fort in 1636, is at the junction of railway lines to Ryazan, Tambov and Voronezh and has large locomotive and carriage repair shops. Manufactures include pistons for vehicles and tractors, iron castings, wire, alcohol, flour, clothing, and fruit and vegetable preserves. There are many orchards in the vicinity. The noted horticulturalist I. V. Michurin (1855–1935) lived there and the town was renamed (1932) in his honour. The Michurin Central Genetic laboratory and the Scientific Research Institute of Fruit Growing are now located there. Michurin's home has been preserved as a museum. (R. A. F.)

**MICKIEWICZ, ADAM** (1798–1855), generally recognized as the greatest Polish poet, the leader of the romantic movement and an apostle of Polish national freedom, was born at Zaosie, near Nowogrodek (Belorussia), on Dec. 24, 1798. From 1815 to 1819 he studied at Wilno (Vilnius), and while teaching at the *Gymnasium* in Kovno (Kaunas) (1819–23) still spent much time there. In 1817 he joined the Philomaths, a secret student organization, later incorporated in the Aretophiles (Filareci).

His first volume of poems, *Poezye, I*, appeared in 1822 and included ballads and romances; his second, *Poezye, II*, which contains parts ii and iv of *Dziady*, was published in 1823. Later in the year Mickiewicz, with the other Aretophiles, was imprisoned pending trial, at which he was sentenced to deportation to Russia for "spreading wrong-headed Polish nationalism." In Oct. 1824 he left Wilno for St. Petersburg, where he met some of the future Decembrists (Dekabrists; *q.v.*). In Jan. 1825 he was sent to Odessa. While there he visited the Crimea, and wrote his Crimean and erotic sonnets (*Sonety krymskie*, 1826). In Dec. 1825 he moved to Moscow, but his nominal government employment enabled him to pay prolonged visits to St. Petersburg. He was befriended by most of the leading Russian writers, including Aleksandr Pushkin. *Konrad Wallenrod*—a poem describing the wars of the Teutonic Order with the Lithuanians but actually representing the age-long Russo-Polish feud—written in 1826–27, was published in 1828.

In May 1829 Mickiewicz left Russia with a passport obtained on the grounds of ill-health. After traveling from Hamburg through Berlin, Weimar (where he called on Goethe), the Rhine valley and Switzerland he reached Rome in Nov. 1829. News of the outbreak of the Polish insurrection (Nov. 29, 1830) reached him in December but only in April 1831 did he set out for Poland via Paris and Dresden, reaching the region of Poznan in mid-August, too late to take part in the fighting. In March 1832 he joined the Polish emigrés in Dresden and while there wrote the third part of *Dziady* (*Dziady III*, 1833; English translation *Forefathers' Eve*, 1926, 1928).

In Aug. 1832 he settled in Paris, and there wrote, in a biblical prose, the *Księgi narodu i pielgrzymstwa polskiego* (1832; *The Books of the Polish Nation and of its Pilgrimage*, 1925). His masterpiece, *Pan Tadeusz czyli ostatni zajazd na Litwie* (Eng. trans. 1917), was written between Nov. 1832 and Feb. 1834. In July 1834, he married Celina Szymanowska (1811–55), and in December formed a lay religious confraternity for prayer and meditation. In 1835 he expressed the opinion, in a letter to a friend, that too much poetry had been written for mere entertainment and that in the future a poet must be a saint—an echo from the writings of L. C. de Saint-Martin (*q.v.*) which he had probably read in Russia. After 1837 he wrote scarcely any poetry.

He was appointed professor of Latin literature at the University of Lausanne in 1839 but resigned in Oct. 1840 to accept the newly created chair of Slavonic literatures at the Collège de France. In July 1841 he fell under the influence of the mystagogue and mesmerist Andrzej Towiański (1799–1878); he remained in his sway until the summer of 1848, and in May 1844 was suspended from his professorship for teaching Towiański's theosophical doctrines.

In Jan. 1848 Mickiewicz went to Rome to try to win the support of the new pope for the cause of national freedom. On the outbreak of the Italian revolution he organized a small military unit to fight for Italy against Austria and to become the nucleus of a Polish army of liberation, and returned to Paris to find money and recruits for it, but later in the year it began to disintegrate. Between March and Oct. 1849 he edited the radical newspaper *La Tribune des peuples*. Napoleon III relieved him of his post at the Collège de France in 1852, but appointed him librarian at the Arsenal. In Sept. 1855 he was sent to Turkey by Prince Adam Czartoryski (*q.v.*) to mediate between the factions of Poles preparing to fight on the side of the allies in the Crimean War. He died in Constantinople on Nov. 26, 1855, and was buried at the Polish cemetery in Montmorency, near Paris. On July 4, 1890, his remains were reburied in the vault of the Wawel cathedral at Cracow, where many Polish kings are laid to rest.

Mickiewicz's impact on Polish literature brought about the triumph of romanticism over classical stagnation. With his *Dziady III*, a Promethean drama the hero of which, Konrad-Mickiewicz, represents both Poland and Humanity, he introduced a new visionary element into Polish poetry. His love lyrics, succinct and charged with emotion and meaning, raised the image of woman to ideal heights previously unknown in Polish poetry. His popularity is probably due, however, to his essentially classical style of writing. The subjects and forms of his poems are often new but the meaning is always clearly and directly conveyed. His *Books of the Polish Nation* develops the messianic theme in powerful prose. It was condemned by the pope, who saw "presumption and malice" where others recognized a plea for the Christianization of politics, but made a profound impression on H. F. R. de Lamennais (*q.v.*) who imitated its style in *Les Paroles d'un croyant*. *Pan Tadeusz*, one of the few successful epics of the 19th century, is classical in form and spirit though not in subject. Mickiewicz applies the convention of the epic to a heroic theme having much in common with the novels of Sir Walter Scott. The poem has the quality of greatness and, though it does not lack humour, high seriousness. It conveys perfectly the ethos of an archaic society, in which the ideals of chivalry are still alive, and shows the effect of the Napoleonic myth on honest and simple minds, to whom the emperor is an instrument of Providence; "God is with Napoleon—Napoleon with us." For portrait *see* POLISH LITERATURE.

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**MICKLE, WILLIAM JULIUS** (1734–1788), Scottish poet, best known for his translation of Luís de Camões' epic poem *Os Lusíadas*, was born on Sept. 29, 1734, the son of the minister of Langholm, Dumfriesshire. He was educated at the Edinburgh high school and began work as a clerk in a brewery. His father

later bought the business, and, on his death, William Mickle became the owner; but he neglected his affairs, devoting his time to literature, and before long became bankrupt. In 1763 he went to London, where he gained the patronage and guidance of Lord Lyttelton, and, in 1767, published "a poem in the manner of Spenser" called *The Concubine* (retitled *Syr Martyn*, 1777). He was appointed corrector to the Clarendon press, and, in 1776, published his free, but scholarly, translation of *Os Lusiadas*. So great was the repute of this translation that when Mickle—on a naval cruise as secretary to Commodore George Johnstone—visited Lisbon in 1779, the king of Portugal gave him a public reception. On his return his appointment as agent responsible for distribution of prize money from ships captured on the cruise enabled him to live comfortably until his death in Oxford on Oct. 28, 1788.

Mickle has been suggested as the author of the Scottish poem "There's nae luck aboot the hoose" but it is also possible that it was written by Jean Adams (1710–65). Sir Walter Scott admired Mickle's poems and founded *Kenilworth* on his ballad of *Cumnor Hall* which appeared in Thomas Evans' *Old Ballads . . . With Some of Modern Date* (1784).

*See* M. E. Taylor, *William Julius Mickle (1734–1788), a Critical Study* (1937).

**MICMAC,** an Algonkian-speaking Indian people of Nova Scotia, New Brunswick, Prince Edward Island and coastal Quebec, probably were the Indians discovered by John Cabot in 1497. They formed a confederacy of seven bands; their name means allies. Micmac were nonagricultural, used canoes for transportation and were dependent on fishing and hunting. They were consistently friendly to the French and hostile to the English settlers, whom they fought bitterly after the cession of Acadia to Great Britain in 1713; estimated at 3,000 to 3,500 during the 17th and 18th centuries, their descendants (1960s) numbered about 4,000, much intermixed with whites. Their dialect differs considerably from that of their neighbours, so that they may represent a fairly early offshoot of the Algonkian family.

*See* W. D. and R. S. Wallis, *Micmac Indians of Eastern Canada* (1955). (A. L. K.; X.)

**MICON** (fl. 5th century B.C.), Greek painter, was closely associated with Polygnotus (*q.v.*) of Thasos, in conjunction with whom he adorned the Painted Stoa, at Athens, with paintings of the battle of Marathon and of the Greeks and Amazons. He collaborated with the same artist in paintings in the Theseum and the Anaceum, and was esteemed also as a sculptor of athletes.

**MICROANALYSIS, CHEMICAL:** *see* CHEMISTRY: *Analytical Chemistry: Microanalysis.*

**MICROCLINE,** a potassium aluminum silicate, is an economically valuable mineral used in the production of ceramics. It is a triclinic potash feldspar having in the pure state the chemical composition $KAlSi_3O_8$. The deviation from monoclinic symmetry is small, the name microcline being derived from the Greek meaning "small" and "angle" because of the slight variation of the cleavage angle from 90°.

Detailed information on the crystallographic differences between microcline and monoclinic potash feldspar (sandine) is given under FELDSPAR: *Polymorphism.*

Intermediate microclines may have some sodium aluminum silicate, or albite, $NaAlSi_3O_8$, in solid solution, the amount tending to increase as monoclinic symmetry is approached. Most maximum microclines show perthitic unmixing; *i.e.*, they are intergrown with exsolved $NaAlSi_3O_8$. Single crystals of maximum microcline which are virtually pure $KAlSi_3O_8$ and therefore lack perthitic exsolution are very rare. Authigenic crystals or overgrowths on pegmatitic orthoclases are examples. As a rule microclines have initially crystallized as monoclinic materials with some $NaAlSi_3O_8$ in solid solution. In the course of geological time they gradually became triclinic and developed the characteristic albite-pericline (microcline-type) twinning with simultaneous exsolution of $NaAlSi_3O_8$.

Usually microcline has no colour of its own. In places, however, it is found with a beautiful green colour (*see* AMAZON STONE). This is macroscopically monoclinic, microscopically twinned, and shows perthitic exsolution of albite. The nature of the colour, which is pleochroic (*see* MINERALOGY: *Optics*), is still unknown. Microcline is found predominantly in geologically old rocks, though occurrences in younger rocks (especially pegmatites) are sometimes met. (F. H. L.)

**MICROCOSM** (Gr. *mikros kosmos*, "little world"), a philosophical term designating man as being a "little world" in which the macrocosm or universe is reflected. The ancient idea of a world soul animating the universe had as a corollary the idea of the human body as a miniature universe animated by its own soul, and the notion of the microcosm dates, in western philosophy, from pre-Socratic times (Democritus specifically refers to it). Propagated especially by the Neoplatonists, the idea passed to the Gnostics, to the Christian scholastics, to the Jewish Cabalists and to Renaissance philosophers such as Paracelsus. The supposed analogy between the whole and its parts served not only to develop a cosmology in which the reality of the individual received due attention but was also fundamental to astrology and other sciences postulating belief in a metaphysical relationship between man and the rest of nature. In later philosophy the monadology of Leibniz presents a comparable view of man and the universe, and Lotze took *Mikrokosmus* as the title of his major work on the theory of knowledge and reality.

*See* G. P. Conger, *Theories of Macrocosmos and Microcosmos in the History of Philosophy* (1948).

**MICROMANIPULATION** (MICRURGY, MICROSURGERY) is a term applied to a specialized technique for operating on microscopic objects under the high magnifications of the compound microscope. The operations, which include microdissection, microvivisection, microisolation and microinjection, are made with especially fine needles and pipettes and are of such delicacy that a human blood cell less than 8 microns (0.008 mm.) across can be punctured and torn. This technique has many applications, especially in research on cells, cell constituents and embryos, and is also used in various technological examinations.

In 1901 S. L. Schouten, a Hollander, and in 1904 M. A. Barber, an American, independently of one another, described a technique for isolating a single bacterium in the field of the high powered oil-immersion lens. The isolation was accomplished by suspending a drop of liquid, containing the bacteria, on the underside of a cover slip and having the microneedle approach the drop from below. The cover slip was mounted so as to serve as the roof of a three-walled moist chamber. The needles with their tips bent upward were passed into the chamber through its open end.

In succeeding years many modifications of the original instruments used by Schouten and Barber have been developed. The tips of these microtools move in arcs of large circles that are unappreciable under the microscope, since the field appears so large. Remote, fine operating controls attached by flexible shafts eliminate the transmission of trembling of the hand. A well-controlled mechanical stage is essential because a great deal of the microoperative work is done by moving the moist chamber with the mechanical stage.

For examples of the use of micromanipulation techniques, *see* ANATOMY, MICROSCOPIC; EMBRYOLOGY, EXPERIMENTAL; CYTOLOGY.

*See* M. J. Kopac, "Micromanipulation," in *The Encyclopedia of Biological Sciences*, ed. by Peter Gray (1961).

**MICROMETER,** a name generally given to any device for measuring small angles or dimensions. This article will deal with the great variety of appliances used for astronomical measurement.

One of the immediate difficulties of accurate measurement of linear dimensions is to secure coincidence between the measuring appliance and the object measured. For inaccessible (celestial) objects, coincidence is, of course, impossible; for accessible objects, *e.g.*, a photographic plate, the plate and the measuring appliance are likely to get in each other's way. The remedy is that either the measuring scale or the thing measured should be insubstantial. Certain devices, such as interferometers, can be regarded as representing the first alternative; but, in general, the simplest solution is to arrange that the thing measured shall be insubstantial, *i.e.*, an optical image, accessible and offering no interference with our measuring tools, but forming a faithful reproduction to scale

of the object whose dimensions we really wish to know. Both in the telescope and the microscope a real image is formed in the focal plane; in this case we place the "pointer" of our micrometer —a movable wire, a scale ruled on glass, or some other fiducial mark—and move it about in the midst of the ghost that we are measuring. We view the coincident pointer and image through an eyepiece, which acts as a magnifying glass. Most micrometers make use of the principle of the screw; the pointer is displaced uniformly by turning a screw. If, for example, the step of the screw is 0.5 mm., and the screwhead is read to $\frac{1}{100}$ of a revolution, we measure to 0.0005 mm. (about equal to the wave length of light). Needless to say, many precautions are necessary if we would actually attain such high accuracy.

**Filar Micrometer.**—The first micrometer used with a telescope was made by William Gascoigne, about 1638. It consisted of two pointers with parallel straight edges, which could be brought together or separated by turning a screw. He made measurements of the diameters of the sun, moon and planets, which are still extant and prove that his invention made a great advance on earlier methods of measurement. The modern successor of this instrument is the filar micrometer, in which the two pointers are replaced by parallel wires or spider webs, carried on metal frames. Two screws are provided, one of which moves the pair of wires as a whole, while the other alters the separation of the two wires. In most observations, only the reading of the second screw is required, the first screw being merely an aid in setting. Much work formerly done by visual measurement is now done photographically, and the filar micrometer is now used mainly for measurement of the separations and position angles of double stars. (*See* also HELIOMETER.)

**Traveling-Wire Micrometer.**—This is an appliance used in conjunction with the transit circle (*q.v.*) which has proved very successful in avoiding magnitude-equation and other systematic errors, and is now generally adopted in fundamental observation. The older method was to tap off on a chronograph the observed times of passage of a star across a series of fixed wires set in the focal plane of the telescope. In the traveling-wire or "impersonal" micrometer, the observer continually turns a screw so as to keep a fine wire or web continually bisecting the moving star image. (The turning of the screw moves the eyepiece as well as the wire, so that the bisected star remains apparently stationary at the centre of the field of view.) Electrical contacts are made when the moving frame reaches definite positions, and the time when the wire, and therefore the star, reaches a series of positions is thus automatically recorded on the chronograph.

**Photographic Measuring Machines.**—These are examples of the application of the micrometer to the microscope. There is a wide variety of patterns, and nearly every observatory has its own form, designed to embody some special improvement, valuable either for securing accuracy or for saving time in the particular work there pursued. Many lines of work involve a prodigious amount of measurement of photographs, and the time-saving factor is therefore of great importance. We can only summarize here some of the typical requirements. The photographic plate must be carried on slides allowing it to move in two perpendicular directions, so that any point of it can be brought directly under the microscope. The frame should have great rigidity in order that perfect focus may be preserved. The cross-wires, glass scale or other fiducial marks are in the focal plane of the microscope objective. The actual measurement is usually accomplished by moving the photographic plate relatively to the measuring microscope, or by the motion of the microscope itself relative to the stationary plate. The eyepiece is mainly responsible for the magnification. Magnification by the objective is seldom greater than 3:1; there are, in fact, many advantages in using unit magnification, *i.e.*, the image in the focal plane of the objective is the same size as the photograph itself. It may be recalled that in visual observation we magnify with the eye lens an image formed in the focal plane of the telescope; by inserting a photographic plate in the focal plane this image is materialized and rendered permanent; the objective of the measuring microscope converts this into an insubstantial image, preferably of the original size, and we then make our deferred examination of it with an eye lens.

A recent development has been the introduction of measuring machines which utilize the principle of projection. In this type of instrument an image of the micrometer wire, together with the lens-formed image of a small region of the photographic plate to be measured, are projected onto a white screen. The bisections of the star images are made while the observer sits in comfort watching this screen, which is located at a convenient reading distance from the eyes. This method reduces physical fatigue and the danger of eyestrain; in addition, the measures may be slightly more accurate. Instruments of this type are used to measure photographs of star fields for the determination of parallax and proper motion. In proper motion work the photograph at one epoch is sometimes taken through the glass of the plate; *i.e.*, with the plate "the wrong way round"; the two plates to be compared are then placed film to film so that corresponding images are very close together. In this case the comparison resolves itself into measuring exceedingly small distances between pairs of images, and there are comparatively few sources of error.

Similar principles apply to machines for measuring spectra (celestial or laboratory). Here the motion and measurement are in one dimension only, and a line is a somewhat easier object to set on, either with single or parallel wires, than a star image. Whenever possible the measurements are made relatively to a comparison spectrum, so that only small differences of position are to be measured. (A. S. E.; X.)

**MICRONESIA** (from Gr. *mikros*, "small," and *nēsos*, "island"), one of the four main divisions of Oceania (*q.v.*), lies west of Polynesia and north of Melanesia. It consists of the Mariana, Caroline, Marshall and Gilbert island groups and isolated Nauru Island. The Gilberts are part of the British Gilbert and Ellice Islands colony. The phosphate island of Nauru, a United Nations trust territory, is administered as a joint responsibility of Great Britain, Australia and New Zealand. Guam since 1899 has been a U.S. possession. The remainder of Micronesia comprises the Trust Territory of the Pacific Islands, since 1947 a United Nations strategic area trusteeship administered by the United States.

**Geography.**—Micronesian islands range between 2° 45′ S. and 20° 32′ N. lat. and 131° 10′ and 177° E. long., an area as vast as the continental United States. Except for the high islands of volcanic origin, such as Guam, Saipan and Tinian in the Marianas, and Yap, Palau, Truk, Ponape and Kusaie in the Carolines, Micronesia consists entirely of scattered low coral islets. The latter, more than 2,000 in number, account for only 20% of Micronesia's 1,055 sq.mi. of land. Guam with its 209 sq.mi. is the largest island in Micronesia, while Agrihan, another of the Marianas, has the highest altitude, 3,166 ft. The United States maintains both sea and air transport between Guam and the more important islands of the trust territory. British-controlled shipping orients the Gilberts and Nauru toward Australia and New Zealand.

Temperatures average about 80° F. and show little seasonal change. Characteristics of altitude and latitude are responsible for marked local differences in rainfall, and populations located near the equator sometimes experience extremely long droughts. Destructive typhoons periodically visit the western islands, but malaria and certain other diseases often associated with tropical climates are lacking.

**History.**—Ferdinand Magellan's discovery of the Marianas in 1521 marked the onset of Micronesia's absorption by the western world. In the following decades Guam became a vital watering stop for Spanish crews sailing the galleon route from Mexico to Manila in the Philippines. Jesuit priests in 1668 began the wholesale conversion of natives throughout the Marianas. When the Chamorros resisted they were forcibly brought under Spanish rule and suffered great losses in population and cultural autonomy.

In the mid-1880s eastern Micronesians, especially on Kusaie, were exploited by New England whalers whose actions were vigorously opposed by Protestant workers of the Boston mission. German planter-traders in the Marshalls, building a commercial empire on the conversion of coconuts into copra, received the sup-

port of their government when Germany in 1885 proclaimed a protectorate over the area. In that year Spain successfully resisted German moves to expand into the Carolines when, recalling 16th-century discoveries by Spanish navigators, it convinced Pope Leo XIII of its prior claim to the islands. Britain entered the political arena in 1892 by declaring a protectorate in the Gilberts and outlawing slave-labour recruitment for Central American plantations. Phosphate was discovered on German Nauru and British Ocean Island in 1900. An Anglo-German agreement allowed it to be mined by a British company. The Spanish-American War led to the U.S. annexation of Guam and to Germany's purchase of the rest of Spain's interests in Micronesia. German administrative centres were established at Saipan, Yap, Ponape and Jaluit in the Marshalls.

Japanese naval forces in 1914 seized all German holdings north of the equator, and Australians occupied Nauru. Both territories were later assigned as mandates by the League of Nations. Japanese administration, centred at Koror in Palau, stressed agricultural and fisheries development for export to the homeland and encouraged immigration from Japan's overcrowded provinces. By 1940 about 85,000 Japanese colonists accounted for nearly two-thirds of Micronesia's population. Native customs and living conditions changed most in the Marianas and Palau, where larger numbers of Japanese had settled. By comparison with the Germans, Japanese officials tended to limit or belittle local practices of the island peoples. From 1919 the British phosphate commissioners, representing Great Britain, Australia and New Zealand, managed phosphate operations on Nauru and Ocean Island. The same nations held the League mandate for Nauru, although administration became Australia's direct responsibility.

About 1935 Japan began to militarize the mandated islands, and after the attack on Pearl Harbor in 1941 moved quickly to occupy Guam, Nauru and the Gilberts. For Micronesians World War II meant population dislocation, battle-damaged properties and deprivation of trade and medical supplies. The Allied invasion, after restoring the Gilberts in 1943, moved on to take key islands in the Marshalls, Marianas and Palau. Following Japan's surrender in 1945 all Japanese civilians as well as the military were repatriated. Micronesia's resident population during the postwar years was almost all indigenous, the native population being estimated at 135,000.

**Administration.**—The oldest of the four administrations now maintained in Micronesia is the Gilbert and Ellice Islands colony, dating from 1916 and including as two of its five districts the Gilbert Islands and Ocean Island. Its resident commissioner has headquarters at Tarawa Island in the Gilberts. He is responsible for all functions of government, reporting to the colonial office in London through the high commissioner of the Western Pacific at Honiara, British Solomon Islands. Local government is carried on by native organizations under supervision of British officials.

The trust territory of Nauru, formed under the United Nations in 1947, is governed by an administrator appointed by the commonwealth government of Australia and responsible to the minister for territories at Canberra. He holds all powers of government. Since 1951 a local government council of eight elected indigenous members has aided him in the maintenance of peace and order among Nauruans. As with all UN trust territories the trusteeship council in New York city receives annual reports from the administering authority and sends a visiting mission to the area every three years.

The U.S. Trust Territory of the Pacific Islands is headed by a high commissioner, appointed by the president and responsible to the secretary of the department of the interior. The high commissioner's office is located on Saipan. District administrators serve at Koror, Yap, Truk, Ponape, Majuro (Marshalls) and Guam. Islands in the Mariana district other than Rota were in 1953 transferred to jurisdiction of the navy department for strategic military reasons as permitted by the trusteeship agreement. In 1962 administration of Rota and Saipan districts was returned to civilian control and the two were combined to form the Mariana Islands district. In most districts an advisory congress composed of elected Micronesian representatives is empowered to enact legislation subject to the high commissioner's approval. An independent judicial system operates under a chief justice who is appointed by and reports to the interior secretary.

The unincorporated territory of Guam has progressed farther in the practice of self-government than any other Micronesian area. Since 1950 Guamanians have been full citizens of the United States. By popular vote they elect delegates to a unicameral legislature which meets twice annually in Agaña to pass laws subject to only limited gubernatorial veto. The judiciary is separated from executive and legislative offices. The governor is appointed by the president and reports to the secretary of the interior. In 1960 for the first time a Guamanian was named to this top island post.

**Economy.**—For most Micronesians daily subsistence is ensured by cultivation of taro, breadfruit, coconut and sweet potatoes, supplemented by lagoon or deep-sea fishing. Administrators urge continuation of these traditional practices for they realize the limitations of local resources for other economic development. Copra —the dried meat of coconuts and the source of oil for soap and margarine—is the leading export. Handicraft products and raw shell for button manufacture trail far behind. Imports greatly exceed exports and consist mainly of foodstuffs, clothing, hardware and building materials. In some islands wage labour and small business are an important means of earning money. Several thousand natives, only a few of them skilled, work regularly for administrative agencies, trading companies and small service enterprises. Guam constitutes a special case, where wage employment for Guamanians has come to dominate the local economy because of the presence of an extensive military establishment and its attendant "stateside American" community.

Only Nauru and Ocean islands are involved in the quarrying of Micronesia's most valuable export, phosphate. The raw material shipped from these two islands for refinement as fertilizer helps to maintain the high standard of living enjoyed by the inhabitants. As landowners they receive compensation in royalties and land rents. On Ocean Island, however, mining had so seriously eroded native living areas that in 1946 the entire population was resettled on Rabi Island in Fiji. Since that date imported labour has worked the mines on a contract basis.

**Ethnology.**—Micronesia has not long—relatively speaking—been inhabited by man. Without transportation like the outrigger sailing canoe long stretches of water could not be crossed, and without food plants such as taro, coconut and breadfruit voyagers could not survive on the small islands. These conditions had been met when migrants from eastern Asia and Indonesia entered western Micronesia, possibly as early as 3000 B.C. The wanderers were racially Indonesian-Mongoloid with some pygmy Negroid admixture from New Guinea and spoke languages of the Malayo-Polynesian family now widespread in Oceania. Eastern Micronesia may have been entered from the Solomons and New Hebrides and later from Fiji and western Polynesia. The movements of Micronesians in prehistoric times are slowly being clarified by painstaking archaeological excavation and comparative ethnology, but by mid-20th century all except the broad outline was still tentative.

The material culture of old Micronesia demonstrates the close bond between daily living and physical setting. Changes have been great in this respect, though some of the old technology still survives. Families lived in thatched, one-room houses with detached cooking huts. A larger building often dominated the residential area, serving as a clubhouse for males or as a council house in which heads of families deliberated. Men and women shared the routine of work, the former assuming the heavier and more dangerous tasks while women undertook chores associated with homemaking. Food was cooked in earthen ovens and eaten by the household group that had produced it. Specialized fishing techniques maximized utilization of marine resources. Surplus yields of breadfruit and pandanus, preserved in pits or dried in rolls, supplemented taro and coconut in leaner seasons, and men drew sap from coconut flowers to make toddy, a substitute for drinking water. Tools and utensils were expertly fashioned from local supplies of shell, fibre and wood.

Since they lived in a tropical climate, Micronesians needed little clothing. Adults wore sarongs and loincloths made from plaited

mats of pandanus leaf or from loom-woven fabrics of banana fibre. Both sexes tattooed all or part of the body with intricate designs, and personal adornment received considerable attention. Flowers in great profusion, worn in the hair, in pierced ear lobes, and as wreaths and necklaces, vied with more durable decoration in shell.

Communities were small, comprised of hamlets of 20 to 50 residents or of villages of a few hundred at most, located near stream, lagoon or sea because the water provided both food and a means of transportation. Dugout hulls with balanced outrigger and lateen sail reflected superlative achievements in canoe design. Navigational skills, of atoll peoples particularly, demonstrated a remarkable understanding of star movements and patterns of wind and wave. Since the self-sufficiency of communities discouraged an economic exchange of goods, most travel served social and political ends.

The social relations of Micronesians have always depended first upon family and other kinship bonds and secondly upon face-to-face contacts with nonkinsmen in the local community. Islanders have commonly channeled their social, economic and political activities along lines of mutual aid and obligation among local groups related by blood or marriage. This practice has hindered official attempts, as in the U.S. trust territory, to develop loyalties to larger territorial entities.

Premarital sexual freedom prevailed within the restrictions of incest. Though marriage was marked by little ceremony, the union reflected social and economic ambitions of the families involved. Adoption, a widespread custom, gave children an alternate set of parents rather than permanent replacements. Established households included various relatives who did not belong to the immediate family. A much larger kin group, composed of persons related to a common ancestor through their mothers and not living in common residence, played a dominant role in most island societies.

Male heads of lineages, clans and other kin groups acted as leaders within the community. In some islands they formed democratic councils; elsewhere they were ranked as a hierarchy of titles with privilege associated with those at the top. Kindreds, singly and in confederation, engaged in war and in competitive exchange of gifts and feasts. Shell and ceramic beads and large stone disks (often exceeding three feet in diameter) were used as money in formal exchanges between families in the western Carolines. Individuals as members of corporate kin groupings shared inherited rights to ownership and use of land, and hereditary status generally outweighed personal merit in determining succession to political office. On most high islands and the Marshall atolls, class stratification accompanied the emergence of powerful chieftains whose people gave them goods and services in tribute. The worldly authority of such chiefs gained support from the popular belief in their divine ancestry.

Micronesian religion allowed no separation of the spiritual from the physical. While Christianity has been successful and forms of worship have changed, Micronesians retain a fundamental conviction of the total unity of things.

Ceremonial burial prepared the soul of the deceased for its dangerous journey to the afterworld. Ghosts continued to be a vital force among the living and, according to belief, could aid or destroy humans depending on the vigilance shown by surviving relatives in memorial observance. Certain ancestral spirits were accorded the higher status of deity. These ghosts, gods and multitudinous nature spirits, both feared and respected, were supplicated in war, drought, sickness and other adversity. Sacred places and unpretentious shrines served individualistic shamans in their mediation through prayer, incantation and offerings. Black magic and white were practiced in social relations.

*See* also PACIFIC ISLANDS.

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(L. E. MS.)

**MICRONESIAN LANGUAGE:** *see* MALAYO-POLYNESIAN LANGUAGES.

**MICROORGANISM:** *see* BACILLUS; BACTERIOLOGY; FUNGI; PROTOZOA; VIRUSES.

**MICROPALEONTOLOGY,** the study of small fossils, differs from paleontology (*q.v.*), of which it is a division, mainly in the smaller size of specimens and the methods and techniques used in their preparation and study. It differs also in its more extensive use in stratigraphy (*q.v.*), the study of layered rocks, and in petroleum geology (*see* PETROLEUM).

**Types of Microfossils.**—Some microfossils belong to biological groups whose members are characteristically small. Fossil Foraminifera belong to the Protozoa, or one-celled animals, as also do the Radiolaria. Ostracods are very small crustaceans with a clamshell-like covering. Diatoms are minute plants with boxlike outer skeletons. The small size of other microfossils may stem from the fact that they are fragments of larger plants or animals. Fossil spores and pollen belong in this category as do also the embryonic shells of mollusks; skeletal plates of sea cucumbers; scales, teeth and earbones of small fish; worm jaws; and the minute calcite prisms of which clamshells are composed. There are, in addition, a number of minute fossils whose relationships are unknown, but which are classified as microfossils.

**Collection and Preparation.**—Microfossils are almost never collected singly, but by the hundreds or even by the thousands in rock samples in which they occur. The collector rarely knows whether or not his samples contain microfossils until they have been processed in the laboratory. This may be done by reducing the sample to fine dustlike particles and manually picking the microfossils out of the pulverized rock debris, or floating them out with a liquid the specific gravity of which is such that it will lift the microfossils and not the matrix. After removal, the fossils are placed in cardboard well slides for study and storage. A wide-field stereoscopic microscope with reflected light and capable of magnification ranging from 10 × to 100 × is used to study most microfossils.

Samples that are suspected of containing spores and pollen are digested in a series of acids—hydrofluoric (HF), hydrochloric (HCl) and nitric ($HNO_3$) are commonly used—and the residue centrifuged out of the containing liquid. The residue is then stained and preserved in glycerine jelly. A drop of this jelly placed on a transparent slide and covered with a transparent cover slip, is then ready for study under a binocular biological microscope, using transmitted light and magnifications ranging from 100 × to 1000 ×. A mechanical stage is used for scanning the slide and also for recording the location of spore and pollen grains.

Pollen grains range from 10 microns to 130 microns in size (0.0004 to 0.005 in.). Spores average about 100 microns (.004 in.) in diameter. Animal microfossils probably average 500 microns in size, with extremely small forms ranging downward to 25 or 30 microns. The upward range is very great. Some discoidal foraminifera are as much as five inches in diameter, but are almost paper-thin. Others are one inch or so in diameter and as much as one-fourth inch thick. One giant is one inch thick and more than three inches long. These are considered microfossils only because they belong to a biological group whose members normally fall in the proper size range.

The large forms present a special problem in preparations and study. Because their internal structure is significant, they must be sectioned. They are ground on a hand or mechanical lap until the plane of grinding passes through the desired internal structures. The ground surface is then cemented to a transparent microscope slide and the remaining side ground down until the slice is so thin that it is translucent. The slide is then studied under the microscope, using transmitted light.

**Significance in Science and Industry.**—The animal and plant groups to which microfossils belong have evolved or changed through geologic time. In many instances this change has been sufficiently great to cause the microfossils of one geologic age to differ from those of other ages. Once the sequence of changes had been established for the whole of known geologic time through

which the various groups have evolved, a micropaleontologist was able to establish the age of an unknown sample containing microfossils by comparing it to the known sequence.

Because microfossils are such good time markers, and because they come out of a drill hole intact, while larger fossils are broken beyond recognition, they have been used extensively in petroleum exploration and development drilling.

Although there were a few workers before his time, Alcide d' Orbigny (1802–57) of Paris is generally considered the father of micropaleontology as a science. From his time to about World War I, interest in the science was mainly academic and the workers were few. About the time of World War I, microfossils were first used in petroleum work. They were quickly found to be of great value in this field and work on them progressed very rapidly. In the early 1960s more than a thousand persons, most of them employed in the petroleum industry, were working with these minute fossils.

The American Museum of Natural History established a department of micropaleontology in 1940 as a centre for research on microfossils and for the dissemination of knowledge relating to them. A 58-volume reference work, containing descriptions and illustrations of more than 1,500 genera and about 25,000 species and subspecies of Foraminifera, has been published by this department. An international quarterly known as *Micropaleontology* is also published by the department. It has more than 1,000 subscribers located in every country in the world where work in this field is in progress.

*See* also GEOPHYSICAL PROSPECTING; GEOLOGY.

*See* D. J. Jones, *Introduction to Microfossils* (1956); D. B. Ericson and Goesta Wollin, "Micropaleontology," *Scientific American*, vol. 207, no. 1, pp. 96–106 (July 1962). (B. F. E.)

**MICROPEGMATITE,** in petrology, a fine-grained intergrowth of quartz and alkali feldspar, the latter usually poor in soda. The intergrowth is so fine that it can be resolved only under the microscope but is otherwise indistinguishable from the coarser intergrowths known as graphic granite, for one of which the name pegmatite (*q.v.*) was originally suggested by the French mineralogist R. J. Haüy (1743–1822).

The quartz-feldspar interfaces are planar and in section the quartz areas tend to be triangular. Over large areas these patches of quartz are in parallel optical orientation and it was long supposed that they were actually continuous, either above or below the plane of observation. A detailed study of the coarser intergrowths common in many pegmatites indicated that the various quartz patches are usually separate individuals. Both the angular (runic) character of the quartz areas and their optical parallelism are evidently responses to growth conditions. The commonest angular relation between feldspar and quartz—a rule discovered by and later named after the Russian geochemist A. E. Fersman (1883–1945)—results in an angle of 42° 16′ between the *c*-axes of the two minerals. Other angular relations occur, but there seems no doubt that the basic control is crystallographic. Where the intergrowth is coarse enough and sufficiently abundant to permit chemical analysis, the bulk composition averages about 25% quartz and 75% feldspar. This is a composition often found in granites and rhyolites, and one which experimental work indicates would have a relatively low melting temperature. There is thus good reason to suppose that micropegmatite represents an end stage or residual liquid, a view long held by many petrologists. To the extent that this view lends support—both implicit and explicit—to magmatic theories concerning the origin of both granite and granite magma, it is hotly contested by contemporary antimagmatists.

Micropegmatite is found particularly in granite, quartz porphyry and diabase. Granophyre is composed largely or wholly of micropegmatite. In diabase it may be interstitial, or form pods, seams or veins, and the notion that the resulting "red rock" is a final product of fractional crystallization of diabase magma is one of the major supports of N. L. Bowen's hypothesis that granite magma is generated in this way (*see* GEOCHEMISTRY: *The Reaction Series*). It is easy to show, however, that only a relatively small amount of granite magma would result from the process, and the amount of micropegmatite is often embarrassingly large, particularly in the numerous gabbro-granophyre associations of the British Tertiary province. The idea that micropegmatite represents in some way a residual or endstage liquid is also difficult to reconcile with its occurrence in the phenocrysts but not in the matrix of certain felsitic or glassy rhyolites.

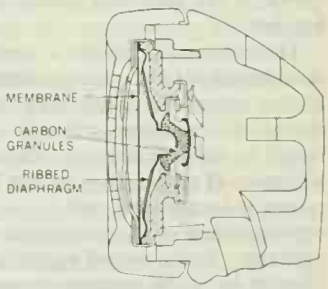
Something very similar to micropegmatite evidently may also form by devitrification of rhyolitic glass; in some spherulitic rhyolites the spherules consist of an exceedingly fine but clearly graphic or micropegmatitic intergrowth of quartz and alkali feldspar. For further discussion of the magmatic and other theories referred to in this article *see* GEOCHEMISTRY: *Geochemistry of the Lithosphere*; MINERALOGY; PETROLOGY: *Plutonic Complexes*.

(F. Cs.)

**MICROPHONE,** a device for converting acoustic power into electric power which has essentially similar wave characteristics. The first successful instrument for this purpose was the electromagnetic telephone transmitter used by Alexander Graham Bell in 1876. The term microphone was first used by David E. Hughes in 1878, when he elucidated the basic principle of the loose contact. By virtue of this principle, the variable resistance of a carbon telephone transmitter, under the influence of the varying sound pressure, controls the energy delivered by a battery so that the sound waves are converted into corresponding but amplified electric waves. It was the sensitivity of such a device in amplifying feeble sounds that gave rise to the name microphone (Gr. *micros*, "small" + *phone*, "sound").

While telephone transmitters comprise the largest class of microphones, the name microphone in modern usage is applied mostly to types which do not form part of a conventional telephone set. Microphones for receiving underwater acoustic waves are generally known as hydrophones. Such instruments also can be used to pick up sound waves in solids.

Apart from telephone transmitters, the largest fields of application of microphones occur in hearing aids, sound-recording systems (principally magnetic tape recorders) and dictating machines. Most of these microphones are of the crystal type, but considerable numbers of magnetic and other types are found also. Another widespread application of microphones is in public-address systems employed in assembly halls, lecture rooms, announcing and paging systems, etc. The microphones used for this purpose divide about equally between the crystal and the dynamic types. Microphones find extensive use also in communication systems, either radio or wire, for providing either better quality of response than can be obtained with the conventional telephone transmitter, or hands-free operation.




BY COURTESY OF BELL TELEPHONE LABORATORIES

FIG. 1.—CROSS SECTION OF A WESTERN ELECTRIC COMPANY T1 TELEPHONE TRANSMITTER

The most exacting applications of microphones are in radio and television broadcast pickups, sound recording and sound measurement. Choice of microphone type for such purposes depends upon the nature of the application. The requirements to be satisfied may include: (1) substantially uniform and transient-free response over a wide range of frequencies, perhaps from 25 to 15,000 cycles per second or higher; (2) linear (*i.e.*, directly proportional) response over a wide range of input pressures; (3) high or moderately high sensitivity; (4) a high degree of freedom from inherent noise; (5) stability of characteristics under rugged handling conditions and over a substantial temperature range; (6) directional characteristic (*i.e.*, direction from which sound is most readily detected) adapted to the purpose at hand; and (7) size small enough to cause no serious disturbance to the sound field or, in television, to be as unobtrusive as possible. Usually some compromise must be reached between the desired characteristics.

**Classifications.**—Microphones represent one class of the broad category of devices known as transducers, that is, devices capable

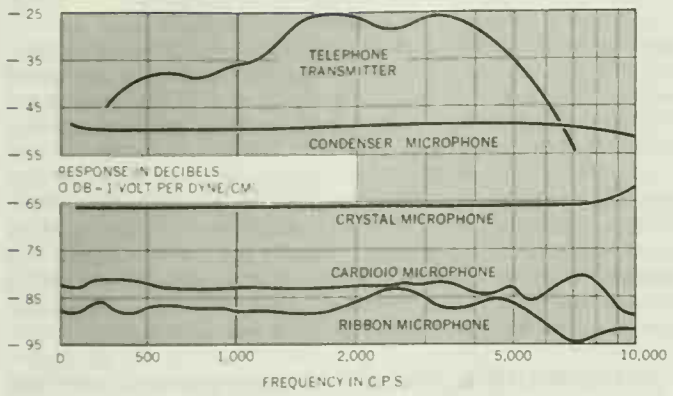



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FIG. 2.—FREQUENCY CHARACTERISTICS OF DIFFERENT TYPES OF MICROPHONES

of being actuated by waves from one or more transmission systems or media, and of supplying related waves to one or more other transmission systems or media. Thus a microphone is an acousto-electric transducer.

Microphones may be classified in various ways. One basis of distinction is whether the microphone is "active" or "passive"; *i.e.*, whether it controls a local source of direct-current energy, such as a battery or power pack, so that in converting the sound input into electric output it introduces amplification, or whether the process of conversion takes place without amplification, the electric output being derived solely from the sound input.

Amplifying or active microphones, developed chiefly for telephone systems, are used for other purposes also. Usually efficiency is a primary object, together with reasonably uniform response over the range of speech frequencies. The amplification from incident power to output power may be as much as two thousandfold.

Nonamplifying or passive microphones have been developed mainly for applications where higher quality is desired, as, for instance, in sound recording systems, broadcasting systems and sound measurement work. Such a microphone is commonly followed in the electrical circuit by one or more stages of amplification.

The conversion, within a microphone, of sound pressure variations in the air into corresponding electrical waves usually occurs in two operations which take place simultaneously. In the first operation, the sound wave impinges on a surface, generally referred to as a diaphragm, which is capable of slight movement. Variation of air pressure on this diaphragm causes it to move to and fro in a manner corresponding to the movement of the air particles. In the second operation, the diaphragm by its movement causes a corresponding change in some property of an electric circuit. Thus, for example, the displacement of the diaphragm may cause variations in the resistance of a carbon contact, in electrostatic capacitance, or in the motion of a coil or conductor in a magnetic field. In each case motion of the diaphragm produces a variation in the electric output.

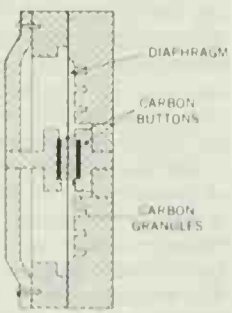


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FIG. 3.—CROSS SECTION OF A DOUBLE-BUTTON CARBON MICROPHONE

Thus, the sound vibrations are first converted into mechanical motion, then the mechanical motion is converted into electric waves. Hence, in studying the operation of a microphone two things must be considered, (1) the mechanical movement of the diaphragm, and (2) the method whereby this movement sets up the desired electric waves. Either part of the process may be taken as a basis for classifying microphones.

From the standpoint of diaphragm operation, microphones may be classified as pressure type, velocity type or a combination of the two. Any microphone that has its diaphragm exposed to the sound wave on only one side is a pressure-operated type, that is, the displacement of the diaphragm is approximately proportional to the instantaneous pressure of the impressed sound wave. In a velocity microphone, the diaphragm is exposed on both sides to the sound wave, so that its motion can be made to correspond closely to the difference in pressure, and hence to the instantaneous particle velocity of the sound wave. According to the means or method employed to convert diaphragm movement into electric waves, microphones may be classified as carbon, condenser, crystal, ceramic, variable reluctance, moving-conductor, moving-coil, ribbon, magnetostriction and hot-wire.

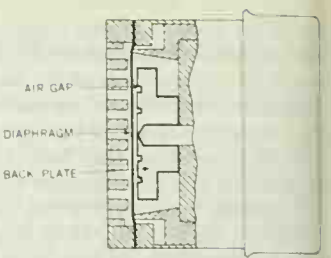


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FIG. 4.—CROSS SECTION OF A CONDENSER MICROPHONE

Depending on response to different directions of sound incidence, microphones may be classified as omnidirectional, bidirectional or unidirectional. In accordance with the impedance level of the output, which is important in the design of connecting circuits, microphones may be classified as low-impedance or high-impedance. Microphones also may be described in accordance with manner of use, as for example, throat microphones which are designed for use in direct contact with the throat, lip microphones which operate in close proximity to the lips and lapel microphones adapted for positioning on the clothing of the user.

**Carbon Microphone.**—Outstanding among pressure types is the carbon microphone, which possesses not only historical interest but great modern importance. Both Emile Berliner and Thomas A. Edison in 1877 invented telephone transmitters whose operation depended on variable contact resistance, while Henry Hunnings in 1878 invented a transmitter employing a large number of finely divided carbon granules so as to obtain many points of microphonic contact whose resistance changed with sound pressure, thus introducing large amplification. Anthony C. White in 1890 invented the solid-back transmitter, using a "button" of granular carbon placed between a fixed electrode and a movable one actuated by a diaphragm.

Modern telephone transmitters employ the same basic principles. Usually they are designed to be mounted in a telephone handset in conjunction with a receiver. Older types of transmitters, with clamped diaphragm, back cavity and carbon-filled cup, are characterized by a single sharp resonance. In a recent type (fig. 1), not only is the sensitivity considerably increased but the response over the speech frequency range is much improved through the employment of a doubly resonant system (fig. 2). The substantially uniform response over the range from about 400 to 3,200 cycles per second (c.p.s.) contributes a great deal both to articulation and to naturalness of conversation.

A microphone employing a single carbon button provides a linear relation between input pressure and output current for only a small range of sound pressures. For applications requiring low distortion over a wide range of outputs, together with a broader range of uniform frequency response, a double-button carbon microphone may be used (fig. 3). By mounting the diaphragm under great tension, the resonant frequency can, at the expense of some loss in sensitivity, be moved up to a fairly high frequency, 5,000 to 8,000 c.p.s., giving fairly uniform, or "flat," response over a wide range. Such microphones give high output, are rugged and are little affected by temperature or humidity. For high quality work, however, there is still a limitation fundamental to any carbon transmitter, namely, a characteristic background hiss due to arcing at minute carbon-granule contacts.

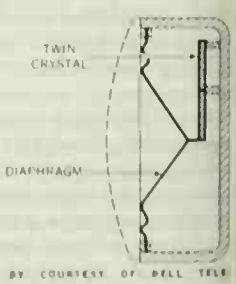


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FIG. 5.—CROSS SECTION OF A CRYSTAL MICROPHONE

**Condenser Microphone.**—The condenser (also called capacitor) microphone, originally described by A. E. Dolbear in 1880 and developed in practical form by E. C.

Wente in 1916, is likewise of the pressure type. It consists typically of a thin stretched diaphragm separated by about one-thousandth of an inch from a parallel fixed plate (fig. 4). The diaphragm acts as one plate of a variable capacitor which is connected in series with a resistor and a direct-current source. The motion of the diaphragm in the condenser in response to sound waves varies the capacitance, producing a variable electric current.

Condenser microphones have excellent frequency response and reproduction quality. They have a small output, which usually is brought to a higher level by a built-in "preamplifier." In modern practice their use is largely confined to sound measurement and high-quality recording.

**Crystal and Ceramic Microphones.**—Still another pressure type is the crystal microphone, which depends for its operation on the piezoelectric effect; *i.e.*, the generation of a voltage by the deformation of a crystal through applied pressure (*see* PIEZOELECTRICITY). Since Rochelle salt crystals exhibit greater piezoelectric activity than any other known crystals, they are commonly used in crystal microphones. The first such use was by A. M. Nicolson in 1919, but it was not until 1931 that C. B. Sawyer developed a practical form of microphone employing two thin oppositely polarized Rochelle salt plates assembled to form a so-called "bimorph" element. This element may be driven in any one of several ways. In the direct-actuated type the sound pressure acts upon the crystal itself, while in the diaphragm-actuated type the sound pressure acts upon the diaphragm which is coupled to the crystal. Greater sensitivity can be obtained from the latter (fig. 5).

A crystal microphone gives good frequency response, hence good fidelity, but relatively low output as compared with carbon microphones. An advantage is that no external voltage or current is required. Loss of sensitivity at higher temperatures is a limitation, as is susceptibility to humidity damage. Crystal microphones are useful mainly for low-cost applications.

Polarized barium titanate has been used in place of Rochelle salts in what are called ceramic microphones. These are less sensitive than the crystal type but have the advantage of being able to withstand higher temperature and humidity.

**Dynamic Microphone.**—The dynamic (also called moving-coil) microphone falls within the general class of moving-conductor microphones; *i.e.*, microphones in which an electric voltage is generated in an electric circuit through motion of a conductor in a fixed magnetic field. In the dynamic microphone a coil is attached to a diaphragm which the sound waves cause to move back and forth in a magnetic field, thereby inducing a voltage in the coil. This principle was invented almost simultaneously by Charles Cuttris and Jerome Redding in the United States and E. W. Siemens in Germany in 1877. In its modern form, this type of microphone was perfected by Wente and A. L. Thuras in 1931. Dynamic microphones are advantageous because of their low-impedance output, and have considerable usage in recording, broadcasting and public address systems, especially where ruggedness is essential.

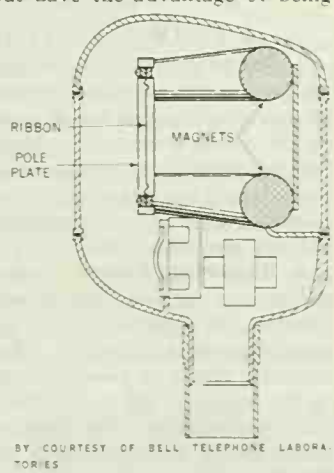


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FIG. 6.—CROSS SECTION OF A RIBBON MICROPHONE

**Magnetic Microphone.**—The magnetic microphone (also called variable-reluctance microphone) depends for its operation on variations in the reluctance of a magnetic circuit. The first transmitter of Bell, patented in 1876, consisted of a diaphragm-driven armature which, by its motion in the field of an electromagnet, modified the reluctance of the magnetic circuit and induced a voltage in a coil. Thus a magnetic microphone was the earliest form of microphone. However, the earlier magnetic microphones were considerably inferior in quality and stability to the carbon,

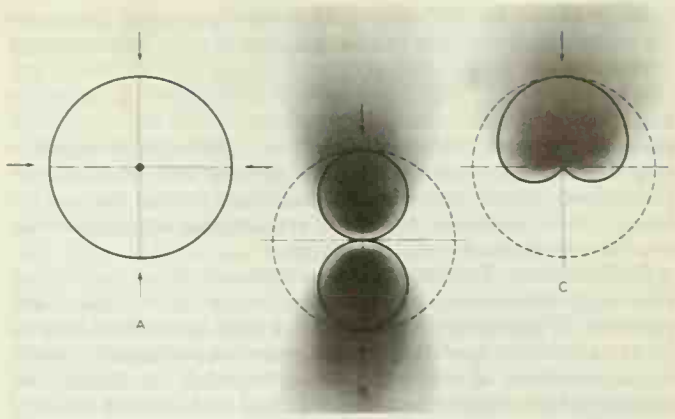


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FIG. 7.—DIRECTIONAL CHARACTERISTICS OF MICROPHONES: (A) OMNI- OR NONDIRECTIONAL; (B) BIDIRECTIONAL; AND (C) UNIDIRECTIONAL (CARDIOID)

dynamic, condenser or ribbon instruments and were not extensively used. A modified small magnetic microphone is now widely used in applications where ruggedness, low weight and high sensitivity are important, as, for example, in military applications and hearing aids.

**Ribbon Microphone.**—A ribbon microphone is a form of moving-conductor microphone in which the moving conductor is a thin metallic ribbon, acted upon by the sound waves, which is suspended in a magnetic field, normally between the poles of a permanent magnet (fig. 6). The ribbon may be exposed to the sound waves on only one side, thus making a pressure microphone, which has an omnidirectional response, or it may be free (*i.e.*, exposed on both sides), constituting a velocity microphone, which has maximum response to sounds coming from front or rear, and thus gives a bidirectional characteristic. The ribbon microphone was invented by W. H. Schottky and Erwin Gerlach in Germany in 1923, and perfected in its modern form by H. F. Olson in 1931. Ribbon units of the pressure type and the velocity or free-ribbon type may be combined to obtain a unidirectional characteristic, as discussed below. Ribbon microphones, either omnidirectional or unidirectional, are used extensively in broadcasting and sound measurement.

**Unidirectional and Polydirectional Microphones.**—A unidirectional characteristic of microphone response is frequently advantageous for minimizing the effect of undesired noises or adverse room acoustics, for reducing the sound feedback from a loudspeaker into the microphone, etc. Such a pattern may be obtained either by combining a bidirectional microphone element and a nondirectional one (*i.e.*, adding the response characteristics at [A] and [B] of fig. 7 to obtain the characteristic shown at [C]), or by combining one or more microphone elements with an acoustical phase-shifting network. In the former approach, the commonest combinations are a ribbon velocity element with either a ribbon-pressure element or a dynamic-pressure element. Frequently the two response patterns are so combined as to yield an over-all characteristic of cardioid shape. The combined ribbon microphone was developed by J. Weinberger, H. F. Olson and F. Massa. The ribbon-dynamic combination was developed by R. N. Marshall and W. R. Harry, using special equalization techniques to match the characteristics of the two elements. Microphones employing acoustical phase shift to obtain unidirectional operation have considerable use in recording, broadcasting and public address systems.

In 1935 H. J. von Braunmühl and W. Weber developed a condenser microphone using two plastic membranes installed at the opposite sides of a shallow perforated casing, which was capable of operating either as an omnidirectional or a unidirectional microphone by suitable electrical connection of the membranes. Some of the highest quality microphones built have been based upon this type of structure. By appropriate design combinations, other desired response characteristics, as, for example, a polydirectional characteristic, can be obtained.

**Microphone Amplifiers.**—With modern techniques, amplifiers for use with microphones can be constructed with frequency and linearity characteristics that are practically perfect for almost any range of interest. Negative feedback is employed to minimize amplitude distortion, and resistance-capacitance interstage coupling to minimize frequency distortion. Although microphone amplifiers were formerly of the electron-tube type for the most part, transistors came to be increasingly used for this purpose because of their small size, low power consumption and adaptability to a low impedance microphone output.

**Performance Testing.**—The performance of a microphone may be determined either by listening tests or by acoustic measurements. Properly conducted listening tests by qualified personnel can give fairly good information regarding performance under actual conditions of use. The usual method is to compare the microphone for which information is desired with a known and used type. There is, of course, no assurance that the comparison is valid except for the conditions of test.

Acoustic measurement of microphone performance assumes two different aspects: comparison with another microphone used as a reference standard, and absolute measurement response. In either case the problem is to determine the microphone response, which is defined as the ratio of the open-circuit voltage generated at the terminals of the device to the acoustic pressure actuating the diaphragm. Since the presence of the microphone distorts the sound field, the undisturbed sound pressure existing prior to placing the microphone in the sound field is usually taken as the input pressure, the corresponding ratio being known as the free-field response.

In the comparison method, a reference microphone whose characteristic has been determined is introduced into a sound field and its output measured, for example, on a recording instrument. The output of the unknown microphone is then measured in the same sound field, and the ratio of the two outputs, when applied to the known response characteristic of the standard, yields the overall response of the unknown. A miniature condenser microphone is generally used as the reference standard.

Through a technique referred to as the reciprocity method, the absolute response of a microphone can be determined without an acoustic standard simply by measuring primary quantities, using an auxiliary reversible microphone first as a microphone and then as a sound source. The method depends on the validity, for the calibrating device, of the reciprocity principle, in accordance with which transmission in one direction through a linear passive device bears a reciprocal mathematical relationship to transmission in the opposite direction. *See* also ACOUSTICS OF BUILDINGS; RADIO; HIGH-FIDELITY SOUND SYSTEMS.

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**MICROSCOPE,** an instrument for producing enlarged images of objects that are too small to be seen unaided. Images formed by a microscope may be viewed directly or with a viewing screen or photographic apparatus. Specimens for microscopy may be either transparent or opaque. The compound light microscope can be used for viewing objects as small as bacteria; the electron microscope extends the range to small viroses and large molecules. Living material can be studied with the light microscope but in the electron microscope the material is killed by the methods of specimen preparation and examination.

This article discusses the various types of microscopes and their uses. Related discussions will be found in the articles OPTICS; LENS; VISION; ELECTRON; *Quantum Theory of Electrons: Electron Wave Length*. Related articles on the use of microscopes include ANATOMY, MICROSCOPIC; HISTOLOGY; CYTOLOGY.

The material in this article is arranged under the following main headings:

I. Common Features and Principles
  1. Use of Waves
  2. Resolving Power
  3. Magnification
  4. Classification
II. The Light Microscope
  A. History
  B. Simple Light Microscope
    1. Optical Characteristics
    2. Common Forms
  C. Compound Light Microscope
    1. Monocular Microscopes
    2. Binocular Microscopes
    3. Aberrations of the Objective
    4. Eyepiece
    5. Condensers
  D. Image Formation
    1. Geometrical Aspects
    2. Diffraction and Resolution
    3. Equivalence Theory
    4. Magnification
    5. Phase Contrast
  E. Illumination
    1. Transmitted Light
    2. Incident Light
    3. Photomicrography
  F. Use of the Light Microscope
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    3. Micrometry
    4. Binocular Microscopes
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    6. Ultramicroscopy
    7. Phase Contrast
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    2. Transmission
  C. Component Parts
    1. Lens System
    2. Vacuum System
    3. Electrical System
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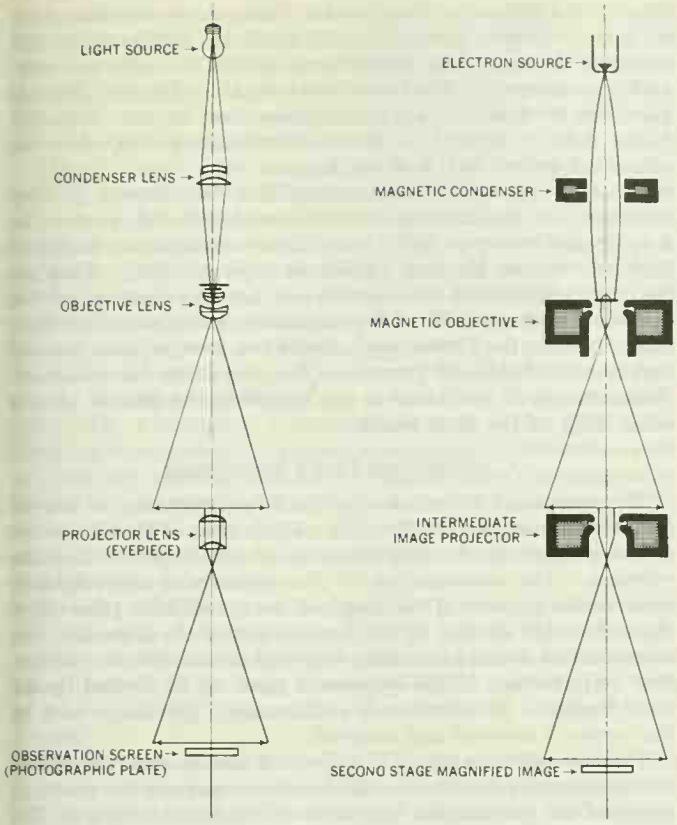
    2. Ultramicrotomy
    3. Electron Metallography
  E. Theory of Electron Lenses

## I. COMMON FEATURES AND PRINCIPLES

**1. Use of Waves.**—Microscopes make use of such wave motions as those associated with electrons or light; these waves are bent as they pass through the microscope so that the image produced on the viewer's retina is magnified. The nature of waves places inherent limitations on the microscope; *e.g.*, a perfect image is not attained because of diffraction, and waves coming from two points that are less than approximately half a wave length apart are not resolvable (separable).

**2. Resolving Power.**—Only when the images of adjacent points in a specimen are separated can the detail be discerned clearly. An indistinct image remains indistinct no matter how many times it is magnified. The ability to resolve, also called the resolving power or power of resolution, is inversely proportional to the length of the wave; the shortest waves thus produce the greatest resolution. For example, electron waves, which are 1,000 times shorter than light waves, produce 1,000 times greater resolution than do light waves. The respective resolving powers are 5 angstrom units (Å) for the electron microscope and 2000 Å for the light microscope; in other words, the electron microscope can resolve details separated by 5 Å and the light microscope can resolve details 2000 Å apart (1 Å = $10^{-8}$, or 0.00000001, cm.). Proton waves, which are five times shorter than electron waves, should have a resolving power of about 1 Å, but technical difficulties have barred full development of the proton microscope.

**3. Magnification.**—The ability of a microscope to magnify depends, in addition to its power of resolution, on the physical characteristics and design of its parts. For example, a pocket magnifier will not produce satisfactory magnifications greater than three diameters, or three times (3×), since greater magnifications are accompanied by spherical and chromatic aberrations arising from the structure of the lens, particularly near its edges. These aberrations can be substantially reduced by joining two such lenses into a single compound lens. The useful magnification of com-




REPRINTED BY PERMISSION FROM V. K. ZWORYKIN AND OTHERS, "ELECTRON OPTICS AND THE ELECTRON MICROSCOPE," JOHN WILEY AND SONS, INC.

FIG. 1.—COMPARISON OF WAVE PATHS IN THE LIGHT MICROSCOPE AND IN THE MAGNETIC TYPE OF ELECTRON MICROSCOPE

pound light microscopes is limited to about 2,000×. The electron microscope can produce a useful magnification of about 20,000× when the image is viewed with a fluorescent screen and about 1,000,000× when the image is photographed and then enlarged. Most electron microscopes have a resolving power of 20 Å and a magnification of 100,000×.

**4. Classification.**—Microscopes can be classified broadly according to the kind of waves they use and can then be subdivided according to the number or type of lens systems used and their source of radiation. A lens system may consist of a single lens or of several lenses grouped in one unit. Microscopes that employ one lens system are called simple microscopes; the best-known examples are the pocket magnifier, hand reading glass and jeweler's eyeglass. In electron microscopes, an important subsidiary method of classification is based on whether electrostatic or magnetic lenses are employed. Microscopes that use two or more lens systems are called compound microscopes; examples are the ordinary laboratory light microscope and the electron microscope (fig. 1). In a compound microscope, the lens system nearest the specimen is called the objective; it has a short focal length and forms a real, enlarged image that becomes the object of the second lens system, which is called the eyepiece, or ocular, in the light microscope and the projector lens in the electron microscope. The source of radiation is an important basis for classification in the electron microscope, where the object may be made to emit electrons or to transmit electrons emanating from another source.

## II. THE LIGHT MICROSCOPE

### A. History

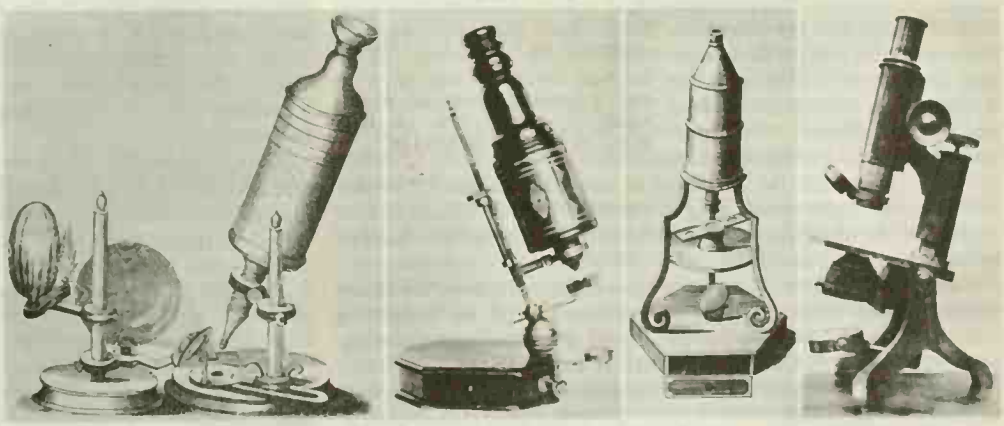
Anton van Leeuwenhoek (*q.v.*) in the 17th century invented the simple microscope (fig. 2) that consists of a single lens with a relatively high magnification. Zacharias Janssen devised the first compound microscope in 1590; it was composed of a convex objective and a concave eyepiece. In 1611 Johannes Kepler suggested the construction of a compound microscope that used convex lenses for both the objective and the eyepiece, but apparently he did not construct such an instrument. Christoph Scheiner constructed Kepler's microscope about 1628 and used it for visual observation and microprojection. The Kepler microscope gave a larger field of view than Janssen's and became the prototype of the modern microscope (*see* BACTERIOLOGY).

Christiaan Huygens, in about 1684, invented the simple but effective two-lens eyepiece that is named after him and is widely used in modern times. Charles A. Spencer (1813–81) advanced the design of microscope objectives by introducing higher numerical apertures; he also improved colour correction by using glass-fluorite combinations. The dark-field microscope condenser was invented in about 1853 by Francis H. Wenham.

Among the most famous names in the history of microscope development is that of Ernst Abbe (1840–1905), who designed the apochromatic objective and the compensating eyepieces for use with these objectives. The homogeneous immersion objective was first described and made by R. B. Tolles in 1874. In 1902 F. E. Ives set forth the basic system for modern binocular eyepieces. Frits Zernike, in 1935, successfully applied phase contrast to the microscope; for this he was awarded the Nobel prize in physics for 1953.

### B. Simple Light Microscope

**1. Optical Characteristics.**—The magnifying power of a simple microscope is the ratio of the size of the image produced on the observer's retina by the instrument to the size of the retinal image when the object is viewed without optical aid. The standard distance for determining microscope magnification is 10 in., or 25 cm., which is the shortest distance at which the normal eye can accommodate; *i.e.*, focus on an object. Fig. 3(A) shows a naked-eye view of the object $y$ at a distance $d$; fig. 3(B) shows a view of the same object moved closer to the eye and seen through a lens. In fig. 3(A) the size of the image on the retina is proportional to the tangent of the angle $\alpha$ subtended at the eye by the object (*i.e.*, it is proportional to the object height divided by the distance, or $y/d$), and in fig. 3(B) it is proportional to the tangent of the angle $\alpha'$ subtended at the eye by the virtual image $y'$. Thus the magnification $M = \tan \alpha'/\tan \alpha$. For the standard viewing distance, $d = 25$ cm. and $\tan \alpha = y/25$. The value of $\tan \alpha' = y'/$



(LEFT, CENTRE LEFT AND RIGHT) BETTMANN ARCHIVE, (CENTRE RIGHT) CULVER PICTURES, INC.

FIG. 2.—HISTORICAL MICROSCOPES: (LEFT) COMPOUND MICROSCOPE USED BY ROBERT HOOKE, 1665; (CENTRE LEFT) LEEUWENHOEK'S SIMPLE MICROSCOPE, 1673; (CENTRE RIGHT) FRENCH MICROSCOPE, 18TH CENTURY; (RIGHT) MICROSCOPE OF SIR RONALD ROSS, 1857–1932

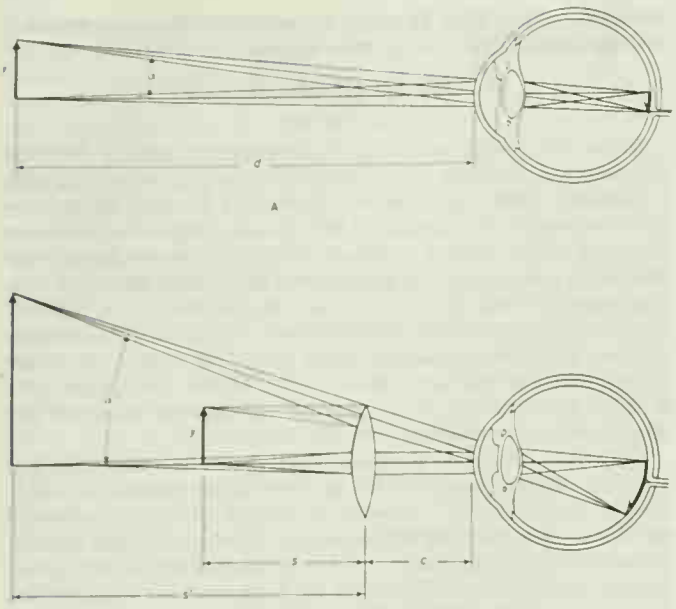



FIG. 3.—COMPARISON OF VIEWS OF OBJECT *y* SEEN (A) WITH UNAIDED EYE AT NORMAL VIEWING DISTANCE OF TEN INCHES AND (B) THROUGH LENS AFTER OBJECT HAS BEEN MOVED CLOSER TO EYE WITH LENS FORMING A VIRTUAL IMAGE

$(s' + c)$ varies with the distance $(s)$ between the object and the lens, the distance $(c)$ between the eye and the lens and the focal length $(f)$ of the lens. The focal length is the distance between the lens and the point at which rays passing through the lens converge, or focus. If the object is at the first principal focus of the lens, $s = f$ and $s'$ approaches infinity. The eye distance $c$ then becomes negligible in comparison with $s'$ and $\tan \alpha' = y'/s' = y/f$. Thus $M = \tan \alpha'/\tan \alpha = 25/f$ where $f$ is the focal length of the lens in centimetres. This is the usual formula for specifying the magnification of a simple microscope. It presupposes that the object is at the first principal focus of the lens and that the eye is accommodated for the infinitely distant image.

The lateral extent of the object area that can be seen through the magnifier increases with the diameter of the lens and decreases as the distance between the eye and the lens increases.

The principal aberrations in a simple lens affect the outer parts of the field of view of an extended image. They are astigmatism, curvature of the field, distortion and chromatic difference of magnification; and it is principally with respect to the degree of freedom from these defects that magnifiers of the same power but of different types may differ one from another.

**2. Common Forms.**—The least expensive magnifier is a double convex lens. Its performance is acceptable for magnifications up to 3×, and it finds common application in folding pocket magnifiers, watchmakers' loupes and reading glasses. For larger magnifications such simple lenses provide images that fall far short of satisfactory quality in several respects; they are lacking in contrast, colour fringes border objects in the outer parts of the field of view and there is marked cushion shaped distortion.

FIG. 4.—THREE FORMS OF MAGNIFIERS. (A) CODDINGTON; (B) DOUBLET; (C) HASTINGS TRIPLET

Various lens constructions have been used to improve the image quality of the simple microscope. There is first an interesting form, apparently devised by Sir David Brewster but generally credited to Henry Coddington, that is essentially a very thick double convex lens with a restricting diaphragm at its midsection, as shown in fig. 4(A).

Another type that is considerably superior to the double convex lens is the doublet magnifier shown in fig. 4(B). It consists of two plano-convex lenses mounted with curved surfaces facing each other. The separation between the lenses may vary from very little to a distance nearly equal to the focal length of the lens closer to the eye. The longer forms are better corrected, especially for colour, but their very short working distance (distance from lens to object) makes them inconvenient to use. Manufacturers differ in respect to the compromise they adopt between colour correction and working distance.

Fig. 4(C) shows a still better magnifier that consists of three elements; *i.e.*, two external flint lenses enclosing and cemented to a single double convex crown lens. Such magnifiers are known as Steinheil triplets, Hastings triplets or triple aplanats. They are the least sensitive of all magnifiers to lateral excursions of the eye when they are used. They are almost completely free from colour fringes; the field is satisfactorily free from astigmatism and curvature of field, and there is a fair correction for distortion. When the eye is held close to the magnifier, the field of view is about 70% of the focal length.

### C. Compound Light Microscope

The compound microscope consists fundamentally of an objective and an eyepiece. The total magnification of the microscope is the product of the magnifications of the objective and the eyepiece. The magnification of the objective is approximately equal to the quotient of the length of the optical tube (also called the body tube) divided by the focal length of the objective; this magnification number is usually engraved on the objective mount. The magnification of the eyepiece is equal to 25 divided by the focal length of the eyepiece in centimetres. The image seen by the viewer is inverted and reversed.

The numerical aperture (N.A.), which also is usually engraved on the objective mount, is a number that expresses the resolving power of the lens and the brightness of the image it forms. The numerical aperture is expressed mathematically as $n \sin u$, where $n$ is the refractive index of the medium separating the object and the objective and $u$ is the half-angle of the largest light cone that the objective can utilize in this medium. In general, the higher the N.A., the higher is the quality of the lens.

A compound light microscope may be equipped with one, two or three eyepieces for monocular, binocular or trinocular (binocular plus camera) vision and with one to four objective lenses. The basic instrument can be elaborated with a variety of accessory equipment that adapts the microscope for special uses.

**1. Monocular Microscopes.**—Fig. 5 shows a standard monocular microscope that is adequate for most microscope work done by the biologist, bacteriologist or physician. (One of the three objectives mounted in the objective turret has been cut away in the diagram). Customary optical equipment for such a microscope consists of a battery of three objectives with magnifications of approximately 10×, 43× and 97× and two interchangeable eyepieces of magnifications of 5× and 10×. The total magnifications therefore range between 50× and 970×. Higher and lower powers may be obtained with other objectives and eyepieces that are interchangeable with the above. A microscope of this type also is equipped with a substage condenser and a mirror. Microscopes with a magnification that can be continuously varied while the image remains in focus were introduced in 1960; these employ a variable-power, or zoom, lens system between the objective and the eyepiece.

*The Stand.*—The microscope stand should be accurately constructed and arranged for the convenient manipulation of the optical parts, the object and the illuminating system. The stand generally consists of a base, an arm and a body tube.

The base, usually made in a horseshoe pattern, supports and is attached to the stage, the arm and the substage apparatus. It should be sturdy, relatively heavy and sufficiently broad to give the microscope good stability.

The arm is frequently fastened to the base through a joint that allows the body tube to be tilted to any angle between the horizontal and the vertical.

The body tube is connected to the arm through a rack and pinion focusing slide and usually a fine adjustment slide. Into the lower end of the body tube, called the objective end, is usually

screwed a nosepiece in which one or more objectives are screwed. The upper end of the body tube, called the eye end, contains the eyepiece. The distance between the objective and eyepiece end is called the mechanical tube length and usually measures 160 mm. Some microscopes are equipped with a so-called drawtube by which the tube length can be varied.

The structures of the microscope stand take various forms, depending upon the work to be done, but it is convenient to think of them as classifiable into three main classes according to the complexity of design and equipment. The simplest class, which is suitable only for the most elementary work, is not provided with a substage condenser and may have only a coarse adjustment for focus. The intermediate class, which is adequate for general laboratory use, requires a substage condenser, fine adjustment for focus, a mechanical stage and a battery of objectives and eyepieces; the objectives usually are mounted on a revolving nosepiece. Fig. 5 represents a typical microscope of this class. The advanced research worker requires more elaborate refinements such as a complete centring substage, a rotatable stage, a binocular eyepiece and a massive stand that can be used for photography as well as for visual observation. A binocular microscope equipped with a third eyepiece to which a camera can be attached is known as a trinocular microscope.

*Focusing Adjustments.*—The body tube is mounted on a dovetail slide to which a rack is screwed. The arm of the microscope carries a pinion that engages with the rack to permit its movement along the axis of the body tube in machined guides. This type of coarse focusing adjustment is the one almost universally employed.

The fine adjustment slide also works in machined guides but is operated by a mechanism capable of adjusting the position of the body tube by small amounts. The reduction of motion is accomplished in two stages. The first stage is a fine-pitch screw that translates the turning motion of the control knob into a slow lateral movement. This lateral movement is further reduced into an extremely fine vertical motion of the body tube by means of an L-shaped lever. All bearing surfaces ride on balls or rollers, and the driving force acts against a preloaded spring so that the motion is free and yet finely controlled.

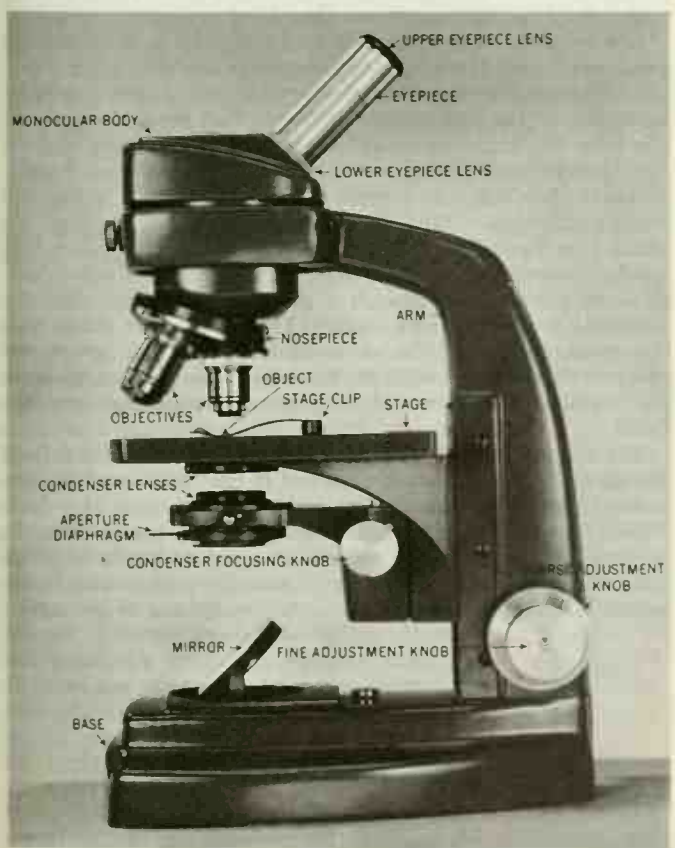



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FIG. 5.—THE PARTS OF A STANDARD MONOCULAR MICROSCOPE

*Nosepiece.*—The nosepiece may contain one, two, three or up to six objectives. Multiple nosepieces are convenient to use since they are made so that when the various objectives are swung into position, after the object has once been centred and brought in focus, the object remains in focus and in the centre of the field. When the nosepiece and the objectives are made in this way they are said to be parfocal. Single nosepieces are made for individual centring when more precise centring is required; *e.g.*, in petrography.

*Stage.*—The stage, which supports the object, is frequently provided with either an integral or a detachable mechanical stage. This is a mechanism for systematically moving the object laterally or transversely by means of racks and pinions. The mechanical stage usually has graduations that are used for cataloguing the position of an object. Some microscopes are equipped with rotating and centring stages.

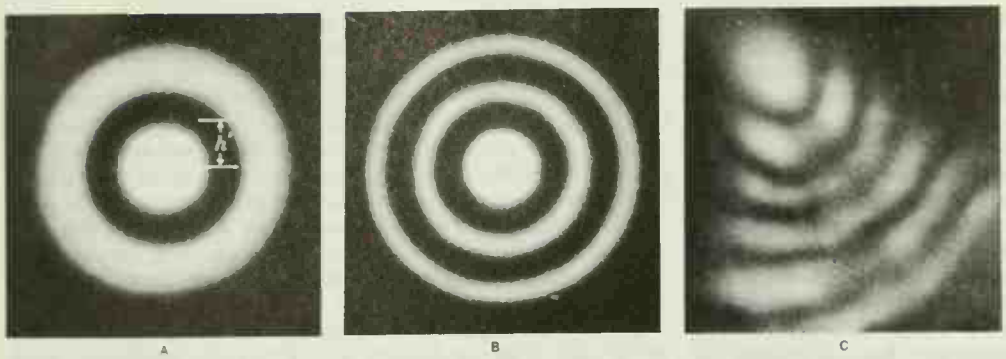
*Substage.*—The substage is the part that holds the illuminating condenser and the mirror. The illuminating condenser may be focused by either a screw motion or a rack and pinion motion, depending upon the particular instrument. The more elaborate microscopes have mounted beneath their condenser support an iris diaphragm that can be rotated and centred. Equipment of this type permits complete control over the illumination system of the microscope; such control is desirable in research work.

**2. Binocular Microscopes.**—Some microscopes employ a prism system with two oculars for convenience of viewing with both eyes. When one objective is used with such a system, the image seen is not stereoscopic unless the design provides for bisecting the aperture of the condenser and objective in such a way that the eyes perceive slightly different views of the object. To obtain truly stereoscopic vision, a complete microscope equipped with image-erecting prisms as in prism binoculars must be used with each eye. (*See* BINOCULAR INSTRUMENT: *Binocular Microscopes.*)

**3. Aberrations of the Objective.**—The quality of the image seen with the compound microscope depends primarily on the quality of the real image formed by the objective. Any imperfections in this image are magnified when the image is viewed through the eyepiece. The aberrations of the objective should therefore be reduced to the smallest practicable values. The primary aberrations for which microscope objectives must be corrected are spherical and chromatic aberration. Spherical aberration produces a hazy image; chromatic aberration produces colour fringes at the boundaries of objects in the centre of the microscope field and reduces the contrast in the image.

Abbe pointed out that even when aberrations are controlled the sine condition must be fulfilled if images of objects of finite size are to be well defined. The sine condition can be expressed mathematically as $n \sin u / \sin u' = \text{constant}$, where $n \sin u$ is the numerical aperture and $u'$ is the angle that a marginal ray makes with the axis in the image space. The constant is the magnification of the objective. If the spherical aberration has been corrected but the sine condition has not been fulfilled, the pencils of rays that come from an object point a little off the axis are brought to focus at different distances from the axis on the image side, giving different magnifications according to the zone of the lens through which the pencils pass.

The effects of these aberrations on the image may be demonstrated with a test object known as a star slide, which consists of tiny pinholes in an opaque metal film on glass. These holes, when viewed through the microscope, appear as tiny bright stars on a black background. The image of one such point object is shown greatly magnified in fig. 6(A). This image is sensibly (optically) "perfect"; *i.e.*, the rings that surround the central image spot are due to diffraction not to aberration. With the introduction of spherical aberration, the appearance of the star image degenerates to that shown in fig. 6(B), where much of the light has been lost from the central spot and spread out into the surrounding rings. The image contrast under such a condition is greatly lowered.



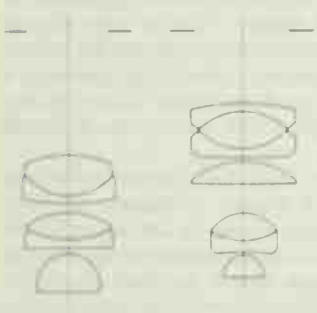
A B C

FIG. 6.—IMAGES OF A POINT OBJECT IN (A) SENSIBLY "PERFECT" OPTICAL SYSTEM; (B AND C) ABERRANT SYSTEMS. (A AND B DRAWINGS FROM PHOTOMICROGRAPHS; C: PHOTOMICROGRAPH)

Similarly, if the sine condition is not fulfilled, the off-axis image degenerates to a comet-shaped figure as in fig. 6(C). In the latter case the contrast is lowered and in addition the image has spread in an unsymmetrical manner, resulting in a very blurred image. This aberration is known as coma.

*Achromatic Objectives.*—Most microscope objectives are achromatic; *i.e.*, they are corrected for colour aberration so that the image is free of unwanted colours. With an achromatic objective rays of light of two different wave lengths originating from a point on the axis in the object space come together, after passing through the objective, at the same point on the axis in the image space. The wave lengths considered by the designer are usually those of the *C* (red) and *F* (blue) lines of the Fraunhofer spectrum. If the *C* and *F* rays were brought together for a paraxial zone (*i.e.*, in a zone of the lens near its optical axis), the marginal zone of the lens would be chromatically overcorrected; that is, the blue rays would cross the axis at a greater distance from the lens than the red rays cross it.

Achromatic objectives must also be corrected for spherical aberration. Spherical aberration occurs when the lens fails to bring to a common focus all the rays of even one colour that fall on it coming from an axial object point. In a lens uncorrected for spherical aberration, black areas in the object are imaged as gray and outlines are indistinct. Spherical aberration can be corrected to a limited degree by constructing the achromatic lens of a positive element of low index of refraction and a negative element of high index. In general, in such a lens, it is possible to make the rays for some one zone (the margin, for example) unite in a common focus with rays near the axis. Rays passing through intermediate zones generally fail by a small amount to pass through that same point, but if the numerical aperture of the lens is not too large the image may appear sensibly perfect. As the numerical aperture is increased, the zonal spherical aberration increases rapidly, and it is in large part to keep this aberration within usable limits that the construction of high-power objectives is so elaborate. Even with the best design, however, not more than three zones in a high-power lens can be brought to a common focus; the other zones exhibit considerable spherical aberration, which in some zones may be overcorrected (*i.e.*, focusing farther from the lens than the axial zone) or undercorrected.



A B

FIG. 7.—LENS SYSTEMS USED IN MICROSCOPE OBJECTIVES (A) ACHROMATIC, (B) APOCHROMATIC

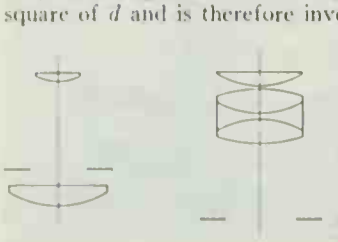
*Apochromatic Objectives.*—In 1886 Abbe introduced apochromatic objectives; *i.e.*, those in which three colours, instead of two as in achromatic objectives, are brought to a common focus. Such objectives have a superior colour correction throughout the visible spectrum. This superiority is achieved by using fluorspar (fluorite) in some of the lens components. In addition, the correction for spherical aberration is further refined by the use of more components. The superior design permits a higher numerical aperture with apochromatic objectives than is practical with achromatic objectives of the same power.

Fig. 7 shows the optical construction of two objectives, one achromatic and the other apochromatic.

*Aberration Associated With a Cover Glass.*—Microscope objectives of numerical aperture 0.40 and above are more sensitive to cover glass thickness than those of lower numerical aperture. Most objects are mounted on glass slides about 1 × 3 in. in size and are covered with a piece of glass 0.15 to 0.25 mm. thick. The cover glass introduces spherical aberration, and if the cover-glass thickness differs by a few hundredths of a millimetre from that for which the objective is calculated, it can seriously affect the quality of the image. A small change in cover-glass thickness can be compensated by a change in the tube length of the microscope; *i.e.*, if the cover-glass thickness is somewhat greater than that for which the objective is designed, overcorrection of spherical aberration is introduced and can be compensated by shortening the tube length of the microscope. Conversely, if the cover glass is too thin, compensation can be achieved by increasing the tube length of the microscope. Modern apochromatic objectives are constructed with so-called correction collars with which the separation between lens components can be adjusted so as to introduce spherical aberration that will compensate for the variation in cover-glass thickness. The performance of oil immersion objectives is not affected by change of thickness of the cover glass; since the oil with which such objectives are used has the same index of refraction and dispersion as the cover glass, any variation in cover-glass thickness is automatically compensated by an equal and opposite change in the thickness of the oil.

**4. Eyepiece.**—The eyepiece serves primarily as a magnifying glass that is used to examine the real image formed by the objective. The simpler type of eyepiece is made with a large collective, or field, lens (the lens nearer the object) that bends the ray pencils from the objective toward the axis without greatly altering the convergence or divergence of the rays in the individual pencils. Above the field lens, and at some distance from it, is a second and much smaller lens, called the eye lens, which converts each ray pencil into a parallel or only slightly diverging ray system that can be focused by the eye. After emerging from the eye lens, all these pencils pass through a small circular area called the eyepoint, or the Ramsden circle. This area is the image that the eyepiece forms of the objective aperture. The eye of the observer should be placed at the Ramsden circle in order to obtain the largest field of view and the maximum brightness over that field.

The magnification of the microscope may be computed from the diameter of the Ramsden circle $d$ in millimetres and the numerical aperture (N.A.) of the objective by the formula $M = \text{N.A.} \times 500/d$. When $d$ is less than the diameter of the pupil of the observer's eye, the illuminance (illumination) of the retina, on which subjective brightness of the image depends, is proportional to the square of $d$ and is therefore inversely proportional to the square of the magnification. On the other hand, when $d$ is larger than the diameter of the eye pupil, its value has no effect on the subjective brightness of the image. The magnification at which the value of $d$ is just equal to the diameter of the eye pupil is called the normal magnification. It provides maximum resolving power without loss of brightness.



A B

FIG. 8.—SIMPLE EYEPIECES (A) HUYGENS, (B) COMPENSATING

*Huygens.*—The Huygens eyepiece (fig. 8[A]) is the commonest type of eyepiece used with the microscope. It consists of a plano-convex collective lens and a plano-convex eye lens. The curved side of these lenses faces the objective. The focal length of the collective is about three times that of the eye lens, and the separation between the two lenses is roughly twice the focal length of the eye lens.

*Compensating.*—The compensating eyepiece is used to correct, or compensate, the colour difference of magnification that exists in all high-power achromatic and apochromatic objectives. The achromatic quality of these objectives applies only to the position of the images formed with light of different colours. No matter how well designers have been able to correct objectives for chromatic aberration, they have been unable to eliminate a difference in magnification that is due to the wave length of light; consequently, when such objectives are used with the Huygens or any other achromatic eyepiece objects near the edge of the field are fringed with colour. By making the eye lens of the eyepiece a compound lens consisting of a crown and a flint element, this colour fringe can be eliminated. The distance from the eye lens to the eyepoint of this eyepiece is relatively small. It becomes extremely small when made in high powers; *i.e.*, above 10×.

Another form of compensating eyepiece, called the orthoscopic, consists of a single lens and a cemented triplet (fig. 8[B]). For comparable focal lengths, the orthoscopic eyepiece provides a considerably longer eye distance than does the Huygens eyepiece. Since it also compensates any chromatic difference of magnification, most compensating eyepieces of powers higher than 10× are of this form.

*Ramsden and Kellner.*—The Ramsden eyepiece (fig. 9[A]) consists of two plano-convex lenses mounted with their curved surfaces facing each other. In order to make the working distance (distance from collective lens to focal plane) assume a practically useful value, the lenses are mounted closer together than they should be for complete achromatization (correction of chromatic aberration), and even then their eye distances are uncomfortably short.

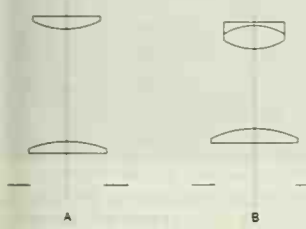



FIG. 9.—POSITIVE MICROSCOPE EYEPIECES: (A) RAMSDEN; (B) KELLNER

By using a collective lens of longer focal length and achromatizing the eye lens, Kellner succeeded in producing an eyepiece that has longer eye distance and better achromatization. (*See* fig. 9[B].)

*Location of Lower Focal Plane.*—Eyepieces are classed as positive or negative according to the location of their lower focal plane. Eyepieces are called positive if this focal plane is external to the lens system and negative if it lies within the lens system. Huygens eyepieces are of the negative type while Ramsden, Kellner and orthoscopic eyepieces are of the positive type. Huygens eyepieces are frequently used for making measurements of the linear dimensions of objects by mounting a micrometer scale in the focal plane of the eye lens. This plane, while not identical with the lower focal plane of the eyepiece, is not far from it and also lies between the two lenses of the eyepiece. As a consequence the image is subjected to some geometric distortion due to the collective lens of the eyepiece but the micrometer scale lying above it is not distorted. Measurements made under such conditions are more or less in error depending on how large a part of this field of view they cover. Positive eyepieces having their lower focal plane external to both lenses are not subject to this error, for both image and scale are subjected equally to whatever distortion the eyepiece may cause, and they are therefore preferred for use with micrometer scales.

**5. Condensers.**—The objects studied with the microscope are extremely small and the quantity of light falling on them from windows or lamps is totally inadequate. To overcome this lack of illumination, lens systems quite similar to objectives are placed beneath the object stage. These are called substage condensers, and their purpose is to concentrate light on the object so that it can be seen against a bright background, or field. The condenser should furnish a cone of light of the maximum angular extent that the objective is capable of receiving.

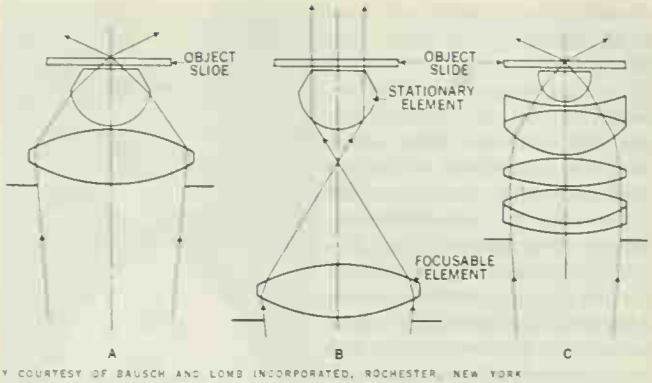



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FIG. 10.—SUBSTAGE CONDENSERS: (A) ABBE; (B) VARIABLE FOCUS; (C) ACHROMATIC

The Abbe condenser (fig. 10[A]) is a 1.25 N.A. condenser that utilizes only two lenses. Because of its simplicity and good light-gathering ability it is extensively used for general microscopy. It is not well corrected for aberrations but it serves very well for general visual observations. To obtain greater illuminated field coverage, a modified Abbe condenser called a variable focus condenser is sometimes used. The lower element, when focused downward, as indicated in fig. 10(B), brings light to a focus between the elements and illuminates a large field on the object slide. When the lower element is focused upward, it becomes a conventional Abbe condenser.

For research microscopy and colour photomicrography a more highly corrected condenser, such as the achromatic condenser (fig. 10[C]), is generally required. This is normally a 1.40 N.A. condenser and is corrected for chromatic and spherical aberration.

## D. Image Formation

**1. Geometrical Aspects.**—The geometry of image formation in a light microscope is quite simple. It is easy to trace a group of rays from a single object point and find that they come more or less together in a region in the image space. It makes no difference how close two neighbouring object points are to each other; *i.e.*, as long as this distance is finite their images will be separated by a finite distance and two discrete images can be expected. This is found to be true until the distance between the object points becomes equal to half the wave length of light. They are then not distinguishable as two objects.

**2. Diffraction and Resolution.**—Since light has wavelike properties, the explanation of image formation by rays is only a convenient approximation that overlooks diffraction phenomena that are inevitable in the propagation of waves. It is diffraction that limits the resolving power of any well-designed optical system. Because of diffraction, the image of a point object can never be a point but at best is a small circular spot of light surrounded by faint circular bands (fig. 6[A]). The central spot that contains most of the light flux is called the Airy disk after Sir George B. Airy, who computed its size and the distribution of intensity within and around it. The radius $h'$ of the Airy disk determines the smallest resolvable separation of the images of two object points. The corresponding least resolvable separation $h$ in the object is $h = 0.61\ \lambda/n \sin u$, where $\lambda$ is the wave length of the light and $n \sin u$ is the numerical aperture.

The above formula indicates that three variables may be adjusted to reduce the least resolvable separation $h$. The wave length $\lambda$ may be reduced, the refractive index $n$ may be increased and the angle $u$ that the objective can accept may be increased.

The wave length $\lambda$ may be reduced by using selective filters to isolate the short wave length end of the spectrum; *i.e.*, the blue and violet region. This effect may be extended still further into the ultraviolet region, but here special optics and special techniques are required since it is not possible to see the image

directly (*i.e.*, with the eye) and furthermore optical glass does not transmit very far into the ultraviolet region. Since optical materials that do transmit into the ultraviolet are quite expensive, the ultraviolet objectives most commonly used are reflecting systems or combined reflecting-refracting systems of the general construction shown in fig. 11. For the image to be made visible, wave-length conversion techniques such as photography, fluorescence or flying-spot electronic scanning are required.

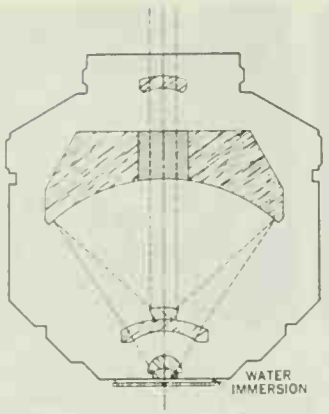


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FIG. 11.—COMBINED REFLECTING-REFRACTING MICROSCOPE OBJECTIVE

Within the limits of the visible spectrum, resolution can be improved by increasing the angle $u$ toward the theoretical maximum of 90°. Apochromatic objectives of 0.95 N.A. represent about the practical limit to which the angle $u$ can be pushed. Beyond this, further gain in resolution is achieved by the use of immersion objectives in which a fluid is used between the object slide and the front lens of the objective. The immersion fluid is normally oil ($n = 1.52$), although water ($n = 1.33$) and monobromonaphthalene ($n = 1.66$) have been used to some extent. Objectives as high as 1.60 N.A. have been produced for use with monobromonaphthalene but the practicable limit with oil as the immersion fluid is about 1.40 N.A.

**3. Equivalence Theory.**—The original diffraction theory of image formation, as applied to microscopes, assumes that the object is self-luminous. In 1873 Abbe developed a theory for microscopes in which the object was not considered self-luminous but served to diffract the light passing through it. He studied the diffraction patterns in the second focal plane of the objective experimentally and verified many conclusions of his theory. For many years there was considerable disagreement as to whether the older theory for self-luminous objects is applicable to nonself-luminous objects. It was finally established that, while the two theories are not generally equivalent, nevertheless, with the wide-angle illumination normally employed in microscopy, Abbe's theory for images of non-self-luminous objects is equivalent to the older theory for self-luminous objects.

**4. Magnification.**—To make fine detail visible, something more than resolving power is necessary; the image must be magnified enough so that the detail is visible to the eye. The basis for calculating how much magnification will be necessary to see detail of a given degree of fineness lies in the resolving power of the eye, which in angular measure is about one minute of arc; this corresponds to about 350 lines per inch at a viewing distance of ten inches.

If, in the resolution equation $h = 0.61\ \lambda/n \sin u$, 0.5 is used instead of 0.61, $\lambda$ is assumed to be 0.0005 mm. (the wave length of blue-green light) and $n \sin u$ (N.A.) is assumed to equal 1.00, then $h = 0.00025$ mm., corresponding to 100,000 lines per inch. This is really somewhat too high for ordinary conditions of light microscopy, but it is a convenient figure to remember. The resolution of any light microscope objective may be said to equal 100,000 lines per inch multiplied by the N.A.

The best the eye can do, however, is to resolve 350 lines per inch, so for the 1.00 N.A. objective the microscope must provide a magnification of 100,000/350 or 286×. The eye cannot work at the limit of its powers for long without serious fatigue, hence it is desirable to supply more magnification than the minimum required.

A reasonable rule is to make the magnification 750 times the N.A. Even this can be exceeded in some types of material with profit, but it should always be the rule to employ the lowest magnification that permits comfortable seeing, for excessive magnification produces images of lower brilliance and poorer definition, with the result that the amount of object detail that can be seen is frequently reduced.

**5. Phase Contrast.**—Details within a normal microscopic object are seen because they have regions of varying density. In normal bright-field illumination (*i.e.*, with a strongly lighted background) a completely transparent specimen is very difficult to see in any detail. Dark-field illumination (*i.e.*, with a dark background) on such a specimen shows up border effects because of edge scattering and diffraction but shows little detail otherwise. Another method of observation, known as phase contrast microscopy, is of considerable value in viewing transparent media since it makes visible details that cannot be seen within such media by normal methods.

The refractive index of a transparent object, such as a live cell in a fluid medium, varies only slightly from point to point. These index variations give rise to diffraction spectra in the rear focal plane of the objective. The waves diffracted by irregularities in the object are a quarter wave out of phase with the undiffracted waves that pass through the surrounding areas. In the phase contrast method developed by Zernike, a shift of a quarter wave is introduced artificially in the undiffracted waves to cause a field contrast that is due to interference with the diffracted light. Either dark-field or bright-field contrast can be obtained (*see* fig. 12), depending on the direction of the quarter wave phase shift.

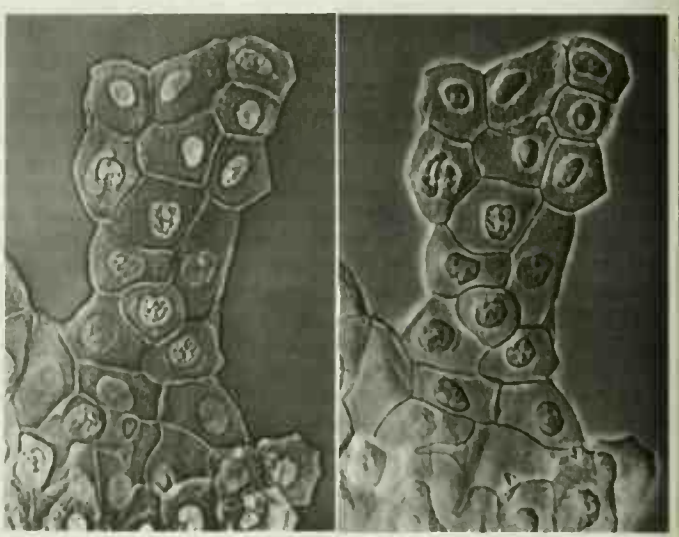

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FIG. 12.—UNSTAINED MICROSCOPE PHASE CONTRAST IMAGES OF EPITHELIAL CELLS FROM FROG NICTITATING MEMBRANE. AT FULL APERTURE, MAGNIFICATION ABOUT 240 ×: (LEFT) BRIGHT CONTRAST; (RIGHT) DARK CONTRAST

A typical arrangement for producing phase contrast imagery is shown in fig. 13. An annular diaphragm in the focal plane of the condenser is imaged at infinity by the condenser and then reimaged by the objective in its rear focal plane. An annular phase-shifting element is placed in this rear focal plane, where it is superimposed on the image of the annular substage diaphragm. All the light energy that is not diffracted by index gradients in the transparent specimen passes through the phase-shifting element, as indicated by the solid line rays in fig. 13, acquiring a quarter wave shift with reference to the diffracted energy (broken lines), some of which misses the phase-shifting annulus. Also, to render the diffracted and undiffracted portions more nearly equal in order to provide maximum contrast, an absorbing layer is added to the phase-shifting annulus. The end effect of these two changes in the undiffracted portion of the beam is to simulate intensity distribution that could have been produced by density gradations rather than index gradations.

### E. Illumination

Objects may be illuminated by transmitted or by incident light, and in either case it is possible to cause the object to appear dark against a bright background or bright against a dark background. Several kinds of illuminators and illuminants are required to produce the different types of illumination.

**1. Transmitted Light.**—Most microscopy is done with trans-

mitted light obtained from either natural or artificial sources. Many kinds of electric lamps, ranging from a 15-watt light bulb to a small carbon arc, may be used. If an artificial source is employed, it is nearly always mounted in a housing of some sort with optical aids such as collective lenses and ground glass disks to provide an illuminating beam of the character best suited to the purpose.

If the objective in use is low in power (*i.e.*, less than 10×) and low in N.A. (*i.e.*, less than 0.10), a concave mirror can be used with an extended light source such as the sky to give adequate illumination. Most microscopes, however, are equipped with higher-power objectives, and the concave mirror is incapable of delivering an illuminating cone of light of sufficient angular aperture to fill such objectives with light. In such cases the substage condenser is used with a plane mirror. The condenser must be brought into alignment with the optical axis of the microscope; for this purpose the better microscopes are provided with centring screws. If the condenser is equipped with an iris diaphragm, it is possible to employ narrow-cone oblique illumination by rotating the diaphragm and shifting it laterally.

The condenser should be of sufficient N.A. to attain the highest limits of the most powerful objective on the microscope. Since the focal length of the condenser determines the size of the image of the light source that it projects into the plane of the object, the focal length should be small in order to avoid the necessity of making the condenser inconveniently large. The field of view of the microscope is so small when used with high-power objectives that it is quite possible for a short-focus condenser to fill the field with light; but when low-power objectives are used, the field of view is so large that it can no longer be covered with the short-focus condenser, and to meet this situation the condenser may be made divisible so that part of it may be removed, leaving the rest of it to function as a condenser of longer focal length and lower N.A., as described above. The variable focus condenser (fig. 10[B]) is a more convenient means of achieving the same end.

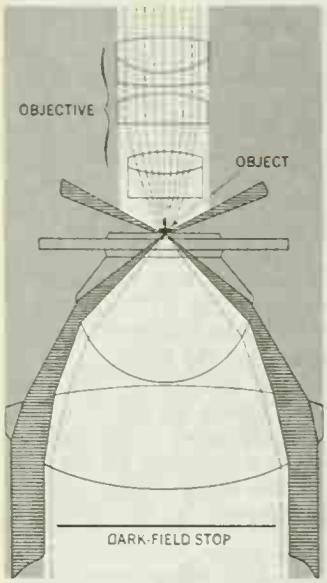


FIG. 14.—ABBE CONDENSER

When objectives of the immersion variety are used, the substage condenser should be immersed and precisely focused if full advantage of the high N.A. objective is to be secured.

*Dark-Field Illumination.*—The principle of dark-field illumination is to illuminate the object with a hollow cone of light, no part of which will pass directly into the objective. The object must lie at the apex of this cone, where it will receive light and deflect and reflect some of the light into the objective. This results in objects appearing bright against a black background. The Abbe condenser may be used with a central stop to obtain dark-field illumination (fig. 14), but it is not corrected well enough to produce a cleanly limited hollow cone of light with a sufficiently high concentration of light on the object.

The best dark-field illuminator is one that is corrected for spherical and chromatic aberration and also fulfills the sine condition. A reflector whose surface is a paraboloid of revolution has no spherical aberration for an infinitely distant object or image and is therefore used in dark-field illumination. Only a small annular section is used to reflect a strong conical beam of light to the object as shown in fig. 15.

The spot of light is very intense, but because of lack of fulfillment of the sine condition the paraboloid is less satisfactory than the cardioid condenser. The cardioid is not a true cardioid but is a pair of spherical surfaces arranged as shown in fig. 16 to reduce spherical aberration to a minimum and to obey the sine condition reasonably well. This condenser is used for critical dark-field work, such as the study of colloids, because the more concentrated light makes visible ultramicroscopic particles that are not made visible by the paraboloid condenser.

*Polarized Light.*—When a Nicol's prism or other polarizing apparatus is placed between the mirror and the condenser, the object can be illuminated by a cone of light in which all the waves vibrate parallel to one direction. If the object has any properties that cause it to modify the state of polarization of the light coming through the polarizer and condenser, these modifications can be observed, provided a second polarizing prism (analyzer) is used in conjunction with the eyepiece.

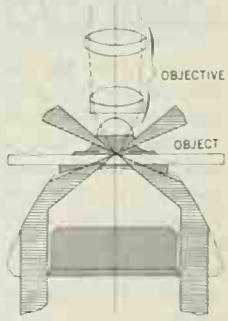


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FIG. 15.—PARABOLOID CONDENSER

If the analyzer is set with its polarizing axis at right angles to that of the polarizer, no light should be seen in the eyepiece, unless portions of the object have the power of modifying the state of polarization of the illuminating beam. For the complete examination of an object with polarized light, it is necessary to be able to rotate the polarizer and analyzer together while keeping the object at rest, or else to rotate the object between the stationary polarizing prisms. It is also necessary to be able to rotate one of the prisms relative to the other. Accessories of various types are used to examine the many kinds of objects that show polarization effects, such as fibres and crystals.

**2. Incident Light.**—Opaque objects are illuminated from the

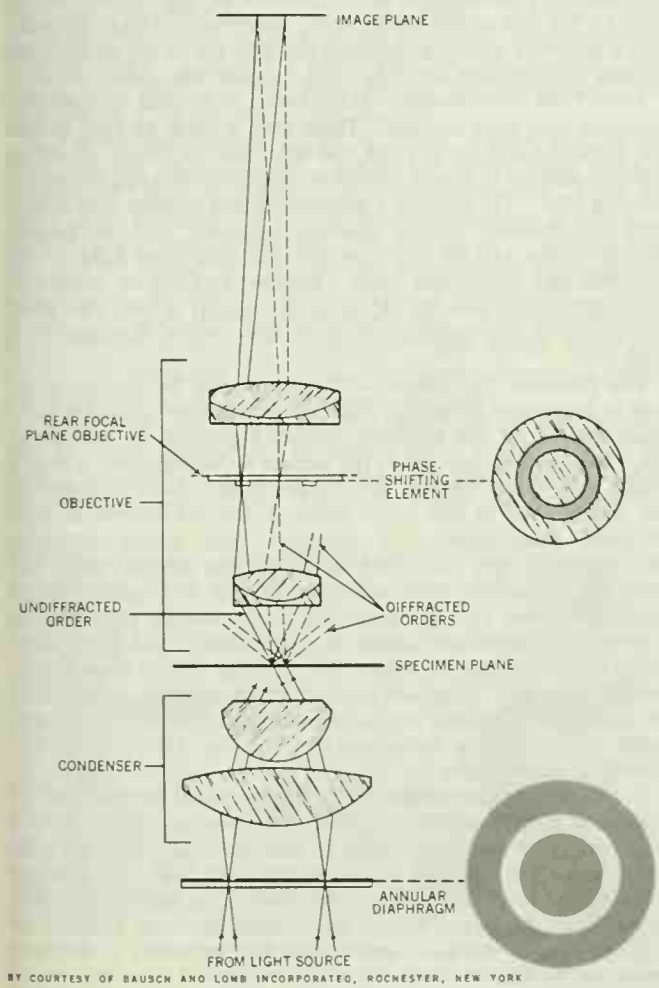


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FIG. 13.—OPTICAL SYSTEM FOR PRODUCING PHASE CONTRAST IN MICROSCOPE

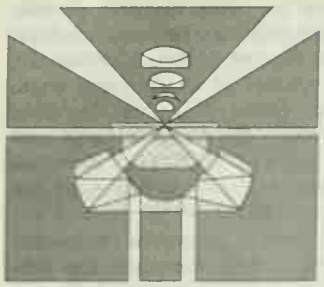


FIG. 16.—CARDIOID CONDENSER SHOWING PATHS OF LIGHT RAYS

objective side by one of three general methods: (1) bright-field illumination, (2) oblique illumination and (3) conical, or dark-field, illumination. For the most part specularly reflecting objects are illuminated with vertical illumination. Rough objects are often illuminated obliquely.

*Vertical Illumination.*—This is accomplished with a vertical illuminator (fig. 17), which is a device located between the objective and the eyepiece; the illuminator contains a plane glass reflector that reflects light from a source at the side of the microscope through the objective onto the object and also transmits light from the object to the eyepiece. The objective of the microscope acts as a condenser for the light going to the object, converging light onto the specimen under an angle equivalent to the numerical aperture of the objective.

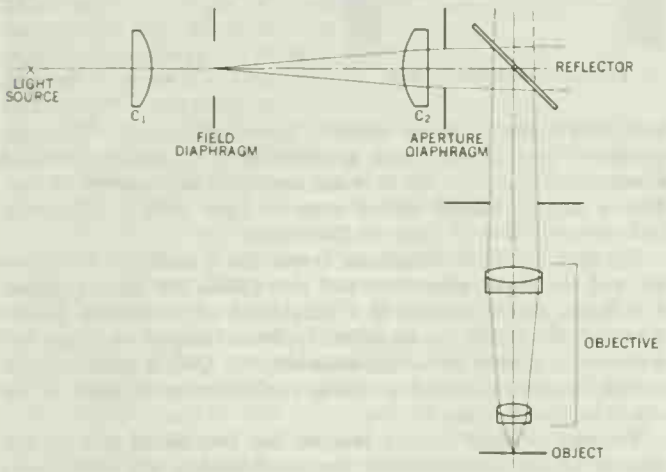



FIG. 17.—VERTICAL ILLUMINATOR (*see* TEXT)

Such illuminators are provided with both an aperture diaphragm and a field diaphragm so that both the quantity of light reaching the specimen and the size of the illuminated area can be controlled. The plane glass reflector of the modern vertical illuminator is given a coating of zinc sulfide, which, because of its higher index of refraction, provides a higher reflectance than uncoated glass.

In 1938 L. V. Foster showed that a vertical illuminator that employs polarized light increases the light incident on the object up to 50% (fig. 18). Such a device is especially useful for examining metal specimens.

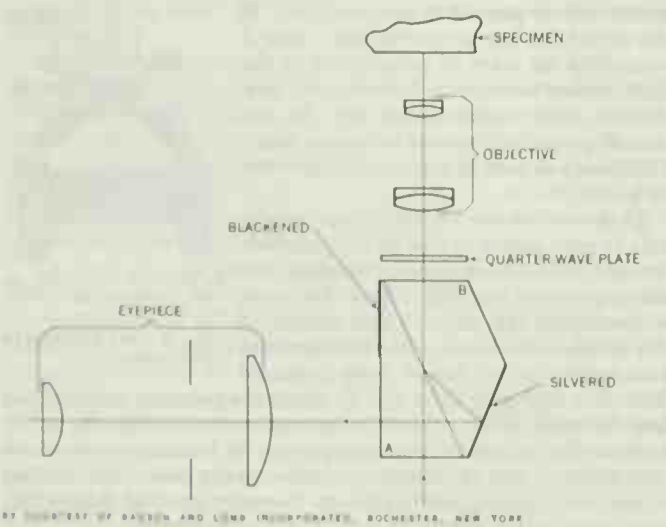



FIG. 18.—POLARIZING VERTICAL ILLUMINATOR WITH QUARTER-WAVE PLATE (*see* TEXT)

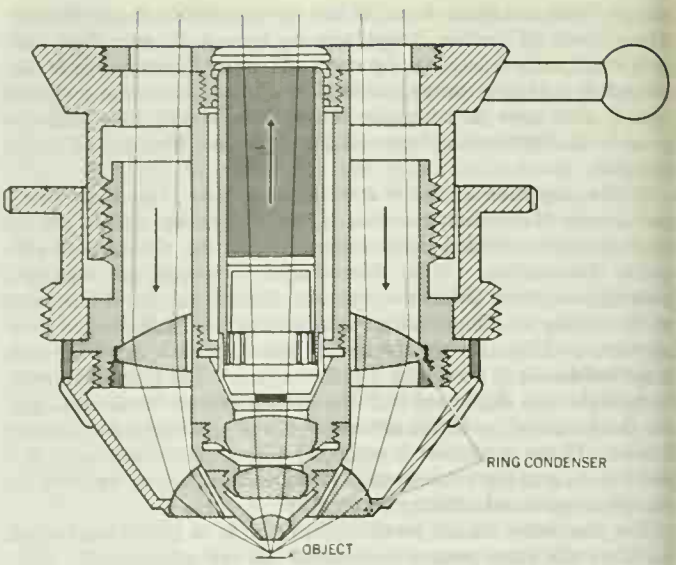



FIG. 19.—LEITZ ULTROPAK

*Oblique Illumination.*—The vertical illuminator usually has provision for introducing a small right-angle prism over half the aperture of the objective as a substitute for the plane glass reflector. This permits oblique illumination of an opaque object and also allows a great increase in the quantity of light incident on the object. For low-power (long-focus) objectives, oblique illumination is generally obtained by letting the light fall on the object from a lamp so stationed that the light reaches the object directly.

*Dark-Field Illumination.*—Many forms of annular incident illumination have been devised. These send a beam of light around the objective and focus it on the specimen by means of strong aspheric mirrors or strong condenser lenses surrounding the objective (fig. 19). The result is a negative of that secured with bright-field illumination; *i.e.*, the specular reflecting surfaces perpendicular to the axis of the objective will reflect no light to the objective and will appear black. Inclined surfaces or rough surfaces reflect light into the objective and appear bright; this effect is opposite to that obtained when strictly vertical illumination is used.

*The Inverted Microscope.*—The microscope for opaque materials is frequently inverted. Such an arrangement provides automatic leveling of the specimen surface regardless of whether or not it has parallel faces, since the surface to be examined is simply placed face down on the microscope stage. Such microscopes are widely used in the metal industry and are known as metallurgical microscopes. If provided with means for photomicrography they are called metallographic microscopes. The latter are frequently large and complex with (1) built-in spring shock absorbers that stabilize the image during photography, (2) viewing projection screens for comfortable prolonged viewing of the image and (3) means for changing rapidly from bright-field to dark-field, polarized light or phase contrast observation. An intense light source, such as an automatic carbon arc, is normally built into the equipment. (*See* also METALLOGRAPHY: *Optical Metallography.*)

**3. Photomicrography.**—If the microscope is focused upward slightly from the position employed for visual use it will form a real image that can be recorded on photographic film. No additional lenses are required, but a camera body with provision for checking the focus and a shutter for controlling the exposure time is desirable. Improved images are obtained by using a projection eyepiece that is designed specifically for projecting a flat, real image on the film.

(*See* also PHOTOGRAPHY: *Scientific and Applied Photography: Photomicrography*). (J. VK.)

### F. Use of the Light Microscope

The science of using the microscope is known as microscopy. In order to become proficient in the use of the microscope it is necessary to work with the instrument frequently. Knowledge as to the nature of the object to be viewed is especially important when using transmitted light, or transillumination. For example, a fibre such as a single nylon thread or a human hair, when examined with light passing through the fibre, may look either like two opaque fibres separated by a bright line or like a single bright line. The reason for examining such an object also must be considered, for it might be more desirable to look for surface effects than for internal structure.

**1. Resolution.**—The significance of N.A. (see *Diffraction and Resolution*, above) is its use as a measure of the resolving power of a microscope. A 10× objective of N.A. 0.25 is capable of separating into recognizable detail two objects separated by a distance of 0.001 mm. This resolution is possible only under very ideal conditions and with skilled use of the microscope. It is impossible to see detail finer than 0.001 mm. with an objective of N.A. 0.25. If object detail of this size is resolved, it must be magnified large enough for the eye to see it. A total magnification of 100× can be secured with the 10× objective and 10× eyepiece so that this detail will appear to the eye to be 0.1 mm. The unaided eye can easily distinguish detail of this size, for the eye has a resolution of about 1 to 1½ minutes of arc.

An angle of 1 minute of arc at the eye is equal to 0.07 mm. at a distance of ten inches from the eye. A simple way for the microscopist to test his acuity or resolution is to look at a printed page, a halftone or some other object whose size can be measured. The object is then placed far enough away so that the detail cannot be seen. The microscopist moves closer to the object and, when the detail is just perceptible, he measures the distance from the eye to the object and calculates the angle. By continual use of the microscope and attempts to see fine detail, it is possible to improve acuity. If acuity is low, higher eyepiece magnifications can be used until the total magnification becomes about 1,000 times the N.A. of the objective in use.

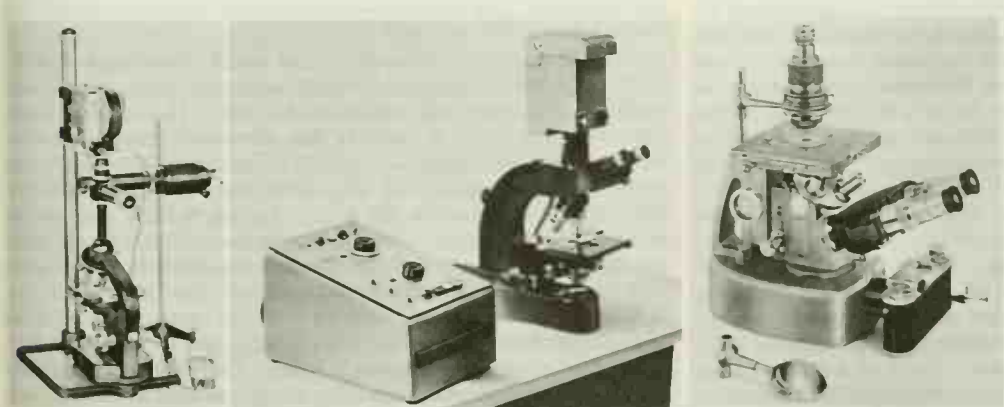
**2. Transillumination.**—Thin layers of objects such as organic material are translucent. When they absorb some parts of the spectrum more than others, they appear coloured. If an object is to be examined for the purpose of learning its structure it must be illuminated by sending light through it. Transillumination is made possible by the substage condenser and a source of illumination. An electric light bulb frosted on the inside is suitable for most work in bright-field microscopy. Special microscope lamps, which consist of a concentrated light source, lamp condenser, iris diaphragm and filters, are desirable for many special problems confronting the advanced microscopist.

Transillumination is used in such procedures as the examination of tissue sections and in making blood counts. Since the objects are extremely thin and for the most part transparent, they are usually stained to make them more visible. They are always mounted on slides and protected by a cover glass. The standard slide is 1.5 mm. thick and the standard cover glass is 0.18 mm. thick. (*See* also Anatomy, Microscopic; Histology.) The light source, whether a simple lamp bulb or a professional type of lamp, should be placed about ten inches in front of the base of the microscope and the substage mirror aimed to send light through the condenser and objective. The alignment can be tested by looking through the microscope tube without the eyepiece. The microscope should be raised or lowered by the focusing adjustments until the back lens of the objective is seen filled with light. This observation and adjustment is best made with the 10× objective. If the lens cannot be made to appear bright by focusing, the substage mirror should be tipped. If light appears but the size of the spot is very small, the substage condenser should be raised by its focusing adjustment. When the lens of the objective is bright, an eyepiece should be placed in the microscope tube and slowly focused on the object. The beginner should make certain that the object is under the objective and that it has a number of opaque areas within it. The object cannot be seen unless it contains opaque areas. Prepared slides for practice and study can be purchased. A favorite subject for examination by beginners is the flea, whose legs, head and many other body parts can be seen comparatively easily because of their size and contrast.

After the 10× objective has been used with success, the objective of next higher power should be swung into place and focused on the same object. The object will be found nearly in focus and only a small amount of adjustment of the fine-focus knob will be necessary.

Objects such as blood smears and weakly stained tissue sections display very weak contrast and require other attention to illumination. The brightness of the field can be made so great that the detail in the object is flooded; this often occurs when high-power objectives are used. The contrast can be governed somewhat by using the substage iris diaphragm. The size of the diaphragm should be reduced until about one-third of the aperture of the objective is illuminated when viewed without the eyepiece. If the object is discernible and is not fringed with diffraction lines, the microscope should be left at this setting.

A great deal can be learned about illumination and its effects by examining regular periodic structures, such as the skeletons of diatoms. The skilled microscopist uses diatoms to improve his acuity, to test his microscope optics and to learn how to use his instrument most effectively. A diatom is a unicellular plant whose protoplasm is contained within a delicate silica network. Mounted diatoms, which can be purchased, have been treated so that only the silica skeleton remains. *Pleurosigma angulatum* is a diatom well suited for microscopy practice and for testing illumination with a medium-power objective (*e.g.*, 43×). If the objective is well corrected and has an N.A. of 0.65 or 0.85 it will be possible to see an array of tiny hexagons. After the microscope is focused on the edge of some tear in the diatom, the substage iris diaphragm is closed to its smallest opening and the microscopist looks down at the rear lens of the objective with the eyepiece removed. There should be visible an image of the small iris at the centre of the lens and six moonlike images of the iris at the edge of the lens. These six images are diffraction images of the iris caused by the periodic structure of the diatom. Unless these six images are present the hexagonal structure cannot be seen. The microscopist gradually opens the diaphragm until the six diffraction images and the central image merge. He replaces the eyepiece, and the hexagonal structure is clearly evident.



BY COURTESY OF (LEFT) WILD HEERBRUGG INSTRUMENTS, INC.; (CENTRE) E. LEITZ, INC.; (RIGHT) UNITRON INSTRUMENT CO.

FIG. 20.—OPTICAL MICROSCOPES USED IN PHOTOMICROGRAPHY: (LEFT) MONOCULAR INSTRUMENT USED WITH MOTION PICTURE FILM; (CENTRE) MONOCULAR INSTRUMENT WITH AUTOMATIC EXPOSURE CONTROL; (RIGHT) INVERTED BINOCULAR INSTRUMENT WITH LIGHT SOURCE AT TOP

A diatom that tests the optics of the best microscope and the technique of the most skilled microscopist is *Amphipleura pellucida;* it can be used to test an apochromatic oil-immersion objective used with an achromatic aplanatic substage condenser. In order to see the dots, which are about 0.00025 mm. in diameter, it is necessary to use illumination that makes an angle of about 45° with the structure. This illumination can be checked by viewing without the eyepiece in the manner described above. The angle of illumination should be adjusted so that two diffraction images of the iris diaphragm are apparent on the side of the lens opposite the bright image of the iris diaphragm. If a small iris diaphragm is used, either on axis or off, a source of bright light is essential. Under such conditions, filters can be used to control the wave length of light used.

**3. Micrometry.**—Microscopic objects can be measured linearly by using a filar micrometer in place of the regular eyepiece. Before such a measurement is made, the scale of the filar micrometer must be calibrated with a stage micrometer or some other known object. Stage micrometers accurate to 0.1$\mu$ are available and should be used if the measurements are to be relied upon. The stage micrometer is ruled on a 1 × 3-in. slide over a length of 2 mm. in intervals of 0.01 mm. It is advisable to calibrate all objectives at one time. The filar micrometer is then placed in the microscope and clamped in position. The stage micrometer is focused with the lowest power objective available, and the ruled area is brought to the centre of the field. The movable line of the filar micrometer is moved to the left side of the field and made parallel with the lines on the stage micrometer. The drum of the filar micrometer is turned until the movable line coincides with a chosen line of the stage micrometer. After settings and readings become consistent, a record is made of them. In making settings, the drum should be rotated in the same direction for all readings in order to avoid error-causing backlash that may exist in the screw. A setting on a line in the stage micrometer about 1 mm. to the right of the first should then be made. A reading for 1 mm. of the stage micrometer might be 10.53 and would give a factor of $\frac{1}{10.53}$, or 0.09496. This is the factor that would always be used with this objective and filar micrometer when converting to the actual size of an object. That is, if an object measured 4.25 filar micrometer units, its actual size would be 4.25 × 0.09496 or 0.4036 mm. Some measurements do not require the precision of a filar micrometer. A regular eyepiece can be equipped with a micrometer disk and, after being calibrated, can be used for estimating object sizes.

**4. Binocular Microscopes.**—A monobjective microscope equipped with a binocular eyepiece has the advantage that both eyes are used to see the same object and thus there is no need to suppress the vision of one eye. Even when both eyes are used there is no depth, or stereoscopy. Stereoscopic effect can be secured only when different images are seen by the two eyes. These two images can be provided in a monobjective microscope by splitting the illuminating beam of light into two parts so that oblique beams pass through the object. These oblique beams are made to pass, one to the right eye and the other to the left eye, by the use of half-moon diaphragms over each eyepiece. These diaphragms should allow light coming through the inside halves of the exit pupils of the two eyepieces to pass to the eyes. If the outside halves of the pupils are used, the depth effect will be pseudoscopic. This method of providing depth perception in a microscope is fundamentally sound but is rarely used.

Low-power binocular microscopes made up of two separate microscopes are very practical and popular. Their magnifications range from 5× to more than 100×. The image is always erect in this type of microscope instead of being inverted, as in the monobjective microscope. Binocular microscopes of low power are used largely with gross objects where third-dimensional effect is as important as linear magnification. They do not require any substage accessories other than a mirror to reflect light around or through the object. Top illumination is usually adequate.

**5. Specimen Preparation.**—Dry material such as leaves, powders, sand and crystals can be laid on a 1 × 3 glass slide and retained in place with a cover glass. If the slide is to be a permanent preparation, the cover glass can be fastened to the slide with masking tape or by ringing the slide with paraffin or asphalt and attaching the cover glass to the ring; if the object is thick, the cover glass can be attached to a cardboard ring glued to the slide. The same material may be mounted by embedding, if the object is not soluble in the embedding material. Also, if the material is transparent, the index of refraction of the embedding material must be quite different from that of the object or the object will be hard to see without staining. For instance, a fly's wing can be mounted either dry or in balsam. If glass particles or pieces of sand are to be mounted, it is best to make a dry mount. To keep the particles from rolling around, a drop of albumen (egg white) can be placed on the slide. When small particles are dusted on a surface coated with albumen they will stick quite well.

Liquid mounts can be made easily but they tend to dry out in a few hours. A drop of pond water, for example, can be placed on a glass slide and covered with a cover glass. Examination will reveal paramecia, rotifers, vorticellae, stentors and possibly forms of algae.

**6. Ultramicroscopy.**—The ultramicroscope is a light microscope that is used to examine objects too small to be seen with a conventional light microscope. Particles are said to be ultramicroscopic when they are smaller than the wave length of light; *e.g.,* the small particles in a colloid such as colloidal gold. The ultramicroscope has three forms: (1) cardioid ultramicroscope; (2) slit ultramicroscope; and (3) dark-field illuminator.

Any microscope on which a cardioid condenser can be mounted can be used to see the ultramicroscopic particles in a colloid. The cardioid condenser is a substage accessory capable of concentrating a beam of light into a very small spot and under a high obliquity. This condenser provides a hollow cone of illumination whose N.A. varies from about 1.10 to more than 1.40. The objective used with this condenser must have an N.A. of less than 1.10 (it often is about 0.90) so that the amount of direct light that passes through the objective from extraneous field rays is held to a minimum. When the cardioid condenser and objective are adjusted and a sol is mounted in a chamber for examination, the colloidal particles receive a strong beam of illumination that cannot pass through the objective unless it is deflected by the particles. The particles thus appear as self-luminous objects against a dark background. Care must be taken in preparing the slide so that fat globules do not become attached to the slide or cover glass; such globules can cause scattered light to appear in the background. Slides and cover glasses may be kept clean by storing them in a solution made by dissolving 5 g. of cleansing powder in 100 ml. of water. When required, a slide and cover glass are removed from the solution and allowed to dry. They are then shined by wiping them with a clean piece of gauze or a clean, lintless towel. Special slides made in the form of chambers should be used for best results in ultramicroscopy. These slides are made from fused quartz, and their central part is lower than the ring support for the fused-quartz cover glass by about 0.001 to 0.002 mm. The fused-quartz slides and cover glasses can be cleaned in sulfuric acid and alcohol.

The slit ultramicroscope developed by H. Siedentopf and R. Zsigmondy makes use of an illumination system mounted at right angles to the optical axis of the microscope. The colloidal solution (or other fluid) is made to flow through a special chamber equipped with fused-quartz windows. The illumination beam can be rotated by an adjustable slit around the axis of an objective that is used to focus the slit at a reduction through one quartz window in the chamber. An arc lamp is focused on this slit, and the special objective is focused through the other quartz window into the sol. The slit can be made vertical when the microscope is focused on the beam of light as it passes through the solution and the thickness of the illuminated beam can be measured if a calibrated micrometer eyepiece is used. The examination of colloids with this instrument reveals various coloured starlike points and scintillating points of light. The reddish "stars" result from particles larger than the bluish stars. The scintillating "stars" are unsymmetrical.

The dark-field illuminator is a less exact form of the ultra-

hicroscope and is used to make small microorganisms visible. ince it gives less concentrated light in a thin and small spot, its djustment is less critical than the cardioid condenser and it does ot require quartz slides and covers. Material, such as a drop f saliva, can be placed on a clean slide and covered with a lean cover glass; if examined with an oil-immersion objective, t will reveal mouth bacteria and several forms of spirochetes. The objective must be equipped with either a funnel stop or an ris diaphragm to reduce its N.A. below that of the dark-field ondenser in order to make these objects appear bright against dark background.

**7. Phase Contrast.**—Until phase contrast methods were discovered, the microscopist had to fix and stain the cells and pathological sections he wished to examine. The nucleus of cells became dark when stained. It has been found that the index of refraction of a cell nucleus differs from that of the surrounding protoplasm. The phase microscope makes it possible to increase this difference and examine living cells and unstained tissue sections. Increasing the path difference causes invisible differences to appear as amplitude differences (*i.e.*, absorption, or contrast, differences). The phase contrast accessories consist of special objectives with phase plates in their apertures and a special substage condenser that regulates the illuminating cone of light so that it corresponds with the phase-shifting zone in the objective.

The object material is mounted unfixed and unstained on a slide and is covered with a cover glass. The phase contrast microscope is used in the regular manner with the added requirement that the illuminating annulus must fit tightly into the phase annulus in the back aperture of the objective. A focusing-tube microscope is supplied as an accessory and replaces the eyepiece temporarily while the condition of superposition is checked or adjusted. The substage condenser should be provided with a similar means for adjustment. The eyepiece can be replaced when the very slight phase difference in the object becomes outstandingly evident as an amplitude difference if the phase plate is correct and a phase difference exists in the object.

**8. Ultraviolet Microscopy.**—There are two chief advantages arising from the use of ultraviolet microscopy. First, resolution can be increased over light microscopy because of the shorter wave length, with the result that finer details can be seen than with the visible light microscope. Second, biological materials display increased differential absorption to various portions of the ultraviolet, a characteristic of importance to the biochemist and bacteriologist. Methods involving the use of ultraviolet radiations and quartz monochromatic objectives corrected for only one wave length in the ultraviolet are employed. Reflecting objectives with a low N.A. and catadioptric objectives with a high N.A. have been made that are achromatic over the visual and ultraviolet spectrum. A catadioptric objective is one that uses both mirrors and refracting lenses. The refracting lenses correct both the residual spherical aberration of the spherical mirrors and the chromatic errors of the quartz cover glass that is required to transmit the ultraviolet. The reflecting objectives are used with reflecting condensers of the same design.

The proper use of these optics requires an illumination system in which the wave length of the illuminating beam is known and can be controlled. Thus it is necessary to use a monochromator with wave-length calibration and a source rich in ultraviolet radiation. Since the eye cannot detect ultraviolet light but can be damaged by it, photography is used to record the image. Eyepieces used with ultraviolet optics are made of fused quartz or other material that transmits ultraviolet. Since the reflecting and catadioptric objectives are not affected by chromatic errors, they can be focused with visible light and photographs made without further adjustment.

The technique developed by J. E. Barnard brought ultraviolet microscopy into an important position in bacteriological research. Bacteria are almost uniformly transparent to visible light but are not transparent to certain regions of the ultraviolet spectrum. Bacteria either must be stained in order to be examined in visible light or they must be examined in phase-contrast or dark-field illumination. With ultraviolet illumination staining is unnecessary and the organisms can be photographed alive at various wave lengths.

**9. Opaque Microscopy.**—The science of metallurgy is concerned with the crystal structure of iron, steel and alloys. Special microscopes called metallurgical microscopes are used for examining the surface of metals. They differ from the biological microscope in their method of illuminating the object. Since metal specimens prepared for microscopic examination are opaque, the illumination must come from above by the vertical-illumination method. Most metallurgical microscopes are made inverted so that the metal specimen can be laid with its polished side down on a stage. The objective is beneath the stage and points upward through a hole in the stage; the image is brought into focus by moving the stage and object up and down with a rack and pinion.

The biological microscope can be used for examining opaque specimens by equipping it with a vertical illuminator and laying the metal specimen with its polished side up when the objective points down. The objectives used either on a metallurgical microscope or on a biological microscope with a vertical illuminator must be specially made for the purpose because the objects are not protected by a cover glass and the tube length is always quite different from that of the ordinary biological microscope. The vertical illuminator consists of (1) a thin flat plate of glass set at 45° to the axis of the objective and close to it on the image side; (2) a semicircular mirror; or (3) a Foster prism.

If the flat reflector is used it should be coated with antireflection film on one side and high-reflection film on the other. The high-reflection film should reflect 50% of the light while transmitting 50% in order to give best results. The semicircular mirror is sometimes replaced with a 45° reflecting prism that covers half of the aperture of the objective. (*See* also METALLOGRAPHY: *Optical Metallography.*)

The Foster prism is a calcite polarizing vertical illuminator that transmits and reflects plane-polarized light (*see* fig. 19). The plane of polarization of the transmitted beam is at right angles to the plane of polarization of the reflected beam. Thus if the polished metal specimen is specularly reflecting, no light will reach the eyepiece and the sample will appear black. A quarter-wave plate is placed between the prism and the objective with its axis 45° to the plane of polarization of the Foster prism. Since the light will pass through the quarter-wave plate twice, the plane-polarized light transmitted to the specimen will be circularly polarized. The light passes through the quarter-wave plate again on its return and becomes a plane-polarized beam but is rotated 90° to its original direction. Since the Foster prism reflects light polarized in this plane, the field of view will be bright. This type of illuminator provides bright-field illumination when the quarter-wave plate is used and polarized light illumination without the plate. Illumination by polarized light is used in testing for glassy inclusions, oxides and grain orientation. (L. V. F.)

### G. Chemical Microscopy

Chemical microscopy includes the microscopical techniques and problems with which chemists have to deal. It does not include the specialized subjects of biological microscopy, metallography and petrography, although chemists are often involved in work related to these fields and may borrow and adapt apparatus and preparative techniques from them. It overlaps the field of microchemistry, since it includes qualitative analytical reactions performed on a small scale (a drop or less of solution). In such analyses, the reagents may be those employed in ordinary qualitative analysis, with the advantage that group separation may be unnecessary because of the characteristic crystalline appearances of the precipitates obtained. Specific reagents that function in the presence of ordinarily interfering ions are also employed.

Crystalline substances may be identified by their microscopical properties, such as angle, refractive index and double refraction, which can be compared with tabulated data when available or with known samples. Solid derivatives of liquid or solid organic compounds can be utilized in the same way to supplement or confirm ordinary tests. Mixtures of solids can be separated into their components mechanically for further analysis or small particles

of contaminants can be collected. Often constituents of mixtures can be identified *in situ* under the microscope by optical means.

Quantitative microscopical analysis of mixtures is feasible when recognizably different components are present; analysis can be made by comparison with standard samples, by counting the particles of different kinds (*e.g.*, foods, drugs, papers, fabrics, ore concentrates) or by measuring the areas of the components on a sectioned mass (rocks, ceramics, alloys) to find the composition by volume. Such analyses are particularly valuable when the components are chemically similar or complex and when determination of elements would not directly reveal the amounts of the structural constituents present.

Microscopical studies of crystals are particularly useful in physical chemistry of the solid state (*e.g.*, in the study or determination of (1) melting and transition temperatures and ranges; (2) condensation of sublimates; (3) contact angles and wetting of surfaces; (4) mechanisms of transformations; (5) phases in polymorphism and systems of double salts, hydrates or reciprocal salt pairs; (6) factors governing formation and "digestion" of precipitates; (7) modifications of crystal shape by different solvents or other substances).

Microscopical examination is important in the study of particulate materials, especially those finer than the range of sieve tests (less than about 50$\mu$). The particles are usually far from uniform in size. Statistical analysis of the frequency of different sizes, rather than ordinary averaging, is essential for correlation with the performance of the material and is often greatly dependent on the total surface presented for the light scattering and colour (pigments), reactivity (ores, cement, sprays and dusts) or interfacial forces (flotation, emulsification).

The effects of physical condition on the appearance of coloured materials and the various kinds of structural colours shown by colourless substances are best investigated microscopically. Photometric measurements over the entire spectral range can be made with the microscope on small fields. Hardness can be determined quantitatively by measuring minute indentations produced under controlled conditions. The effects of temperature can be observed by means of heating or cooling chambers. Technical processes may be miniaturized or products may be examined at various stages of manufacture or service; such procedures are useful in studies of dyes, paints, rubber, plastics, adhesives, paper, ceramics, corrosion, abrasion and weathering.

Chemical microscopy often supplies unsought information, particularly in analysis or technology, and reveals physical conditions that may be more significant than chemical composition. It emphasizes rather than obscures the heterogeneity of materials and the resulting fact that in them different things happen at different places and at different times under a given treatment. Its direct visual approach often furnishes an independent attack on problems ranging from research to trouble shooting and may suggest more extensive investigations or clarify previous inquiries.

Although most work in chemical microscopy is done with light microscopes, the electron microscope is a valuable adjunct although its use is limited as regards sampling, preparation techniques and applicability to volatile or heated specimens. The electron microscope has greatly extended the knowledge of colloids derived from classic experiments with the ordinary microscope and ultramicroscope.

Microscopes equipped for use with polarized light (often called chemical microscopes) are valuable not only for determining the identifying optical properties of crystals but also for studying molecular orientation in complex polymers, tissues and other aggregates of submicroscopical crystallites. The observable changes in arrangement caused by growth or mechanical treatment (*e.g.*, the stretching of rubber or of nylon fibres after extrusion), chemical alterations (as in the nitration of cellulose fibres or tanning of leather) and the spontaneous alignment of large molecules to form liquid crystals (as in soaps) are potential evidence in the investigation of cryptocrystalline matter and the nature of some processes in biological growth. Many of the findings of X-ray diffraction studies in these fields are closely related to observations with the polarization microscope. (C. W. MA.)

## III. THE ELECTRON MICROSCOPE

### A. History

The development of the electron microscope was spectacular and rapid. In 15 years this instrument reached a degree of perfection

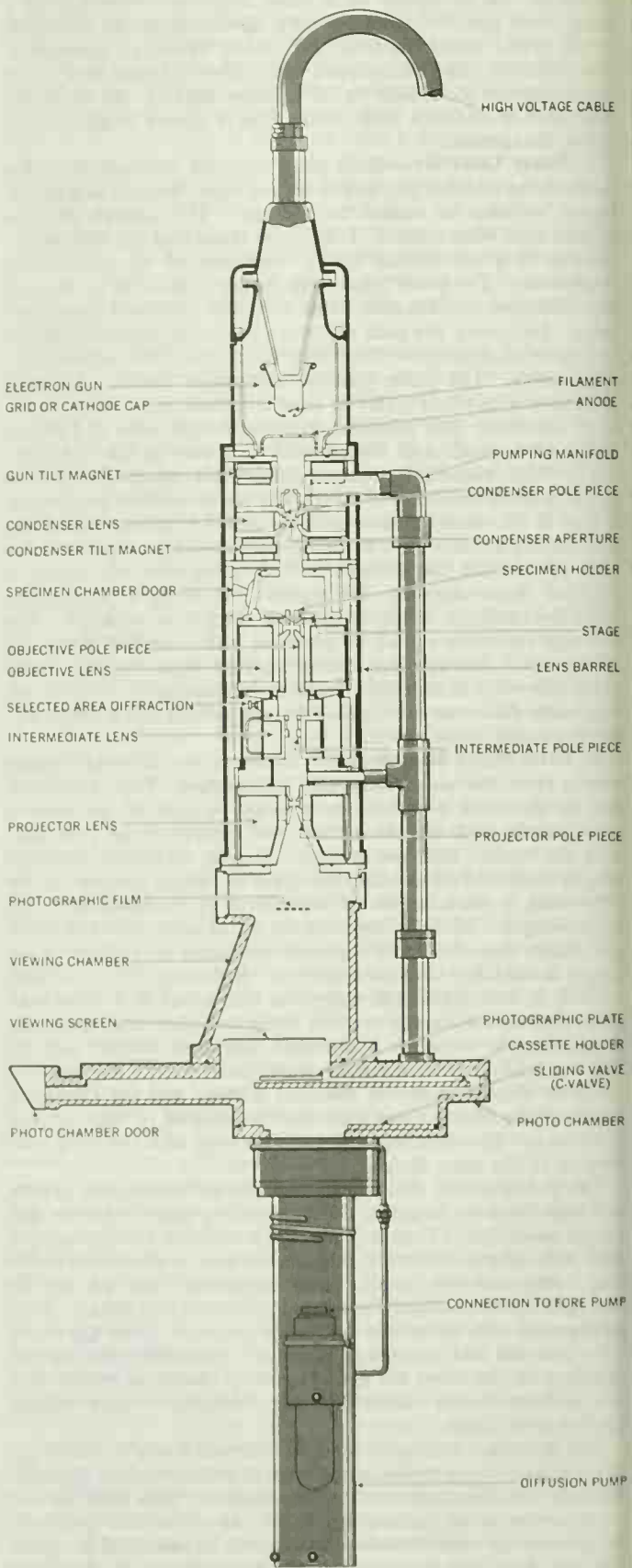



FIG. 21.—CROSS SECTION OF EMU 3 ELECTRON MICROSCOPE

comparable in many respects to that attained by the light microscope after nearly 300 years of development.

In 1924 Louis de Broglie (*see* BROGLIE) advanced his hypothesis that there was something of a wave nature associated with material particles, in particular with electrons. He derived a formula that showed that the wave length of an electron accelerated by a potential of 60,000 volts is 0.05 Å, or $\frac{1}{100,000}$ as long as the wave length of ordinary light. (*See* also ELECTRON DIFFRACTION.) In 1926 Erwin Schrödinger initiated the development of wave mechanics by recalling the analogy between mechanics and optics demonstrated by W. R. Hamilton in 1830 and by combining Hamilton's analogy with De Broglie's ideas. (*See* also QUANTUM MECHANICS: *Advent of True Quantum Mechanics.*)

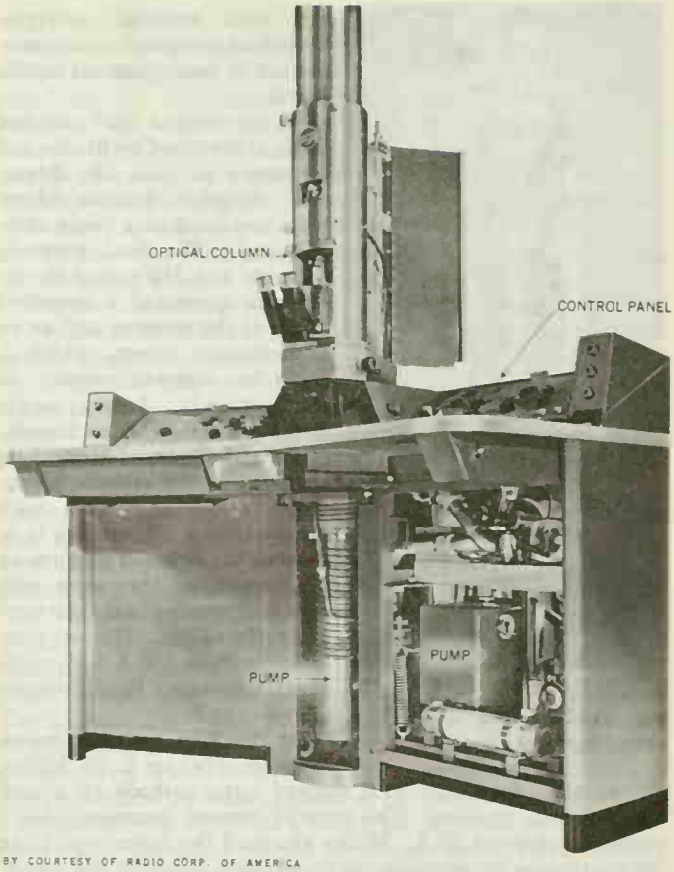
While Schrödinger had much of the information necessary for the development of an electron microscope, it was not until after the work of Hans Busch in Germany that the practical significance of this information became apparent. In 1926, after 15 years of intermittent work on the trajectories of electrons in magnetic fields, Busch published a theory stating that magnetic or electric fields possessing axial symmetry act as lenses for electrons or other charged particles. Busch's work thus called attention to an important practical aspect of the De Broglie and Schrödinger theories and initiated a new science of instrumentation that later became known as electron optics. In 1927 Busch experimentally verified his theory with a magnetic lens. It was not until 1931, however, that C. J. Davisson and C. J. Calbick in the U.S. reported corresponding verification on the lens properties of an axially symmetrical electric field.

In 1932 Ernst Brüche and H. Johannson in Germany produced images of a heated oxide cathode with an electron microscope system using electrostatic lenses and a 300-volt electron beam. In the same year M. Knoll and Ernst Ruska, also in Germany, constructed an electron microscope using short magnetic lenses and 60-kilovolt electrons and with it produced images of the electron source in a discharge tube. In 1932 Knoll and Ruska also stated that an electron microscope using high-velocity electrons should be capable of surpassing the resolving power of the light microscope by a large factor. By 1936 the emission-type electron microscope for the observation of various types of cathodes had reached a high degree of development.

The actual work on the development of the more generally useful transmission type of electron microscope for the observation of nonemitting substances, which was suggested by K. Rudenberg in 1931 in a German patent application, was started by Knoll and Ruska in 1932. In 1934 Ruska described the construction of a new electron microscope using magnetic lenses; this instrument was built specifically for attaining high resolution in the study of specimens by transmitted electrons. Shortly afterward, L. Marton in Belgium became the first to attempt to use the electron microscope with biological materials. Other work was being done at this time by L. C. Martin, R. V. Whelpton and D. H. Parnum in England.

None of these early instruments, however, provided resolutions surpassing that of the light microscope. But in 1935 E. Driest and H. O. Müller, working with Ruska's microscope, in which they had incorporated a number of changes suggested by Ruska, exceeded the resolution of the light microscope. The work on Ruska's microscope was continued by F. Krause, who obtained a number of electron micrographs of various materials. Krause also showed that if specimens were made sufficiently thin they were not destroyed by the electron beam, thus disproving an earlier belief that specimens must be stained in such a way that a "skeleton" outlining their form would be left after they were destroyed by the electron beam.

In the meantime, B. von Borries and Ruska were designing an improved magnetic electron microscope for the German firm of Siemens and Halske, and in 1938 they described a practical instrument for general laboratory use. In its early form, this instrument was capable of resolving details down to 100 Å. At the same time and independently of the work by Borries and Ruska, another practical magnetic electron microscope was designed in Toronto by A. Prebus and J. Hillier and described in 1939.




BY COURTESY OF RADIO CORP. OF AMERICA

FIG. 22.—ELECTRON MICROSCOPE, TYPE EMU 3

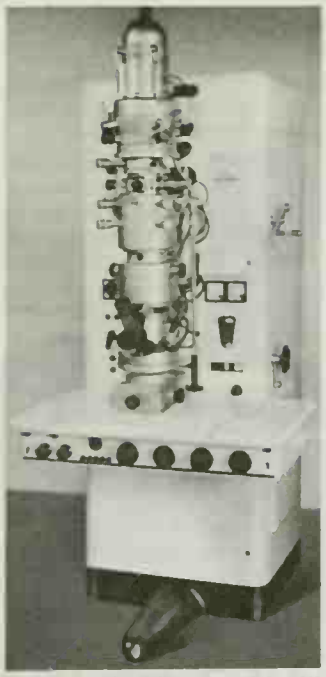
After these beginnings new electron microscopes were described in rapid succession. In 1939 Hans Mahl, working in the laboratories of the Allgemeine Elektrizitäts Gesellschaft in Berlin, produced an electron microscope of high resolving power by using electrostatic lenses. In the same year Marton designed a magnetic instrument for the Radio Corporation of America in which electronically regulated power supplies designed by A. W. Vance were used for the first time. Late in 1939 H. Boersch described his shadow-type electron microscope. In 1940 R.C.A. announced the development of a commercial electron microscope (*i.e.*, a type made in quantity for sale) designed by Hillier and Vance that was capable of a resolving power of around 24 Å. M. von Ardenne described an elaborate magnetic electron microscope that was capable of resolving 20 Å. Ruska and Borries had, in the meantime, improved the resolving power of the Siemens instrument to 22 Å.

In 1945 Hillier described a means for making a magnetic objective accurately symmetrical and achieved a resolving power of 10 Å. Refinements brought the resolving power of the leading commercial instruments to the range 5 to 10 Å, which is about the expected limit.

Fig. 21 shows a cross-sectional diagram of the optical column of a type EMU 3 electron microscope manufactured by the Radio Corporation of America; fig. 22 is a photograph of the same instrument showing the column, control panels and pumps. Fig. 23 is a photograph of an electron microscope manufactured by Siemens and Halske in Germany. Other electron microscopes are made in England, France, the Netherlands and Japan.

### B. Types of Electron Microscopes

**1. Emission.**—The first electron microscopes were of the emission type. In all emission electron microscopes, the object is the source of the electrons, although the instruments may use different kinds of sources and may be differentiated on this basis; *e.g.*, as thermionic emission, photoelectric emission, secondary emission



BY COURTESY OF SIEMENS AND HALSKE WEST BERLIN

FIG. 23.—ELECTRON MICROSCOPE, TYPE "ELMISKOP" 1

and field emission subtypes. Only those using thermionic emission are of much practical significance.

In its original and simplest form, as described by Brüche and Johannson in 1932, the thermionic emission electron microscope consisted of a single cathode lens. The final electrode potential was 750 v. and the instrument projected a magnified image of the emitting surface on a fluorescent screen, where it could be observed visually or photographed. Later instruments provided greater magnification and employed higher field strengths at the cathode to improve resolution. The main value of these instruments is in showing the emission patterns on the cathode as they vary with crystal structure, heat treatment and surface films. The best resolution is about 400 Å. (*See* also FIELD EMISSION: *Field Emission Microscopy.*)

In the field emission microscope invented by E. W. Müller, electrons are drawn out of a pointed metal cathode by a very high potential gradient. This type of electron microscope has a resolution of about 10 Å. Müller also used this instrument as an ion microscope by reversing the accelerating potential and admitting a trace of hydrogen or helium into the envelope. The gaseous atoms adsorb to the surface, where they lose their electrons, and the positively charged nuclei are pulled out by the applied field. The heavier mass of the nuclei increase the resolving power to about 2.7 Å. With this type of microscope, operated with helium, it is possible to see clearly the individual atoms in the metallic point.

**2. Transmission.**—The illuminating and image-forming systems of the transmission electron microscope, shown in fig. 24, are analogous to the components of a light microscope. Electrons emitted from the tip of a hot tungsten filament are accelerated toward the anode through the circular opening in a shield, or Wehnelt cylinder, that is negatively charged with respect to the cathode. The filament, Wehnelt cylinder and anode constitute a cathode lens and form an image of the filament tip; the image also is called the crossover. The cathode lens assembly, sometimes referred to as the electron gun, is analogous to the lamp of a light microscope. Beyond the crossover the electrons pass through a magnetic lens that condenses, or focuses, an image of the crossover at some distance beyond, depending upon the strength of the current through the windings. In fig. 24 the crossover is focused at the object plane to produce

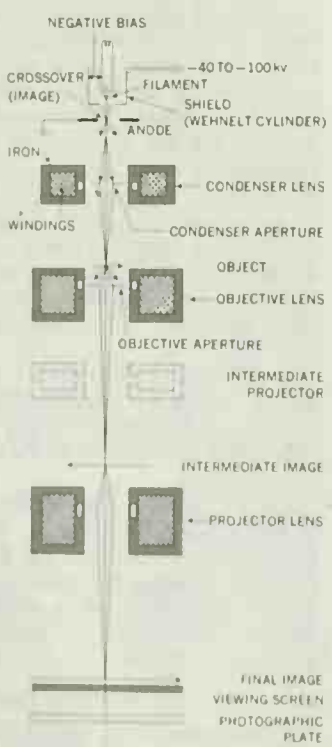



FIG. 24.—SCHEMATIC DIAGRAM OF ILLUMINATING AND IMAGE FORMING SYSTEMS OF A MAGNETIC TRANSMISSION ELECTRON MICROSCOPE

the highest intensity and the smallest illuminated area. When higher or lower currents pass through the condenser coil, the intensity of illumination at the object decreases and the area illuminated increases. The diameter of the aperture in the condenser lens is usually 0.1 to 0.3 mm. The size of the aperture of the condenser lens controls the convergence angle, or aperture of illumination, at the specimen (object). This angle is $10^{-4}$ to $10^{-2}$ radian and is greatest when the crossover is focused at the object plane. Sometimes two condenser lenses are used to achieve a wider range of spot size, angular aperture and intensity of illumination.

Details of the special ways for preparing objects to be examined with the electron microscope are described under *Use of the Electron Microscope.* In general, objects must be less than 1000 Å thick, must be able to withstand a vacuum and should not undergo morphological change when irradiated by an electron beam. All atoms scatter electrons to some extent; the amount of scattering increases with the atomic weight of the atom. This scattering is the main source of contrast in the electron image; the relative darkness of the specimen parts depends on ability to scatter electrons out of the imaging pencil. A small circular objective aperture 10 to 50$\mu$ in diameter enhances contrast in the image by removing from the beam all electrons scattered through angles greater than a certain value.

In fig. 24 the objective lens forms a magnified image of the object while utilizing only those electrons that have passed through the object without being scattered through angles greater than $10^{-3}$ to $10^{-2}$ radian. The magnification produced by a single lens (usually 50× to 200×) is approximately equal to the distance from the lens to the image divided by the focal length of the lens. In order to achieve direct magnifications of about 200,000×, two additional magnifying lenses, called projector lenses, are usually employed beyond the objective. By adjusting the amount of current in the objective coil, the final image can be brought to a sharp focus on a fluorescent screen as judged by visual observation with the naked eye or with a light magnifier that gives an additional magnification of 5× to 10×. The image also can be recorded on conventional photographic plates or film inserted above or below the viewing screen. Exposure time usually is 1 to 5 sec.

Micrographs are rarely recorded at the highest magnifications of which the instrument is capable since it is much more convenient to use relatively small plates or film with fine grain and arrive at the final magnification by enlarging the negative with a photographic enlarger. If the plate grain is sufficiently fine no loss of detail occurs through recording at low magnifications since the resolving power of the instrument is fixed by the objective lens and its characteristics are maintained approximately constant while the magnification is varied by the projector system.

## C. COMPONENT PARTS

The electron microscope has three major component systems: (1) the lens system; (2) the vacuum system; and (3) the electrical system.

**1. Lens System.**—Any axially symmetrical electrostatic or magnetic field can act as a lens for electron beams. Of the various possible electron lenses, three are used most frequently. They are the electrostatic cathode lens, the electrostatic unipotential lens and the simple magnetic lens.

*Electrostatic Cathode Lens.*—The electrostatic cathode lens derives its name from the fact that the cathode, which is also the object, is one of the electrodes of the lens. An example is shown diagrammatically in fig. 25. The cathode A emits slow electrons that are accelerated and focused by the symmetrical field produced by two electrodes with coaxial circular apertures at potentials $V_1$ and $V_2$ with respect to the cathode. An image of the cathode is

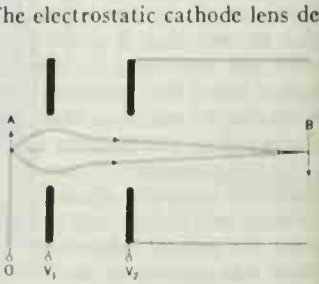



FIG. 25.—ELECTROSTATIC CATHODE LENS

produced at B. The focal length of the lens, and hence the position and magnification of the image, depends upon (1) the potentials applied to the electrodes; (2) the diameter of the apertures; and (3) the spacing between them.

A more versatile cathode lens designed by Johannson consists of three circular apertures in front of the cathode. In this system the potential on the first electrode is adjusted to focus an image of the cathode on a fluorescent screen. By varying the ratio of the potentials applied to the second and third electrodes, the positions of the principal planes and hence the magnification of the system can be varied.

*Electrostatic Unipotential Lens.*—The electrostatic unipotential lens, so named because there is only one difference of potential between the electrodes, is the essential component of all high-resolution electrostatic electron microscopes and is the most thoroughly investigated of the electrostatic electron microscope lenses. Since its object and image regions are at the same constant potential, the regions have the same refractive index and the object-side and image-side focal lengths are identical.

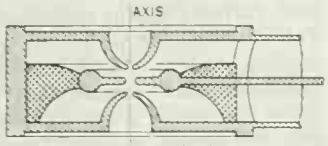



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FIG. 26.—SCHEMATIC CROSS SECTION OF MAHL'S UNIPOTENTIAL ELECTRON MICROSCOPE PROJECTION LENS

In its fundamental form, the unipotential lens consists of three parallel and coaxially aligned apertured disks (fig. 26). The two outer electrodes are electrically connected so that they are at the same potential, which is positive relative to the source of electrons in the system and equal to the full accelerating potential applied to those electrons. (In the interest of safety and simplicity of construction, a high negative potential is applied to the source of electrons so that the remainder of the instrument, including the outer electrodes of the lenses, can be kept at ground potential.) The central electrode of the lens is electrically insulated from the other two and is operated at a high potential (usually negative) to them.

The design of a unipotential lens to be used in a high-power electron microscope must allow for a number of critical factors, such as the attainment of high lens strengths by the production of high gradients in the electrostatic field on the axis of the lens and the attainment of good optical properties by the proper shaping and polishing of the electrodes. By 1939 Mahl had developed a unipotential lens that had a focal length of 5 mm. at 50 kv. and was capable of resolving 70 Å. Mahl's lens is the one shown in fig. 26.

*Magnetic Lens.*—All magnetic lenses are fundamentally alike in that the field strength on the axis varies from zero to a maximum and then back to zero. They are unique in that they cause the image to rotate about the axis.

Magnetic lenses were used to concentrate electron beams as early as 1899. These early "concentrating coils" consisted of a simple coil of wire wound coaxially with the beam and carrying an electric current (fig. 27[A]). By 1925 the magnetic coil was firmly established as the best means of concentrating an electron beam in high-voltage cathode ray oscillographs. At that time D. Gabor showed that the concentrating action could be improved considerably by encasing the ends and outside of the coil with a sheet of soft iron. Fig. 27(B) shows a weak magnetic lens encased in soft iron. Fig. 27(C) is a diagrammatic representation of the pole pieces of an objective lens of short focal length with electrodes to compensate for asymmetries in the field. The bore in the latter case probably would be about 3 mm. The maximum power of this type of lens is limited only by the magnetic properties of the iron of the pole pieces and, to a lesser degree, by the magnetic properties of the soft-iron casing on the coil. Thus the high-power magnetic lens is simply a powerful electromagnet consisting of an exciting coil, a soft-iron yoke and soft-iron pole pieces that concentrate the magnetic field to a small volume. A circular opening is bored through the pole pieces along the axis of symmetry to provide an unobstructed passage through the magnetic field for the electron beam.

Magnetic lenses can be built with focal lengths of about 1 mm. and a resolving power of 5 A. They have the disadvantage, compared with the electrostatic unipotential lens, that both the exciting current of the lens and the accelerating potential of the electron beam must be stabilized. This requirement introduces considerable complexity into the electrical circuits. On the other hand, the focal length of the magnetic lens can be varied over wide ranges by adjusting the exciting current; this feature reduces considerably the mechanical complexity of an instrument that uses magnetic lenses.

Magnetic lenses have other advantages over electrostatic lenses. For instance, the inherent aberrations of the magnetic lens are of smaller magnitude, with the result that a given resolving power can be attained more easily than with electrostatic lenses. When the magnetic lens is used, only half as many surfaces must be accurately shaped and aligned; moreover, the surfaces are simple planes, cones or cylinders instead of elaborately curved surfaces. Also, the necessity for attaining high mechanical precision in the presence of high-voltage insulation is not encountered in the magnetic lens. Finally, magnetic lenses of short focal lengths can be used with electron accelerating potentials that are several times greater than those that can be used with electrostatic lenses.

**2. Vacuum System.**—When the electron microscope is used, it must be exhausted to remove residual vapours and gas and to maintain a pressure of .0001 to .00001 mm. of mercury (atmospheric pressure under standard conditions is 760 mm. of mercury). The instrument is exhausted by pumping on the column with one or more gaseous diffusion pumps, which are highly efficient at low gas pressures, in series with a mechanical pump that is capable of pumping against the back pressure of the atmosphere. Specimens and photographic materials are inserted into and removed from the vacuum through a system of vacuum gates, valves and air locks. On the more advanced instruments this system is controlled through automatic or semiautomatic machinery that requires little attention from the operator. Components of the optical system, such as the gun and lenses, are joined together with vacuum-tight gaskets. Parts are moved, *e.g.*, during alignment or the scanning of a specimen, by vacuum-tight shafts or sliding joints.

**3. Electrical System.**—This system consists of a high-voltage

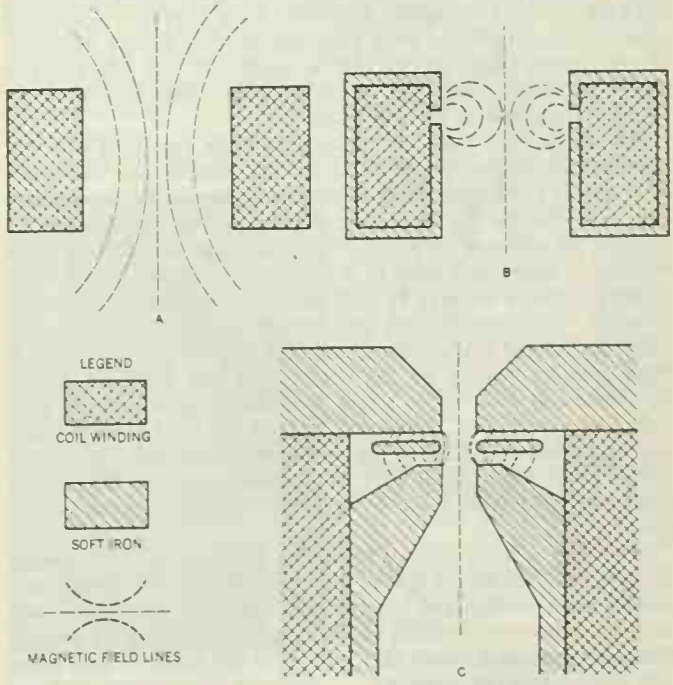



FIG. 27.—CROSS SECTIONS OF MAGNETIC ELECTRON LENS (A) SIMPLE SOLENOIDS; (B) IRON-ENCASED COIL WITH GAP TO CONCENTRATE MAGNETIC FIELD; (C) ENLARGED VIEW OF POLE PIECES OF HIGH-POWER MAGNETIC LENS SHOWING PLACEMENT OF COMPENSATING IRON RODS

supply from which can be selected two to four values of beam potential in the range of 40 to 100 kv. with an output of 10 to 400 microamperes. Since the focal length of the lenses varies directly with the beam potential, the output of the supply must be stabilized so that it does not vary by more than 1 v. for even short periods of time. Similarly, the currents for the lenses, once they have been set for focus and magnification, should not vary by more than 1 part in 200,000 during the focusing and recording operations.

Successful electron microscopes have been built with electrostatic lenses of the type shown in fig. 26 in place of the magnetic objective and projector lenses shown in fig. 24. In such instruments, a condenser lens usually is not employed and the beam is focused by the electrostatic lens that comprises the gun system. This type of microscope is electrically simpler than the magnetic type since no separate electrical supply is needed to energize the lenses. But other electrical factors, such as arc-over between lens electrodes and insulation problems, have prevented the electrostatic system from becoming practical.

### D. Use of the Electron Microscope

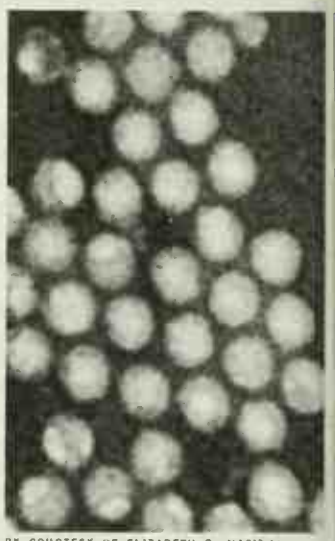
**1. Methods for Preparing Specimens.**—The interaction between electron beams and a specimen examined by electron microscopy is quite different from the analogous process in a light microscope. Specimens therefore have to be prepared in ways that conform to the peculiarities of the instrument. Following the introduction of commercial electron microscopes around 1940, the major advances in the science were due mainly to the discovery of appropriate methods for the preparation and handling of materials.

The conditions that apply for electron microscopic examination are as follows: (1) The specimen must be placed in a vacuum and hence loses volatile constituents, *e.g.*, water, at ordinary temperatures. (2) Specimens must be very thin, usually less than $\frac{1}{10,000}$ mm. (1000 Å), since greater thicknesses scatter electrons excessively. (3) Electrons cannot be back-reflected efficiently for the observation of opaque surfaces. This once seemed to preclude the use of electron microscopy for the observation of important classes of materials such as metallic surfaces. (4) Contrast in the electron image results almost entirely from the scattering of electrons by atomic nuclei in the specimen (rather than by absorption). Atoms of low atomic number (or weight), which constitute the bulk of most biological materials, have very low scattering power. Small particles with such composition cannot generally be seen unless their contrast can be enhanced. (5) The electron beam can produce heat and chemical changes that may alter the apparent structure of the specimen.

*Film Supports.*—Supports for objects to be examined with the electron microscope should be as thin as possible and composed of atoms of low atomic number so that scattering by the support does not obscure the scattering pattern of the material to be studied. A common technique for producing thin film supports consists of applying a drop of a 2% to 3% solution of collodion (chiefly cellulose nitrate) in amyl acetate to the surface of a dish of water. The drop spreads spontaneously over the surface and, when the solvent evaporates, a thin film of collodion 50 to 200 Å thick remains floating on the surface. These films are picked up over metal disks about 3 mm. in diameter with holes or slots sufficiently small (*e.g.*, 0.003 in.) so that the films remain intact over the openings. One of the commonest supports is a disk of electroplated mesh about $\frac{1}{8}$ in. in diameter and with 200 square holes per linear inch; these holes measure 0.002 to 0.003 in. on a side.

A number of other plastics and resins can be prepared in similar fashion. If they do not spread on water, they can be spread on a smooth glass surface and stripped after drying. Specimens such as dusts, smoke and aerosols can be caught on metal grids without films and examined where they adhere to the edges of grid wires and project into the openings.

Inorganic films that are stronger and able to withstand high temperature also can be used for supporting specimens. Such films are most commonly made of carbon and silicon monoxide, which are evaporated in a vacuum onto collodion-filmed grids. The collodion may be removed later by immersing the grids in a solvent. Carbon is evaporated from two electrodes tapered, or necked down, at their point of contact and heated to a high temperature by the passage of an electric current. Silicon monoxide is vaporized from a conical helix of tungsten wire (0.020 in. in diameter) that also is heated electrically.



BY COURTESY OF ELIZABETH C. MACLEAN

FIG. 28.—ELECTRON MICROGRAPH OF POLIOMYELITIS VIRUS, NEGATIVE STAIN. MAGNIFICATION 340,000 ×

*Electron Stains.*—A major problem in the examination of small organic particles such as viruses and protein molecules with the electron microscope is that they consist mainly of lightweight atoms that scatter electrons weakly and so cannot be distinguished from the atoms that cause scattering in the supporting film or material in which the organic particles may be embedded. This problem can be solved by treating organic materials with chemicals that contain heavy atoms; the heavy atoms combine with the organic material (positive staining) and enhance their visibility. Of these chemicals, which are called electron stains, the one most widely used on tissues is osmium tetroxide; stains that contain tungsten, molybdenum and uranium also are commonly used. Some of these reagents combine with a wide variety of chemical groups while others are more selective so that the possibility exists for the identification of portions of a specimen according to its affinity for particular stains.

Another way of enhancing the visibility of small isolated specimens of low scattering power is to dry them on a thin film in a solution of a dense chemical with which they do not react. This leaves the specimen surrounded by or embedded in a dense matrix. The stain accentuates the outline of specimens of low scattering power by entering into pores or openings. This method, called negative staining, is frequently more effective than positive staining since it avoids the use of strong chemicals that may distort the morphology.

*Shadow Casting.*—Still another method of enhancing contrast in the electron microscope image is the so-called shadow-casting process introduced by R. Williams and R. Wyckoff in 1945. In this technique a specimen is first placed in a vacuum chamber where metal atoms are vaporized from an electrically heated tungsten filament and caused to strike the specimen at an oblique angle. The metal atoms travel in a straight line until they strike a cool surface, where they stick. Any projections will collect a metal coating on the side toward the evaporating source; the side away from the source will be free of metal. The effect of accentuating surface detail in this way is similar to the effect in aerial photographs taken when the sun is low in the sky. Areas where the metal deposits have high contrast correspond to highlights, and the areas shielded from the metal correspond to shadows. The height of objects in a specimen can be calculated from the length of the shadows and the angle at which the metal arrives at the specimen (*i.e.*, the

BY COURTESY OF A. E. VATTER AND R. F. BILS

FIG. 29.—ELECTRON MICROGRAPH OF REPLICA OF SURFACE OF MIXTURE OF BARIUM TITANATE AND STRONTIUM OXIDE, SHADOW-CAST. MAGNIFICATION ABOUT 10,700 ×

angle formed by a line drawn from the evaporation source to the specimen and the plane of the specimen).

When a shadowed specimen is photographed in the electron microscope the shadows on the negative are dark and therefore appear white when the negative is printed. Such a print may cause confusion since viewers are accustomed to interpreting dark areas, not white areas, as shadows. These micrographs, therefore, are usually put through an intermediate positive transparency and printed as negative prints. The result is a three-dimensional effect of light and shadow that is meaningful to the eye.

*Replication of Surface Structure.*—The structure of the surface of bulk materials (such as the etched surface of metals) usually is studied indirectly in the electron microscope from a thin film impression of the surface that can be examined by transmission. The simplest method of preparing a replica begins with the application of a solution of collodion to the surface to be examined. After the film is thoroughly dry it is stripped from the surface and supported over a metal grid. This is a negative replica since projections on the original appear as depressions on the replica. A positive replica is obtained by making a second replica from the first so that the topography of the final replica is the same as that on the specimen. With this method the negative replica, since it does not go in the microscope, can be made with a film thick enough to be handled conveniently. Inorganic films (such as carbon) also are used. When it is difficult to separate the replica film from the sample, the original sample (or the intermediate replica if it is a two-step process) is dissolved chemically. Replicas placed in the electron microscope are nearly always shadowed with metal to enhance the contrast of the surface and to impart a three-dimensional effect to the final micrograph.

Replicas may also be made by shadowing the original surface with metal, backing the metal with a thin film and stripping the metallic structure from the surface for examination by transmission with the electron microscope. This yields an exceptionally faithful representation of the original since the backing film contributes much less to the final image than does the metallic deposit. What is seen is exactly what would be seen if the original surface could be shadowed and observed by transmission. This transfer technique makes possible the utilization of very smooth substrates that otherwise could not be used because of their thickness. The surface employed in one such method is that of freshly cleaved mica, which is a crystal plane and smooth down to atomic dimensions. Molecules are placed on this surface and are shadowed; their contrast is enhanced free from the confusion of substrate structure that is present when ordinary film supports are used. The metallized molecules are then backed with a thin support film and stripped for observation by transmission in the usual way.

**2. Ultramicrotomy.**—Sections of biological materials examined in electron microscopy should be not more than 0.1 $\mu$ and preferably about 0.02 $\mu$ thick, compared with a thickness range of 1 to 10 $\mu$ in light microscopy. D. Pease and R. Baker first produced reliable sections at 0.1 to 0.2 $\mu$ in 1948. In the years immediately following, refinements were introduced in microtome mechanics, cutting edges, methods of preparing the block of tissue to be cut and the handling of the fragile cut sections. By the mid-1950s the art had been advanced to the point where consistent sectioning could be performed down to about 0.05 $\mu$ and less. In the preparation of such sections, biological tissues are stabilized (fixed) by chemicals, treated with electron stains, dehydrated and infiltrated with a monomeric resin that, after polymerization, supports fragile structures and imparts good cutting qualities to the matrix. The face of the block to be cut is trimmed down to about 0.1 to 0.2 mm. on a side. The commonest cutting edge, introduced by H. Latta and J. Hartmann in 1950, is a glass knife produced by fracturing plate glass in such a way that two fractured faces perpendicular to the original glass surface meet at an angle of 45° to form the cutting edge. As the sections are cut they float on a water trough attached to the knife edge, from which they are picked up over openings in metal holders. Successive sections adhere at their edges as they are cut, producing a ribbon of successive layers of the material that can be examined serially to reconstruct a three-dimensional picture of the bulk material.

**3. Electron Metallography.**—The study of metals is an important application of electron microscopy. The most common approach is through replica techniques; but in such methods only the surface is displayed and there is no way of using the beam to explore the metal in any depth. It is possible to reflect electrons impinging on a metal surface efficiently only if the angle between incident and reflected beams and the surface is about 8° to 15°. The image therefore appears very foreshortened in one direction and interpretation is difficult. This scheme is useful in some instances but is not widely used.

A novel reflection electron microscope (or mirror microscope) for the observation of metallic surfaces was built by L. Mayer. In this instrument the electron beam is directed toward the specimen at nearly perpendicular incidence. A high negative charge placed on the specimen allows the electrons to approach very close to the surface but turns them around and reflects them much in the same way light is reflected by a mirror. The reflected beam is focused to form an image of the reflecting surface. In this image, detail is a function of the deflections that the reflected electrons receive as they approach the specimen surface; *i.e.*, a function of the structure of the surface. Resolution is about 2000 Å.

BY COURTESY OF J. DAVID ROBERTSON

FIG. 30.—ELECTRON MICROGRAPH OF CROSS SECTION THROUGH A NERVE FIBRE. MAGNIFICATION ABOUT 44,000 ×

For the study of metallic films by transmission electron microscopy the thickness of metallic specimens should not exceed 5000 Å and preferably should be much less. Thin metallic films can be made by vacuum deposition from the vapour state, electrode-position or deposition from the liquid state. Thick specimens can be thinned suitably by chemical etching, by bombardment in a vacuum or by electrolytic polishing. The production of thin specimens by cutting or machining is not generally satisfactory, since the structure is altered by the forces applied.

Metals examined by transmission electron microscopy show remarkable patterns because most metals consist of a conglomerate of crystals whose regular structures produce Bragg reflections and interference effects in the transmitted beam (*see* ELECTRON DIFFRACTION). These patterns can be related to atomic dislocations, to faults and stresses and to orientation in the crystal lattices. If two dissimilar metallic crystals with slightly different periodicities are superimposed on one another (usually by vacuum vaporization and deposition), moiré patterns appear with periodicities greater than occur in either of the crystals alone. The effect is similar to the production of beats between two sound frequencies that are close together. An imperfection in one crystal lattice will show up as a magnified imperfection in the moiré pattern. In this way certain properties of crystal lattices can be detected at a level that is beyond direct resolution with the electron microscope.

BY COURTESY OF G. A. BASSETT ET AL.

FIG. 31.—MOIRÉ PATTERN PRODUCED BY PARALLEL SUPERPOSITION OF GOLD AND COPPER CRYSTALS. MAGNIFICATION ABOUT 2,000,000 ×

Thermionic emission microscopes, though not as widely used as the transmission type, have been applied successfully to the study of surface structure of metals and the alterations that occur in them as a result of heat treatment.

### E. THEORY OF ELECTRON LENSES

If a magnetic lens has a gap length $L$ in centimetres that is

large compared with the axial bore through which the electrons pass, the focal length $f$ is given by the equation

$$\frac{1}{f}=\frac{1}{L}\times\frac{0.187\,NI}{\sqrt{V}}\times\sin\frac{0.187\,NI}{\sqrt{V}}\ \text{cm.}^{-1}$$

where $f$ is in centimetres, $V$ is the accelerating potential in volts and $NI$ is the ampere turns. The image is rotated by an angle $\theta_i=\pm\dfrac{0.187\,NI}{\sqrt{V}}$ radians in addition to the usual 180° resulting from the formation of a real image. Many lens fields may be represented by the symmetrical bell-shaped function $H_z=\dfrac{H_o}{1+\left(\frac{z}{a}\right)^2}$ where $H_z$ is the component of the field in gauss along the lens axis ($z$-axis), $H_o$ is the maximum value of $H_z$ and $2a$ is the breadth of the bell-shaped function at $H_z=\dfrac{H_o}{2}$. The focal length is then given by the formula

$$\frac{1}{f}=0.77\times\frac{0.15}{\sqrt{V}}H_o\sin 2a\frac{0.15}{\sqrt{V}}H_o\ \text{cm.}^{-1}$$

and the angle of rotation $\theta_i=\dfrac{\pm\,0.15\pi aH_o}{\sqrt{V}}$. Both these formulas assume that the object is at a point where the field is of negligible magnitude.

An approximate formula for the focal length of the electrostatic unipotential lens is given by the equation

$$\frac{1}{f}=\frac{3}{16}\int_{-\infty}^{+\infty}\left(\frac{dV/dz}{V}\right)^2dz\ \text{cm.}^{-1}$$

where the $z$-axis is the lens axis. No rotation occurs as in the magnetic lens.

The minimum focal length for an electron microscope lens is between 1 and 5 mm. Electron lenses, except for certain kinds of cathode lens, are always convergent.

Electron lenses are subject to the same geometrical lens aberrations that occur with uncorrected glass lenses. For example, chromatic aberration occurs but can be minimized by using monochromatic beams. Pincushion distortion may occur under certain conditions to produce a variation in magnification from one part of the field to another. The most important aberration is spherical aberration, which causes each point of the object to be imaged as a blurred disk whose radius, called the spherical aberration error, is $d_{sph}=C_s\alpha^3$, where $\alpha$ is the half-angle of the cone of illumination (aperture angle) leaving a point at the object and $C_s$ is the spherical aberration constant of the lens. For magnetic electron microscope objectives, $C_s$ has values between 0.1 and 2 cm. and is one of the chief factors limiting the resolving power of electron microscopes. A second factor that limits sharpness is the wave nature of electron beams. Because the beam is a wave, the best image of a luminous point that can be produced by a lens is a circular diffraction pattern consisting of a central bright disk whose radius, the diffraction error, $d_{diff}$, is given by the Airy formula $d_{diff}=\dfrac{0.16\lambda}{\alpha}$, where $\lambda$ is the wave length and $\alpha$ is the aperture angle.

A comparison of the formulas for the spherical aberration error and the diffraction error shows that they depend on $\alpha$ in inverse proportion so that the combined effect of the two is a minimum when they are approximately equal, as they are when $\alpha=\left(\frac{\lambda}{C_s}\right)^{\frac{1}{4}}$. Typical numerical values for $\lambda$ and $C_s$ require that $\alpha$ be in the range $10^{-3}$ to $10^{-2}$ radian, which is extremely small compared with the apertures of optical microscopes and results in a great depth of field. For the optimum $\alpha$, the smallest distance between resolvable points, or resolving power, becomes $d_o=C_s^{\frac{1}{4}}\lambda^{\frac{3}{4}}$. It would appear from this that $d_o$ could readily be reduced by reducing $\lambda$; *i.e.*, by raising the accelerating potential. This cannot be done since $C_s$ also depends on $\lambda$ and the resolving power is affected very little when the beam voltage is raised above about 50 kv.

*See* also references under "Microscope" in the Index.

(C. E. H.)

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**MICROTOMY** is the technique of cutting animals or plants, or their parts, into minute slices for examination under the microscope. *See* HISTOLOGY.

**MIDAS,** king of Phrygia (*q.v.*), is first mentioned in extant Greek literature by Herodotus (i, 14) as having dedicated a throne at Delphi, before Gyges (*q.v.*); *i.e.*, before or little after 700 B.C. Later reports that he married a daughter of Agamemnon, king of Aeolic Cyme (Pollux, ix, 83), and that Midas, or Midacritus (a Greek sailor named for his royal patron?), traded with a western Tin Island (Hyginus, 274; Pliny, *Natural History*, vii, 57 [197]) suggest the picture of a real king with commercial interests. The name Midas appears on the façade of one of the great rock-cut monuments of the upper Sangarius (Sakarya) region; and before 700 B.C. Assyrian troops crossed swords in the Taurus region with those of "Mita of Mushki," probably the same Midas, known there as king of a more easterly people, the Moschi (the biblical Meshech). The name Midas was probably dynastic, alternating in Phrygia with Gordieus (*cf.* Herodotus, i, 14 and 35; viii, 138). Both names are perpetuated in those of towns near the upper Sangarius, "Midas city" (*Midaeion, Midaeum*) being about 60 mi. west of the more famous Gordium (*q.v.*).

The name Midas was, however, already ancient and legendary. It appeared also among the cousins of the Phrygians, the Briges (perhaps pronounced *Vriges*) who "as the Macedonians say" (Herodotus, vii, 73) had remained in Europe when their kin migrated to Asia; for it is in a valley under Mt. Bermion (modern Vermion), "where roses grow wild," that Herodotus locates "the garden of Midas, son of Gordieus," where he captured Silenus (Herodotus, viii, 138), the wine-daemon and familiar of the god Dionysus. From this Dionysiac cycle of legend come the lighthearted legends of the foolish Midas, familiar in late classical versions (Ovid, *Metamorphoses*, xi, 90 ff.; Hyginus, 191, etc.). Midas treated the captive Silenus kindly and was rewarded by Dionysus with a wish. Midas wished that all he touched might become gold, and nearly starved to death. Dionysus then granted him release on bathing in the Pactolus torrent (near Sardis): that is how that stream came to produce alluvial gold. Again, Midas decided a musical contest between Apollo and the satyr Marsyas against the god, who thereupon gave him ass's ears. Midas concealed them under a turban, swearing his barber, who had to know, to tell "no living soul." The barber, bursting with his secret, whispered it into a hole in the ground, which he then filled up; but reeds grew from the hole and broadcast the whisper. These legends were no doubt first elaborated in the gay burlesque of the Athenian satyr plays.

The last historical Midas is said to have committed suicide when his kingdom was overrun by the Cimmerians (*q.v.; cf.* Strabo, i, 61), soon after 700.

*See* H. J. Rose, *A Handbook of Greek Mythology*, 5th ed. rev. (1953); A. R. Burn, *The Wood of Hesiod*, pp. 180 ff. (1936).
(A. R. Bu.)

**MIDDELBURG,** capital of the province of Zeeland, Netherlands, is situated in the middle of the former island of Walcheren, a few miles northeast of Flushing. Pop. (1962) 22,984 (mun.). It was a flourishing medieval town and had much trade with the East and West Indies. The Gothic town hall (*c.* 1520), has a square and a façade adorned with 25 statues of counts and countesses of Holland and Zeeland. The abbey of St. Nicholas, founded 1150 and with 16th-century tapestry, is the seat of the provincial government. Both town hall and abbey sustained severe war damage in 1940 and have been rebuilt in the old style with some modern additions. Middelburg is connected to Roosendaal by rail. The metal and textile industries and the tourist trade form the main occupations. Completion of the drainage and dike construction plans will link Zeeland more directly with the rest of the Netherlands and encourage industrial development. (J. de W.)

**MIDDLE AGES,** a modern term, coined consciously to define the contrast which its authors felt between the centuries which succeeded the downfall of the ancient world and their own time. To them the world of old Greece and Rome was in some ways nearer and more intelligible than the Europe held together by a common religious system. It would seem unnecessary to observe that the men and women who lived during the thousand years or so preceding the Reformation were not conscious of living in the middle ages. A few—Petrarch was the most conspicuous among them—felt that their lot was cast in a dark time, which, as it had begun with the decline of the Roman empire, might end if Rome would "begin to know herself"; but they were only a few. Yet, so strong are the associations and implications of the phrase, that we often unthinkingly speak of the medieval world as though it were a world consciously medieval, inhabited by beings who thought of themselves as medieval. This absurdity has been accentuated by obeisance to specialism. Conveniently enough, scholars are described as medievalists and modernists, or they are said to profess modern or medieval history.

**Conventional Sense of Term.**—As time goes on, the term "middle ages" will necessarily become more and more meaningless. The persons who first used it were making a gesture of their sense of freedom, and yet at the same time they were implicitly accepting the medieval conception of history as a series of well-defined ages within a limited framework of time. They did not speak of the six ages or believe in the chronology of Joachimite prophecy (*see* Joachim of Fiore), but nevertheless they inherited a scheme of history which began with the Garden of Eden and would end with the Second Coming of Christ. In such a scheme the thousand years from the 5th to the 15th centuries after Christ might well be regarded as a distinct, respectable period of history, which would stand out clearly in the providential pattern. In modern times, we have discarded the Eusebian chronology (*see* Eusebius of Caesarea); we look back to an almost infinite past and forward to an almost infinite future. In the eyes of a scientist a period of a thousand years is neither here nor there. Moreover, the content of history, both before the middle ages and contemporary with them, has been immensely enlarged. The significance of many aspects of medieval life has been changed by our knowledge of previous civilizations—of the civilizations with which medieval Europe was in contact.

**Limits of the Period.**—If we set our preconceptions on one side, the middle ages are the period in the history of European people, and especially of the western peoples, since the downfall of the Roman empire. Historical studies have differed and will continue to differ about the dates when this period should begin and end. The breach between ancient and later history was not so clearly defined as we are wont to say—some distinguished scholars, for example, led by Henri Pirenne, would deny that there was any real breach until the Muslims occupied the Mediterranean—but the settlement on a large scale of the Germanic peoples within the borders of the Roman empire and the failure of the central imperial government to maintain itself, were developments so striking as to justify the use of the terms "ancient" and "medieval" to describe the state of society before and after them. It is impossible to fix any date, for tastes differ, and the date 250 or 410 or 476 has only a dogmatic significance in the minds of various historians. It is a convenience like the limits of legal memory or the legal doctrine that the house of lords and its personnel dates from the year 1295.

It is still more impossible to fix any date as marking the end of the middle ages. The view that the fate of Constantinople in 1453 was a catastrophic event, unexpected and devastating, which had violent effects upon the whole temper of western society, is quite discredited. The view that the breach between the papacy and various European countries—an event which we describe as the Reformation—diverted the stream of history or introduced new life into history has more truth in it but is grossly exaggerated. If we give a sufficiently wide interpretation to the movement known as the Renaissance, and remember that, although it was most consciously intense during the 15th and 16th centuries, it had no obvious beginning and has had no end, we may define the end of the middle ages as the point, reached in different ways and at different times, at which the spirit of the Renaissance was victorious in political, social and artistic life. There has never been anywhere a complete breach with medieval institutions or modes of thoughts.

**Political Developments.**—The settlement of peoples and the gradual development of national states under the joint influence of native habit and the living traditions of the ancient world were not matters of a day. They required more than 1,000 years. Everywhere natural forces and conscious contrivance can be traced together, although the element of contrivance varied considerably in extent. Two great kingdoms, Germany and Italy, began to lose their political unity almost as soon as they had acquired it; they had to wait until the 19th century before they found it again. Switzerland and the Low Countries (the modern Netherlands and Belgium) were strongly welded into political units in a process in which it is difficult to disentangle the elements of nature, accident and artifice; but the unity, once acquired, has on the whole been permanent. Only a long and complicated process of events could decide that Portugal was to be separated from Castile, and Castile united to Aragon, that Catalonia was to be part of the kingdom of Aragon and not linked up with the Mediterranean littoral north of the Pyrenees, that Hungary was to be attached to the German marchland of Austria and that the Tweed river was to separate in part the kingdom of Scotland from England.

In these political developments the effect of Roman imperialism, working through geography and tradition, was not very marked. It might be an obstacle to be overcome, as in Italy and the Rhine valley, or an incentive to unity, as in France. But within the structure of society the element of contrivance was largely proportionate to the strength of classical influence, whether this were continuous or consciously revived. The extent and force of this influence have been the theme of endless discussion. How far the land settlement of the Franks was a continuation of the Roman system in Gaul, whether city life in north Italy and on the Rhine was completely interrupted, or, to take examples of a different kind, the extent to which the folklore and legendary literature of medieval peoples was drawn from native sources or derived from the treasure house of the east and the fancies of sophisticated brains, and whether medieval art is mainly popular or "learned" in origin—these are some of the problems which still arouse controversy. On the whole the tendency is to emphasize the extent of the artificial and learned element in later centuries and to minimize the importance of continuous classical survivals in the early middle ages. The continuous and ever-present influence of the ecclesiastical system is, it is hardly necessary to say, undisputed and is regarded as exceptional even by those who deprecate the view that it was the really formative factor in medieval life.

**Intellectual and Cultural Characteristics.**—Whatever the final issue of these discussions may be, it is no longer possible to draw a sharp distinction between culture or intelligence in medieval and modern times. Compulsory education and the impact upon our everyday life of scientific inventions are recent develop-

ments which separate us in external and possibly in more far-reaching ways from the middle ages, though their civilizing effects are still uncertain. The isolation in which so many people lived in earlier days, and the immense differences in wealth, social importance and external trappings between class and class have largely disappeared; the sum of human happiness and comfort is probably greater than in medieval times; but the contrast, once so fashionable, between the ages of darkness and the ages of light has no more truth in it than have the idealistic fancies which underlie attempts at medieval revivalism. The fascinating perplexity felt by students of medieval life is due precisely to the fact that our forefathers were not barbarians struggling forward, unaided, to a state of civilization, but were vigorous, intelligent, semicivilized people who fell at every turn under highly sophisticated influences. Even before they settled down in the 5th century they had, more or less consciously, entered upon what is termed the "heroic age," in which an exotic element, derived perhaps from the east by way of the Black sea and the great trade routes of central Europe, gave direction to their barbaric qualities. Some of them, like the Visigoths, fell at once under the influence of Roman jurisprudence.

All in due course were affected by the church and were introduced to forms of organization, thought, art and conduct which they appropriated as best they could. Three or four centuries later their men of learning came under the steadily increasing influence of Greek thought, as transmitted by the Greek-speaking scholars of the eastern empire, by Arabs and Jews; an influence which reached its height in the 13th century. By this time social contact with the east, never entirely lost, had been deepened by the establishment of western states in the Levant, the result of the crusades. Hence the process of sophistication, if the term may be used, was intensified by new periodic injections. However indigenous the expressions of political, social, literary and artistic life were, they flourished in an atmosphere of self-consciousness. They were not all spontaneous and were rarely "artless." The results were naturally varied, some bizarre and grotesque, with the seeds of decadence in them, some simple and effortless, some extraordinarily beautiful; some foolish, others profound; some pagan, others Christian.

These facts help to explain the strange inconsistencies of the medieval world. To return to our starting point, they also make the usual distinction between the values, moral and intellectual, of medieval and later times very misleading. If we search in history for examples of sheer goodness, or of forms of delicate perception, or of intellectual greatness, of legal acumen or of constructive ability, we can find them as readily in the middle ages as elsewhere, just as we find, as nowhere else, depths of religious experience. All that was fresh and vigorous in the European peoples could be drawn out and directed in the service of religion and art, learning, and even of statesmanship. Similarly, it could be perverted into an intensity of persecution or cruelty, into decadent orgies of sophisticated superstition, just as it could respond to eccentric and heretical influences, or find its own vent in ways which seem to us to be startlingly modern. A sedentary society, throwing off a continuous stream of wanderers; a conventional society, ruled by custom, yet indulging all sorts of adventures of the spirit; a pagan society responsive at every turn to the teaching of the Christian religion—such was medieval society.

Mankind has not yet found the way to health without belief in its past. It steps back with relief into the old tried paths from the highest, the best thought-out experiments in constructive revolution. Societies, during the thousand years after the 5th century, found health in the vigorous persistence of custom and the veneration of custom. The essential thing to remember is that medieval belief in custom was not a dead weight but a conscious discipline in a changing world. Lawyers and church have idealized it in the light of their belief in a universe bound together by law. Moreover men instinctively clung to their trust in custom, for the conception of the universe with which they were presented did not permit of that constant discovery of the inner relations of things which we call science. However speculative or transitory modern science is, it has secured popular allegiance by using the mysteries of nature—heat, electricity and so on—in the everyday service of man, so that conservatism nowadays shares its old power with a belief in science. Yet, as has been well said, modern science was both made possible by the earlier, medieval belief in the reasonableness of the world and was also an adventurous reaction against the rationalism of medieval thought. It was a revolt against the rigidity of law, but the belief in law was at the root of the new investigation into facts. The conception of sovereignty illustrates the same tendency in the political world; it was a recognition of the fact that certain social entities were directing their energies in their own self-regarding way, and a repudiation of the belief (due to a mingling of Christian and Roman ideas) in the unity of mankind under a universal law of nature; yet a long discipline had been required, under the regime of custom, in order to make the conception of sovereignty safe or tolerable. Its value is on the wane, and the trust in law in the medieval sense seems to be returning.

**Influence of the Church.**—The Christian church shaped the European peoples in two ways. It gave direction to the energy of the robust European peoples, and it offered a higher interpretation of the meaning of life. Suicidal strife, with the succeeding stagnation, was checked. The Romans had impressed on the barbarians a system of law and order which they had neither the ability nor the desire to maintain. The church maintained this system in its own way and, while accepting the traditional social arrangements of the barbarians, enabled them to develop. The response was very extraordinary. Indeed the danger of absorption was so great that the church in self-defense strengthened its organization and emphasized its unity in the papacy. Hence we have the interplay of political and ecclesiastical forces which runs through the history of feudal and afterward of national or urban societies, and profoundly modified the structure of the church itself. Throughout the middle ages the church maintained the conception of unity and its claim to interpret the moral law. But its other great function, though sometimes lost in the development of organization, was never forgotten. There again the peoples responded. Their craving for certainties or for adventure was met by the development of dogma, the various monastic experiments, the crusades. They produced an endless series of saints. They tried to comprehend in their schools and universities the learning of the ancient world and to harmonize it with the teaching of the theologian. They built thousands of buildings, bringing all their energy to expression in the name, if not in the service, of a church and the saints. Our political systems, our scientific thought and our art are developed from those of the middle ages, and the conscious reactions against the fundamental ideas of the medieval church are a tribute to its strength.

For some medieval institutions, *see* COMMUNE (MEDIEVAL); FEUDALISM; KNIGHTHOOD, CHIVALRY AND ORDERS; SERFDOM AND VILLEINAGE. For the history of the period, *see* especially CRUSADES; BYZANTINE EMPIRE; HOLY ROMAN EMPIRE; and articles on the European countries. *See* also references under "Middle Ages" in the Index.

BIBLIOGRAPHY.—For the origin of the idea and nomenclature from 1469 *see* Paul Lehmann, "Vom Mittelalter und von der lateinischen Philologie des Mittelalters," *Quellen und Untersuchungen zur lateinischen Philologie des Mittelalters*, 5:1–25 (1914); George Gordon, *Medium Aevum and the Middle Age* (1925). A list of writings is given in L. J. Paetow, *A Guide to the Study of Medieval History*, rev. ed., p. 140 (1931). T. E. Mommsen's "Petrarch's Conception of the Dark Ages," *Speculum*, 17:226–242 (April 1942), is important. The discussion on periods in history by D. Gerhard, *Amer. Hist. Rev.*, 61:900–913 (July 1956), is a helpful guide. *See* also O. Halecki, *The Limits and Divisions of European History* (1950). (F. M. P.)

**MIDDLE AMERICA,** the portion of Latin America which to geographers is considered a part of North America embraces Mexico, Central America (Guatemala, British Honduras, El Salvador, Honduras, Nicaragua, Costa Rica and Panama) and the West Indies. On the map the boundaries are sharp: the Mexico-United States, Panama-Colombia frontiers, and the waterways separating the Lesser Antilles from South America. However, many of Middle America's historical, anthropological and structural characteristics are linked to North or South America.

Unique to Middle America is the structural region which lies between Mexico's volcanic axis (approximate latitude 19° N.)

and the Lake Nicaragua-Río San Juan depression, and extends eastward to the Virgin Islands. This folded and faulted east-to-west trending region is composed of a mainland segment (mantled by volcanic materials in the west), ridges and troughs of the Caribbean floor and the Greater Antilles. The Lesser Antilles, an arc of volcanic and coral islands, and the northwest-to-southeast-trending folded and volcanic structure of Costa Rica and Panama connect Middle America with South America. These bridges facilitated the movement of Indians into Middle America from the south. Their cultures were less sophisticated than the Aztec, Maya or Toltec cultures of central and south Mexico and northwestern Central America. (*See* also AZTEC; TOLTEC; MAYA INDIAN.) (J. T.)

Central and southern Mexico, Guatemala, British Honduras, El Salvador and part of Honduras are recognized by archaeologists to have constituted a cultural unity in pre-Columbian times. The name Mesoamerica is now generally used to refer to this culture area, which is the main subject of this article.

For the geography, natural resources and population of Middle America *see* CENTRAL AMERICA; NORTH AMERICA; WEST INDIES; WEST INDIES (FEDERATION), THE; and articles on the various countries; for history *see* LATIN AMERICA; for anthropology *see* INDIAN, LATIN-AMERICAN.

**Middle America as a Culture Area.**—The archaeological-ethnological culture area of Middle America, or Mesoamerica, includes what is now Guatemala, British Honduras, Salvador, the western half of Honduras and the southern two-thirds of Mexico. The southern boundary of the area runs through central Honduras to the Gulf of Fonseca on the Pacific. The northern boundary extends from the Río Soto la Marina, on the Gulf of Mexico, to the Río del Fuerte, on the Gulf of Lower California. Like all culture area limits, these were not immutable borders but tended to shift by period with the expansion and contraction of cultural influences and the movements of peoples. In general, however, the area as defined was the home of native Indian cultures of an essentially Middle American type over a long period of time.

This Middle American culture type is expressed in the common sharing of traits and patterns of behaviour which can be traced far back in the archaeological record. Fundamental among these are domesticated food plants and the ways in which they were cultivated and used. Maize (corn) was the staff of life, and it was prepared by grinding in flat stone troughs, or metates. These metates are found archaeologically among the first evidences of sedentary agricultural life which date in the second millennium B.C. The ground maize, mixed with limewater, was baked into thin flat cakes, or *tortillas*. There are archaeological clues that maize flour was so cooked in ancient times, and these *tortillas* are the standard fare for the Mexican and Guatemalan peasantry today. Beans, squash, maguey, potatoes, cacao and many other food plants in addition to maize were raised by the ancient Middle Americans.

Besides the common possession of domesticated plants, the Middle American Indians shared such complex traits as stepped pyramids (used as platforms for religious buildings), a ceremonial ball game played by two teams with a rubber ball, certain pottery forms (including the pan bowl, grater bowl and *incensario*), a culture-hero deity represented as a feathered serpent, and a 260-day religious calendar.

**Cultural-Geographical Divisions.**—Notwithstanding the culture-area unity of Middle America, the region can be divided into several cultural-geographical divisions, each with its own interrelated but distinguishable pre-Columbian past. We have defined ten such subareas (*see* map). They may be summarized as:

1. *The Northwest.*—This subarea was marginal to the centres of civilization farther south and probably was not brought under strong influence from these until the Classic period. In early post-Columbian times it was held by peoples of Uto-Aztecan speech such as the Cora, Huichol and Acaxee.

2. *The Northeast.*—Although marginal to centres farther south, the Northeast subarea appears to have been influenced by them from Formative period times. The Huastec, a Maya-speaking tribe, is the best-known group in the subarea.

MAP OF MESOAMERICAN ABORIGINAL CULTURE AREA, SHOWING THE TEN CULTURAL-GEOGRAPHICAL REGIONS

3. *The West.*—This subarea gives clues of a complex internal history interrelated at times with developments in the Valley of Mexico. In the 16th century it was the home of the Tarascan empire.

4. *The Southeast-Central.*—With the Valley of Mexico as its centre, this subarea is one of the most important in Middle American culture history. Following a long Formative period development it was the seat of the Teotihuacán, Toltec and Aztec civilizations, all of which profoundly influenced the rest of the Middle American area.

5. *Oaxaca.*—Oaxaca was the centre of early high cultural developments in the Formative and Classic periods. At the historic horizon the Zapotecs and Mixtecs held the subarea.

6. *Central Veracruz.*—In the 16th century this was the subarea of the Totonacs, whose forebears may have been the builders of Tajín, a great politico-religious centre of the Gulf coast.

7. *Southern Veracruz-Tabasco.*—The subarea is defined by the "Olmec" art style, probably the earliest of the great styles of Middle America. The late prehistoric inhabitants of the territory, Nahuatl (Uto-Aztecan-speaking) and Popoluca (Oto-Manguean) tribes, do not appear to have been responsible for "Olmec" art and civilization.

8. *The Maya Highlands.*—The upland basins of Chiapas and Guatemala saw a very early Formative period occupation of settled village farmers. It was there that the Classic, Postclassic and Historic period highland Maya lived.

9. *The Maya Lowlands.*—In the jungles of northern Guatemala, adjacent Mexico and British Honduras the lowland Maya civilization reached its zenith. The Chol Maya occupied the south, the Yucatec the north.

10. *The Southern Periphery.*—The Maya probably moved during the Classic period into Salvador and western Honduras where they influenced and impinged upon local peoples such as the Lenca and Jicaque. In late Classic or Postclassic times the Uto-Aztecan-speaking Pipil invaded Salvador from Mexico.

**Periods.**—Chronological periods in Middle American prehistory and archaeology are based upon geological estimates, radiocarbon datings, native calendars, legendary histories, ethnohistoric accounts and archaeological stratigraphy and cross-dating. There is dispute concerning the interpretations put upon these sources of evidence. The dates below conform to the general consensus.

| | |
|---|---|
| Early Hunting period (?–7000 B.C.) | The earliest remains of man in Middle America. Pleistocene environments and the hunting of large, now extinct, mammals. |
| Food-Collecting and Incipient Cultivation period (7000–1600 B.C.) | Post-Pleistocene era of small game hunting, plant collecting and the first plant domestication. |
| Early Formative period (1600–800 B.C.) | The beginnings of village farming and of a way of life characteristically Middle American. |
| Late Formative period (800–100 B.C.) | The rise of the complex cultures of Middle America. |

| | |
|---|---|
| Classic period (100 B.C.–A.D. 900) | The florescence and crystallization of the great native civilizations of Middle America. |
| Postclassic period (A.D. 900–1520) | The collapse of the Classic world and the rise of new civilizations, of which the Aztec empire was one. Terminated by the Spanish conquests of 1520–1550. |

The date of A.D. 900 for the close of the Classic period follows the Goodman-Thompson correlation of the Maya and Christian calendars. The Spinden correlation would set the close of the Classic period back 260 years.

**Early Hunting Period.**—It is assumed that the first inhabitants of Middle America were early American Indians, of Asian and Mongoloid derivations, who migrated into the area at some time during the final, or Wisconsin, stage of the Pleistocene. It is probable that such early immigrants were huntsmen following herds of large mammals, including the mammoth. Human artifacts and mammoth bones have been found together, in the same geological strata, in the Valley of Mexico at Santa Isabel Ixtapan. These strata date from the terminal substage of the Wisconsin glacial advance, and the associated radiocarbon readings are approximately 9000 B.C.

**Food-Collecting and Incipient Cultivation Period.**—With the increased dryness and change of fauna following the glacial retreat of the Wisconsin substage, the inhabitants of Middle America were forced to turn from big-game hunting to other means of subsistence. These were the hunting of smaller game and the collecting of wild food plants. From dry cave refuse in Tamaulipas, in the Northeastern subarea, this mode of existence is recorded in new types of projectile points, carrying baskets, dried plant remains and crude stone implements for grinding these plant-seed foods. Along with wild plant collecting, some plants, including squash, were cultivated as early as the Infiernillo phase (*c.* 7000–5000 B.C.). Cultivation of plants increased gradually, with the addition of beans in the Ocampo phase (4000–3000 B.C.) and a primitive maize in the La Perra phase (3000–2500 B.C.). Cultivated plants are estimated to have provided about 30% of subsistence in the subsequent Guerra phase (1800–1600 B.C.).

**Early Formative Period.**—By 1600 B.C. some village communities in Middle America were sustained largely or wholly by agriculture. It is not clear where this development first took place. Although the sequences in the Tamaulipas caves show a slow and steady transition from incipient to full cultivation, it is likely that this subarea was marginal to village farming cultures located somewhere farther south in Middle America. The Early El Arbolillo I phase, of Central Mexico, the Chiapa I phase, of Chiapas, and the Ocos and Arévalo phases, of Guatemala, are among the earliest of the Early Formative period cultures. All of these phases have pottery, a trait unknown in the Food-Collecting and Incipient Cultivation period. In addition to pottery, handmade figurines, usually in the human female form, are common to the Early Formative period phases. Some of the Early Formative archaeological sites, such as those of central Mexico or Tamaulipas, show no evidences of ceremonial building or artificial mound construction. Others, particularly those farther south, have such structures.

In general, there is widespread similarity among Early Formative period phases in ceramics and figurines, and this suggests that such traits may have been diffused through Middle America from a single source. It seems most likely that this source was located in the southern part of the Middle American area although, as yet, this cannot be demonstrated. Nor can it be certain that ceramics and pottery figurines had their new world origins in Middle America. It is probable, however, that these origins are to be found either in southern Middle America or northwestern South America.

**Late Formative Period.**—The Late Formative period was a time of transition from the simple agricultural village to more complex societies organized around politico-religious capitals or nuclei. It has been noted that in the Early Formative some village communities had mounds which probably served as platforms for temples or ceremonial buildings. In the Late Formative period such constructions were larger and more elaborate and were often clustered together into ceremonial centres which functioned as political and sacred capitals of multivillage territories. Along with this development of the ceremonial centre came the beginnings of monumental art, writing, and calendrics. La Venta, in the Southern Veracruz-Tabasco subarea, is an outstanding centre of the Late Formative with carved stone altars and steles, pyramidal mounds and richly furnished burials, all dating from 800 to 400 B.C. Slightly later, in the same subarea, are the calendric inscriptions at Tres Zapotes which date toward the close of the Late Formative. In Oaxaca, the carved steles and hieroglyphics of the Monte Albán I phase are approximately contemporaneous with late La Venta and Tres Zapotes.

Another Late Formative period trend which is as significant as the elaborations in ceremonial architecture, art and intellectual achievement is urbanism. This has been noted particularly in upland terrain. In the Valley of Mexico a living community two square kilometres in extent is identified with the Tzacualli, or Teotihuacán I, phase. Similarly, at Kaminaljuyú, in the Guatemalan basin, there is a large urban zone, indicated by deep and extensive occupation detritus around the main temples of the Miraflores phase.

**Classic Period.**—The characteristic Middle American aesthetic and religious patterns which began in the Late Formative were crystallized in the Classic period. In the Maya Lowlands subarea polychrome ceramics, the use of the corbeled vault in temple construction, and the foreshadowings of typical Maya art and the probable beginnings of Initial Series calendrics all belong to a Protoclassic subperiod (100 B.C.–A.D. 300). The full Maya artistic, architectural and calendric-hieroglyphic traditions are then ushered in during an Early Classic subperiod (A.D. 300–600). Tikal, Uaxactun and Copán all attained their first glories in these centuries. In the Late Classic subperiod, between A.D. 600 and 900, ceremonial centres in the Maya Lowlands proliferated in number as did the carving and erection of the inscribed and dated steles and monuments.

Elsewhere in Middle America the Zapotecan traditions were brought to full flower in the Monte Albán IIIA phase; the great site of Tajín flourished in Central Veracruz; and from the thriving urban capital of Teotihuacán, in central Mexico, influences radiated out to all quarters of the Middle American area.

The breakdown of the Classic period civilizations began with the destruction of the city of Teotihuacán at about A.D. 700. This metropolis appears to have fallen before the warlike Toltecs, peoples of Uto-Aztecan speech who invaded central Mexico from the north and who established their capital at Tula, in Hidalgo. Between A.D. 700 and 900 southern Middle America was disturbed by wars and migrations, and the old regional cultures were seriously disrupted. These events were probably correlated with the further expansion of Nahua (Uto-Aztecan) tribes out of central Mexico and into Chiapas, Guatemala and Salvador.

**The Postclassic Period.**—Four trends characterized the Postclassic period. First, there was a completion of the breakup of the old regional Classic period cultures with their distinctive art and architectural styles and religious traditions. Second, the new Postclassic cultures displayed more secular orientation. Third, fortifications, fortified sites and an increase of warlike themes in art bespoke a more militaristic attitude throughout much of Middle America. Fourth, the urban-type community, which first appeared in the Late Formative and was known through the Classic period, was emphasized even more than previously.

In the later Postclassic period, Tenochtitlán, the Aztec capital, located where Mexico City now stands, became the dominant force in Middle America. An Aztec state or empire reached from coast to coast through central and south Mexico; however, many tributary nations were held by the Aztecs in rather loose bonds, and when Cortés marched from Veracruz to Tenochtitlán he was aided by tribes anxious to free themselves from the Aztec yoke. In the Maya Lowlands the Toltec-controlled centre of Chichén-Itzá lost its position of leadership at about A.D. 1200. Thereafter, there seems to have been something of a Maya resurgence with the Yucatecan capital being established at the walled city of Mayapán.

**Lower Central America.**—This region—eastern Honduras,

GEORGE HOLTON-PHOTO RESEARCHERS, INC.

FANGED RATTLESNAKES FLANK ENTRANCE TO 12TH-CENTURY TEMPLE OF WARRIORS AT CHICHÉN-ITZÁ

Nicaragua, Costa Rica and Panama—lies outside of the Middle American culture area (*see* map). For the greater part, its peoples, languages and cultures are more closely allied with northwestern South America than with upper Central America and Mexico.

At the historic horizon, in the 16th century, tribes of Chibchan linguistic affiliation lived in what is now Panama, Costa Rica and most of Nicaragua. These tribes, from south to north, included the Cuna, Guaymí, Boruca, Talamanca, Ulva, Sumo, Matagalpa and Miskito. In central and eastern Honduras were the Lenca, Jicaque and Paya. The language of the Lenca appears distantly related to that of the Mayan and Nahua tribes, but Jicaque and Paya are unaffiliated languages. Along the west coast of Nicaragua and extending down into northwest Costa Rica were tribes of Middle American linguistic ties such as the Chorotega (of Macro-Oto-Manguean language stock) and the Nicarao (of Nahua or Uto-Aztecan stock).

Earliest evidences of human occupation in lower Central America come from Panama, where shell mound food-collectors and fishers lived at about 4000 B.C. Their way of life changed but little over the next two or three thousand years, although in this time they acquired the art of making simple plain or incised pottery.

At a later time, probably during the first millennium of the Christian era, agricultural communities, comparable although not specifically related to those of the Middle American Formative period, are also known from Panama. This horizon marks an introduction of polychrome painted and modeled pottery and, possibly, the first metallurgy. Later Panaman and Costa Rican cultures, such as the Coclé, Veraguas and Chiriquí, probably are derivative from this early horizon. Specific Middle American influences appear, however, on a relatively late level (after 900 A.D.). These are seen in the forms and designs of pottery styles and are believed to be derived from Nahua tribal migrations down the Pacific coast of Nicaragua and Costa Rica.

In general, goldwork, cast as ornaments, was of outstanding quality in Lower Central America, particularly in Panama and Costa Rica. Metallurgy apparently reached these regions from Andean South America before metals were known in Middle America.

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**MIDDLE ANGLIA,** a province of Anglo-Saxon England lying between East Anglia and Mercia, certainly comprised the basins of the Nene, Welland and Great Ouse, with the districts in and west of the fens. The probability that Charlbury, Oxfordshire, lay in what Bede calls the region "In Feppingum" among the Middle Angles, and the inclusion in the diocese of Leicester (afterward Dorchester) of the counties of Oxford, Bedford, Buckingham and part of Hertford, suggests the wide extent of the province. The Tribal Hidage, which was probably drawn up in the 7th or 8th century A.D., names many peoples who must be allotted to this area; one, the Gyrwe, are known to have had an ealdorman of their own, and probably the others had also. Parts of the area were settled early, but nothing is known of its political history until 653, when it was subject to Mercia, under the rule of Penda's son, Peada. St. Guthlac, who was born there, belonged to the Mercian royal family. Peada introduced Christianity, but no permanent see was created until 737, when one was placed at Leicester. St. Wilfrid administered the province in his exile of 691–705. The province contained the religious foundations of Peterborough, Ely, Oundle and Crowland.

*See* R. G. Collingwood and J. N. L. Myres, *Roman Britain and the English Settlements* (1936); F. M. Stenton, *Anglo-Saxon England,* 2nd ed. (1947). (D. Wk.)

**MIDDLE EAST,** a term that in modern usage, dating from World War II, has come to be applied to the lands around the eastern end of the Mediterranean sea, including Turkey and Greece, together with Iran and, more recently, the greater part of north Africa.

The central part of this general area was formerly called the near east, a name given to it by the first modern geographers. For convenient reference, these geographers, who were European, divided the vast territorial mass of the orient into three parts named according to the distance of each from Europe: the near east, the middle east and the far east. This was a useful, if egocentric, practice, whereby the old middle east began at the river valleys of the Tigris and the Euphrates or at the western borders of Iran and extended to Burma and Ceylon. (The term "far east," although it included much of what was later termed "southeast Asia," was applied primarily to China and Japan.)

The change in usage came about because "middle east" was the name given to the British military command set up in Egypt in anticipation of World War II. During the war this new, if inaccurate, application of the term became general and it continued to be used in the postwar period, when the area to which it was applied was much in the news. In spite of the strongly expressed disapproval of both British and American geographical societies, this use became customary.

It is not easy to visualize the "middle east" as a unit. Indeed, if by the word "unit" something homogeneous is implied, it might fairly be said to have less of the qualities of potential unity than such other comparable concepts as "Europe" or "Latin America." The concept is an artificial one, imported, as it were, into the area by those external powers which found it necessary to concert a policy with regard to it. Thus defined, the middle east consisted during World War II of the following states or territories: Turkey, Greece, Cyprus, Syria, Lebanon, Iraq, Iran, Palestine

(now Israel), Jordan, Egypt, the Sudan, the Arab kingdom of Libya and the various states of Arabia proper: Saudi Arabia, Kuwait, the Yemen, Muscat and Oman, Bahrain, Qatar, the so-called Trucial sheikhdoms and Aden colony and protectorate. Subsequent events have enlarged the number of lands included in the definition. The three western Arab territories of Tunisia, Algeria and Morocco, all formerly tied to France, have become closely connected in sentiment and foreign policy with the other Arab states. Morocco too became temporarily the site of highly important U.S. air bases. In addition, geographical, cultural and religious factors often oblige statesmen and others to take account of Afghanistan and Pakistan in connection with the affairs of the middle east.

The inclusion of Greece in the definition of "the middle east" may at first seem somewhat incongruous, but it must be remembered that the middle eastern (then near eastern) question in its modern form first became apparent when the Greeks rose in rebellion to assert their independence of the Ottoman empire in 1821 (*see* EASTERN QUESTION); Turkey and Greece, together with the largely Arabic-speaking lands around the eastern end of the Mediterranean, were also formerly called the Levant (*q.v.*). Although the independence of Greece has long been an accomplished fact, geographical and other factors still involve Greece closely in the fortunes of the middle east and compel those concerned with the area to pay close attention to this country.

For those western states that gave it the name, the middle east was really a series of related strategic necessities demanding a close relationship with certain states and territories. In consequence, military arrangements were made which involved political, cultural and economic considerations and comprehended a wide area. The centre was always the same. The perimeter varied from time to time.

In the centre, however, there was, and remains a genuine element of homogeneity. If the term "middle east" is artificial and extraneous, that of "the Arab world," often and appropriately applied to its inner core, represents a reality that closely affects the lives, the interests and the sentiments of the people to whom it refers, and all governments that have to deal with one or more Arab states must take this into account. No government can enter into close relations with Iraq, Jordan, Egypt or Algeria, for example, without being obliged to take account of the relationship existing between these and other Arab states. Likewise, there can be no significant dealing with Israel without regard to the whole Arab world. No less important is the geological chance by which middle eastern oil is in fact either Persian or Arab.

Because it constitutes a land bridge between the three continents of Europe, Asia and Africa, the middle east has from ancient times attracted the attention of military conquerors. Revolutionary modern developments in military weapons, and so in world strategy, have diminished its significance in this respect, but the area has lost little of its political consequence in world affairs. Indeed, in political strategy, lying as it does between the western part of the Communist world and the continent of Africa and dominating the southern littoral of the Mediterranean, it remains of first importance. (H. S. D.)

**MIDDLE RHINE HIGHLANDS** lie mainly in northwest Germany (where the German name is the Rheinisches Schiefergebirge) but also extend westward as the Ardennes, through southeastern Belgium and northern Luxembourg, with an overlap into eastern France beyond the Meuse. The feature is a greatly varied plateau with areas of rugged relief, in the Eifel (*q.v.*) and the Rothaargebirge in the Sauerland, though these nowhere exceed 3,000 ft. Other highlands include the Taunus (*q.v.*), the Hunsrück south of the Moselle and the Westerwald. Impervious schists, slates and sandstones are the main rocks, but there are volcanic outcrops, and considerable areas of limestone where the relief is smoother, the soils more fertile and the land more closely settled. The plateau is cut by the gorge of the Rhine and the deep meanders of its tributaries, such as the Moselle; and in the west the Meuse traverses the plateau flowing from south to north. (R. E. Di.)

**MIDDLESBROUGH,** a municipal, county and parliamentary borough, the largest town in the North Riding of Yorkshire, Eng., 50 mi. N.W. of York by road and 240 mi. from London. Pop. (1961) 157,308. Located 7 mi. from the North sea, on the south bank of the Tees river estuary with the Cleveland hills and moorland to the south of it, Middlesbrough is an international port and an iron, steel and chemical centre of world importance. It is a Roman Catholic episcopal see (1878).

As an industrial town, Middlesbrough dates from 1830 and undergoes continuous development. Most of the industrial building is on the bank of the Tees. The main railway station is in the north of the borough on the edge of the industrial area, and east of it are the docks. Dredgings from the clearing and deepening of the river are used in the reclamation of land on both north and south banks. River management has been since 1854 under the Tees Conservancy commission which has transformed the Tees from a narrow stream into one of the most navigable rivers in the country.

An immense program of rehousing, clearance and redevelopment of the old central district was begun after World War II. The southwestern district of Acklam covers the site of the Acklam village, which in 1829, with 105 inhabitants, had more than twice the population of Middlesbrough. There is a fine town hall (1889); an art gallery; an archaeological and scientific museum; and a public library containing collections of early bibles and theological, philosophical and classical works. Constantine College of Technology (1929), offering advanced courses in technology and commerce, is the centre for these studies for all Teesside. The borough's health and welfare services pay especial attention to children and the aged. The many parks and other open spaces include the wooded Stewart park at the south, where a granite vase marks the site of the cottage at Marton-in-Cleveland in which the explorer Capt. James Cook was born in 1728.

Middlesbrough has road and rail links southeast with the seaside towns of Whitby and Scarborough; southwest with Darlington; south with York and Leeds. Fast freight trains run to English and Scottish business and industrial centres. The Tees (Newport) bridge (1934), a vertical lift bridge, conveys road traffic to and from districts on the north bank, supplemented by a transporter bridge (1911), which ferries vehicles and pedestrians. Industries, beside iron and steel manufacture, include shipbuilding, bridge building, the manufacture of a wide range of iron and steel products and the processing of chemicals. Chief international exports are iron, steel and chemical products; chief imports are iron, manganese and chrome ores; scrap and pig iron; timber, chemicals, oil and coal.

There are deepwater docks at Lackenby, 4 mi. E., with one quay, completed in 1963, 3,215 ft. long, providing five berths. A major oil port has developed on adjacent reclaimed land.

From the year 686 until the Reformation, there was a Benedictine priory of Middleburg under the jurisdiction of Whitby abbey with, from the 12th century, a church of St. Hilda. When, after the dissolution of the monasteries, these fell into ruin, Middlesbrough remained a small agricultural village until 1829, when the railway pioneer Joseph Pease bought 500 ac. of land there, preferring it to Stockton-on-Tees for the export of coal. In 1830, with the extension to Middlesbrough of George Stephenson's Stockton and Darlington railway, the building of town dwellings began. The first dock was opened in 1842. But coal exporting began to decline, and the future of the town was not assured until iron smelting could begin following the discovery of iron ore in the Cleveland hills. Expansion thereafter was rapid. Middlesbrough was made a municipal borough in 1853 and a county borough in 1889. (E. C. P.)

**MIDDLESEX, LIONEL CRANFIELD,** 1ST EARL OF (1575–1645), lord treasurer of England under James I, spent his early years as a merchant in London. He engaged in a great variety of business activities, including the exportation of cloth and moneylending. He became acquainted in 1612 with the lord privy seal, the earl of Northampton, who valued his advice on matters of trade, and through Northampton's efforts Cranfield was brought into the royal service. In July 1613 he was knighted and was made surveyor general of the customs. After Northampton's death in 1614, Cranfield found himself without an influential pa-

tron, and his work during the ensuing two years consisted mostly of supplying information and advice to the privy council. In 1616 Cranfield allied himself with the king's favourite, George Villiers (afterward duke of Buckingham) and under his patronage Cranfield was rapidly promoted in the royal service. He was made master of requests in 1616, keeper of the great wardrobe in 1618, master of the court of wards in 1619 and was appointed to the privy council in 1620. A chief reason for these promotions was the valuable work he performed in instituting reforms in the household, the navy, the wardrobe, the customs and the exchequer.

In the parliament of 1621 Cranfield was one of the ablest privy councilors in the house of commons. During the first several weeks of the session he gained a favourable reputation as a reformer, and throughout the whole session he performed a very valuable service as an intermediary between the crown and the commons. His zeal for reform led him even to attack his colleague, Francis Bacon, who was impeached by parliament. Cranfield was created Baron Cranfield in July 1621 and earl of Middlesex in Sept. 1622. His greatest honour came in Oct. 1621 with his appointment as lord treasurer. As minister in charge of finances, he made a vigorous attempt to increase the king's revenues and to reduce his expenditures. He was somewhat successful with the first project, but in regard to the second he failed to obtain the support of either Buckingham or the king. His program of retrenchment was ultimately defeated; and he succeeded only in making himself unpopular.

After 1622 the relations between Middlesex and Buckingham became increasingly strained and a final break between the two men occurred during the winter of 1623–24. Buckingham, who was already antagonized by the lord treasurer's retrenchments, apparently thought that Middlesex was heading a plot against him. Middlesex had also offended Prince Charles (afterward Charles I) by withholding grants of money and by speaking too forthrightly. The result was that during the parliament of 1624 Buckingham and Charles encouraged the house of commons to institute impeachment proceedings against Middlesex. He was charged with numerous offenses, including the acceptance of bribes, neglect of the ordnance and maladministration of the wardrobe and the court of wards. He was found guilty on four charges and sentenced to loss of all offices and declared ineligible ever to hold them again. He was also to be imprisoned during the king's pleasure and fined £50,000. His remaining years were spent in retirement, but he received a full pardon from the king in 1626, and when he died in London in 1645 he was buried in Westminster abbey.

*See* R. H. Tawney, *Business and Politics Under James I: Lionel Cranfield As Merchant and Minister* (1958). (R. C. Jo.)

**MIDDLESEX,** a county of England which under the London Government Act 1963 was to become part of Greater London on April 1, 1965, except for Staines and Sunbury-on-Thames to be transferred to Surrey and Potters Bar to Hertfordshire (*see* LONDON).

The county is bounded by the counties of Hertfordshire, Essex, London, Surrey, Buckinghamshire. Area 232.3 sq.mi. It lies entirely within the Thames basin. South of an irregular line from Uxbridge to Hyde Park and thence to Tottenham there are gravel deposits rising in terraces from the Thames and its tributary the Lea. North of the line the London clay emerges from under the gravel to form undulating country around Harrow. The highest ground is in the north rising to 504.2 ft. near Bushey heath, with projections southward toward Hampstead and Harrow which are topped by remains of the sandy and pebbly Bagshot beds. Glacial deposits are also present; for example, pebbly beds at Stanmore heath, clay and sand at Finchley, chalky boulder clay at Southgate, while the Reading beds emerge in the northwest near Harefield. The west is watered by the Colne, Crane and Brent rivers and the east by the Lea.

**Early Settlement and History.**—The river Thames is the key to the history of the development of the county of Middlesex; implements and weapons of all periods have been found in its banks. The lower Thames valley provides opportunities for the study of the Stone Age and the deposits of gravel laid down by the river have produced many flint implements. The Pleistocene Ice Age provided periods of arctic climate alternating with milder spells and the swollen rivers deposited materials eroded by the melting glaciers of the north. From the Middle Stone Age (*c.* 8000 B.C.) traders and settlers used the Thames as their highway in order to avoid the interior country which was either marshy or covered with impenetrable forests. The earliest settlements to be established belonged to the Iron Age (*c.* 500 B.C.) at Brentford (Old England) and "Caesar's camp" at Heathrow. Bronze Age burials have been found at Sunbury, Littleton reservoir and Ashford. The exact purpose of the famous earthwork called Grims dyke that ran within the county from south of Pinner Green to Wealdstone, is as yet unknown. In the 1st century B.C. Belgic tribes had established themselves in southeastern England, and Middlesex formed part of the Catuvellauni territory. It is probable that the invading army of Julius Caesar used a route afterward to be known as Watling street to reach the Catuvellauni stronghold near Wheathampstead (Hertfordshire). The Romans had stations at Staines and Brentford and large pottery works at Sulloniacae (Brockley hill). They also built Ermine street, which led from the city of London to Stamford, and the London-Silchester road through Staines. The Roman site at Staines was on Greenfield common.

The Roman order in Middlesex finally collapsed in the early part of the 5th century, and 100 years later the East Saxons began to colonize the area which soon after admitted the supremacy of Mercia. Being thus positioned between the East and the West Saxons it obtained its name, the earliest record of which is in a charter of 704. Evidence of Saxon occupation has been found at Hanwell and Shepperton. The county suffered much from the Danish invasions to which the city of London provided the main resistance.

In succeeding centuries Middlesex experienced the hardship consequent upon civil disturbances; *e.g.*, the rebellion against John and the Peasants' Revolt. During the Civil War, Hounslow heath, Colnbrook and Uxbridge provided camping grounds for opposing armies. Brentford was the scene of Prince Rupert's brilliant cavalry charge. The Crown hotel at Uxbridge, used without avail to discuss terms of peace, is still called "Treaty house."

Suburban Middlesex is so much the product of the 20th century that it is hard to believe that once it formed the country retreat of royalty, of persons attached to the court and of wealthy London merchants. The most outstanding building is Hampton Court palace but there also exist examples of many stately mansions, such as Osterley, Syon and Swakeleys, while fine specimens of 18th-century architecture are to be found at Hampton, Twickenham, Brentford, Chiswick, Enfield, South Mimms and Harefield interspersed among arterial roads and semidetached villas. Here and there an old village centre is hemmed in by housing estates or there is a medieval church, a tithe barn, a village green or a riverside terrace, but historic Middlesex does not easily reveal itself. (*See* also HAMPTON COURT; TWICKENHAM; BRENTFORD AND CHISWICK; ENFIELD; UXBRIDGE; STAINES.)

**Administration and Population.**—From early times Middlesex was dominated by the City of London, which in the 12th century acquired the right of appointing the sheriff of the county. Until 1889 the two sheriffs nominated annually by the City for itself also held jointly the office of sheriff of Middlesex, acting as one person in matters which concerned the Middlesex shrievalty. As a result of the City's pre-eminence no county town grew up in Middlesex as the seat of county government. The claims of Brentford have been put forward based, no doubt, on the fact that it was the polling place where for several centuries the sheriff in his county court proclaimed the election of knights of the shire. Clerkenwell was normally the seat of the Middlesex sessions of the peace, but the Easter and Michaelmas sessions were regularly held at Westminster. Felonies and other serious offenses outside the cognizance of quarter sessions were tried at the Old Bailey on the delivery of the jail of Newgate.

The Local Government act of 1888, operative from April 1, 1889, profoundly affected Middlesex. Fifty square miles of territory with 2,500,000 inhabitants were transferred to the county of London, and the administrative county of Middlesex with a popu-

lation of only 380,000 was set up. By this act Middlesex acquired its own sheriff, and the site of the Guildhall in Parliament square, Westminster, was deemed to be still in the county of Middlesex for the purpose of holding sessions of the peace. The present Middlesex Guildhall, completed in 1913, is also the administrative centre of the county; and the county council meetings are held there.

There are 18 municipal boroughs (Acton, Brentford and Chiswick, Ealing, Edmonton, Enfield, Finchley, Harrow, Hendon, Heston and Isleworth, Hornsey, Southall, Southgate, Tottenham, Twickenham, Uxbridge, Wembley, Willesden, Wood Green), eight urban districts (Feltham, Friern Barnet, Hayes and Harlington, Potters Bar, Ruislip-Northwood, Staines, Sunbury-on-Thames, Yiewsley and West Drayton) and no rural districts. The county is within the metropolitan police district and within the jurisdiction of the central criminal court. It has one court of quarter sessions divided into eight petty sessional divisions. There are two county parliamentary divisions and 27 borough constituencies.

Middlesex is under the ecclesiastical jurisdiction of the bishop of London with the bishops of Kensington and Willesden as suffragans and is divided between two archdeaconries, Middlesex and Hampstead. A few places were exempt from such jurisdiction and were peculiars—for example, those of the archbishop of Canterbury and the dean and chapter of St. Paul's cathedral.

The principal public schools are Harrow, Highgate and Mill Hill. There are also five teacher-training colleges. Some of the grammar schools are of ancient foundation.

The population of the administrative county of Middlesex was 2,234,543 in 1961, having decreased by 34,772 since 1951. As part of the metropolitan area Middlesex suffers from the congested condition of London, and one of the most pressing problems facing not only Middlesex but the whole of the greater London region is a decentralization of people and work into the country beyond the "green belt." The development plan approved in 1956, to serve as a guide to all development within the county until 1971, was reviewed in 1962.

**The Economy.**—Growing London attracted improved communications—roads, railways and canals—and the transport services pushed the real countryside farther and farther away, replacing it with a gargantuan urban spread so that approximately 70% of the county is now built up, though the northern and western fringes remain rural. Only about a fifth of the county is covered by crops and grass and the numbers of cattle and sheep are the lowest for English and Welsh counties, London excepted. On the Lea and Thames alluvium, however, more than 3,500 ac. are devoted to market gardening, especially green vegetables. Middlesex, in common with other counties on the periphery of London, provides the necessary domain for a great capital. There are the airfields, the reservoirs, the gasworks, railway sidings, laundries, factories and dormitories that serve the metropolis, all competing for the limited amount of available land confined within the encircling metropolitan "green belt" in which the outer reaches of the county lie. Most of the trunk roads have now been converted into dual carriageways (four-lane highways) and the increase in traffic has been so great that a motorway heading for South Wales and providing a fast route to London Heathrow airport is carried on a viaduct over the existing Great West road for nearly two miles.

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**MIDDLETON, ARTHUR** (1742–1787), South Carolina planter, politician, Revolutionary leader and signer of the Declaration of Independence, was born at Middleton Place, near Charleston, S.C., on June 26, 1742. He received most of his education in England where he read law at the Middle Temple in London. After returning to South Carolina in 1763 Middleton was elected to the provincial legislature and in the controversies that precipitated the American Revolution became one of the extreme Whig leaders. He was a member of the council of safety in 1775–76; a member of the committee of the provincial congress that drafted the South Carolina state constitution; and a delegate to the continental congress, 1776–78. It was during this latter period of service that he signed the Declaration of Independence. At the siege of Charleston in 1780 he served in the militia, was taken prisoner when the city fell to the British and was sent to St. Augustine as a prisoner of war. After being exchanged in July 1781, he served in the continental congress, 1781–83, in the South Carolina legislature, 1785–86, and on the original board of trustees of the College of Charleston. He died on Jan. 1, 1787.

(H. T. L.)

**MIDDLETON, CONYERS** (1683–1750), English writer, a participant in some of the 18th-century pamphlet wars, was born at Richmond, Yorkshire, on Dec. 27, 1683. He graduated from Trinity college, Cambridge, took orders, and in 1706 obtained a fellowship at Trinity, which he resigned on his marriage a few months later. In a dispute with Richard Bentley (*q.v.*) he first established his reputation for invective. In 1721 he was found guilty of libel against Bentley. Observations made during a visit to Italy on the pagan origin of church ceremonies and beliefs were embodied in Middleton's *Letter From Rome* (1729), which revealed a tendency toward skepticism that became clearer in a pamphlet war with Daniel Waterland. Middleton at this time was accused of unorthodoxy and for some time ceased to write on theological subjects. His *Life of Cicero* (1741) enhanced his reputation at the time but in fact was largely borrowed from an earlier work by William Bellenden. The last major controversy in which Middleton was involved was occasioned by the publication (1747–48) of his discourses on miracles, in which he denied the incidence of miracles after the earliest years of the church. On July 28, 1750, he died at Hildersham, near Cambridge.

**MIDDLETON, THOMAS** (1580–1627), English dramatist, drew men as he saw them, like Chaucer, with comic gusto or searching irony. The son of a London citizen, he was baptized on April 18, 1580, at the church of St. Lawrence in the Old Jewry, London. By 1600 he had spent two years at Queen's college, Oxford, and had published three books of verse. He learned to write plays by collaborating with Thomas Dekker, John Webster and other authors for the producer Philip Henslowe. Soon he was pouring forth high-spirited comedies, acted by boy players at St. Paul's and Blackfriars. Later he wrote for many theatres, including the Swan and the Globe. As a popular playwright who was also a freeman of London, he was often commissioned to write and produce lord mayor's pageants and other civic entertainments, and in 1620 he was appointed city chronologer. His chief stage success was *A Game at Chesse* (1624), in which the Black King and his men, representing Spain and the Jesuits, are checkmated by the White Knight, Prince Charles. This political satire drew crowds to the Globe until the Spanish ambassador protested and James I suppressed the play. Middleton lived at Newington Butts, Surrey, and he was buried there on July 4, 1627.

His masterpieces are two tragedies, *Women Beware Women* (1621?, publ. 1657) and *The Changeling* (1622, with William Rowley, publ. 1653). The first recalls Webster's *The White Devil* in the subtle plot by which the duke of Florence (Francesco de Medici) entraps Bianca and in the sudden revenges by which each crime is paid for in blood. The dramatic scene of a chess game which symbolizes the duke's success is characteristic of the tragic irony by which the black characters always outwit the white until in the end the white characters themselves turn black.

*The Changeling* is a still more powerful study of crime and its psychological effects, though it would be a better play without the intrusive underplot written by Rowley. Beatrice-Joanna, a willful and passionate girl, clears the way to marrying for love by arranging a murder, only to find herself at the mercy of the murderer, De Flores, who has no mercy: "Can you weep Fate from its determined purpose? So soon may you weep me." She is "the deed's creature."

His comedies picture a society dazzled by money, in which most men are out for what they can get, no matter how. *Michaelmas*

*Terme* (1605?, publ. 1607) is one of the richest in irony. The crafty London merchant Quomodo delights in the skill with which he entangles a young gentleman and takes over his country estate; then, like Ben Jonson's Volpone, he tries one scheme too many and falls into the pit he has dug. In *A Trick to Catch the Old-one* (1606?, publ. 1608) two rival usurers, Lucre and Hoard, are so eager to score over each other that both are taken in by Lucre's clever nephew, whose strategy later furnished a plot for *A New Way to Pay Old Debts* by Philip Massinger. Sir Bounteous Progress in *A Mad World, My Masters* (1604?, publ. 1608) is a delightful old country gentleman who prides himself on his generosity to all except his grandson and heir, Dick Follywit. The madcap heir helps himself to a share in the family wealth by masquerading as a lord, a robber and the leader of a company of players, but the old knight has the last laugh and forgives all when his mistress turns up as Follywit's new wife.

*A Chast Mayd In Cheape-side* (1613?, publ. 1630) is a still more exuberant comedy with hilarious scenes making fun of naïve or complacent London citizens. These racy comedies of London life are essentially masculine, realistic and antiromantic. Even when the main character is a woman, for example Moll in *The Roaring Girle* (1604–10?, with Dekker, publ. 1611), she is a masculine spirit who prefers her freedom to marriage. She is drawn from an actual Moll Cutpurse who dressed as a man and took tobacco on the stage. Another spirited woman is the wife in *No Wit, No Help Like a Woman's* (1615?, publ. 1657), who restores the family fortunes by playing the dashing gallant so well that she outwits the fortune-hunting suitors of Lady Goldenfleece and wins the lady for herself and finally for her brother.

The tragicomedies are farfetched in plot but strong in dramatic situations. Charles Lamb praised *A Faire Quarrell* (1616?, with Rowley, publ. 1617) for "the vigorous passions, and virtues clad in flesh and blood." Captain Ager, with his conflicts of conscience, is one of Middleton's few heroes. *The Witch* (1610–16?, publ. 1778) is a less successful revenge play. Hecate and other witches sing two songs which were also used in *Macbeth*, where the speeches of Hecate were probably added to Shakespeare's play by Middleton. *The Spanish Gipsie* (1623) was printed in 1653 as by Middleton and Rowley, though some critics believe that John Ford was also part author. The play dramatizes two stories by Cervantes, *The Force of Blood* and *The Little Gipsy*.

Most of Middleton's other plays are comedies: *The Phoenix* (1603?, publ. 1607), where the disguised prince suggests Shakespeare's *Measure for Measure; Your Five Gallants* (1605?, publ. 1607), a rogue's gallery of gentleman-sharpers; probably *The Puritaine* (1606?, publ. 1607 as by "W. S."); *More Dissemblers Besides Women* (1615?, publ. 1657); *The Widdow* (1616?, publ. 1652); and *Any Thing for a Quiet Life* (1621?, publ. 1662). His tragedy *Hengist, King of Kent* (1616–20?), was printed in 1661 as *The Mayor of Quinborough*. He collaborated with Dekker in *The Honest Whore* (1604) and perhaps in *Blurt Master-Constable* (1601, publ. 1602) and *The Familie of Love* (1602?, publ. 1608); with Rowley and Massinger in *The Old Law* (1618?, publ. 1656); and with Rowley in a masque, *The World Tost at Tennis* (1620). Opinion is divided on the authorship of *The Revenger's Tragedy* (1606?, publ. 1607), traditionally attributed to Cyril Tourneur, and *The Second Maiden's Tragedy* (1611, publ. 1824); the evidence for Middleton is stated by S. Schoenbaum, *Middleton's Tragedies* (1955). He wrote in verse *The Wisdome of Solomon Paraphrased* (1597), *Micro-cynicon. Sixe Snarling Satyres* (1599), and *The Ghost of Lucrece* (1600; ed. by J. Q. Adams, 1937); and in prose several pamphlets, including two satires, *The Blacke Booke* (1604) and *Father Hubburds Tales, Or The Ant and the Nightingale* (1604).

"Middleton," writes T. S. Eliot, "was a great observer of human nature, without fear, without sentiment, without prejudice." (*Selected Essays;* publ. by Faber and Faber, 1951.) A dramatist rather than a poet, he had the dramatist's power to imagine natural characters and to bring them to life.

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**MIDDLETON, THOMAS FANSHAW** (1769–1822), first Anglican bishop of Calcutta, was born on Jan. 28, 1769, at Kedleston, Derbyshire, educated at Cambridge and ordained in 1792. He attained distinction by his work *The Doctrine of the Greek Article Applied to the Criticism and Illustration of the New Testament* (1808) and in 1812 became archdeacon of Huntingdon. On May 8, 1814, he was consecrated as the first bishop of the see of Calcutta, which had been constituted by statute in 1813 to include the whole of India and Australia. Middleton was much perplexed by the position of the Anglican missionaries in Bengal, whose roving commission to evangelize did not fit into the picture of Anglican parochial life as he understood it; he seems not to have felt the same difficulty in south India, where settled Christian congregations existed, and, although a high churchman, was prepared to license the missionaries of the Society for Promoting Christian Knowledge, who were German Lutherans. Middleton traveled extensively and interested himself in the condition of the Syrian Christians of Travancore. His principal claim to fame was the foundation of Bishop's college at Calcutta in 1820 for the training of missionaries and schoolmasters of the Indian church. He died in Calcutta on July 8, 1822.

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**MIDDLETON,** a market town and municipal borough (1886) in the Middleton and Prestwich parliamentary division of Lancashire, Eng., on the Irk, near the Rochdale canal, 6 mi. N.E. of Manchester. Pop. (1961) 56,674. St. Leonard's parish church, except for the tower arch which is of the 12th century, was rebuilt in 1524 as a thank offering for the victory of Flodden Field. The Queen Elizabeth grammar school, founded by Thomas Cardinal Langley in 1421, was refounded by the brothers Nowell, two former pupils, by letters patent in 1572. Chief industries are cotton spinning, calico printing, dyeing and bleaching, chemical manufacture, engineering and jam making.

**MIDDLETOWN,** a city of Connecticut, U.S., in Middlesex county, is on the west bank of the Connecticut river, 15 mi. S. of Hartford. It was settled in 1650 and was incorporated as a town in 1651. It occupies the site of the ancient Indian village of Mattabesec (or Mattabesett) but was given its present name in 1653. The city of Middletown was chartered in 1784, making it one of the oldest cities in the United States. The city and town were consolidated in 1923.

Middletown was a seaport and a shipbuilding centre in the 18th and 19th centuries, a base of the "triangular trade" in rum, slaves and molasses with Africa and the West Indies before the American Revolution and later of the China Clipper trade. The coming of the steamship brought about a decline of its traffic. It is a manufacturing and trading centre (rubber footwear, textiles, marine hardware, power tools, paper boxes, brake linings, cotton webbing, patterns and automobile accessories). Commercial river traffic, once important as a means of communication, is confined almost exclusively to transportation of coal and oil. Middletown is the seat of Wesleyan university, established in 1831 by the Methodist Church but now nonsectarian. Located in Middletown are a state mental hospital and a state school for delinquent girls. In 1955 the Atomic Energy commission erected an experimental laboratory in Middletown. Since 1890 a large Italian and Polish immigration has changed the character of the population substantially. For comparative population figures *see* table in CONNECTICUT: *Population.* (E. E. Sr.)

**MIDDLETOWN,** a city of Orange county, N.Y., U.S., on the Wallkill river, 65 mi. N.N.W. of New York city. The chief industries are dairy, fruit and vegetable farming and the manufacturing of cosmetics, saws, valves, clothing and leather goods. It is also a summer resort centre. Orange County Community college,

opened in 1950, is located there. The New York State Homeopathic hospital for mental diseases, founded in 1874, and two other hospitals provide medical facilities. The village of Middletown, until 1798 part of Ulster county, was first settled by farmers about 1756 and organized in 1785 around the local Congregational church. Its name was derived from its location on the Minisink road midway between the Hudson and Delaware rivers. The town prospered as the centre for a number of turnpike companies and as the terminal of the Erie railroad after 1843. The now defunct New York, Ontario, and Western railroad, organized in 1879, had shops there. Middletown was incorporated as a village in 1848 and chartered as a city in 1888. For comparative population figures *see* table in NEW YORK: *Population.*

(E. M. A.)

**MIDDLETOWN,** a city of Butler county, Ohio, U.S., on the east bank of the Miami river, midway between Dayton and Cincinnati, whence comes the name. Founded in 1802, Middletown soon became an agricultural trading centre for a region that produced an abundance of corn, wheat, livestock, tobacco, fruits and vegetables. Local products found markets in Cincinnati and New Orleans by freight wagons, river flatboats and the Miami-Erie canal boats. Later, four railroads passed through the city: the Baltimore and Ohio, the Big Four, the Erie and the Pennsylvania Tobacco, paper and steel made the city important industrially. In 1900 George M. Verity built a mill in Middletown that produced sheet steel from ore to finished product by the continuous rolling process. The tobacco factories later disappeared, but paper and steel mills continued to flourish. Airplane products are also manufactured. Incorporated as a city in 1883, Middletown adopted a council-manager form of government in 1949. Pop. (1960) 42,-115; Hamilton-Middletown standard metropolitan statistical area (Butler county), 199,076. For comparative population figures *see* table in OHIO: *Population.* (W. E. SH.)

**MIDDLETOWN,** a town of Rhode Island, U.S., 26 mi. S.E. of Providence, on Aquidneck Island; it derives its name from its location between the other two towns on the island, Newport and Portsmouth. Middletown is closely related both historically and presently to Newport (*q.v.*), from which it was set off and incorporated as a separate town in 1743. Predominantly agricultural, it is known for its fine dairy farms and blooded stock. Bounded on both sides by Narragansett bay, it is a resort town with excellent ocean beaches and is also increasingly a residential area for Newport. St. George's school, a private school for boys, founded in 1896, is located there.

The most interesting historical site is Whitehall, the residence built in 1729 by George Berkeley (*q.v.*), Irish poet and philosopher who lived there from 1729 to 1731. The town has other early 18th-century residences of distinction which add to its attractiveness. For comparative population figures *see* table in RHODE ISLAND: *Population.* (W. D. MZ.)

**MIDDLE WEST,** also frequently called the midwest, the northern portion of the central United States, is usually defined to include the states of the north central region of the census bureau: Ohio, Indiana, Illinois, Missouri, Michigan, Wisconsin, Iowa, Minnesota, Kansas, Nebraska, North and South Dakota. Missouri and all or most of the western tier of states are sometimes excluded. The term "middle west" came into general use with the settlement of the far west.

Identification of the middle west as a region or section rests on geographical, historical, economic and other grounds. The region exhibits great diversity in climate, soil and resources. Although it has no large deposits of oil or precious metals, it does possess a vast extent of rich farming land, an excellent river and lake system, extensive forest lands principally in the lake states, and enormous deposits of base metals and minerals, notably iron, limestone and coal.

**The Beginnings.**—Settlement north of the Ohio river, which marks the southeastern boundary of the middle west, began slowly. The few land seekers who crossed the Appalachians before the Revolution settled mostly in Kentucky and Tennessee. During the Revolution, states with no claim to western lands insisted that those lands should become the common possession of the United States. By 1783 enough states had agreed to cede their western lands north of the Ohio to the national government so that the creation of a public domain was assured. Kentucky and Tennessee, as extensions of Virginia and North Carolina, were settled under regulations of their parent states but the region north of the Ohio was occupied under rules laid down by congress. In 1785 congress adopted a land law providing that Indian title be extinguished and the lands surveyed before being offered for sale. The survey system provided that the land be laid out in rectangular townships, six miles square. Each township was to be divided into 36 sections of 640 ac.; these in turn could be subdivided into halves, quarters, etc. The land was to be sold at auction at a minimum price of a dollar an acre, with alternating townships offered in their entirety, intervening ones in lots of 640 ac. One section in each township was to be reserved for the benefit of the common schools. Congress sought to assure compact settlement and wide distribution of the land.

Seven tiers of townships lying immediately west of the Pennsylvania border were designated for survey and sale but bureaucratic deliberateness and Indian hostility prevented prompt action. Meanwhile numerous land speculators sought large grants west of the surveyed land. The most energetic of these, the Ohio company organized by New Englanders, arranged a large purchase on the Muskingum river. Congress, at the insistence of the company, adopted a plan of government for the territory in the famous Northwest ordinance of 1787. This ordinance prohibited slavery, guaranteed trial by jury and other civil rights, and provided for the later formation of states. Under the first stage of government, the district, the government was controlled by officers appointed by the central government. When the adult male population reached 5,000, a second or territorial stage, which permitted an elective legislature, could be entered. When the total population reached 60,000, the territory was eligible to draft a constitution and enter the union on a basis of equality with the other states. Three to five states were to be erected in the Northwest Territory. Although often hailed as a great liberal document, the ordinance in the district stage allowed settlers fewer political rights than the English colonists had before the Revolution. The saving feature of the plan consisted of permitting the territory to grow to statehood.

**Territory to Statehood.**—For a decade after 1783 Indian hostility discouraged immigration. A small settlement at Marietta, in what later became Ohio, and a few scattered along the river as far south as Cincinnati marked the beginning of white occupation. After two disastrous attempts had been made to quell the Indians, troops under Gen. Anthony Wayne decisively defeated them at Fallen Timbers near the rapids of the Maumee in 1794 and the next year the treaty of Greenville brought peace to most of what became Ohio. By 1800 the rush of people to the middle west was beginning in earnest. Thereafter the spread and direction of settlement is roughly charted in the dates of admission of the states: Ohio entered the union in 1803; Indiana in 1816; Illinois, 1818; Missouri, 1821; Michigan, 1837; Iowa, 1846; Wisconsin, 1848; Minnesota, 1858; Kansas, 1861; Nebraska, 1867; North and South Dakota, 1889.

In 1796 congress, in revising the land law of 1785, raised the minimum price an acre to $2.00. Four years later it reduced to 320 ac. the minimum amount that could be purchased and allowed four years to complete payment. In 1800 the Northwest Territory had a population of 51,000 compared with about 2,600,000 each in the northeastern states and the south. By 1840 population of these two sections had doubled; that of the middle west had increased almost sixtyfold to 3,300,000. By 1870 the population of all three sections was roughly equal—a condition that would continue for many decades.

Unlike the region south of the Ohio, which drew settlers largely from the older southern states, the Ohio valley was attractive to immigrants both from the older states and from Europe. Germans, Irish, Scandinavians and others joined the push into the region, contributing to the heterogeneity of the population.

With relatively little waste land in the region, productive farms soon blanketed the area. With growing markets in the south, east and Europe, the great problem was to find ways to reach

these markets with the farm produce. Bulky commodities such as corn and wheat could be marketed locally or down river as grain or flour. Corn could also be sent to market as pork, beef or whiskey. In the first decade of the 19th century, farmers in the Scioto valley fattened cattle on corn and drove them across the mountains to eastern markets, thus initiating a business that would continue until railroads made such long drives unprofitable. Hogs were sometimes driven but more often were slaughtered locally and the meat processed and barreled for river shipment.

In the second decade of the century steamboats came into extensive use on the rivers. Agricultural and related commerce of the interior further increased with completion of the Erie canal in 1825. The success of this canal and the need for more transportation induced the states of Ohio, Indiana, Illinois and Wisconsin to launch ambitious canal building projects all aimed at connecting the Great Lakes with the Ohio or Mississippi rivers. By the 1850s railroads had begun to capture the carrying trade of the upper Mississippi valley and during this decade New York displaced New Orleans as the great ocean port of the middle west. The superintendent of the eighth census, in reviewing the grain trade of the United States up to 1860, declared it to be "one of the chief marvels of modern commercial history . . . the leading agency in the opening up of seven-eighths of our settled territory." Without the great European demand for American foodstuffs, he declared, "Capitalists could not have been encouraged to construct our immense canals, and lines of railroads, nor to have built our fleets of grain-carrying vessels to traverse the lakes and seas."

The richly productive farms also called into existence innumerable rural villages to serve their immediate needs and cities, many located along the waterways, to supply machinery and to collect, process and market the vast flood of meat and grain. Cincinnati became known to the world in the 1820s as Porkopolis. Later Carl Sandburg heralded Chicago as "Hog Butcher for the World" and "Stacker of Wheat." (*Chicago Poems*, Henry Holt and Co., New York, 1916.) Slaughtering and meat processing plants, flour mills, breweries, distilleries and a host of other industries emerged. Chronic labour shortage, rich soil, large fields and growing markets combined to encourage both invention and the widespread use of farm machinery. Before 1860 the McCormick brothers, for example, moved to Chicago and Jerome I. Case, manufacturer of threshing machines, located in Racine, Wis. Others established themselves in this area. By 1860 approximately half the farm implements produced in the United States were being manufactured in the middle west. Similarly machine shops provided equipment for the lumber camps and the burgeoning sawmills of the lake states. They continued to supply the industry when it moved to the Pacific northwest. Even after the rest of the nation was settled, the middle west did not lose its primacy. In the second half of the 20th century, seven of the ten leading agricultural states were in the middle west and three (Indiana, Illinois and Iowa) contributed about one-sixth of the total national value of farm produce. Of the six leading manufacturing states, three (Illinois, Michigan and Ohio) were in the middle west.

The middle west is the region of checkerboard patterns on the land. The air traveler going west knows when he reaches Ohio because for the first time he sees farms that still retain the rectangularity imposed by the first surveys. The square townships spread westward to the great plains and beyond. The survey township tended to become the basis for the smallest unit of civil government. Elections were held, taxes levied, roads laid out and built in relation to township and section lines.

**Education.**—With 40 to 150 farms and a village or two in a township, and land reserved for support of schools, the establishment of common schools was relatively easy. Perhaps to a greater extent than anywhere else in the nation, a situation existed peculiarly favourable for the creation of a uniform, tax-supported common school system. Also important was the development of state universities, which in the middle west attained a distinction not achieved in the older states. Organized early in the political history of the state, they were shaped partly in imitation of older universities, partly to serve the practical needs of the frontier communities. Thus Greek, Latin and moral philosophy appeared in the same curriculum with surveying, chemistry and normal training. Something akin to the "elective system" appeared by the 1850s although it went unpublicized until Harvard adopted it more than a decade later. Moreover, a system of middle or high schools was called into existence largely to serve as preparatory departments for the state universities. Thus was created a system of public education that extends from the elementary school through the university.

**Politics.**—In politics the middle west was tied initially more closely to the south than to the northeast and tended to support the Democratic party. As that party came to be the voice of the southern slave owners in the 1840s, middle westerners, unhappy with both Whigs and Democrats, helped create the new Republican party and contributed heavily to the Republican presidential victory in 1860. The region supported the Union with men and material during the Civil War and for decades thereafter held the Democratic party responsible for the war. The Republican party ruled supreme in most of the middle western states much of the time from 1865 until the great depression of the 1930s.

But the region was not without political ferment. Before the Civil War there were rural protests against railroad rates. Immediately after the war a host of splinter parties, some within the Republican party, appeared, dedicated to bringing railroads, grain elevators, and sometimes banks and corporations under state regulation. When, in the late 1860s, Oliver H. Kelley and associates formed the Patrons of Husbandry, also called the Grange (*q.v.*), the protesters found a focus and a vehicle for united action. Grangers captured the state government and wrote regulatory laws in most of the middle western states in the early 1870s and the U.S. supreme court upheld the right of states to regulate. The middle west also contributed support to the Greenback (*q.v.*) movement and in the 1890s provided leaders and support for the Populist party. This party offered a comprehensive list of reforms which, although rejected by the voters in 1892 and 1896, found its way in succeeding years, into the platforms of the major parties and later into the law of the land.

In the 20th century the region continued to furnish reformers, conspicuous among whom were Robert M. La Follette, Wisconsin; Albert B. Cummins, Iowa; and George W. Norris, Nebraska; all nominal Republicans. Nor had agrarian protest ended. In 1916 the Nonpartisan league arose in North Dakota, protesting against the familiar monsters: railroads, elevators and banks. During the great depression, the middle west was the land of the farm holiday, and milk strikes. The sit-down strike was introduced in the U.S. and the C.I.O. (Congress of Industrial Organizations) was born in the middle west in the same years. During and after World War I, the region came to be known as the isolationist middle west.

**The Nature of the Land.**—Although often described as the most materialistic part of the country, intent upon work and moneymaking, the middle west made substantial contributions to the literature, art and architecture of the nation and the influence of men such as Twain, Hemingway, Frank Lloyd Wright and many others transcends national boundaries.

The middle west, whatever else it is, is a region of material abundance, variety and practical unorthodoxy.

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**MIDFAI, JAMIL AL-** (1890– ), statesman and several times prime minister of Iraq. After attending the Engineering college in Istanbul he became an artillery officer in the Turkish army. Abandoning the latter in 1916 he joined the sherifian forces under Faisal (later King Faisal I of Iraq) in the Arab revolt in the Hejaz; served his prince in Syria (1918–20); and, as an ardent Iraqi nationalist, led tribal forces from Syria into Iraq (June 1920), causing an anti-British tribal affray in Tall Afar. Readmitted to Iraq in 1921, he assumed important provincial gov-

ernorships, showing honesty, moderation and capacity. He became prime minister, minister of the interior and later president of the chamber in 1930, twice briefly prime minister in 1933–34, minister of defense and again prime minister in 1937 for 16 months of barely maintained order and acute financial difficulty. He accompanied the regent Abd-ul-Ilah into brief exile in 1941 but returned to become prime minister under the restored monarchy and a protagonist of Arab unity. He loyally accepted office again in the troubled period of 1948, later to become president of the senate. He was again prime minister, at a time of internal stress and disorder, in 1953. He was already in retirement at the time of the antimonarchical military coup of July 1958. *See* also IRAQ.

*See* S. H. Longrigg, *Iraq, 1900 to 1950* (1953). (S. H. Lo.)

**MIDGET** is a type of dwarf in which the bodily proportions remain relatively normal. *See* DWARFISM AND GIGANTISM.

**MIDHAT PASHA** (1822–1883), twice grand vizier of Turkey, was born in Constantinople in Oct. 1822. His father, a civil judge, trained him for an administrative career, and at the age of 22 he was attached as secretary to Faïk Effendi, whom he accompanied in Syria for three years. On his return to Constantinople, Midhat was appointed chief director of confidential reports, and after a new financial mission in Syria was made second secretary of the grand council. In 1854 his enemies caused him to be given the nearly impossible task of settling the revolt and brigandage rampant in Rumelia. His measures were drastic and their success was startling; the government therefore made him an official of the first rank and restored him to his place in the grand council. He restored order in Bulgaria in 1857. In 1861 he was made vizier and pasha, and entrusted with the government of Nis, where his reforms were so beneficial that Sultan Abdul-Aziz charged him, in conjunction with Fuad Pasha and Ali Pasha, to prepare the scheme for adapting them to the empire. This scheme was afterward known as the law of the vilayets. He organized the council of state in 1868, and was then made governor of Baghdad (1869), where his success was as decisive as at Nis, but attended with much greater difficulties. In 1872 the antireform influence of the grand vizier, Mahmud Nedim, seemed to Midhat a danger to the country, and in a personal interview he boldly stated his views to the sultan, who appointed Midhat grand vizier in place of Mahmud. Too independent, however, for the court, Midhat remained in power only three months (Aug.–Oct. 1872). After a short governorship of Salonika he was appointed minister of justice and then president of the high council.

While sympathizing with the ideas and aims of the "Young Turkey" party, Midhat was anxious to restrain its impatience. The sultan's obduracy, however, led to a coalition between the grand vizier, the war minister and Midhat Pasha, which deposed the sultan in May 1876. His nephew Murad V was in turn deposed in the following August and replaced by his brother, Abdul-Hamid II. Midhat Pasha then became grand vizier, reforms were freely promised and a constitution was promulgated on Dec. 23 with a great flourish. In the following February, however, Midhat was dismissed and banished for alleged plotting against Abdul-Hamid II. Again recalled in 1878, he was appointed governor of Syria, and in August exchanged offices with the governor of Smyrna. But in May 1881 the sultan again ordered him to be arrested, and although he effected his escape and appealed to the powers, he shortly afterward surrendered, claiming a fair hearing. The trial took place in June, when Midhat and others were sentenced to death. On the intercession of the British government the sentence was commuted to banishment. The remaining three years of his life were spent at At Ta'if, Arabia, where he died, probably by violence, on May 8, 1883. To great ability, wide sympathies and patriotism he added absolute honesty. *See* also TURKEY: *History*.

(G. F. B.; E. Z. K.)

**MIDHURST,** a town in West Sussex, Eng., on the river Rother, lies 12 mi. N. of Chichester by road. Pop. (1961) 2,070. The name of Midhurst (Middeherst) first occurs in the reign of Henry I. It was definitely called a borough in the reign of Edward I and was governed by a bailiff until early in the 19th century. In an act of 1883 it was mentioned as one of the towns which had long ceased to be municipal. It is now a parish of the Midhurst rural district. Midhurst sent two members to parliament from 1311 to 1832 and one member from 1832 to 1885; Charles James Fox entered parliament in 1768 as its member. From early in the 13th century a market was held by the burgesses every week and later there was a fair on Whit-Tuesday. The church of SS. Mary Magdalen and Denis is mainly Perpendicular, but very much rebuilt, and there are many old houses including a partly 15th-century inn. The grammar school was founded in 1672. In Cowdray park are the ruins of Cowdray house (1530), which was destroyed by fire in 1793. Three miles north at Lord's common is the King Edward VII sanatorium for tuberculosis.

(L. F. S.)

**MIDI, CANAL DU,** 150 mi. long, connects the Mediterranean sea at Sète with the navigable river Garonne at Toulouse, providing a water link across southern France from the Mediterranean to the Atlantic ocean. It was built between 1666 and 1681 by Pierre Paul Riquet of Béziers and passes through the lowland Gate of Carcassonne between the eastern Pyrenees and the southwesternmost part of the Massif Central in the Montagne Noire. There are 65 locks, 48 of them on the Mediterranean side. From the Étang de Thau west of Sète the canal passes the vineyards of the plain of Languedoc, crossing the Orb river by an aqueduct at Béziers, and reaching the Aude valley north of Narbonne. It follows this valley to Carcassonne and then continues westward past Castelnaudary, where the last olive groves marking the Mediterranean climate are left behind and maize (corn) begins to appear. An obelisk to the memory of Riquet stands by the summit of the canal on the Mediterranean-Atlantic watershed at 630 ft. above sea level in the Seuil de Naurouze, whence the canal descends by the Hers valley to reach the Garonne river at Toulouse, enclosing the old part of that city in its arc as it approaches the junction. The water in the canal is maintained by a supply canal (*rigole*) from the St. Ferréol reservoir at 1,100 ft. in the Montagne Noire, where Riquet built a dyke 800 yd. long to impound the *bassin* ("lake") 168 ac. in extent. From Toulouse, the lateral canal of the Garonne, built 1838–56, continues the waterway to the lower Garonne at Castets, in place of the shifting channel of the river. It follows the valley, crossing from right to left bank at Agen. Connection with the Rhône river is provided from Sète to Beaucaire by the Canal du Rhône à Sète, by way of the lagoons of the Languedoc coast.

Construction of the Canal du Midi gave a great stimulus to the trade and urban growth of Toulouse (*q.v.*), but its relative importance diminished after the coming of railways. The traffic is chiefly agricultural produce and fertilizers, oil, timber and building materials. (AR. E. S.)

**MIDIAN,** one of the wandering tribes the Israelites had dealings with in the nomadic stage of their history. According to Gen. xxv, 2 the Israelites considered Midian as belonging to the populations of the Arabian peninsula, descendants from Abraham by his second wife Keturah. The main dwelling area of the Midianites seems to have been the region east of the Gulf of Aqaba. The frequent contacts of Moses with their priest Jethro suggest their presence near Mt. Sinai (Ex. ii, 15–21; iii, 1; xviii), but the identification of Mt. Sinai is disputed (*see* SINAI; for the supposed influence of Midianite religion on Yahwism, *see* KENITES). Other traditions relate battles against the Midianites in the region of Moab (Num. xxxi). The Book of Judges tells how Gideon drove out the Midianites into western Palestine (Jud. vi–viii). Then they disappear from Israel's horizon, though they are sometimes mentioned in later texts; *e.g.*, as gold and incense traders (Isa. lx, 6). But there remained a vivid memory of Yahweh's salvation through Gideon, "the day of Midian" (Isa. ix 4; in Hebrew text ix, 3). (L. H. GR.)

**MIDLAND,** a city of Michigan, U.S., and the seat of Midland county, is 18 mi. W. of Bay City. In the 19th century it was a booming lumbering town. In 1888 the chemist Herbert H. Dow (*q.v.*) came to Midland, where he founded the Dow Chemical company; after 1900 both the town and company continued to expand. Other industries include oil and gas, agriculture and dairy products, and the manufacture of concrete, plastic toys, silicones and fibre drums. Much of Midland's natural beauty was

restored when Dow created 70 ac. of beautiful orchards, rolling lawns and gardens, and artificial ponds surrounded by pine stump and local rock fences. Following Midland's centennial in 1950 there was a flourish of new building: churches, schools, homes, libraries, industrial structures, stores, additional hospital space and a community centre. Many of these, including the First Methodist and St. John's Lutheran churches, were designed by the architect Alden B. Dow, son of H. H. Dow. For comparative population figures *see* table in MICHIGAN: *Population.* (K. C. C.)

**MIDLAND,** a city of western Texas, U.S., and seat of Midland county, is on the southern edge of the High Plains midway between Fort Worth and El Paso. Its mean annual temperature is 63° F. (17° C.) and its average annual rainfall is 16.6 in. Midland was started in 1884 as a depot on the Texas-Pacific railroad and was incorporated as a city in 1906. It has a council-manager form of government which went into effect in 1947. Farms, located largely in the northern part of the county, produce cotton, grain sorghums, swine and sheep. Midland is the hub of a 12-county ranching region famous for fine Hereford cattle.

Midland is also the headquarters for the Permian basin, an extensive area holding a sizable part of the nation's known oil reserves. Oil was discovered in the basin in 1923; three years later the industry began moving into Midland. With over 65,000 producing wells in the basin and about 650 company offices in the city, Midland became one of the nation's ranking oil centres. Other industries include a chemical plant, tool and machine shops, cottonseed-oil mills, compresses and potash mining. Midland is also the trade and financial centre for the area. Midland has a public library with over 8,000 volumes on geology, an annual rodeo and fair, a community theatre, a symphony orchestra, and over 900 ac. of park area. As a result of the oil development, the population increased rapidly. Pop. (1960) 62,625; standard metropolitan statistical area (Midland county), 67,717. For comparative population figures *see* table in TEXAS: *Population.* (E. WE.)

**MIDLOTHIAN,** a county in southeastern Scotland. The ancient county is now divided into the county of the city of Edinburgh (*q.v.*) and the administrative county of Midlothian; the joint area is 366.2 sq.mi. The county is bounded on the north by the Firth of Forth and the city of Edinburgh, once popularly called the Heart of Midlothian (a name perpetuated by a well-known football club). The county extends 5 or 6 mi. from the city boundary to the south, west and east, and about 20 mi. to the southwest and east-southeast.

The north central lowland, southeast of Edinburgh, is the basin of the North and South Esk. Near the mouth of the Esk at Musselburgh are flat well-drained postglacial raised beaches. At a higher level are erosion surfaces between 100 and 500 ft. and from 500 to 750 ft. (higher near the hills), separated by fairly steep slopes. All these surfaces are planed across mainly Carboniferous rocks lying in a syncline pitching to the northeast. Round the edges is the Calciferous Sandstone series, including important coals, and inside this is Millstone Grit, with Coal Measures in the centre. The soils of these low plateaus include considerable stretches of peat on wide moors at about 700 ft. in the south of the county. Most of the rest is fertile farmland on gently rolling boulder clay with occasional sandy stretches. The glacial upset of drainage caused the present streams to cut gorges and the steep sides of these streams are clad in mixed deciduous woodland. The general pattern of large square fields and big farmsteads is broken by shelter belts and woodlands of pines, beech, etc., and by parkland, with oak and beech trees, round mansion houses. The southwestern wing of the county includes analogous low plateaus cut mainly across the Calciferous Sandstone series. These plateaus occur in the right-bank part of the Almond basin, the water of Leith basin up to the boundary with Edinburgh and in part of the Pentland hills. The Pentlands (Scald Law 1,898 ft.) comprise a dissected plateau of rounded grassy or heathy summits from 1,500 to 1,900 ft. mainly consisting of lavas and tuffs with some conglomerates and sandstones all of Old Red Sandstone age. The southeastern wing of the county is largely in the basin of the Gala Water, tributary to the Tweed. This river flows southeast in a lowland corridor of about 500 ft. between the dissected plateau of the Moorfoot hills (summits mainly 1,500 to 1,700 ft. culminating in Blackhope Scar 2,137 ft.) and the southwestern fringes of the Lammermuir hills. The whole of this area is mainly cut in Silurian lightly metamorphosed shales and grits.

The mean annual rainfall varies from under 25 in. near the coast to more than 45 in. in the hills where a number of artificial reservoirs supply water to Edinburgh and Midlothian and also to the Union canal (not used except as a source of water for industry). Spring is often rather cold and dry, with some sea mists. July and August tend to be a little wetter than the spring and autumn, but the mean monthly sunshine is 4½ to 5 hours per day on the lowlands. (A. T. A. L.)

On many hilltops are remains of fortified settlements (*e.g.,* Kaimes hill), forts (*e.g.,* Dalmahoy hill and Corsehope hill), or cairns (*e.g.,* Carnethy hill). Among other archaeological remains are mounds, the foundations of a broch (stone tower), parts of stone circles and some standing stones such as the "Cat Stane" near the Almond. During the Roman occupation Inveresk was an important settlement and remains including pavements and a bathhouse have been excavated there. Dere street, the main Roman road from England, entered the county over Soutra hill and probably ran into Inveresk and thence to Cramond. On the other side of the Pentland hills is Castle Greg, another fort site believed to be Roman. An earth house excavated at Crichton Mains contained many stones bearing Roman marks, suggesting that there had been another Roman camp in the vicinity.

The many ecclesiastical buildings include some remains of the great Cistercian abbey at Newbattle and the church of the Knights Templars at Temple. There are two churches dating in part from the 12th century, one from the 13th century and, among later buildings of interest, the elaborately decorated 15th-century Rosslyn chapel is perhaps the chief one. Little secular building from before 1400 survived invasions from England but there are numerous later castles (notably Borthwick, Rosslyn, Crichton) and houses and a number of old bridges. The historic interest of Midlothian centres on Edinburgh. Famous battle sites are at Pinkie (1547), Carberry Hill (1567) and Rullion Green (1666).

The population of the administrative county in 1961 was 711,954. There are five small burghs: Bonnyrigg and Lasswade (6,331), Dalkeith (8,864), Loanhead (5,023), Musselburgh (17,273) and Penicuik (5,824). The landward part (as opposed to the burgh parts) of the county (68,639) is divided into eight county districts. The administrative county is a single parliamentary constituency with the exception of Musselburgh which is part of the Edinburgh (East) constituency. The administrative headquarters of the county are in Edinburgh.

Intensive market gardening is focused on the raised beaches between Dalkeith and the coast. There is arable stock farming, including dairying, on the boulder clays, and this is more intensive on the lower erosion surfaces (oats, barley, potatoes, swedes, wheat, and some fruit and vegetables) and more orientated toward stock on higher, cooler, wetter surfaces. There is hill sheep farming on the moorlands.

Coal mining is the principal industry and the main coalfield lies in the valleys of the Esk rivers but there is a smaller coalfield in the Calders. The National Coal board has expanded output in the former by sinking two new shafts. For many years, in the Calders area, shale was mined as the basis of an oil extraction and refining industry, but this has now ceased (*see* CALDER). Fireclay, roadstone, sands, limestone and sandstone are extracted and bricks are made.

The largest manufacturing industry is papermaking. Nine mills operate in the county, the main centres being Penicuik, Lasswade, Musselburgh and Balerno. The main engineering establishments are wireworks in Musselburgh, hydraulic and marine works at Loanhead and a foundry and an electronic equipment factory at Dalkeith. Carpets are made at Bonnyrigg and Eskbank, and nets at Musselburgh. There are also a number of large industries producing ales and food products including flour and oatmeal.

The main roads and railways in the county radiate from Edinburgh. In the eastern part Dalkeith also is a road centre.

(J. McB.)

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**MIDNAPUR** (MIDNAPORE), a town and district located in the Burdwan division of West Bengal, India. The town, headquarters of the district, lies on the left bank of the Kasai river, 80 mi. W. of Calcutta by rail. Pop. (1961) 59,532. The Hanuman and Juggernaut temples are the main attraction of the town. The town is linked by rail and road with the main centres of India.

MIDNAPUR DISTRICT covers an area of 5,258 sq.mi. Pop. (1961) 4,341,855. The Rupnarayan and the Kasai flow through the eastern stretches of the district, and by depositing silt on their flood plains render this part agriculturally productive. Rice, pulses, oilseeds and potatoes are the principal crops. The main source of irrigation is the Midnapur high level canal, which takes off from an anicut across the Kasai river below Midnapur town. The Kasai valley project offers wider irrigation facilities. The western upland, still covered with scrub vegetation, contains rich arable land at the bottom of depressions between rocky ridges. Rice is grown there; maize (corn), millets, oilseeds and pulses are cultivated in the uplands. In the coastal region to the south embankments have been constructed to keep out the salt water. Kharagpur (*q.v.*) is the largest town and Geonkhali on the right bank of the Hooghly opposite Hooghly town is a minor port. From there Hijli tidal canal runs westward and is navigable for 50 mi.

The early history of Midnapur centres on the town of Tamluk of Tamralipta on the Rupnarayan river which can be traced back to the beginning of the Christian era as a capital of an ancient kingdom. It is mentioned as a flourishing seaport by Ptolemy, and by the Chinese travelers Fa-Hsien (5th century) and Hsüan Tsang (7th century). It declined in the 16th century because of the silting up of the channel that connected it with the sea. In the 1960s Haldi, at the mouth of the Kasai, was developed as an outport of Calcutta (*q.v.*). Digha on the southwest has a fine sea beach. The district has eight colleges affiliated to Calcutta university. (S. P. C.)

**MIDRASH,** a term applied to certain methods of biblical exegesis and to a class of Jewish writings employing these methods. It is derived from the Hebrew root *darash*, "to search" or "to investigate," and indicates intensive study or searching of the spirit of a passage, as opposed to literal interpretation (*peshat*). The Talmud poetically describes Midrash as a hammer that wakes to shining light the sparks that slumber in the rock (Sanhedrin 34b). The word appears twice in the Old Testament, in II Chron. xiii, 22 and xxiv, 27, rendered in English as "story" or "commentary." Midrash proper originated in the period of the scribes (*q.v.*), though the earliest extant collections date from the 2nd century A.D. Such "searching" became necessary because the formulated Law, in the Pentateuch, required reinterpretation in later days, and because of the disagreement between the Pharisees and Sadducees over the status of the Oral Law (*see* JEWISH SECTS DURING THE SECOND COMMONWEALTH).

The Midrashim may be divided into two broad groups: (1) The Midrash of the academies, Midrash Halakha, often called tannaitic Midrash; this may be defined as the scholastic deduction of the Oral Law (*halakha*) from the written law. (2) The Midrash Haggada, homiletic works whose purpose is edification rather than legislation. Both seek to reveal the inner meaning of the Bible.

Haggadic Midrash was highly esteemed, but it was not so authoritative as halakhic. This was natural from the essential difference between the two. *Halakha* may be dull and legalistic but it is sober; whereas *haggada* is rarely dull, often highly imaginative and edifying, but does not insist on sobriety. While it includes many elements of extreme interest in folklore, archaeology and history, it stands in much the same relation to theology as a collection of sermons by great preachers does to canon law. Thus, on July 20–24, 1263, at a great disputation at Barcelona between Rabbi Moses ben Nahman and the Dominican Pablo Christiani, the former disarmed his opponent by disavowing the binding character of the *haggada*, on which Pablo had based his case, and by declaring that some passages were merely points in sermons, expressing at most the individual opinions of the preacher and lacking the sanction of authority.

Nevertheless, the extent of arbitrary invention in Midrash must not be exaggerated. In addition to strict truth and sheer fantasy (*e.g.*, between a genuine fact of archaeology or lexicography, recovered in a parable or exemplified in a saying, and a digression of apocalyptic exuberance) there is an intermediate portion that must neither be categorically denied nor accepted absolutely. Ancient historians must not be brushed aside because their methods fail to conform to modern historiographic standards; their writings must be carefully tested. This is the way to treat the quasi-historical portions of Midrash. Judiciously used, the Midrash and the Apocrypha (which to some extent fill the gap between the Old Testament and the rabbinic Midrashim) may sometimes present a clue to a lost line of tradition; this tradition may or may not be valuable historically, but its recovery is of interest, since it was accessible to the particular Old Testament writer who discarded it or used it only incidentally.

Thus, Gen. xlviii, 22 contains a cryptic allusion to the capture of Shechem (in English versions the term "portion" or "mountain slope" is used for Heb. *shechem*, "shoulder"). In ch. xxxiv of the apocryphal Book of Jubilees (probably late 2nd century B.C.) a story of this war is detailed, and similar accounts are preserved in various Midrashim. It is unlikely that these were mere elaborations of Gen. xlviii, 22: it may be inferred that an extracanonical tradition continued after the compilation of Genesis and ultimately assumed the exaggerated forms now extant.

Midrashic exposition was based on the theory of progressive interpretation. Since the Scriptures were of divine origin, every word, every letter had a definite meaning. Moreover, every word had "70 aspects." This means that generation after generation could extract new lessons, all of which were deemed latent or implicit. Some of these interpretations were arbitrary, but more often the arbitrariness lay not in the teaching but in the deduction. Often the biblical text supplies no more than a hint or suggestion, and the particular application in *halakha* or *haggada* must be taken on its merits; the teaching does not necessarily fall because the exegesis is illegitimate. As an example of the sparks that might be hammered out of the rock, the *Mekilta* on Ex. xx, 25 ("And if you make me an altar of stone, you shall not build it of hewn stones; for if you wield your tool upon it you profane it") infers from the unusual form of the word "it" that the prohibition of iron applies only to "it" (*i.e.*, the altar) and not to stones used in building the Temple. This *halakha* is followed by a haggadic explanation of the prohibition: iron shortens life, the altar prolongs it; iron causes death and sorrow, the altar produces reconciliation between God and man; therefore iron may not be used in building the altar. Midrashic exegetical methods are often seen in the New Testament. Thus, emphasis on a single word is illustrated by Gal. iii, 16, where the argument rests on the word "seed" or "offspring" (and not the plural "seeds" or "offsprings"); in rabbinical writings the same word is used to support other arguments.

The more important Midrashim are:

1. *Mekilta*, on Exodus. This begins at Ex. xii, the first legislation (the ordinance of the Passover). The later portions of Exodus are not commented on in the surviving Midrash, but there is reason to believe that the original was fuller. This famous Midrash was of the school of the *tanna* Ishmael, but it was completed in the school of the patriarch Judah in the 2nd century A.D. It is divided into nine tractates, each named individually.

2. Another recension of the *Mekilta*, cited by medieval authors, was that of Simeon ben Yohai.

3. *Midrash ha-Gadol* ("The Great Midrash"), a composite work on the Pentateuch, apparently compiled in the 13th–14th century, discovered in Yemen at the end of the 19th century, contains much otherwise lost material.

4. *Sifra* ("Book") (*de-Be Rab*), on Leviticus, which it follows almost verse by verse. Probably redacted by Rabbi Hiyya in the beginning of the 3rd century A.D.

5. *Sifre* ("Books") (*de-Be Rab*), on Numbers and Deuter-

onomy (2nd and 3rd centuries). The *Sifre* have survived in poor condition—passages cited by Rashi in the 11th–12th century are missing from modern editions. It is referred to in the Talmud as covering Exodus also; this was no doubt a fuller edition.

6. *Midrash Rabba,* on the Pentateuch and Megilloth (*i.e.,* Song of Songs, Ruth, Lamentations, Ecclesiastes and Esther).

7. *Tanhuma* (two recensions), on the Pentateuch, one of the oldest Midrashim, is mentioned once in the Talmud. The name apparently is derived from that of the *amora* Tanhuma bar Abba.

8. *Pesikta (de Rab Kahana),* 33 homilies on the principal festivals. This is an early (not later than the 7th century) Midrash that was lost during the middle ages; it was known only from quotations till the mid-19th century, when Leopold Zunz collected them and reconstructed the entire work.

9. *Pesikta Rabbathi,* a similar but separate collection of 51 homilies, dating from the 8th or 9th century.

10. *Midrash Shohar Tob (Midrash Tehillim),* on Psalms. Place and time of compilation are disputed.

11. *Valkut* ("Wallet"), title of several midrashic collections, the most famous of which is the *Valkut Shimeoni,* compiled in Germany in the 13th century and covering the entire Old Testament. It is of special importance because it quotes a number of text sources that are no longer extant.

*See* also TALMUD.

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**MIDSHIPMAN,** the title used in the Royal Navy from about 1660 for "young gentlemen" in training at sea to qualify for service as commissioned officers. Continental and U.S. navies from their foundings adopted the title and system. The equivalent French title is *aspirant,* the Spanish, *guardia marina.* By the latter half of the 20th century, all British midshipmen were students at the Britannia Royal Naval college, Dartmouth, while midshipmen of the U.S. navy attended the United States Naval academy at Annapolis, Md.

**Royal Navy.**—As lord high admiral of England, James, duke of York, believed it was necessary to train "sea officers" and to start early. Before his time there was no corps of professional naval officers. With the approval of his brother, Charles II, James inaugurated the first step in a development which took about 200 years.

Until about 1720 midshipmen were in theory volunteers, accepted aboard ship with a letter of service, which led them to be called "king's letter boys." Kipling, Taffrail (Dorling, H. T.), Bartimeus (Lewis Ritchie) and other writers affectionately used the term "snotty" for midshipmen.

The system underwent many changes. The entering age varied. The title "naval cadet" was introduced to denote a rank below midshipman. A naval academy, established at Portsmouth in 1729, was reorganized in 1773 and renamed the Naval college in 1806. In 1837 the boys went to sea directly and had schoolmasters to aid the ships' officers in their instruction. But in 1857 the afterward famous training ship "Britannia" was established. The Royal Naval college at Osborne was used until 1921.

In May 1955 the officer entry to the Royal Navy was changed to a new system. Cadets were to enter between the ages of 17 years 8 months and 19 years. The new course at Dartmouth required about two and one-half years. Cadets joined on a common entry basis and specialized later. After one year as cadets, including sea training in the Dartmouth training squadron, they were promoted midshipmen, but continued to receive training as well as professional and academic instruction. Upon leaving Dartmouth, where they served as cadets and midshipmen, they were promoted acting sublieutenants and went to sea for 18 months of further instruction in ships of the fleet. No longer were there any midshipmen serving afloat. This was a sentimental loss to the Royal Navy because many of the most brilliant officers in the history of the service first distinguished themselves for gallantry and seamanship while midshipmen.

**U.S. Navy.**—In the early days of the U.S. navy, during the Revolution, the Barbary wars, War of 1812 and Mexican War, many young men distinguished themselves while in the rank of midshipman. Until 1845 all service as midshipmen was in seagoing ships. David G. Farragut became a midshipman at the age of 9, and was promoted to lieutenant at 24. Usually, however, the age at entrance was 14 to 20.

The United States Naval academy was established at Annapolis, Md., by George Bancroft, the historian, then secretary of the navy, in 1845. Congress provided that midshipmen should be appointed to the academy by senators and representatives. This policy, which already applied to the United States Military academy, had the advantage of bringing in young men from all sections of the country, in proportion to population, thus making the navy a national rather than a sectional institution. In the beginning a midshipman spent one year at Annapolis, three years at sea and another year at Annapolis for study and final examinations. Upon passing these examinations he was promoted to "passed midshipman."

In 1862 the grade of ensign was established as the equivalent of the rank of second lieutenant in the army and the passed midshipmen were given the rank of ensign.

At various times the students at the naval academy have been called in turn acting midshipmen, midshipmen, cadet midshipmen and cadet engineers, naval cadets, and, again, since 1899, midshipmen. Graduates of the academy are commissioned ensigns in the line or staff corps of the navy, or second lieutenants in the marine corps, army or air force. A candidate must not be younger than 17 nor older than 22 on July 1 of the year he enters.

(J. B. HN.)

**MIDWAY, BATTLE OF,** on June 3–6, 1942, is generally regarded as the turning point of the Pacific phase of World War II and the most decisive naval battle of the war. The fighting took place in the waters north and west of Midway Islands (*q.v.*). The opposing U.S. and Japanese fleets did not come in sight of each other (except for submarines) and the action was chiefly by carrier-based and land-based airplanes. The Japanese lost heavily —four aircraft carriers and about 250 planes—and failed to capture Midway. The U.S. losses were much lighter, though they included the carrier "Yorktown" and many carrier-based and land-based planes with their highly trained crews. *See* WORLD WAR II: *The War in the Pacific.*

**MIDWAY ISLANDS,** a circular atoll in the central Pacific ocean at the western end of the Hawaiian chain about 1,300 mi. N.W. of Honolulu and just east of the international date line (latitude 28° 13′ N., longitude 177° 23′ W.). About 6 mi. in diameter, the atoll encloses two islands, Eastern and Sand ($1\frac{1}{4}$ and $1\frac{3}{4}$ mi. long respectively). The area of Midway Islands is 2 sq.mi. Pop. (1960) 2,356.

First reported and claimed for the U.S. in 1859 by Capt. N. C. Brooks, the atoll at first was called Middlebrooks and then Brooks. The name Midway dates from its formal annexation by the U.S. in 1867. The same year a coal depot was established there for transpacific steamers, but was never used. In 1903 Pres. Theodore Roosevelt placed Midway under the control of the U.S. navy department, and Sand Island became a station of the Hawaii-Luzon submarine cable in 1905. Transpacific aviation gave Midway new importance in 1936 when the island was made a regular stop on the San Francisco–Manila run.

In 1940 the U.S. navy began work on a major air and submarine base at Midway. In World War II the battle of Midway (June 3–6, 1942), characterized mainly by attack of carrier-based planes on one another and on ships, marked the turning point of the Pacific war (*see* WORLD WAR II: *The War in the Pacific*).

After the war, the development of long-range planes reduced Midway's importance as a commercial air base and regular stops there were eliminated in 1950. That year also saw the reduction

of Midway's U.S. navy establishment to a housekeeping force. When Hawaii became a state in 1959, Midway was not included. (J. H. K.)

**MIDWEST, THE** (U.S. area): *see* MIDDLE WEST.

**MID-WEST NIGERIA,** a region of the Federation of Nigeria, comprising the provinces of Benin and Delta which previously formed the eastern part of Western Nigeria. It is bounded north by Kabba province, Northern Nigeria, and east by the Niger river. Area 15,000 sq.mi. Pop. about 2,000,000 at the time of its formation. Most of the region lies below 500 ft., but in the north, near the border with Northern Nigeria, it rises to more than 1,500 ft. Much of its surface is covered with tropical rain forest, where rainfall exceeds 70 in. a year. In the Niger delta which, with its mangrove swamps, is a maze of interconnecting waterways, annual rainfall totals of more than 100 in. are recorded. The capital is Benin (*q.v.*) with a population of *c.* 54,000, and a majority of the population has associations with the ancient Benin kingdom. This majority includes the Edo-speaking peoples (about 450,000) and the Urhobo (about 270,000). There are other important ethnic groups such as the Ibo (about 300,000), the Ijaw (about 100,000) and the Itsekiri of Warri who are smaller in number but nonetheless influential.

After several years of political pressure and agitation to separate Benin and Delta from Western Nigeria, a referendum was held in the two provinces in July 1963. A large majority voted in favour of separation and the new region was created the following month. An interim government was appointed until elections were held in Feb. 1964. These resulted in a victory for the National Convention of Nigerian Citizens, which then provided the government.

The acid, sandy soils which characterize much of the region, together with the high rainfall, make it unsuitable for cocoa, and rubber, timber and oil palm products are the principal exports. Efforts were being made in the early 1960s to increase the production of rubber and to improve its quality. At Sapele there is a large mill producing plywood and veneers. There is no mineral production, but deposits of lignite and natural gas have been located. Roads are few and poor apart from the main road from Lagos to Eastern Nigeria which passes through Benin and will eventually cross the Niger by bridge at Asaba. The creeks and waterways of the western part of the Niger delta and the Forcados and Escravos rivers are used for transport, and oceangoing ships are able to reach Warri and Sapele. (R. M. P.)

**MIDWIFERY,** the art and practice of attending upon women in childbirth, was in all early civilizations the exclusive province of women, and the profession of midwife must be one of the oldest. It is clearly recognized in the earliest books of the Old Testament and was an accepted element in the social structure in ancient Greece and Rome. But the old obstetrical learning, meagre as it was, disappeared in the chaos of the middle ages, and the little that survived became grossly adulterated by superstition. Childbirth in those days was associated with an appalling infant mortality and with grave danger to any mother who was unable to deliver herself expeditiously and unaided.

In Europe in the 17th century a slow and hesitant movement for the training of midwives began. In the 18th century maternity hospitals appeared in the larger cities and became training centres; but it was not until the 19th century that the training and control of midwives' practice were put on a statutory basis. The Netherlands, Scandinavia, Germany and France were all in advance of Britain in this, for, despite urgent representations by public medical bodies, it was not until 1902 that the British parliament passed the first Midwives act. This law set up a Central Midwives board for England and Wales "to secure the better training of midwives and to regulate their practice." Similar acts for Scotland and Ireland followed in 1915 and 1918. These acts enabled the boards to prescribe the outlines of the training of pupil-midwives in hospitals recognized for the purpose, to examine and license candidates and to regulate the practice of all such certified midwives.

This was a great advance, for at that time the great majority of births in England and Wales were domiciliary (*i.e.*, took place in the patients' own homes) and were attended by midwives. Later there was a great swing over to hospital confinement: in England and Wales the percentage of births in hospitals and nursing homes as distinguished from domiciliary births rose from 40% in 1937 to 66% in 1962, and in Scotland from 34% to 77% in the same 25-year period.

After the introduction of the Midwives acts there was a steady rise in the educational standards, social status and professional skill of British midwives, most of whom were trained as state registered nurses (S.R.N.) before becoming state certified midwives (S.C.M.). (R. W. Jo.)

In the U.S., a midwife is a person who attends, or who bargains, contracts or agrees to attend, any woman at or during childbirth and who is not licensed to practise the healing arts generally or obstetrics in particular. In the early 1920s the licensing of midwives was discontinued and was replaced by programs aimed at training and supervising the midwives more efficiently. In later years, however, there was a tendency toward the elimination of midwives. In 1920 Massachusetts was the only state in which midwives had no legal status; by the middle 1960s they had no status in 10 other states. A number of the remaining states recognized midwives to the extent of requiring them to comply with the vital statistic laws. In the states that actually sought to control midwives, the local laws delegated licensing and supervisory powers to either the state department of health or the board of medical examiners. These laws prescribed the preliminary training and education required of midwives, the subjects to be covered in the licensing examination and the grounds for which a license may be revoked or suspended.

*See* also CHILDBIRTH; MATERNAL AND CHILD HEALTH; NURSING; OBSTETRICS. (G. E. H.)

**MIDWIFE TOAD,** a European member of the frog and toad group with remarkable breeding habits. The common form of central Europe, *Alytes obstetricans,* is about two inches in length, of dull grayish coloration and plump form, with warty skin and large eyes. Although toadlike, it belongs to a quite distinct family, Discoglossidae. It inhabits most of western Europe. A second species, *A. cisternasii,* occurs also in Spain and Portugal.

JOHN MARKHAM

MIDWIFE TOAD (ALYTES OBSTETRICANS) OF EUROPE

The midwife toad is nocturnal and slow in its movements. It is thoroughly terrestrial. Toward evening the males reveal their presence by a clear whistling note. The breeding season lasts throughout spring and summer, and the female spawns two, three or even four times in the year. Mating takes place on land; the male seizes the female round the waist, and stimulates her cloacal region with his toes until the eggs are forcibly expelled. The eggs are large and yellow, and produced in two rosarylike strings, as if strung together by elastic filaments, continuous with the outer gelatinous capsules. While the eggs are being extruded, the male positions himself and discharges milt (sperm-containing fluid) over them to effect fertilization. This having been accomplished, the male twists the egg strings round his legs and returns to his usual retreat, resorting to a short immersion in the water during exceptionally dry nights. When the time for hatching has come, after about three weeks, the male enters the water; the larvae, measuring slightly over a half inch, bite their way through their tough envelope, which is not abandoned by the father until all the young are liberated. The tadpoles grow to a large size before metamorphosis.

*See* also AMPHIBIA.

**MIE,** prefecture (*ken*) of Japan, in the Kinki region, central western Honshu, facing Ise bay, was formed from the provinces of Ise (*q.v.*), Iga, Shima, and two counties of Kii after the Restoration of 1868. Area 2,226 sq.mi., pop. (1960) 1,485,054. The most sacred Shintō shrine of Japan, the Grand Shrine of Ise, is located in Mie (*see* also SHINTŌ). Ise-Shima and Yoshino-

Kumano National parks are centres of the tourist industry. Important products include cotton and woolen textiles, Bankoyaki porcelain, lumber, cement, glass, lobster and shrimp, and dairy produce. The prefecture is the chief centre of cultured pearl production. The Tsu (*q.v.*) on the west shore of Ise bay is the prefectural capital. (C. A. Mr.)

**MIEREVELT** (Miereveld), **MICHIEL JANSZOON VAN** (1567–1641), Dutch portrait painter, who was patronized by the royalty of many countries, was born at Delft on May 1, 1567, the son of a goldsmith, who apprenticed him to the copperplate engraver J. Wierix. Antonio van Montfort (Blockland), who had seen and admired two of Mierevelt's early engravings, "Christ and the Samaritan" and "Judith and Holofernes," invited him to enter his school at Utrecht. He remained at Utrecht till the death of Montfort (1583), and then settled at Delft. Devoting himself first to still life, Mierevelt eventually took up portraiture, and the many commissions entrusted to him necessitated the employment of numerous assistants, by whom hundreds of portraits were turned out in factory fashion. The works that are certainly his are remarkable for sincerity, severe drawing and harmonious colour, but comparatively few of the 2,000 or more portraits that bear his name are wholly his handiwork. He went frequently to The Hague, where he entered the Guild of St. Luke in 1625. Mierevelt also executed some mythological pieces. Many of his portraits were reproduced by Dutch engravers. He died at Delft on June 27, 1641.

The Rijksmuseum in Amsterdam, Neth., has the richest collection of Mierevelt's works, chief of them being portraits of princes of the house of Orange. Other portraits by him are in the Hague museum, the town hall of Delft, and in nearly all the leading continental galleries; and in the museums of fine arts of Richmond, Va., and Boston, Mass.

**MIERIS, FRANS VAN,** the Elder (1635–1681), Dutch painter, son of Jan van Mieris and chief member of a family of Leiden painters, was born, according to Arnold Houbraken, at Leiden on April 16, 1635. He was married there in 1657, elected a member of the guild on May 14, 1658, and died at Leiden on March 12, 1681.

Mieris took service with Abraham Torenvliet, a glazier who kept a school of design. In his father's jewelry shop he became familiar with the ways and dress of people of distinction. His eye was fascinated in turn by the sheen of jewelry and stained glass; and, though he soon gave up the teaching of Torenvliet for that of Gerard Dou and Abraham van den Tempel, he acquired a manner that had more of the finish of the exquisites of the Dutch school than of the breadth of the disciples of Rembrandt. He seldom chose panels of which the size exceeded 12 to 15 in., and never ventured to design figures as large as life. Characteristic of his art in its minute proportions is a shiny brightness and metallic polish. The subjects he treated best are those in which he illustrated the habits or actions of the wealthier classes; but he sometimes succeeded in homely incidents and in portrait, and he occasionally ventured on allegory. He often rivaled Terborch in the faithful rendering of rich and highly coloured woven tissues. In the form of his composition, which sometimes represents the framework of a window enlivened with greenery, and adorned with bas-reliefs with figures to the waist, his model is Gerard Dou.

Mieris received valuable commissions from Archduke Leopold, the elector-palatine, and Cosimo III, grand duke of Tuscany. His practice was large and lucrative. If there is a difference between the painter's earlier and later work, it is that the former was clearer and more delicate in flesh, while the latter was often darker and more livid in the shadows.

One of his best-known pieces, a party of ladies and gentlemen at an oyster luncheon, in the Hermitage at Leningrad, U.S.S.R., bears the date of 1659. Another beautiful example, the "Doctor's Visit," in the Kunsthistorisches museum, Vienna, Aus., is dated 1656. In the same gallery is one of his masterpieces, "The Cavalier in a Store." The National gallery, London, has his "Lady With a Parrot," and a self-portrait is in the Detroit (Mich.) Institute of Art.

**MIES VAN DER ROHE, LUDWIG** (1886– ), a dominant figure in the architectural revolution of the 20th century, was born in Aachen, Ger., on March 27, 1886. He had no formal professional education but acquired valuable experience in the Berlin office of Bruno Paul, noted designer, and with Peter Behrens, Germany's outstanding industrial architect, in whose office Walter Gropius and Le Corbusier also worked. After World War I Mies developed a series of radically new projects for tall office buildings and houses with great clarity of structure, daring use of steel and glass and an exquisite feeling for space, proportion and materials. They became points of reference for all modern architects. His Barcelona pavilion, 1929, could well be called a contemporary Parthenon. From 1930 to 1933 Mies was director of the Bauhaus in Berlin, but in 1938 he left Germany to become head of the department of architecture at the Illinois Institute of Technology, Chicago, where he planned the campus layout and buildings. Probably the most coherent institutional group in the United States, it includes Crown hall, a large clear-span steel hall with glass walls that was a new departure in academic buildings. Mies van der Rohe completed in 1951, on the lake front in Chicago, the steel and glass apartment towers that were a dramatic crystallization of his objective architecture based on technology. They received worldwide attention. *See* also references under "Mies van der Rohe, Ludwig" in the Index. (Dl. B.)

**MIESZKO** (later form Mieczysław), the name of three Polish princes of the Piast dynasty.

Mieszko I (*c.* 930–992), prince or duke of Poland, son of Ziemomysl, prince of Gniezno, ruled from *c.* 962 over the lowland Poland. He consolidated the state internally and, thanks to wise policy, extended his dominion over all territories between the Oder and the Bug. Through marriage with Dobrava of Bohemia in 965 he gained both alliance with the Czechs and help in converting Poland, in 966, to Roman Catholic Christianity. Through his undertaking to pay a tribute to the Holy Roman empire from western Pomorze, he secured his position, occupying the mouth of the Oder in 967. He defeated the margrave Hodo, of the Saxon East Mark, in 972; and he repelled the emperor Otto II's expedition in 979. He also entered into connections with Scandinavia, marrying his daughter Swietoslawa (Sigrid Storrada) to Eric, king of Sweden and Denmark. The Russian *Nestor Chronicle* records in 981 the loss by the Poles of the territory round Czerwien and Przemysl to Vladimir Svyatoslavich of Kiev; but between 989 and 992 Mieszko acquired Silesia, Cracow and Sandomierz from the Czechs, with whom he had quarreled. Mieszko just before his death placed Poland under protection of the Holy See by the document known as *Dagome judex*. He was succeeded by his eldest son Boleslaw I.

Mieszko II (990–1034), king of Poland, succeeded his father Boleslaw I (*q.v.*) in 1025 and was crowned in the same year. At first he continued Boleslaw's expansionist policy; but he was defeated in 1031 by the coalition of the Germans and Kievan Russia. The Russians supported the rebellion of Mieszko's two brothers, whom he had banished; and the elder of the two, Bezprym, was then recognized as ruler of Poland in exchange for sending the coronation insignia to Germany. After the murder of Bezprym in 1032, Mieszko II returned to Poland and unified the country in 1034, a few months before his own death. By his wife, Rycheza, daughter of the palatine Ezzo of Lorraine, he left a son, Casimir I the Restorer.

Mieszko III the Old (*c.* 1126–1202), prince of Great Poland from 1138 and grand prince of Cracow, with interruptions, from 1173, was the son of Boleslaw III Wry-Mouth. He inherited the Poznan province, known as Great Poland, on his father's death; but later, when his elder brothers were dead, was able to claim the Cracow throne in accordance with his father's testament. For this, however, he had to contend with the opposition of the oligarchy.

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**MIFFLIN, THOMAS** (1744–1800), political leader and soldier during the American Revolution and first governor of

Pennsylvania, was born of a Quaker family in Philadelphia, Jan. 10, 1744. After graduating from the College of Philadelphia he became a merchant, served in the Pennsylvania assembly (1772–75) and in the first and second continental congresses. Commissioned a major in the continental army in May 1775, he soon was appointed quartermaster general and rose to the rank of major general. Discontented with congress's new regulations for the department and pleading ill-health, Mifflin went home in the summer of 1777 and scandalously neglected the quartermaster's department. He resigned as quartermaster in October. In the political maneuvering of the time he supported Horatio Gates against Washington and after being appointed to the Board of War in Nov. 1777 helped Gates to become its president. He left the board in 1778 and resigned from the army the next year. He was elected to the congress under the Articles of Confederation in 1782 and was made president of that body in Nov. 1783. He was a member of the federal Constitutional Convention of 1787, speaker of the Pennsylvania general assembly 1785–88, president of the state supreme executive council 1788–90 and first governor of the state 1790–99. Mifflin died at Lancaster, Pa., Jan. 20, 1800. (H. H. P.)

**MIGNARD, PIERRE** (1610–1695), French painter, called —to distinguish him from his brother Nicholas—Le Romain, was born at Troyes in 1610, of a family of artists. In 1630 he left the studio of Simon Vouet for Italy, where he spent 22 years, and made a reputation that brought him a summons to Paris. Successful with his portrait of the king, and in favour with the court, Mignard pitted himself against Charles le Brun, declining to enter the academy of which Le Brun was the head and organizing the opposition to its authority. The history of this struggle is bound up with that between the old guilds of France and the new body that Jean Baptiste Colbert, for political reasons, was determined to support. Shut out, in spite of the deserved success of his decorations of the cupola of Val de Grâce (1664), from any great share in those public works the control of which was the attribute of the new academy, Mignard was chiefly active in portraiture. Vicomte de Turenne, Molière, Jacques Bossuet, the marquise de Maintenon (Louvre), the duchesse de la Vallière, the marquise de Sévigné, the marquise de Montespan, the marquise de Seiguelay (National gallery, London)—all the beauties and celebrities of his day sat to him. His readiness and skill, his happy instinct for grace of arrangement, atoned for want of originality and real power.

With the death of Le Brun (1690) the situation changed; Mignard deserted his allies and succeeded to all the posts held by his opponent. These late honours he did not long enjoy; in 1695 he died while about to commence work on the cupola of the Invalides. His best compositions were engraved by Gérard Audran, Gérard Edelinck, Antoine Masson, François de Poilly, etc.

**MIGNE, JACQUES PAUL** (1800–1875), French Roman Catholic priest, editor and publisher of theological literature, was born at St. Flour, Cantal, on Oct. 25, 1800. He studied theology at Orléans, was ordained priest in 1824 and placed in charge of the parish of Puiseaux in the diocese of Orléans. In 1833 he went to Paris and started *L'Univers religieux*. Three years later at Petit Montrouge near Paris he opened the great publishing house which brought out in rapid succession numerous religious works at popular prices. Among the best known of these are: *Scripturae sacrae cursus completus* and *Theologiae cursus* (each in 28 vol., 1840–45); *Collection des auteurs sacrés* (100 vol., 1846–48); and *Encyclopédie théologique* (171 vol., 1844–66). The most noteworthy by far, however, is the *Patrologiae cursus completus*, superintended by the learned Benedictine J. B. Pitra and comprising: *Patrologia Latina*, including the works of Latin ecclesiastical writers up to the time of Innocent III (217 vol., 1844–55; 2nd ed., 1878 ff.); and *Patrologia Graeca*, including Greek writers to 1439 (162 vol., Greek text and Latin translation, 1857–66). The vast scope of the *Petrologiae cursus completus* leaves it still unique and valuable, where other editions of special works do not exist. The indexes in three volumes are arranged so that any reference in the patristic writings may be found easily.

In Feb. 1868 a great fire destroyed the whole of Migne's printing premises, but he established a new house in Paris, which was purchased in 1876 by the publishers Garnier Frères. He died in Paris on Oct. 25, 1875.

**MIGNET, FRANÇOIS AUGUSTE MARIE,** (1796–1884), French historian and archivist, who gave his work a clarity of presentation that had its influence on French historical studies in the 19th century, was born at Aix-en-Provence on May 8, 1796. Educated at Avignon, where he became professor in 1815, he returned to Aix for his law studies and was called to the bar in 1818.

His first work, the *Essai sur les institutions de Saint Louis,* was crowned by the Académie des Inscriptions et Belles Lettres in 1821, but almost immediately Mignet renounced academic life for political journalism in Paris, where he was joined by his friend and compatriot Adolphe Thiers, the future president of the republic. He worked, first, on the staff of the *Courrier Français,* a journal in opposition to the Restoration. In 1830 he helped to found, with Thiers and Armand Carrel, the *National,* a newspaper that assisted in precipitating the July revolution. At this juncture he gave up politics and journalism for his historical work and was appointed keeper of the archives at the Ministère des Affaires Étrangères. He held this post until the revolution of 1848, when he resigned. He was elected member of the Académie des Sciences Morales et Politiques in 1832, becoming its permanent secretary in 1837, and he was elected to the Académie Française in 1836. He died on March 24, 1884, in Paris.

Mignet's historical writings include an early work, *Histoire de la révolution française,* two volumes (1824), which to some degree was coloured by his own political beliefs; *Antonio Perez et Philippe II* (1845); *Histoire de Marie Stuart,* two volumes (1851), which made use of important unpublished documents; and the *Histoire de la rivalité de François I et Charles Quint* (1875). The *Négociations relatives à la succession d'Espagne sous Louis XIV,* four volumes (1835–42), a collection of diplomatic documents, remained unfinished; his important introductory essay to this work was reprinted in *Mémoires historiques* (1843), which also contain many of the obituary articles—acknowledged models of their kind—that Mignet composed as secretary to the Académie des Sciences Morales et Politiques. (H. G. Wh.)

**MIGNON, ABRAHAM** (1640–1697), Dutch painter of still life, was born at Frankfurt am Main. His father, a merchant, placed him under the still-life painter Jacob Merrel, by whom he was taken to Holland about 1660. He then worked under Jan de Heem at Utrecht, where in 1675 he married the daughter of the painter Cornelis Willaerts. Sibylle Merian (1647–1717), daughter of the engraver Matthäus Merian, became his pupil and achieved distinction as a flower painter. He died at Wetzlar or at Frankfurt in 1697.

Mignon devoted himself almost exclusively to flowers, fruit, birds and other "still life," though at times he also attempted portraiture. His flower pieces are marked by careful finish and delicate handling. His favourite scheme was to introduce roses against a dark background.

**MIGNONETTE** (Mignonnette), from the French meaning "little darling," the name given to a popular garden flower, *Reseda odorata* of the mignonette family (Resedaceae), highly esteemed for its delicately fragrant perfume. The mignonette is generally regarded as an annual and is a plant of diffuse reclining twiggy habit, scarcely reaching a foot in height, clothed with somewhat blunt lance-shaped entire or three-lobed leaves, and bearing long spikes—technically racemes—of rather insignificant flowers at the ends of the numerous branches and branchlets. The plant thus naturally assumes the form of a low dense mass of soft green foliage studded over freely with the racemes of flowers, the latter unobtrusive and likely to be overlooked except for their diffused fragrance. It is a native of Egypt and was sent to England from Paris in 1742; since that time it has been widely introduced elsewhere.

The small six-petaled flowers are somewhat curious in structure: the two upper petals are larger, concave and furnished at the back with a tuft of club-shaped filaments, which gives them the appearance of being deeply cut, while the two lowest petals are much smaller and undivided; the most conspicuous part consists of the

anthers, which are numerous and brownish-red, giving the colour to the inflorescence. Though practically an annual, as noted above, since it flowers abundantly the first season and is destroyed by the autumnal frosts, and though recorded as being annual in its native habitat by René Desfontaines in the *Flora Atlantica*, the mignonette, like many other plants treated as annuals, will continue to grow on if kept in a suitable temperature.

Mignonette is not a very useful decorative plant, being grown almost exclusively for its fragrance. This, however, is fleeting, especially after picking. Better than the typical plant in prolonging fragrance are the varieties Machet, Golden Machet, Golden Sunset and Red Monarch. In classifying the odours given off by plants, F. A. Hampton ranks the mignonette in the class of which he makes the violet the type and identifies the origin of the scent as irone.

The outdoor cultivation of mignonette as an annual is common in the United States and England, and demands arose to produce its blooms throughout the year. As the plant is not frost hardy its winter culture is confined to the cool greenhouse and millions of flowers are so grown in the United States and England. The simplest greenhouse method is to sow seeds in July, another lot in August and a final lot in September, for a succession of bloom. The house must be kept shaded and at a temperature of about 65° F. (18° C.). The plants need frequent watering and must not dry out. (N. Tr.; X.)

**MIGRAINE,** a liability to attacks of headache (*q.v.*), often accompanied by vomiting, occurring at varying and usually long, though irregular, intervals. Between attacks the sufferer is in normal health. There is often a history of the same complaint in the family.

Attacks may begin in childhood, when vomiting is the most conspicuous symptom so that they are generally regarded as gastro-intestinal disturbances. Typical attacks usually begin in adolescence, though sometimes delayed until later life. Headache is the outstanding symptom but may be preceded by a disorder of vision or sensation, the former being the more common. The visual symptoms take the form of a shimmering haze that may develop into a zigzag pattern, the so-called fortification spectrum. This tends to spread so as to obscure one half of the field of vision; in the same person in some attacks it is in the right half, in others the left half. Rarely the whole field of vision is affected. If there is disorder of sensation it is a tingling or numbness in one hand and in the lips and tongue of the same side, and if it is on the right side there may be difficulty in speaking. The disorder of vision or sensation ceases after about 20 min. and the headache then begins. These preliminary symptoms occur constantly in some persons, infrequently in others and are altogether lacking in many. The headache is often at the onset unilateral and may remain so, though equally often it spreads and becomes generalized. At first of moderate severity, it increases in intensity and at its height is accompanied by nausea and often by vomiting. It is aggravated by noise, bright light and mental activity and is partially relieved by rest and darkness. A brief sleep is generally followed by improvement. The attack often begins in the early morning and lasts several hours, often a whole day. A severe attack may continue for a day or two with persistent vomiting and consequent exhaustion. Apart from this, recovery is rapid and complete. In some persons mental excitement is apt to bring on an attack; in others, dietetic indiscretion is the cause. In women there is a particular liability at the time of or just before menstruation and attacks are often more frequent at the menopause. In the later years of life the attacks tend to diminish both in frequency and severity and often cease. (C. P. Ss.)

**MIGRATION** is the movement of people from one place in order to settle permanently in another. The course of civilizations has been greatly influenced by mass movements. Although each prominent migration in the annals of mankind has its own peculiar characteristics, it is possible to classify most of them into some broad categories. First, internal and international migration may be distinguished. Within any country there are movements of individuals or families from one area to another, for example the exodus from the countryside to the towns, as distinguished from movements from one country to another. Second, migration may be across land or over sea. Third, it may be free or forced, depending on whether people decide to move of their own free will or whether they are expelled by governments (*see* Deportation and Exile; Minorities; Refugees). (B. Th.)

## HISTORY

Moving from place to place in search of means of subsistence or to escape a stronger foe, men from time immemorial have spread over the greater part of the earth's surface, including even remote islands that would seem to be far beyond the reach of primitive rafts and canoes, as the 10,000 islands of Oceania (*see* Oceania: *Ethnology: Migration*). Within recorded history human migrations have transformed the entire aspect of lands and continents and the racial, ethnic and linguistic composition of their inhabitants. In the course of 400 years—a very short period in human history—the Americas, Australia and Oceania, the northern half of Asia and parts of Africa were colonized by European migrants. The map of Europe, too, is the product of many migrations—not only of the so-called "great people's migration" which accompanied the fall of Rome. Even long afterward—as late as A.D. 900—there was not one German in Berlin, not one Russian in Moscow, nor one Hungarian in Budapest; Madrid was a Moorish settlement; no Turks lived in Ankara, and the few in what is now Istanbul were slaves and mercenaries.

One of the earliest recorded mass migrations, the exodus of the Hebrews from Egypt, was a quest for freedom. Among the movements of peoples throughout the ancient world the colonization of the Mediterranean by Phoenicians, Greeks and, in the west, Etruscans may be noted especially. The great migrations of Germanic peoples attending the decline and fall of western Rome were absorbed into the empire or were admitted as invasions, notable among which were those of the Goths and the Vandals, the latter sweeping through Gaul and Spain across into north Africa. These migrations had an economic character and were caused ultimately by the pressure of the nomad Huns issuing from Mongolia. Cut off from China by the Great Wall, except when there was civil unrest there or the northern frontier was neglected, Hunnish hordes moved westward from time to time, displacing adjacent tribes, which pressed upon others in turn and so produced waves of moving populations.

Arabia, another source of migratory currents, sent forth its last great stream in the 7th century A.D., under the unifying banner of Islam. Within a few decades the Arabs overran much of north Africa and the middle east. By the early 8th century they had moved as far as the Indus valley in the east and southern France in the west, where the tide was turned in 732 by the victory of the Franks at Poitiers. Everywhere the Arabs swept along with them the vanquished foe; Berbers and Iranians made up the bulk of the Arab armies. These upheavals set in motion peoples on the fringe of the conquered areas, and in the 8th century the Magyar tribes of Turkestan began moving farther west.

With the western Mediterranean in Muslim hands the economic basis of France changed radically, and the southward expansion of the Frankish kingdom was blocked. Charlemagne in the early 9th century therefore turned east and fought the Saxons, some of whom fled to Scandinavia. This may well have helped to provoke the Scandinavian raids which culminated in the establishment of the Normans in northern France (Normandy).

In the 10th century the nomad Khitan gained control over Mongolia and conquered northern China. The Khitan rise to power directed the Turkish nomads of Mongolia toward the west, where they found a declining Abbasid empire which the Seljuk Turks eventually took over. Further inflows of Turks were deflected into Asia Minor. In the 13th century the Mongol tribes of Genghis Khan swept forward as far as Hungary and Bohemia, only to recede again after two decades. The great slaughter attending this Mongol invasion left eastern Europe empty and attracted new migrants from the west. The Russians were forced farther north, from the region round Kiev to Muscovy, in the upper Volga basin, in turn displacing the Finns.

In the 14th century the Ottoman Turks began to drift from Asia

Minor into the Balkans, and in 1453 conquered Constantinople. Their ultimate drive was stopped only at the gates of Vienna, in 1529 and 1683. The Ottoman conquest lay across traditional trade routes from Europe to India. A westward passage to India was searched for, and so America was discovered. At the same time the influx of Byzantine scholars strengthened the Renaissance movement.

The Manchu conquest of Mongolia and China in the first half of the 17th century started a new mass migration of western Mongols to the west. This group, about 100,000 strong in all, continued for a century in a series of waves, but spent itself against the power of Russia and never went beyond the lower Volga. Siberia, conquered in the 16th and 17th centuries, was held by Russia, but was colonized very slowly. By 1800 the population was still not far beyond half a million. Up to 1880 more than half the migrants were deportees. Mass colonization set in only after serfdom was abolished in Russia (1861), and was greatly enhanced when the Trans-Siberian railway was opened (1896). From 1801–1914 approximately 7,500,000 migrants went from European to Asiatic Russia, about 4,000,000 of them after 1900. Between World Wars I and II about 6,000,000 people, besides the deportees in concentration camps, migrated into Siberia. In the same period the drift from country to town inside the U.S.S.R. numbered 23,000,000 persons.

The overseas migration of Europeans from the great Age of Discovery until the eve of World War II totaled about 60,000,000. At first the colonies attracted mainly adventurers, merchants and persecuted groups. Before the 19th century the majority of newcomers to South America and the West Indies were enslaved Africans. The total number of slaves shipped from Africa across the Atlantic exceeded 10,000,000. Migrants to the Americas from Spain were a few hundred thousand up to 1790. French migrants to Canada numbered 25,000; by 1760, the date of the British conquest, Canada's population of European stock was 70,000. The white population of all other French colonies on the eve of the French Revolution was of the same order. The population of the United States when the first census was taken in 1790 totaled about 4,000,000 of whom about 60,000 were free Negroes and 700,000 were slaves. In no state did the slave population exceed the white.

In continental Europe up to 1800 there was an internal eastward current, from the more advanced countries to areas being opened up in Prussia, the Habsburg empire and Russia.

From Great Britain a migratory movement gradually began in the 16th century. The first overseas settlements were established in the 17th century, in Virginia, Massachusetts, Bermuda and Barbados, absorbing about 250,000 British migrants. When land confiscation in Ireland was stopped, American colonies became the main field for English expansion. During the 18th century about 1,500,000 British migrants left for the new world.

The great flow of overseas migrants from Europe began in the 1830s, when their annual number first exceeded 100,000. Before World War I this reached a peak of nearly 1,500,000. The main destination was the United States; secondary goals were other American countries, Australia and South Africa. At the same time there was an enormous drift from country to town. Between 1870 and 1910 German migrants overseas numbered 2,800,000, while Germany's urban population rose by 24,000,000.

Migration also eased the conditions of those left behind, thus paradoxically leading to a spectacular growth in the population of Europe where migratory movements to towns became an essential part of industrial development. (X.)

Migrations that have had profound consequences in the history of mankind are those in which men crossed the seas. The effects of such migrations on the sending and receiving countries are variable. In a sense oversea settlement causes the ties of kinship characteristic of the old community to be replaced by a new cohesion based on contractual ties developed in the new environment, but emigration need not cause the country of origin to weaken and decay. The main free migrations of modern times have benefited sending and receiving countries alike.

A grim feature of the 20th century is that free international movement of people has been completely overshadowed by forced migrations (*see* also REFUGEES). After World War II, the partition of India and Pakistan uprooted 18,000,000 people; the Federal Republic of Germany took in 12,000,000 refugees; Japan 6,300,000; southern Korea 4,000,000; Hong Kong 1,300,000; Israel 1,000,000; and Arab refugees from Palestine numbered more than 1,000,000. The International Refugee organization and the Intergovernmental Committee for European Migration settled 1,300,000 refugees overseas. This leaves out entirely what happened within the Soviet and Chinese areas, but even this limited survey gives a total of 45,000,000 forced migrants. Thus in one decade the number of people compelled by governments to move across frontiers was equal to the entire traffic of free migrants across the Atlantic ocean in the century ending in 1913.

## STATISTICS OF MIGRATION

Before the beginning of the 19th century there were hardly any statistical records of the movements of people between countries. The earliest sources came into being as by-products of legislation or rules introduced by governments for some other purpose; *e.g.*, acts to regulate shipping (the United Kingdom and the United States), returns supplied by transport agencies and shipping companies regarding their contracts (Denmark and Switzerland), or population registers kept by communal or ecclesiastical authorities (Belgium, the Netherlands and Sweden). For the first three-quarters of the 19th century people were fairly free to move, so that no country had reason to set up a separate department of migration statistics. When, however, countries began to take an interest in the types of people who were coming in or going out, policy makers had to have statistics. Each government built up its own records separately and there was no uniform definition of an "international migrant." This led to a bewildering variety of records which could not generally be compared. One of the most essential tasks was to distinguish between genuine migrants (*i.e.*, those who are moving to take up permanent residence in another country) from other international travelers. Not until 1912, when the golden age of oversea emigration was almost over, did Great Britain introduce a statistical distinction between outward passengers who were changing their permanent residence for a year or more and those who were going abroad for less than one year.

The six main types of migration figures are those based on control at ports, control of land frontiers, passports, population registers, transport contracts and coupons detached from certain documents. In North and South America, Asia and Africa the usual practice has been to use controls at frontiers and ports, whereas in Europe every kind of system has been in operation. Statistics based on controls at ports are fairly easy to supervise and give accurate dates. However, the degree of coverage varies greatly. In some cases only persons traveling on emigrant ships or in the steerage class were counted. Only since 1907 has the United States treated emigration and immigration figures in the same way. The statistical apparatus based on transport contracts and travel documents was rather complicated and usually failed to separate migrants from other travelers. Population registers kept by local authorities, as in the Netherlands and Sweden, have produced highly accurate data on births and deaths and internal migration; the advantages of such registers led the United Nations Population commission in 1949 to propose them as a possible substitute for frontier statistics in countries where such an innovation was practicable.

Since each sovereign state organized its statistics in the light of its own preoccupations, there grew up a jungle of conflicting definitions and classifications. The International Labour office and the commission of the United Nations strove hard to bring order out of the chaos. The Economic and Social council of the United Nations on Aug. 10, 1948, passed a resolution requesting that steps be taken to improve statistics of international migration. This resulted in the publication (by the Population branch of the Bureau of Social Affairs) of two basic studies, *Sex and Age of International Migrants: Statistics for 1918–1947* (1953) and *Economic Characteristics of International Migrants and Statistics for Selected Countries, 1918–1954* (1958). The information

overs 33 countries and territories, with tables based on original data classifying migrants according to various characteristics. Unfortunately, few countries adopted the recommendations of the United Nations experts and most of the problems remained to be solved. In Great Britain, where records of passenger movements go back to 1803, the statistics remained very defective, based on the manifests of ships on long sea routes only and with no information about migration by short sea routes or by air. The latter was a most unfortunate gap, as it was estimated that about one-third of the people emigrating from the United Kingdom after about 1945 traveled by air.

## MODERN INTERNATIONAL MIGRATION

The most important modern era of migration was the 19th century; it was marked by large-scale movements to America, which lasted until the U.S. Immigration act of 1924. Between World Wars I and II migration tailed off considerably. After 1945 new economic and political pressures made the setting for migration far more complex than it had been in the 19th century.

The main facts about the volume and direction of international migration in the period 1821–1932 are given in the table. The

*World Intercontinental Migration, 1821–1932**

| Emigration: 1846–1932† | | Immigration: 1821–1932‡ | |
|---|---|---|---|
| Country of emigration | Total (000s) | Country of immigration | Total (000s) |
| Europe | | America | |
| Austria-Hungary | 5,196 | Argentina (1856–1932) | 6,405 |
| Belgium | 193 | Brazil | 4,431 |
| British Isles | 18,020 | British West Indies (1836–1932) | 1,587 |
| Denmark | 387 | Canada | 5,206 |
| Finland (1871–1932) | 371 | Cuba (1901–32) | 857 |
| France | 519 | Guadeloupe (1856–1924) | 42 |
| Germany | 4,889 | Dutch Guiana (1856–1931) | 69 |
| Italy | 10,092 | Mexico (1911–31) | 226 |
| Malta (1911–32) | 63 | Newfoundland (1841–1924) | 20 |
| Netherlands | 224 | Paraguay (1881–1931) | 26 |
| Norway | 854 | United States | 32,244 |
| Poland (1920–32) | 642 | Uruguay (1836–1932) | 713 |
| Portugal | 1,805 | Total | 51,826 |
| Spain | 4,653 | Asia | |
| Sweden | 1,203 | Philippines (1911–29) | 90 |
| Switzerland | 332 | Oceania | |
| U.S.S.R. | 2,253 | Australia (1861–1932) | 2,913 |
| Total | 51,696 | Fiji (1881–1926) | 79 |
| | | Hawaii (1911–31) | 216 |
| | | New Caledonia (1896–1932) | 32 |
| | | New Zealand (1851–1932) | 594 |
| | | Total | 3,834 |
| Other countries | | Africa | |
| British India | 1,194 | Mauritius (1836–1932) | 573 |
| Cape Verde Islands (1901–27) | 30 | Seychelles (1901–32) | 12 |
| Japan | 518 | South Africa (1881–1932) | 852 |
| St. Helena (1896–1924) | 12 | Total | 1,437 |
| Total | 1,754 | Grand total | 57,187 |
| Grand total | 53,450 | | |

*Source: A. M. Carr-Saunders, *World Population*, p. 49, Oxford University Press, 1936). †Period covered: 1846–1932, except where otherwise stated. ‡Period covered: 1821–1932, except where otherwise stated.

figure of about 59,000,000 for the people that crossed the seas between 1821 and 1932 is an underestimate. Most of these emigrants were from Europe and nine out of ten of them settled in North America or South America. After this unique international transfer one-eleventh of the population of the earth consisted of people originating in Europe living outside that continent. The United States was by far the largest receiving country (32,000,000 immigrants) and the British Isles the largest sending country (18,000,000 emigrants).

In the years immediately after World War I there were signs that the 19th-century freedom of international movement might be re-established. But this was not to be. In May 1921 the congress of the United States passed a Quota act; and in 1924 came the Immigration act which decreed an annual quota equal to 2% of the number born in each country resident in the United States at the time of the 1890 census. This reduced the total permissible immigration to the United States to an annual figure of 162,000: in several years up to 1913 the annual inflow had been more than 1,000,000. The interwar period saw the spread of rigid immigration restrictions and as a result of the world depression of the early 1930s the flow of international migrants became a mere trickle, with a net inward balance in favour of the emigration countries. Great Britain in 1922 launched an ambitious scheme of empire settlement under which 400,000 settlers received financial help to go to the dominions in the years 1922–31. This scheme, however, did not prosper for long. The population balance sheet of the British empire between 1901 and 1936 was as follows: a net outward movement from Great Britain and Ireland of 3,000,000 and a net inflow into the rest of the empire of 2,750,000. Thus, even in a period when the United States ceased to be an important receiving country and Britain itself organized an oversea settlement policy, the British empire as a whole lost 250,000 people by migration to the rest of the world.

Migration currents in the far east in the 19th century were greatly influenced by the abolition of slavery in the British colonies in the 1830s: labour for the plantations was now recruited by indenture from India and later from China and Japan. Whereas intercontinental movements declined, there was an increase in inter-regional migrations which had important economic and demographic effects. Burma, Malaya, Ceylon, Borneo and Manchuria throve by the influx of immigrants. In contrast to the decrease in traffic in the west, the far east witnessed considerable movements of migrants in the 1920s. The chief countries of origin were India, modern Pakistan, China, Japan and Korea. Moreover, internal migration within certain countries became important; *e.g.*, between 1920 and 1940 the urban areas of Japan had a net gain of 17,500,000 persons, ten times the net outflow of civilians from Japan in that period. As compared with the populations of Asian countries, net outward movements were negligible and had hardly any demographic impact. It is estimated that, between 1834 and 1937, of the 30,000,000 Indians who emigrated about 24,000,000 returned to their homeland, so that the net outward balance was only 6,000,000.

The main countries of immigration after World War II were the United States, Canada, Australia, Argentina, Brazil, Venezuela, New Zealand and Uruguay. The highest rates of net inflow existed in Australia and New Zealand: immigration was responsible for two-fifths of the increase of population in Australia. In the Americas migrants were absorbed most readily by Canada and Venezuela, though in absolute numbers the United States still took by far the largest total. Jamaica lost nearly a quarter of its natural increase through emigration, while Mexico had a net efflux of 250,000 (mainly to the U.S.) which, however, was only 3% of the natural increase.

One of the striking developments after 1945 was the influx of European population (and capital) into certain parts of Africa. In the Federation of Rhodesia and Nyasaland the number of Europeans increased from 105,000 to 274,000 (*i.e.*, by 161%) between 1946 and 1957, and more than two-thirds of this was due to immigration. A similar process was at work in the Belgian Congo (later Republic of the Congo) where there was an even sharper rise in the white population in this period, from 34,000 to 102,000, two-thirds of which was contributed by immigration. The number of white settlers in Kenya rose from 24,900 to 57,700 and in Tanganyika and Uganda from 12,100 to 36,100. The non-Moroccan element in Morocco grew from 305,000 to 460,000, whereas the number of Indians increased by 72% in Kenya, 82% in Tanganyika and 70% in Uganda.

In a world where the volume and direction of migration were heavily influenced by restrictions unfavourable to coloured peoples, some channels remained open, as shown by the immigration of people from the West Indies to the United Kingdom and of Puerto Ricans to the United States. In these cases the fact of common citizenship made possible a relatively large increase in the movement of coloured migrants into these countries. It was a comparatively new phenomenon in the U.K., but the coloured element in the total population was still only about 1%. For the Commonwealth Immigration act, 1962, *see* IMMIGRATION LAW.

## CHARACTERISTICS OF MIGRANTS

Most migrants are young people in the age group of 20–25. The Swedish demographer G. Sundbärg, in his exhaustive analysis of Swedish statistics for the period 1851–1900, showed that, if the rate of emigration for the population as a whole were taken to

be 100, the rates for various specific age groups were: 15–20, 184; 20–25, 350; 25–30, 223; 30–35, 123. J. Isaac obtained a similar result in his inquiry into British emigration after World War II. As a consequence of this age composition, a large proportion of the foreign-born population of a receiving country is in the adult age group: *e.g.*, in 1930 40% of the foreign-born whites in the United States were between 25 and 44 years of age, as against 27% of the native whites.

Males are on the whole more mobile than females: between 60% and 70% of the migrants who crossed the Atlantic ocean between 1850 and 1920 were males. However, when there is a slump in international migration, the sex ratio tends to change in favour of females, because women then tend to join their husbands or relatives who emigrated earlier. Moreover, even when migration is booming the sex ratio can be in favour of women in certain age groups; *e.g.*, among Irish emigrants between 1860 and 1910 there were every year more females than males aged 15–19, since in the United States the demand for Irish girls, mainly in domestic service, kept up well through slump and boom.

A migratory movement usually contains a relatively large proportion of economically active persons. Between 1880 and 1910 the inflow of migrants caused the economically active population of the United States to expand at a rate one-third faster than the total population. The working population showed a net increase of 25,000,000 between 1870 and 1910 and one-fifth of it was due to immigration. In countries of origin the effect is to slow down the growth of the economically active element more than to retard the growth of the total population.

The nearest to a generalization one can reach on the occupational characteristics of migrants is to say that the exodus from the countryside to the towns has always played an important part. Even in as late a period as 1926–30 more than 50% of those who entered Canada were classified as "farming." The flight from the land is a necessary corollary of economic growth both within countries and internationally. Governments tend to look with disfavour on an inflow of immigrants made up entirely of unskilled workers; the statistics, however, often fail to give a reliable indication of degrees of skill. The Immigration commission of the United States in 1911–12 tried to prove that the "new" immigrants from southern and eastern Europe were much inferior in quality to the "old" immigrants from northern and western Europe, by showing that in the period 1899–1909 60% of the former as against 24% of the latter were agricultural and general labourers. However, it was entirely misleading to compare these two inflows in the same period, since the one from northern and western Europe was only a shadow of what it had been before 1899. When the "new" immigration 1899–1907 is set against the "old" immigration of 1871–82, hardly any difference is found between the relative amount of skilled labour in the two movements.

After World War II, with the sharp contraction in the volume of mass migration, international transfers of skilled craftsmen and scientific and technical personnel became relatively much more significant. A *Report on International Migration of Labour in the Construction Industry* (International Labour organization, 1959) gave instructive figures on the movement of various grades of construction workers into and out of the United Kingdom, Australia and Argentina, and into the United States and Canada. The importance of this recruitment in developing national economies is shown by the fact that in 1957 one-third of the houses and other structures erected in Australia were built by immigrant craftsmen, and one-fifth of the men employed in public works were immigrants. The sending countries tend to be anxious about excessive losses of skilled labour. In the words of the Oversea Migration board in Great Britain, ". . . we cannot afford too selective a flow of migrants: a disproportionate loss of skilled and the young is far more dangerous to our economy than a far larger flow outward of a balanced cross-section of our people."

Governments may be expected to take an interest in the level of intelligence and illiteracy among migrants. Up to 1926 the United States, being the world's largest country of absorption, paid a great deal of attention to this. When the tide of immigration from southern and eastern Europe was at its highest, as many as 30% of those who entered the country were recorded as "illiterate"; *i.e.*, unable to write any language. The decisive part played by environment is revealed by studies comparing the children of the foreign-born with the children of native-born Americans. According to the U.S. census of 1900, the illiteracy rate among children (10–14 years of age) of native-born white parents was five times higher than the rate for children of foreign-born white parents (44 per 1,000 as against 9 per 1,000). By 1920 the differential had narrowed to 11 per 1,000 as against 5 per 1,000. The reason for this surprising contrast is to be found in the distribution of the two groups of children over urban and rural areas. The vast majority of the foreign-born settled in industrial areas; in 1900, 60% of the second-generation Americans were to be found in towns and cities as compared with only 30% of the white Americans whose parents had been born in the United States. The difference between the illiteracy rates among the two groups was due largely to the superior educational facilities in the urban areas.

Attempts have been made by the use of intelligence tests to infer differences in innate ability among migrants of different ethnic groups but substantial risk is involved in making such inferences. O. Klineberg in an analysis of the northward movement of Negroes within the United States, for example, found that "the intelligence tests showed no superiority of recent arrivals in the North over those of the same age and sex who were still in the southern cities. There is, on the other hand, very definite evidence that an improved environment, whether it be the southern city as contrasted with the neighbouring rural districts, or the northern city as contrasted with the South as a whole, raises the test scores considerably; this rise in intelligence is roughly proportionate to length of residence in the more favourable environment." (*Negro Intelligence and Selective Migration*, p. 59, Columbia University Press, New York, 1935.) The same very likely holds for international migration.

The ethnic composition of the main currents of international migration has varied greatly from one period to another. Over the course of the 19th century, one group after another became predominant, in successive phases; *e.g.*, in the immigration into France the dominating element was first Germanic, then Latin, then Slavic, and others were becoming significant with the increase in the number of Africans and Asians. A similar process may be seen in Latin America; *e.g.*, in Brazil where the successive phases were Italian, Portuguese, Slavic and Japanese. Between the wars the drastic restrictions on immigration imposed by the United States and the British dominions compelled Slavic and oriental peoples to seek an outlet in the one destination open to them—Latin America. In 1934, 34% of the Japanese enumerated abroad were living in Brazil and Peru and only 17% were in the United States and 3% in Canada, Australia and New Zealand. "It is clear that the Anglo-Saxon nations closed their doors just at the time when the surplus populations of the poorest and most crowded countries were beginning to take full advantage of international mobility. The regime of quotas and prohibitions bore most severely on the southern and eastern European, the Slav and the Asiatic peoples. A redistribution of labour as between continents was a natural result of the dynamic force of industrialism; but the advanced nations would not allow it to run its course when it meant admitting racial groups regarded as unassimilable." (Brinley Thomas, *Migration and Economic Growth*, p. 197, Cambridge University Press, 1954.)

## DEMOGRAPHIC ASPECTS

Migration, being a selective process, affects the structure of the population in the sending and the receiving countries, mainly because of its uneven incidence on different age groups. In an extreme case mass emigration may become self-perpetuating, as shown by the experience of Ireland. Emigration is heaviest in the 15–35 age group, which means fewer children, so that the age group 0–5 becomes smaller than it would have been but for emigration. However, since the propensity to emigrate among school children is less than for the population as a whole, the 0–5 children by the time they are 10–15 years of age constitute a relatively large group. Hence the paradox that a country from which

here is mass emigration has a comparatively large number of een-agers. After a lag of 15 years from the time when the 15–35 ge group is hit by heavy emigration, the number passing into the 5–20 age group is high as compared with the population as a hole. Then the process repeats itself.

The effects of mass immigration on the population of the re-eiving country have been variously interpreted. The late 19th entury "substitution theory" of F. A. Walker in the United States *see* Bibliography) sought to prove that the addition to the popu-ation of the United States through immigration had been nullified hrough its depressing effect on the fertility of the native-born Americans. There was, however, no scientific basis for this theory. G. Mortara's later researches showed that the substantial move-nents of migrants in the 19th century had hardly any net effect n the fertility of the native-born in the receiving countries (*see* Bibliography). Moreover, the long-period decline in the birth rate ad started some time before the largest inflows of settlers took lace. The number of white people in the United States in 1790 vas about 3,200,000 and their descendants living in that country n 1920 numbered about 41,000,000. It is estimated that in the atter year there were about 53,000,000 foreign-born or the de-cendants of previous immigrants since 1790. An instructive ater case of heavy immigration was that of Israel, which absorbed ,160,000 settlers between 1919 and 1954.

In assessing migration trends careful attention must be given o the demographic consequences of the postwar rise in fertility n the traditional immigration countries; *e.g.*, the rate of natural ncrease in Australia after 1945 was between 13.1 and 14.4 per ,000 of the population, much higher than in the 1930s. The verage age at marriage showed a marked decrease; in 1958 the roportion of women aged 20–24 "ever married" was nearly 60%. Moreover, these young couples tended to have more children in he early years of marriage than did their predecessors in the 930s. After 1945 a big inflow of immigrants was needed to cor-ect the deficit in the working age groups arising from the low irthrate of prewar years. There was a high proportion of de-endents among the net inflow of 1,000,000 immigrants in the 1 years ending in 1958: three-quarters of the women who settled n Australia were married and over one-quarter of all immigrants vere children under the age of 15. During this great wave of im-nigration the proportion of the population in the working age roup (15–64) declined.

However, an important new factor has emerged as a consequence f the postwar increase in births and the immigration of children fter 1947. W. D. Borrie calculated in 1959 that "when the full orce of the postwar baby boom hits the work force in 1963, the verage annual increment (to the work force) without any im-nigration will jump to some 70,000, or approximately the same s the actual figure that has applied with immigration over the last en years or so. With immigration continuing at the 'target level' f 100,000 new settlers a year the increment to the work force will e as high as 123,000 by 1963." Thus the working population vould increase at a faster rate than total population and the lemographic "abnormality" of the 1930s be corrected. Heavy nternal recruitment into the labour force from the young age roups would tend to be a substitute for external recruitment. The rospects of immigration into Australia and other traditional ab-orbing countries must be assessed in the light of this important lemographic factor.

## FLUCTUATIONS IN MIGRATION

The movements of people from one country to another (other han expulsions by governments) are the result of innumerable rivate decisions governed by a wide variety of motives. All kinds f promptings have played their part from time to time—lack of ood, religious persecution, the desire to ensure better opportuni-ies for children, political oppression, avoidance of military ser-ice, eviction, or the urge for adventure. One could make a very ong list of such "reasons" for migration classified according to whether they indicate a "push," or a "pull." This approach does ot lead to a satisfactory interpretation of the determinants of hese movements. During the period when international mobility was comparatively unrestricted, the records show the volume of international migration rising and falling with a fairly regular periodicity, the span of the fluctuation (from peak to peak or trough to trough) being usually about 18 to 20 years. This im-phes that certain factors had a widespread influence on the deci-sions of the majority of migrants at various times: it is most unlikely that the sum total of the random array of motives govern-ing the independent decisions of millions of migrants could lead to a regular upswing and downswing in the volume of movement. The common factors at work can be ascertained by studying the time patterns of other variables which are inter-related with migration.

During the heyday of international mobility there were four prominent "booms" in transatlantic migration from Europe—1844–54, 1863–73, 1881–88 and 1903–13; each of these was ac-companied by a boom in capital exports, particularly from Great Britain. An analysis of this phase in the development of the mod-ern world brings out some interesting uniformities. First, each of these upsurges in international migration was in essence a rural exodus transcending national boundaries. Of the 2,000,000 Euro-peans who entered the United States between 1849 and 1854, no less than 80% were from Ireland and Germany. The calamity of the potato famine in Ireland in 1846 precipitated a mass evacua-tion; the number emigrating to the United States, which had been 20,000 in 1843, was no less than 220,000 in the year 1851. The movement out of Germany was due not so much to the political troubles of 1848 but to economic pressure in the countryside. Thus a combination of physical disaster and technical progress (in the form of free trade, a transformation of agriculture and a revolu-tion in transport) led to the first great transfer of surplus popula-tion from Europe to the United States. In the 1880s more than 1,250,000 from Germany and 500,000 from Scandinavia crossed the Atlantic ocean. It was in that decade that the agrarian econ-omy of Europe felt the shattering boomerang effect of technical progress in U.S. agriculture and the revolution in ocean and rail transport. The facts were presented vividly by D. A. Wells in *Recent Economic Changes* (Appleton, New York, 1889): "On the wheat farms of the north-western United States it was claimed in 1887 that, with wages at $25 per month and board for permanent employees, wheat could be produced for 40 cents per bushel; while in Rhenish Prussia, with wages at $6 per month, the cost of pro-duction was reported to be 80 cents per bushel." This spelled crisis for European agriculture and was partly responsible for the third great outflow of migrants. The final efflux from Europe, nearly 10,000,000 between 1903 and 1913, was described in the following words by the United States Immigration commission: "Before coming to the United States the greater proportion were engaged in farming or unskilled labor and had no experience or training in manufacturing industry or mining. As a consequence their employment in the mines and manufacturing plants of this country has been made possible only by the invention of mechani-cal devices and processes which have eliminated the skill and ex-perience formerly required in a large number of occupations." (*Abstract of Reports of the Immigration Commission*, vol. i, doc. no. 747, p. 494, Washington, 1911–12.)

To say that each of these waves of emigration was largely a rural exodus does not mean that the driving forces were entirely in the old world: these transfers of population were the result of a complicated interaction between events in the old world and the new. Corresponding to each major upswing in transatlantic emigration there was a major upswing in capital construction (*e.g.*, railroads and building) in the overseas receiving countries—the United States, Canada, Australia and New Zealand. During these phases there was relative stagnation in capital construction in the United Kingdom and a boom in its export sector. When emigration and capital exports declined relatively to trend, home construction experienced a downswing in the overseas countries and an upswing in the United Kingdom. Thus, there was an in-verse relation between the long swings in investment in the United Kingdom and the receiving countries overseas, particularly the United States; and this arose from the fact that a large part of the capital formation overseas was sensitive to rate of population

growth and the rate of population growth was determined mainly by net immigration. There was also an inverse relation between internal migration and emigration in the sending countries. When capital exports and emigration from the United Kingdom were in an upswing while home construction was declining, surplus labour from the land went overseas rather than to urban areas at home; in the next phase, when investment in the United Kingdom was in an upswing while capital exports were declining, the rural surplus moved into booming urban areas at home. This mechanism was a necessary condition for the long-run economic development of both the mature and underdeveloped countries in the 19th century.

**The Pattern After World War II.**—It is not easy to find a clear pattern in the course of events after World War II. In the 19th century international migration and international private capital movements were closely related and the growth of the Atlantic community was shaped by these parallel flows. In order to understand the character and fluctuations of migration after 1945 it is appropriate to draw a dividing line at the year 1952. The period 1945–52 was one of transition during which the world was recovering from the economic dislocation and distortions caused by World War II. In those years the pattern of private foreign lending was divorced from that of international migration. Private long-term capital amounting to $11,000,000,000 was exported by the United States (which supplied 70%), the United Kingdom, Switzerland, France and Belgium. Whereas up to 1913 the main creditor country, Great Britain, was also one of the leading suppliers of migrants, the greatest provider of private long-term capital now became the United States, a country of immigration which imposed severe restrictions. Between 1945 and 1952 three of the leading countries of immigration, Australia, New Zealand and South Africa, absorbed about 900,000 settlers, but their intake of private capital from the United States was negligible. Moreover, Israel took 500,000 immigrants but very little U.S. direct investment.

To interpret the process of migration in the years immediately after the war one must look beyond the sphere of private capital movements. The dominant feature of those years was the massive flow of public capital, *i.e.*, governmental loans and grants, from North America to Europe. In 1945–52 the net outflow of public funds from the United States was $33,800,000,000, and $22,800,000,000 of this went to western Europe in the form, *e.g.*, of Marshall aid, or the European Recovery program. This not only enabled the recipients, *e.g.*, the United Kingdom, France, the Netherlands and Belgium, to cover their current trade deficits but it gave them a sufficient margin to allow them to export capital (public and private) to the less-developed countries which had traditional connections with them. The United Kingdom, for instance, was able to export $3,700,000,000 of public capital chiefly to its dependencies as well as $4,000,000,000 of private capital mainly to overseas members of the British Commonwealth. This continuance of Britain's traditional role as purveyor of capital to the rest of the commonwealth made it comparatively easy for emigration to these countries to be resumed. The development of Canada and Venezuela proceeded with the aid of U.S. capital and European immigration; other overseas countries were able to import capital and labour from Europe. In short, the stream of public capital from North America to Europe made for a fair measure of mobility of the factors of production (*q.v.*) and for resumption of multilateral trade immediately after the war.

However, this recovery phase was necessarily a temporary one. After 1952 economic aid was greatly reduced, but it was replaced by an immense inflow of U.S. military aid. After 1952 there was a remarkable upsurge of economic activity in western Europe. The gross national product in real terms in the European Economic community countries increased by 70% between 1950 and 1960, whereas in the countries of the European Free Trade association the increase was 40%. Between 1953 and 1960 industrial production in the German Federal Republic and in Italy rose by about 80%; in Belgium the increase was 27%, in Austria 70% and in the United Kingdom 30%. Between 1950–52 and 1960 unemployment in Germany fell from 1,400,000 to the low of 230,000.

The case of the Federal Republic of Germany strikingly repeated in the 1950s the rapid growth through mass immigration which took place in the United States during the 19th century. Between 1945 and 1959 western Germany absorbed more than 12,000,000 refugees, an inflow which was double the world net intercontinental migration in 1945–57. The labour force grew from 21,700,000 in 1950 to 25,300,000 in 1957. Although the circumstances were abnormal and the causes were political, the absorption was reminiscent of the greatest inflows of migrants from the British Isles into the United States; *e.g.*, in 1846–55. The newcomers included a high proportion of skilled labour and highly qualified personnel; they spoke the same language and had the same background as the people in the receiving country and were highly adaptable and mobile; the pressure in the labour market made the trade unions docile and kept down the level of real wages; the receiving country had an advanced industrial technique; the huge input of labour concentrated in a short period induced a "widening" of the capital structure with potent effects on the growth of productivity; and the large inflow of capital together with a high propensity to save resulted in a substantial rise in the rate of investment.

Rapid economic development in western Europe entailed a substantial internal movement of labour and capital within the continent, comparable to the spurts in internal migration in the North American continent during periods of heavy capital imports in the 19th century. The process was accelerated by the development of the European Economic community. These intra-continental movements of labour were partially a substitute for European emigration and this made it more difficult for underdeveloped immigration countries overseas to satisfy their demands, particularly for the more skilled grades.

Despite certain resemblances between the post-1945 growth induced by factor movements and the pre-1913 process, it is the differences which had a decisive effect. In the 19th century the export of capital from Great Britain was accompanied by a permanent migration of a high proportion of skilled labour and highly qualified personnel to the then emerging economies overseas. Foreign lending was mainly portfolio investment and a good deal of it went into the construction of public utilities in underdeveloped countries; with this capital went skilled personnel and experts. There was thus a diffusion of skills and technical knowledge which helped to stimulate rates of growth in the poorer countries. International factor movements in the 19th century helped to narrow the gap between the advanced and the less developed economies.

After World War II the circulatory process within the rich sector tended to widen the gap between rates of growth inside it and in the poorest underdeveloped sector outside it. Factor movements helped to make factor prices in the two sectors more instead of less unequal. Although statistics are inadequate, it is fairly clear that a large proportion of the world's circulation of skilled migrants took place within the North Atlantic economy. Qualified personnel in Europe were in high demand there, when they might otherwise have gone to the underdeveloped areas.

From North America to Europe there was a short-term movement of technical and supervisory staff accompanying the big flow of U.S. direct investment there; these people were highly mobile and few of them settled in Europe permanently. However, they contributed substantially to the spread of new ideas and techniques. As economic integration developed, the short-term turnover of entrepreneurial skill from the U.S. was expected to grow.

From Europe to the U.S. there was a steady migration of qualified personnel for permanent settlement. There was an intercontinental competition for persons trained in the most advanced techniques. The annual rate of increase in the number of engineers in western Europe, about 1%–2%, was well below the rate required to sustain future development even if there were no major technical innovations; *e.g.*, in Great Britain there was concern, to use the words of the Advisory Council on Scientific Policy (cmd. 278, par. 50), "lest the loss of highly qualified scientists, who have been educated in British universities mainly at Government expense over a period of five to six years, reaches unreasonable proportions."

International competition for skilled migrants has far-reaching effects, particularly on the underdeveloped countries. A change in tastes by contact with an affluent way of life can have a strong influence on talented people from poor countries. Persons with a moderate degree of skill may move to richer countries in order to improve their qualifications and from them they can emigrate to countries which offer even better opportunities. This is reminiscent of E. G. Ravenstein's "law of short-distance movement," which was put forward as an explanation of streams of internal migration: "the inhabitants of a country immediately surrounding a town of rapid growth flock into it; the gaps thus left in the rural population are filled up by migrants from more remote districts, until the attractive forces of one of our rapidly growing cities makes its influence felt, step by step, to the most remote corner of the kingdom." (E. G. Ravenstein, "The Laws of Migration," Statistical Journal, vol. xlviii, pp. 198–199, 1885.) Similarly, on a worldwide scale individual migrants of varying skill move by short stages out of the poorest countries, forming "currents of migration" determined by the magnetic influence of the richest destination.

In a free society the individual has a right to come and go as he pleases. However, under a regime of *laissez-faire laissez-passer* the transfer of skilled personnel from poor to rich countries could be on such a scale that the former could never begin to grow. The proper criterion to apply to such movements is that of marginal social productivity. Poor countries often cannot realize their potential rate of growth unless certain preliminary structural changes are made, and this may require state interference; *e.g.*, if the poor country can obtain skilled immigrants from rich countries, the rise in marginal social cost in the latter will be negligible as compared with the large fall in marginal social cost in the new industries in the poor country. One of the most pressing problems of policy is to ensure an international circulation of skill that will ensure that the poorest countries receive the share they need for their economic development, while remaining compatible with the principles of a free society.

In the second half of the 20th century migration between countries did not play the part in economic development which it did in the century ending in the 1920s. The outflow of settlers from the supplying countries no longer generated a powerful effect through its contribution to the rise in incomes abroad. The quality of the migrants, rather than their number, had become important. The marked rise in the rate of natural increase in the traditional immigration countries, particularly Latin America, tended to shift the emphasis to internal determinants of growth. With intercontinental migration becoming relatively less important, internal movements of population within countries and within areas such as the European Economic Community or Latin America or Africa assumed increasing significance. The European Economic Community attracted also the immigration of labourers and their families from countries outside the common market such as Greece, Spain and Yugoslavia; France in addition received refugee white and Muslim immigrants in the early 1960s from its former territory Algeria. In the low-income countries, whether over- or underpopulated, a necessary condition of economic development is the acquisition and diffusion of skills, and it is often more efficient to achieve this through immigration than by relying exclusively on internal education and training. Much, too, depends on the pattern of international capital movements, both private and governmental.

## THE ASSIMILATION OF MIGRANTS

The problems raised by the assimilation of migrants into the societies which receive them have been intensively studied by sociologists. It is widely held that the term "integration" conveys the real meaning better than "assimilation," for it is a mutual rather than a one-way process. There can be a cultural variety within a growing social unity. This view was well expressed by the Canadian department of citizenship and immigration: "Integration . . . is used in Canada to express a theory which contains unity and diversity. The unity is sought in common principles of political philosophy and in participation in common citizenship. The diversity is maintained by reciprocal appreciation of diverse cultural contributions." (*See* also ACCULTURATION; AMERICANIZATION.)

Where immigrants are of a different ethnic origin from that of the receiving country, there are serious conflicts between the ideal of fostering family units and the goal of rapid integration. Much experience has been gained in Latin America from the efforts made to organize group settlement. This is a field in which co-operation between governments, intergovernmental agencies and voluntary organizations is essential, for it is vital that the migrant be given correct information and adequate training before he arrives in the new country. The Intergovernmental Committee for European Migration has devoted much attention to promoting methods of selection, education and pre-training.

The right to control and discriminate is inherent in state sovereignty, but once migrants have been admitted to a country it is highly desirable that certain common principles should be respected. The following principles were drawn up by a conference of nongovernmental organizations interested in migration in 1951, as a basis for an "Immigrants' Charter" which might, it was hoped, eventually achieve general recognition:

"That there should be no discrimination, *de facto* or *de jure*, against a migrant for such reasons as race, religion, political opinions, financial means, country of origin or status as an alien.

"That every migrant should have the right in the receiving country to treatment no less favourable than that granted to nationals of that country.

"That every migrant should have the right to do work in accordance with his abilities and within the laws of the receiving population generally, and should enjoy equal rights as regards conditions of employment, wages, freedom of trade union affiliation, public assistance and social security.

"That every migrant should bear in mind that these rights imply a corresponding series of duties to his new community."

*See* also references under "Migration" in the Index.

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**MIGRATION, ANIMAL.** Among various animals at certain times in their lives occur mass movements or changes of habitat that are of a different class from the normal daily wanderings of the same animals round and about a localized area. These migratory movements, which are sometimes spectacular for either the numbers concerned or the distance covered, result in a change of habitat that is often but not always connected with the breeding season or with a change of climate and food supply. Although best known in birds (covered at length in MIGRATION, BIRD), similar movements occur in land and marine mammals; in reptiles, amphibia and fishes; and in some groups of invertebrates, particularly certain insects. Whether the distance covered is great or small, the animal moves progressively farther from the starting point.

## CONCEPTS

Some ornithologists use the word only for an absolutely regular to-and-fro movement between a breeding area and a nonbreeding area. A. L. Thomson (1926) wrote that true migrations are changes of habitat, periodically recurring and alternating in direction, which tend to secure optimum conditions at all times. W. Heape (1931) considered that there are two fundamentally different types of mass movement in the animal kingdom; when there is a return movement he uses the term "migration" and considers it to be "gametic," caused by the urge for reproduction; when there is no return movement he uses the term "emigration" and considers it "alimental," caused by the search for food. But in many cases the movement may be gametic in one direction and alimental in another, against the view that they differ in origin.

As used in this article, "migration" is defined as a periodic, more or less unidirectional, continued movement, assisted by the efforts of the animal and in a direction over which it exerts a control. This definition includes movements that appear at first sight to be in only one direction, but excludes all drifts caused by the wind or by sea currents, when the animal is only the passive victim of circumstances except when these necessitate an active return movement. When the animals have a long life with annual breeding periods and relatively slow reproduction (as in the birds), the movements are usually regular and the same individual may perform the movement more than once in each direction. In long-lived species with only one breeding period (as in the eel), an individual makes the journey only once each way. In short-lived species with extremely rapid reproduction and changes of numbers (as in the insects), the flights in different directions are often performed by different generations and in different numbers, with perhaps nonmigratory generations occurring at intervals between migratory phases.

Migrants possess remarkable powers of orientation that enable them to move sometimes hundreds or even thousands of miles in one general direction. The mechanism of this ability remains unknown. Some fishes appear to react to currents, but in the air, with both birds and insects, there is seldom any regularity of wind that would guide them for any distance, and even in the sea different currents can usually be found at different depths. A "magnetic" sense has been suggested, but without experimental support. The direction of the sun's rays also has been suggested as a guidance system for migrants, but migrating insects can orient in the tropics at noon when the sun is directly overhead.

In animals that are regularly subjected to severe winter conditions, migration seems to have evolved as an alternative to hibernation in order to escape a difficult season, but there are a few cases known (*see* below, bats and insects) where the same species may both hibernate and migrate.

## SURVEY

**Mammals.**—The Alaskan fur seals breed only in the Pribilof Islands in the Bering sea, where they live from May to November and where the young are born. At the beginning of the winter the females and young swim to the coast of southern California, about 3,000 mi. away, staying there until the following spring. The males, however, move only as far as the Gulf of Alaska, to the south of the Aleutian Islands. In spring both sexes return to the Pribilofs, completing their migratory cycle.

Whales make very definite seasonal migrations without being tied to land areas for producing their young. In the summer the hump-backed whales are found in Antarctic waters to the south of the Indian ocean. In the winter they move to tropical seas, nearly 3,000 mi. away, to the northwest of Australia and near the island of Madagascar and it is there that the young are born. The marking experiments of W. Rayner (1940) and others have shown that individuals return in the following summer to the same areas in the Antarctic as in the previous year.

Among land mammals the South African springbok often makes irregular changes of habitat, but in Bushman Land, south of the Orange river, there is a regular seasonal mass migration from the desert to the mountains for the calving season. The return movement from the hills is not so gregarious. In Newfoundland the caribou move each autumn, after mating, from the high land to the warmer southern part of the island. In the return movement the following spring, the does are heavy with young. Farther west in Canada are somewhat similar migrations. During summer, the herds feed in the northern grass barrens. They move often southward to winter quarters and return in March and April to their summer territory. The same routes are followed each year and the tracks are distinctly visible from the air. Pairing takes place during the autumn migration and the young are produced during the spring trek. The mule deer in the Yellowstone and Yosemite parks "summer" at high altitudes and "winter" at low, in locations that may be as little as 10 mi. apart; in one high valley, at about 7,500 ft., where there are hot springs, snow does not remain on the ground and the small local population remains during the winter.

Mass movements of lemmings have been known for many years in Scandinavia, but opinions differ over calling this a true migration. At intervals of some years, great numbers leave the high lands and move downhill. Sometimes they reach the sea, where many thousands are drowned. According to C. Elton (1942) there is a tendency for the migrations to occur every third or fourth year (*see* also LEMMING).

The majority of bats in temperate climates hibernate in caves or protected hollows during the winter, but some move quite long distances to and from these winter quarters. In the U.S. at least three species are known to migrate to the southern states for the winter and to return in the spring. The large mouse-eared bat in Germany has winter quarters in caves, where large numbers hibernate and from which they spread chiefly between northeast and northwest up to about 150 mi. Marked noctule bats have been recovered up to 470 mi. from the point of marking, and a pipistrel, marked in the Soviet Union, was recovered over two months later in Bulgaria, 720 mi. away, according to G. M. Allen (1939).

**Fishes.**—Migration in fish is influenced by the kind of water (fresh or salt), sea and river currents, depth, the weakness of the young fish and in some cases the long life before breeding. Research has been helped by the improvement of techniques for marking and recovering and for determining the age of fish from their scale structure. Furthermore, the great economic importance of the investigations has stimulated international co-operation and financial support.

In general there is an active migration toward a breeding area (usually against the current), and either an active movement or a passive drift away from the breeding area (usually with the current). Some species (such as the plaice and cod) move entirely in salt water or (as some trout) in fresh water. Others (such as salmon) are anadromous ("up-running"), breeding in fresh water and feeding in salt; while others (such as the eel), called catadromous ("down-running"), breed in salt water and pass most of their life in fresh water.

The migration of eels has long been obscured by the difficulty in obtaining information from the depths of the oceans. J. Schmidt (1922) held that the eels from Europe and those from eastern North America are distinct species that breed in separate areas

n deep Atlantic waters north of the West Indies. Against this ypothesis, D. W. Tucker (1959) suggested that the European nd North American eels are environmental forms of one species, aving a common breeding ground, to which only the American els return. The eels found in Europe arrive there by accident ather than by design; they develop from eggs laid by American arents, the larvae of which are carried away from their proper estination by sea currents. If Tucker's theory is correct, all adult els leaving Europe presumably perish on the return journey to the reeding grounds without producing any eggs. Evidence suggests hat the distance, covered without feeding, may well be too great or survival. (*See* also FISH.)

**Reptiles and Amphibians.**—Migration is not highly devel-ped in these groups. Certain marine turtles visit sandy shores t breeding time and the newly hatched young return to the sea. The vegetarian green turtle (*Chelonia mydas*) of the West Indies s known to move many miles in shallow coastal waters. Some ea snakes come to shore periodically to give birth to their young. oads are known to move considerable distances to a particular ond and several months later there is a return journey of small oads in the opposite direction. Both newts and frogs are known o make similar movements but the distances covered are not great.

**Invertebrates.**—Migration is found in the Crustacea among ertain land crabs that move from inland to the sea at the time of viposition. In the sea the larvae are hatched out and all the oung stages are passed. The adults return inland and are later ollowed by their offspring. There is no evidence in this case of a definite direction, the movements being purely toward and away rom the sea.

Among insects, migration is well known in locusts and butter-lies, but it occurs in nearly all winged orders. The best known re the migratory locust in southeast Europe, south Asia and north Africa, and the desert locust in the northern half of Africa and southwest Asia. All species perform long flights in the adult stage before egg-laying and in some species there are regular to-and-fro seasonal movements. Investigations by R. C. Rainey (1951) and others have shown that, because locusts often fly at heights where the wind speed is greater than their own speed of flight, most of the main movements tend to be downwind. Swarms thus tend to congregate in areas where surface winds meet (convergence zones) and in the centres of cyclonic systems. This carries the locusts from their semiarid breeding areas to regions where rain is likely to fall and hence food for the young hoppers may become avail-able. In 1921 B. P. Uvarov showed that the locust is a gregarious form of a grasshopper that also exists in a nonmigratory, solitary form. According to conditions of food supply and crowding, eggs from one phase can give rise to the other. Thus great swarms of migratory locusts can arise from areas where for many years only the solitary phase has existed. Distances of up to 1,000 mi. or more can be covered by the solitary phases, so that both forms are migratory to this extent. But the gigantic swarms are always the "gregarious" phase.

Among the Lepidoptera probably the best-known migrant is the monarch, or milkweed, butterfly (*Danaus plexippus*) of North America. In the autumn, the monarchs in southern Canada and the northern U.S. congregate in masses and fly steadily south and west to Florida, the Gulf states, southern California and Mexico. In the south (except perhaps in Mexico) they spend the winter in a state of semihibernation and return gradually to the north in the spring, laying eggs as they proceed. According to the latitude, there are one, two or perhaps three generations before the south-ward return in the following autumn. Marking experiments by F. A. Urquhart (1960) resulted in the recapture of monarchs, tagged in the neighbourhood of Ottawa, Ont., at distances of more than 1,000 mi. to the south and southwest, and one was recovered in central Mexico, more than 1,800 mi. from the place of marking.

The greatest migrant butterfly is the painted lady (*Vanessa cardui*), which flies, sometimes in millions, each spring from north Africa into central and northern Europe, sometimes even reaching Iceland. There is evidence of a return to the south in the autumn. In North America the same species migrates in the spring from Mexico into California and also northeastward to spread perhaps over the whole of the U.S. and eastern Canada, sometimes as far north as Newfoundland. In the tropics migrations of butterflies are frequent and conspicuous, often with seasonal changes of direction. Migration is documented in more than 200 species of butterflies and suspected in many more.

Among the moths there are many migrants (probably hundreds of species) including the cotton worm, which invade the cotton belt of the U.S. almost every year from South or Central America. In southeastern Australia the bogong moth (*Agrotis infusa*) migrates in spring (October) from large areas of low-lying, cultivated land to altitudes of about 6,000 ft. in the mountains of New South Wales, where they spend the summer months in caves, in a state of inanimation, returning to the plains in the autumn. These aggregations of millions of moths were already known early in the 19th century to the natives, who used the moths as a source of food.

In the ladybird beetles (Coccinellidae), there is widespread evidence of mass hibernation (or sometimes aestivation), often at high altitudes, the insects migrating sometimes 100 mi. or more to these areas and later returning to their breeding grounds. Mass migration of dragonflies has been recorded in many parts of the world. In North America there is evidence of regular southward autumnal movements along the coast of the northeastern states. In Britain there are many records of immigration of southern species. In Sept. 1947 there was a large immigration of *Sympetrum striolatum* into the southern counties of Ireland, probably having come from southwestern Europe.

In the two-winged flies (Diptera) there is evidence of long-distance migration in a number of families, particularly in the hoverflies (Syrphidae). Various species have been seen in thousands crossing passes on the Pyrenees and the Alps from north to south in the autumn; similar movements have been observed on the east coast of England. Southerly autumnal movements of many groups of dipterans were recorded flying along the New Jersey coast in the U.S. by H. J. Shannon (1926) but have not since been investigated.

Occasional records suggesting migration also exist in other insects. A remarkable case is a pentatomid bug, the sunn pest (*Eurygaster integriceps*), in southwest Asia, which feeds on wheat in the spring, migrates high into the mountains for the summer, moves to a lower level to hibernate and descends to the plains to breed in the spring. Feeding occurs only in the spring.

Among the Hymenoptera is a remarkable migrant, a digger wasp (*Sphex aegyptiacus*), which is predatory on locusts and follows the migrating locust swarms to maintain contact with the food supply for its offspring.

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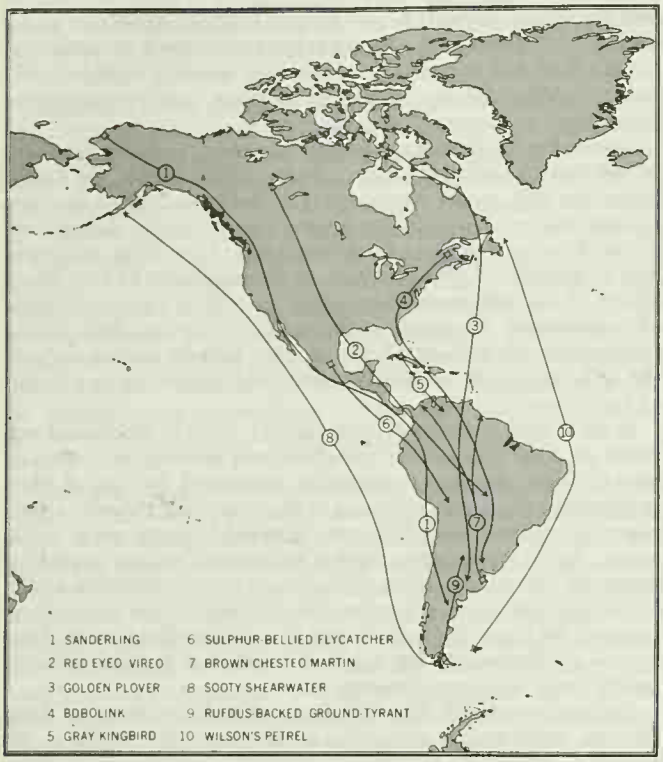
**MIGRATION, BIRD.** Each fall, with remarkable regularity, millions of birds leave the places where they have bred, or where they were born, and fly to other areas to spend the winter. The following spring they return to their breeding grounds. This seasonal movement to and from the breeding area constitutes migration. Although migration occurs among other animals, in no other group is it so extensive and prevalent as it is among birds. This is undoubtedly due in part to the adaptations of many birds for prolonged flight.

The conspicuous appearance and disappearance of many birds with the seasons was probably known to the first races of prehistoric man, for Paleolithic man, about 40,000 years ago, had taken enough notice of birds to draw them and carve them in rock.




FROM J. VAN TYNE AND A. J. BERGER, "FUNDAMENTALS OF ORNITHOLOGY," 1959. REPRODUCED BY PERMISSION OF JOHN WILEY & SONS, INC.

FIG. 1.—POSTBREEDING MIGRATIONS OF TEN AMERICAN BIRDS

In ancient literature there are references to bird migration in the writings of Homer; in the Old Testament; in the Finnish epic poem *Kalevala;* and in the Sanskrit *The Sacred Books of the East.* Aristotle not only recorded migration dates but also speculated on the causes of migration.

Knowledge of migration increased very little from the time of Aristotle until the 19th century; it was not until about the beginning of the 20th century that it was studied scientifically. The development of banding and ringing techniques for marking and identifying individual birds, improvement in the identification of birds in the field and use of the experimental method both in the laboratory and in the field have yielded many insights into the great mysteries of migration; but many problems remain to excite the imagination of scientists.

## GENERAL FEATURES

**A World-Wide Phenomenon.**—Most observations and studies of bird migration have been made in the northern hemisphere, particularly in North America and Europe. Migration, however, is a worldwide phenomenon and occurs also within the tropics and the southern hemisphere. The occurrence of migration in all parts of the world demonstrates that any geographical area may have unfavourable seasonal aspects that induce birds to seek more favourable climes.

**Migratory Status.**—Birds may be classified according to their migratory status in a given area. Four major groups are recognized in most parts of the world: (1) permanent residents; (2) summer residents or summer visitors; (3) winter residents or winter visitors; and (4) transient visitants or passage migrants. Permanent residents are those species that are represented in a particular area throughout the year. A further distinction is made between species in which all members are permanent residents and those (partial migrants) in which many individuals are migrant though the species is represented in a locality throughout the year. Studies made on the movements of individuals indicate that in only a few species are all members permanently resident. Summer residents are those species that move to their breeding grounds in the spring, rear their young during the summer and then return to their wintering grounds in the fall. Winter residents are those species that move from their breeding grounds to spend the winter in a more suitable environment where food is readily available. As a general rule, insect-eating birds, whose food supply is especially threatened by severe weather, tend to winter in warmer climates than do seed-eating species.

Transient visitants include all the species that pass through a locality, usually twice a year: once in the spring, on their way to their breeding grounds, and again in the fall, on their way to their wintering grounds.

**Precision of Migratory Behaviour.**—The movements that occur during migration are not random. Each species has a characteristic geographical distribution during the breeding season (called the summer or breeding range) and also during the nonbreeding season (called winter range). The routes followed between these areas are well established and characteristic for the species or for populations within the species. Migratory behaviour is, therefore, an oriented movement.

From the standpoint of time, also, migration is not random, but occurs primarily in the spring and in the fall in temperate regions (although there may be a few months in which some migratory movements cannot be observed, since species breed at different times and travel different distances between their breeding and wintering areas). In all migrants the times of the year in which migration occurs are fairly precise, more so for the flight to the breeding grounds than for that to the wintering grounds.

Finally, migration occurs at specific times of the day, depending on the species. Many small birds—and larger birds that are secretive—that depend on vegetational cover and that are weak fliers are nocturnal migrants; *e.g.,* rails, cuckoos, wrens and thrushes. Many nocturnal migrants are small insectivorous birds; it is thought that migration at night enables them to feed during the hours of daylight when, presumably, their specific insect prey are active. Studies of nocturnal migrants by viewing them through telescopes against the moon, and also by means of radar, show a pronounced pattern of migrational activity, which begins after sunset, increases rapidly until about 11:00 P.M., and then declines rapidly to a minimum at about 4:00 A.M.

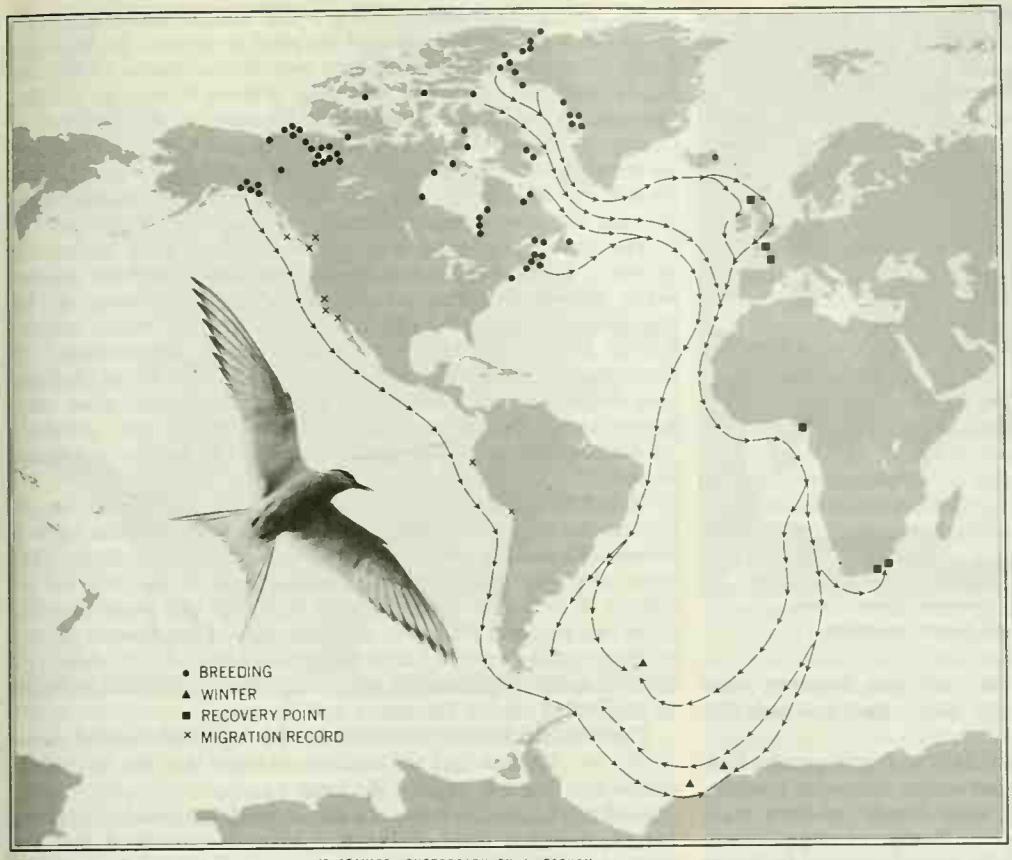
Birds that are fast fliers, that live in the open, or that capture their food on the wing migrate primarily by day; *e.g.,* hawks, pigeons, crows, jays, swallows and shrikes. Some large birds migrate by both day and night; *e.g.,* loons, ducks, geese and many shore birds.

In summary, migratory behaviour occurs among many different groups of birds, is spatially oriented and shows a good degree of spatial and temporal precision. Because of the precision in migratory behaviour, it is possible to describe for many species of birds the breeding range, the wintering range, the route followed and the time, direction and duration of migration.

## EXTENT OF MIGRATION

**Duration and Distance.**—Since the breeding and wintering ranges of many migrants differ considerably, it is not surprising to find much variation in the extent of migration. In the western hemisphere long migrations are known in more than 100 species. Such species usually nest in the United States or Canada and spend the winter in the West Indies or in Central or South America (fig. 1).

Of the land birds of North America the nighthawk and the barn swallow have the longest migration routes. They breed as far north as the Yukon and Alaska and winter as far south as Argentina, a distance of about 7,000 mi. Even such extensive flights as these, however, are exceeded by those of certain shore birds and other aquatic species. Among the snipe, sandpipers, plovers and their allies, several species nest north of the Arctic circle and winter in South America, traveling as far south as Patagonia, a distance of more than 8,000 mi. Birds such as waders, swifts and swallows, which travel from northern Europe to South Africa, fly 6,000–7,000 mi. in each direction. The longest and most remarkable of all migrations, however, is that of the Arctic tern (fig. 2). Its breeding range is circumpolar and extends as far north as land exists and as far south as the Aleutian Islands, Great Slave Lake, Massachusetts and northern Europe. When the young are




FLIGHT ROUTES FROM U.S. FISH AND WILDLIFE SERVICE; PHOTOGRAPH BY J. TOPHAM

**FIG. 2.—MIGRATION ROUTES OF THE ARCTIC TERN. RECOVERY POINTS REPRESENT BIRDS BANDED AS NESTLINGS IN NORTH AMERICA**

full-grown, all the Arctic terns leave their breeding grounds and a few months later arrive in the Antarctic region, 11,000 mi. away!

In addition to these long migrations, short migrations and altitudinal migrations are known among many species of birds. Short migrations, for example, are made by species that nest in southern Canada and the northern United States and winter in the central and southern United States: these include the vesper sparrow, chipping sparrow, grackle, bluebird and woodcock.

Certain birds that live in mountainous areas adjust to the changing seasons by migrating to the foothills and valleys during winter and returning to the high slopes and peaks with the approach of summer. The old world lammergeier, the Himalayan white-capped redstart and the Californian mountain quail behave in this manner. Such vertical or altitudinal migrations accomplish in a relatively short distance the same objectives, with regard to environmental changes, as the lengthy latitudinal migrations. In the Rocky mountain region vertical migrations are known to occur among chickadees, rosy finches, juncos and pine grosbeaks. In the mountains of central California the mountain quail nest at altitudes up to 9,500 ft. and winter in areas below 5,000 ft.; an unusual feature of this migration is that the migrants travel on foot in little parties of 10 to 30 individuals and usually in a single file.

A few vertical migrations are upward in the fall, yet none the less adaptive. At higher altitudes in the winter the Rocky Mountain blue grouse avoids predators and secures a diet of needles and buds of fir trees, whereas the Asian ibis-bill finds water kept open by warm springs and swift currents.

Short erratic flights may also occur among several species in response to irregularly occurring stimuli; for example, many birds of the arid Australian interior move nomadically, appearing in a locality after an infrequent and unpredictable rain, breeding and then moving on. Strictly speaking, these flights are not migratory, since the same breeding area may not be used again.

In general, differences in extent of migration reflect different requirements of species on their wintering and breeding grounds.

**Routes.**—The routes followed by different migratory birds are extremely diverse, depending primarily upon the latitude and extent of the breeding and wintering areas and upon the history of the species. As indicated earlier, knowledge of the routes of migration has been obtained largely through the technique of bird-banding, especially in North America and in Europe. Migration routes are the lanes of travel that are followed generally by a species as a whole and not necessarily by each individual. In species that have extensive winter and summer ranges, migration occurs evenly over a broad front hundreds of miles in width. This is true for species that migrate at night as well as for those that migrate by day. Day migrants, however, appear to be guided by major topographic features such as seacoasts, mountains and large lakes and rivers, with the result that greater numbers of these migrants occur along these landmarks.

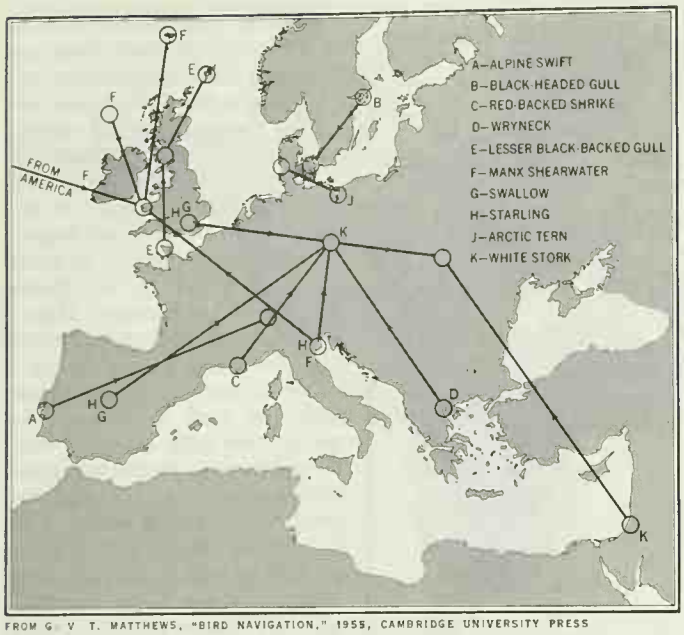
In the western hemisphere the routes of migration occur over large land areas as well as over seas (fig. 1). This is also true in the eastern hemisphere, many birds crossing the Mediterranean on their flights between Eurasia and Africa and some flying over parts of the Indian ocean and the Pacific ocean. Many kinds of small perching birds are known to migrate across at least 600 mi. of sea and some may make even longer journeys. These birds commonly cross such large bodies of water as the Gulf of Mexico, the Mediterranean and the North sea. Some aquatic birds regularly cross the larger oceans.

Many species that breed in North America winter in South America, but no terrestrial South American species that nest in the south temperate zone migrate into North or Central America. In both the new world and the old this is an outstanding difference between migrants that breed in the northern hemisphere and those that breed in the southern. A few sea birds and waders, however, do migrate across the equator from breeding grounds in the far south.

In Europe the general direction of migration in the fall is south and southwest (fig. 3). Some birds, however, move in a southeasterly direction, with a few reaching southern Asia. For most migrants that leave Europe the wintering areas are in northern or tropical Africa.

In Asia migration routes are not so well known, but the following autumnal movements have been observed: westward or southwestward to Europe and Africa; eastward or southeastward to areas bordering the Pacific ocean; and southward to the southern Asian peninsula and the East Indies Islands.

**Altitude and Velocity.**—Earlier observers thought that birds traveled very high and very fast. Recent information, derived from the use of telescopes, radar and range finders, indicates that at or near sea level few migrating birds fly above 3,000 ft. and most probably fly below 1,300 ft. Some strong fliers, such as shore birds, ducks and geese, have been recorded at 5,000–9,000 ft. In mountainous areas birds reach higher altitudes; *e.g.*, in the Himalayas considerable numbers migrate through passes at 18,000 ft. Cruising speeds for migratory birds range from 20 to about 40 m.p.h. in small songbirds and from 40 to about 60 m.p.h. in larger birds, ducks and geese being the fastest flyers. These velocities




FROM G. V. T. MATTHEWS, "BIRD NAVIGATION," 1955, CAMBRIDGE UNIVERSITY PRESS

FIG. 3.—HOMING FLIGHTS OF EUROPEAN BIRDS

are maintained in long-sustained flight. All birds, however, when escaping from predators, can exceed their cruising speeds for short distances.

The flying speed of any individual bird is much greater than the rate of migratory advance of a particular species as a whole. In the spring, species that migrate early usually advance more slowly than those that migrate later. Nocturnal migrants can probably cover from 200 to 400 mi. in a single night. In North America the average daily advance for all birds, recorded as beginning at New Orleans, La., and ending at southern Minnesota, is approximately 23 mi. a day. North of this area the rate is greatly and constantly accelerated as the breeding grounds are reached.

The migratory advance of a species depends upon many factors, the most important of which seems to be the average climatic conditions along the route. In North America the spring season advances northward more rapidly in the northern interior and along the west coast than it does on the Gulf coast and in the Mississippi valley; as a result birds of a certain species, in their spring migration from Brazil and Argentina, may be as far north as northern California before their counterparts reach Florida. Slow and rapid rates of advance during spring migration are exemplified by the Canada goose and gray-cheeked thrush, respectively (*see* fig. 4 and 5).

## FACTORS REGULATING MIGRATION

Birds return to their breeding grounds at essentially the same time each year, and show a remarkable precision in the timing of breeding. The greater yellowlegs, a medium-sized wading bird, for example, which breeds in the Canadian muskegs—after having flown to Patagonia in the fall and back in the spring, a total distance of about 16,000 to 20,000 mi.—have hatched their eggs between May 26 and May 29 inclusive over a period of 14 years. Oceanic birds show great precision in their arrival dates on their breeding grounds. Smaller land birds are more influenced by adverse weather conditions, particularly in the beginning of the migration period; nevertheless, their timing is still relatively precise. Since migratory behaviour shows temporal and spatial precision, at least two fundamental factors are operable. The first is the proper timing of the annual stimulus for migration, which has been most studied for the spring migration. The second is the guidance (navigation) of birds to their particular breeding and wintering areas.

**Annual Stimulus for Migration.**—Changes in food supply, temperature, barometric pressure and other seasonal factors in the environment formerly had been suggested to explain the regularity of migration and breeding. The annual variations in all these factors, however, appeared too great to account for the regularity of migration. Some insight into the intricacies of the annual stimulus was gained in 1924 when William Rowan, a Canadian zoologist, initiated the experimental approach to this problem of timing; later investigators further developed his productive line of research. Rowan reasoned that the most consistent seasonal change was in length of day and that changing day lengths might provide the environmental stimulus for migratory behaviour.

The factors regulating spring migration have been intensively studied. It has been demonstrated that many northern species, while on their wintering grounds, are affected physiologically by the increases in day length that occur after the winter solstice (about Dec. 21). This physiological change is manifested by an increase in the activity of such endocrine glands as the pituitary and the gonad (testis or ovary), by restlessness and, most characteristically, by an increase in body weight, due primarily to the deposition of fat under the skin and in the abdominal region.

It has been postulated that in some way, presumably by affecting the nervous system, this change in physiological state is responsible for the initiation of the spring migratory flight. The proof that day length and the internal state of the bird are involved in initiating the northward migration has been obtained from experimental studies of the slate-colored and Oregon juncos. In these studies captive juncos were induced to migrate about two months earlier than usual by subjecting them to artificial increases in day length during December and January.

The stimulus for the fall migration has not been studied extensively, but the data that are available indicate that the fall migration is not timed in exactly the same way.

Studies of how the increased duration of light each day alters the physiological state of the bird have demonstrated that the eyes, parts of the brain and the pituitary gland are involved. Light stimulus received by the eyes affects nerve cells in the brain (specifically in the hypothalamus), which then synthesize and release a substance that stimulates the anterior lobe of the pituitary gland. This lobe in turn secretes hormones that induce the growth of the reproductive organs and stimulate other endocrine glands. The mechanism for the increase in fat deposition is not known, but the hypothalamus undoubtedly is involved.

Increase in day length after the winter solstice is not the com-

FLIGHT ROUTES FROM U.S. FISH AND WILDLIFE SERVICE; PHOTOGRAPH BY VAN WORMER—NATIONAL AUDUBON SOCIETY

FIG. 4.—SPRING MIGRATION OF CANADA GOOSE

FLIGHT ROUTES FROM U.S. FISH AND WILDLIFE SERVICE; PHOTOGRAPH BY CRUICKSHANK—NATIONAL AUDUBON SOCIETY

FIG. 5.—MIGRATION ROUTES OF THE GRAY-CHEEKED THRUSH

plete explanation, however, for many migratory birds winter in the tropics or in the southern hemisphere, where the day lengths are either relatively constant or decrease after Dec. 21. Additional studies made on the relation between day length and the premigratory physiological state (in a north temperate species) led to the formulation of a hypothesis that may be applicable to migrants that winter in all latitudes. On the basis of the results of experiments on the slate-colored junco, external regulation of the timing of spring migration occurs in two phases. The first occurs in the fall and is called the preparatory phase. The second, which occurs in the winter and spring, is called the progressive phase; it culminates in migration and breeding. During the first phase decreasing day length is a regulatory factor. This decrease is felt seasonally by birds in moderate northern latitudes and is experienced by transequatorial migrants during their flight, even though the days are lengthening at their wintering grounds. (Why these transequatorial migrants begin their spring migrations at the proper time is still to be determined.) The first phase regulates the time at which the second phase begins. In the second phase the rate of physiological change, culminating in readiness to migrate, is regulated by the length of the daily photoperiod.

The final stimulus that starts the birds on their way, and that also regulates their flights during the period of migration, is the weather, though its influence is felt in varying degrees depending on the species. Birds tend to move with favourable winds in the spring and fall. During spring migration in eastern North America, migrants move into or through a given area during the interval between the passage of a warm front (with southerly winds) and the subsequent arrival of a cold front (with northerly winds). Arrival of a cold front and northerly winds forces migrating birds to land and tends to inhibit the onset of a new flight of grounded birds. In the fall the opposite conditions prevail, the southward migration occurring predominantly in cool, clear weather, with northerly winds, after the passage of a cold front.

**Navigation and Orientation.**—Through the study of banded birds it was demonstrated that many individuals tend to return to exactly the same locality in the breeding and wintering areas. This indicates that birds can identify precisely their summer and winter "homes" and that there must be some means by which they find their way from one to the other. The most dramatic proof of the navigational ability of birds has been obtained by removing them from their nests during the breeding season and then releasing them in new areas many miles away. For example, Manx shearwaters, which were removed from their nesting burrows in Wales, returned successfully from release points outside their normal range as far as 930 mi. (air distance) over land or 3,700 mi. over water, the probable route. One of these birds released at Boston, Mass., returned to its nest 3,200 mi. away in 12 days and 12.5 hours! This bird returned from an area outside the range of the species and probably flew an east-west route, which would be at right angles to its normal direction of migration. Its rate of a little more than 250 mi. per day suggests that it flew by the shortest possible route.

Numerous similar studies demonstrate the ability of birds to find their way back to their homes, but there are great differences among species and individuals in ability to "home." There seem to be three basic methods of homing, which, in different species, may operate alone or in combination to determine the course of an actual flight. The first is exploration, with a tendency to seek familiar landmarks and to follow guidelines shown by the terrain. The second is orientation in a constant direction, so that birds, when experimentally displaced, continue on a track parallel to their normal migratory route; this may be combined with a tendency to explore or to settle after a fixed time or distance. The third method, which must largely involve long-range homing over the sea, is navigation, the ability to choose a course for home from any position—though this does not necessarily imply any knowledge of the relative position of home.

There has been much speculation about the mechanisms of orientation and navigation, but no convincing experimental evidence to support, and some theoretical grounds to reject, the suggestions, which include terrestrial magnetism and Coriolis force. Since 1940 the experimental approach has been employed extensively and has resulted in great progress in understanding these mechanisms. These experimental studies have involved observations of caged migrants, which show orientation during the migratory season; caged birds that were trained to find food in a given direction; and wild and trained birds that were released under controlled conditions. The results demonstrate clearly that vision is of great importance and that the environmental cues are the sun and the stars. The capacity to choose a given direction is lost or greatly diminished when there is a heavy cloud cover or when the sun and stars are obscured artificially for caged birds. The experimental results leave no doubt that birds can orient well in relation to the sun and the stars, but how they use this ability to navigate is not clear.

Two theories have been proposed to explain orientation and navigation by means of the sun. One, called the sun-azimuth hypothesis, states that the desired direction is determined by means of the horizontal angle measured around the horizon from the downward projection of the observed sun position to the horizon. In this case the sun is used as a compass, and the position of a place is determined by reference to the sun's azimuth position. Birds that have the ability to maintain a certain direction in unfamiliar territory might use such a mechanism.

The second theory, called the sun-arc hypothesis, provides for complete navigation by means of the sun and not just direction finding. The sun-arc is inclined at an angle from the horizontal. This angle, constant for a given place, is a measure of the latitude of that place. The angle is smaller farther north and greater farther south; hence the highest point on the arc is lower or higher in relation to a given home position. This highest point is due south of the observer in the northern hemisphere and is a reference point in space. Since it is reached at local noon, it is also a reference point in time. The speed at which the sun moves along its arc is practically constant at 15° per hour. The distance the sun advances along its arc is greater to an observer in the east than to an observer in the west. The differences in the angle around the arc from the noon position are directly proportional to the change in longitude.

Therefore, the ability of a bird to orient in a familiar locality at any time of day, but before the sun-arc's vertical displacement has changed appreciably with the advancing season, need involve

only a memory of the sun-arc in relation to the horizon, accurate assessment of the sun's altitude and, to avoid ambiguity, rapid determination of whether the sun is rising or falling. None of these requirements presents great theoretical difficulty. It is assumed that a bird is familiar with the sun-arc on its home grounds and that it can determine, by detecting differences in the angle with the horizontal and the angle around the arc at noon, the change in latitude and longitude of a new location in relation to its home grounds. Both theories require that birds have an "internal chronometer," which enables them to determine where the sun would be at a given time of the day in their home grounds. Experimental studies provide good evidence for the existence of such a timing mechanism.

By placing caged nocturnal migrants in a planetarium and observing their orientation under different skies for short periods of time, it was concluded that these birds can use the stars for navigation. The data were few, however, and when they were re-examined by another investigator, it was concluded that the results showed orientation but no evidence for navigation. Observations of birds in other experimental studies and in nature indicate that a view of the stars is not absolutely necessary for orientation.

## EVOLUTION OF MIGRATION

**Origin of Migration.**—The origin and evolution of migration long have been favourite topics for theoretical discussion, for a complete understanding of this amazing behaviour rests on these topics.

Since birds must have been migrating for many millions of years, and since this behaviour continues in so many different types of birds, the species must benefit or else they soon would become extinct. Although migration occasionally is a hazardous venture for a species, the advantages apparently offset the heavy losses that result each year. One of the primary advantages of migration is that it enables a species to occupy alternately two different areas at a time when each area presents favourable conditions, thus tending to prevent overcrowding and excessive competition for food and nesting sites in areas warm the year round; *i.e.*, the subtropics and the tropics.

Older theories of the origin of migration are based on the assumption that migration has resulted from the response of birds to a repetitive event in their racial history, with this response ultimately becoming hereditary. None of the theories advanced by the early 1960s was completely adequate in explaining the origin of migratory behaviour in birds. Two major theories that had some currency earlier were the "ancestral home" theories: the northern and the southern.

**Northern "Ancestral Home" Theory.**—The northern ancestral home theory postulated that nonmigratory birds occurred over the entire northern hemisphere in earlier ages when climatic conditions were more uniform throughout the year and the vegetation provided birds with a constant source of food and nesting sites. (This condition exists today in some parts of the tropics, where, it may be noted, many birds are still nonmigratory.) However, as seasonal changes in climate became established gradually, perhaps as a result of the advances and retreats of the glacial ice fields, birds presumably were driven southward. When their original nesting sites became available at particular seasons, the birds returned to their ancestral breeding grounds in the north and remained there until they were forced southward again. It is believed that by constant repetition of this behaviour over many years and by many generations, birds developed the habit of migrating.

This theory, however, can be readily dismissed on the grounds that the birds that were originally forced southward would have become extinct long before the glaciers receded, if they had not already been destroyed earlier on their breeding grounds.

**Southern "Ancestral Home" Theory.**—The southern ancestral home theory assumed that the ancestral home of all birds was in the tropics and that because of overpopulation birds left to seek new territories to the north, where there would be less competition for food and nesting sites. Pioneering individuals could go as far northward as their food requirements permitted, but would eventually be forced southward with the approach of winter. With the advent of spring, the stimulus for reproduction would drive them northward again. Modifications of this theory postulated causes other than reproduction and homing instinct as the stimuli for the original movements. Postbreeding wandering and search for food, for example, have been suggested as the causes for the northward movement, and adverse seasonal and climatic conditions and search for food as the causes for the southward movement.

This theory, though supported by much of our knowledge of the behaviour of birds and their response to environmental factors, is, nevertheless, inadequate. It fails, for example, to account for the remarkable routes of migration over large bodies of water and for the great distances that separate the breeding and wintering areas of many species. It also fails to explain how the movements involved in the expansion and retreat of the species became hereditary.

**Continental Drift Theory.**—A more recent explanation of the evolution (but not the origin) of some types of bird migration is the continental drift theory. It postulates that rifting and displacement of continental masses and the consequent development of some ocean basins were factors involved in the evolution of the more highly developed forms of migration, especially in those species that travel great distances and cross large bodies of water.

The evolution of migration according to this theory is envisaged as follows: (1) Before the advent of continental drift many birds were performing short flights between breeding and feeding areas. (2) With the onset of continental drift these areas diverged slowly and were displaced horizontally. (3) Birds, however, because of their innate, well-developed homing behaviour, continued their use of these areas. (4) As the distances increased, only those individuals that had the necessary physiological preadaptations for the long flights survived.

Migratory behaviour, according to this theory, did not evolve into its highly developed forms because it served useful ends but because it was the natural consequence of an inherent behaviour pattern that induced birds to respond to the displacement of continental masses. The adaptive features of migration, such as leaving an area with the approach of winter, would, therefore, be the result of natural selection and not the cause of migration as implied in the theories discussed earlier.

One of the strong objections to the continental drift theory is that the fossil record of birds does not demonstrate the existence of modern kinds of birds in the Cretaceous period, when continental drift began. Since modern birds were present, however, at the beginning of the Eocene and since birds were evolving for about 70,000,000 years before the Eocene, it is not unreasonable to assume that some modern types were present when drift began.

Another objection is that the evolution of the present continents and ocean basins is not known; the geological hypothesis of continental drift, or horizontal displacement, on which this theory of migration is founded, is itself only a theory. Therefore, until further paleontological and geological data are available, the continental drift theory of the evolution of some types of migratory behaviour can be regarded at best as only a working hypothesis.

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**MIGRATORY LABOUR,** a term used to describe persons and families who travel about in search of seasonal farm employment, mainly in the harvesting of fruits, vegetables, sugar beets and cotton. In the United States several major streams of migratory movement are identifiable. From their winter homes in Florida and Georgia, family units and groups move northward through the Atlantic states in the summer and return late in the fall; similar streams of workers originate in Texas and spread out through

he central states and from the southwest through the Pacific tates. These routes identify only general directions of movement. ndividual families and small groups may develop routes that di- erge substantially from the major streams. Case histories of nigratory individuals and families demonstrate that their move- nents do not always follow an established route; their moves are prompted by hope and rumour as well as by accurate job informa- ion or firm offers of employment. Moreover, most families do ot continue as migrants indefinitely; as opportunities for steady mployment are found, the migrant family settles down. Thus, in art, migrancy is an intermediate stage in occupational and geo- raphic relocation.

It is sometimes said that migrancy exists because of the sea- onal labour requirements of agriculture and that people become nigrants because they like that type of life. Neither of these is a alid explanation for the existence of migratory labour. Sociologi- al investigations have demonstrated that such factors as occupa- ional displacement, racial discrimination, illiteracy, ill-health and ndustrial accidents are the basic causes of migrancy. Seasonal arm work provides an opportunity for those who are not prepared or or are not accepted in more desirable occupations.

Migratory labour has also existed in central and western Europe, Australia, Canada and in Central and South America. Women ice workers in Italy, Hungarian wheat harvest workers and Eng- ish hop pickers are examples. The migratory patterns of such killed specialists as sheep shearers in Australia and North America re exceptional in respect to effectiveness of planning and favour- ible earnings. Migratory labour has appeared also in construction, umbering and mining.

Even though many situations have some or all of the character- stics of migrancy, that of United States farm labour is outstand- ng in its magnitude, persistency and intensity of associated roblems. The problems result from the fact that children are in- olved, that periods on the road are prolonged, that distances are reat and that housing is mainly improvised. Education, child are, health and sanitation are difficult enough under migratory onditions; when they are compounded with poverty and uncer- ainty of employment the results are often deplorable.

Efforts are occasionally made by local authorities to ameliorate nigrancy problems by providing special schools, housing, clinics nd child care centres. However, such efforts are severely re- tricted because community services and facilities are designed rimarily for local residents; eligibility is, in fact, customarily ased upon a minimum period of residence.

Migratory workers in the United States are excluded from the rotection of major national and state statutes, including the Labor-Management Relations act, the Fair Labor Standards act nd unemployment insurance. Migratory workers are not union- zed and most are not able to meet the residence requirement for oting rights. Consequently, they stand apart as one of the na- ion's most excluded and unprotected economic groups. *See* also CASUAL LABOUR.

See *Farm Labor Fact Book,* United States Department of Labor, 959; *Migratory Labor in American Agriculture,* Report of the Presi- lent's Commission on Migratory Labor, 1951. (V. FU.)

**MIGUEL,** DOM (1802–1866), pretender to the Portuguese throne from 1828 to 1834, was the third son of John VI and Carlota Joaquina, and was born at Queluz on Oct. 26, 1802. He accompanied his parents in their flight to Brazil in 1807 and returned with them in 1821. In 1822 his father swore to uphold the constitutional regime that had been proclaimed during his absence. Miguel then became the champion of the absolutist cause, and the insurrections that ensued led to his exile in 1824. When John died (March 1826), his eldest surviving son, already emperor of Brazil, was declared king of Portugal, as Pedro IV, to the satisfaction of the liberals. Pedro abdicated in favour of his seven-year-old daughter, Maria da Glória, on condition that she marry Dom Miguel. The marriage took place by proxy on Nov. 29, 1826, but was never consummated. Miguel became regent in 1827 after swearing allegiance to Pedro, Maria da Glória and the constitution which Pedro imposed upon Portugal. Arriving in Lisbon, on Feb. 22, 1828, from Vienna, where he had come under Metternich's influence, Miguel went back on his promises. Rallying the absolutists to his support, he was proclaimed king on July 7, 1828, and proceeded repressively to eradicate constitutionalism. He was recognized by the Holy See, the United States, Spain and Russia.

With the abdication of Pedro as emperor of Brazil (1831), the civil war in Portugal between liberals and absolutists was intensified (*see* PORTUGAL: *History*). After military, naval and diplomatic defeats, Miguel capitulated on May 26, 1834, and renounced all claim to the throne. Maria da Glória became queen. Miguel settled in Germany where he married Princess Adelaide of Lowenstein-Wertheim-Rochefort-Rosenberg (1851). He died at Brombach, Baden, on Nov. 14, 1866.

*See* Arthur Herchen, *Dom Miguel I, Konig von Portugal, Sein Leben und seine Regierung* (1908); Manoel de Oliveira Lima, *D. Miguel no trono (1828–1833)* (1933). (M. CA.)

**MIHAJLOVIC, DRAZA** (1893–1946), Yugoslav army officer, leader of the royal Yugoslav underground army during World War II, was born on March 27, 1893, at Ivanjica, near Cacak, Serbia. Educated at the Serbian Military academy, he fought in the Balkan Wars (1912–13) and in World War I. When, on April 6, 1941, Germany attacked Yugoslavia, he was chief of staff of a motorized unit in Bosnia.

After the swift conquest and partition of Yugoslavia, Mihajlovic organized underground *cety* (plural form *ceta,* "band") of resistance in Serbia; but another underground organization controlled by the Yugoslav Communist party and led by Josip Broz Tito (*q.v.*) was operating mainly in Bosnia and Montenegro. In the autumn of 1941 the *cetnici* (called Chetniks in English) and the partisans fought the Germans together, but their political aims were totally divergent.

On Jan. 12, 1942, Mihajlovic was appointed minister of war of the Yugoslav government in exile. One month later a "Free Yugoslavia" radio station, broadcasting from Tbilisi, Georgia, accused him of collaboration with the enemy. In fact he was preparing for a general uprising in the event of an Allied landing in the Balkans and was also trying to repulse incursions of the partisans into his territory.

Support from London, however, was accorded to Tito who was judged more useful, and in May 1944 King Peter abandoned Mihajlovic.

After the country's liberation Mihajlovic went into hiding but was captured on March 13, 1946. He was tried and sentenced to death for treason, and was shot in Belgrade on July 17, 1946.

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**MIHALACHE, ION** (1882–1953?), Rumanian statesman and party leader, was born on March 3, 1882, at Topoloveni in Walachia. A peasant by origin and a teacher by profession, he founded in 1918 the Peasant party of the old kingdom (Moldavia-Walachia), which had considerable success in the elections of 1919. He was minister of agriculture in Alexandre Vaida-Voevod's cabinet until March 1920. In Oct. 1926 Mihalache became vice-president of the new National Peasant party led by Iuliu Maniu (*q.v.*), formed from the fusion of Maniu's National party of Transylvania with the Peasant party. Mihalache was again minister of agriculture in the Maniu cabinet of Nov. 1928. He was minister of the interior in George Mironescu's cabinet (1930), in the second Vaida-Voevod cabinet (1932) and in the second Maniu cabinet (1933). Mihalache refused to join the National Renaissance front and did not again hold office after King Carol II's assumption of the dictatorship in 1938, though Carol more than once approached him. During World War II he refused to collaborate with the Germans and took an active part in the underground liberation movement, becoming again vice-president of the reconstructed National Peasant party after the Allied victory. After the installation of the Communist-controlled government of Petre Groza in 1945, Mihalache, with Maniu's approval, prepared to leave for the west in order to form a Rumanian government in exile. On the eve of departure he was arrested with Maniu on

July 14, 1947. On trumped-up charges of treason and espionage, he was sentenced on Nov. 11, 1947, to solitary confinement for life. He died in the Sighet prison, probably in 1953. Mihalache never lost contact with his peasant supporters (he always wore the national dress) and was a man of simplicity, uprightness and courage. (B. Br.)

**MIKADO,** archaic title of the emperor of Japan; literally, the "august gate," the place being used for the personage who was too exalted to be referred to directly. According to the earliest legends, recorded in the 8th century A.D., the dynasty was founded in 660 B.C. by the emperor Jimmu, a direct descendant of the sun goddess Amaterasu. Scholars agree that it was probably in the 3rd century A.D. that what eventually became the imperial clan defeated rival chieftains and first asserted suzerainty over the inhabited parts of central and western Japan.

Although by the 6th century the imperial family had lost the military power which gained it hegemony, it had gained something else. The emperor, as high priest of the animistic cult of Shintō *(q.v.)* and as himself of divine ancestry, was invested with an aura of sacred inviolability. The aristocratic and military clans which from the 7th to the 19th centuries held actual power always preferred to rule through, rather than to usurp, the imperial position. Individual emperors were deposed and even murdered in court intrigues; for 60 years in the 14th century there were two courts supported by rival military families; but the imperial institution survived and, by the liberal practice of adoption from collateral branches, preserved its dynastic continuity.

The low point in the imperial family's prestige may be placed in the Tokugawa period (1600–1868) when the court at Kyōto was entirely subordinated to the military government in Edo (modern Tokyo) and limited to purely ritual functions.

The revolution in 1868 is spoken of as the Meiji "restoration," since in destroying the Tokugawa feudal regime and building a centralized nation-state its leaders claimed to be restoring the emperor Meiji to his rightful position as supreme ruler. The emperor was used as a symbol of national unity, and gradually a new cult of state Shintō was created in which patriotism was personalized as loyalty to the emperor and made a sacred duty. The constitution of 1889 vested absolute powers in the emperor. Ministers, judges and chiefs of staff were in theory his personal servants—a system of "legitimized irresponsibility" which contributed to the independence of the military establishment before 1945.

The defeat of Japan in 1945 dealt a mortal blow to the emperor cult and to the official myths of divine origin. In a rescript of 1946, Emperor Hirohito spoke disparagingly of these legends, and in the constitution of that year the emperor, as the symbol of the state with purely ceremonial functions, was deprived of all state power. His position was made similar to that of the British sovereign, and the policy was adopted (while preserving a large element of traditional ceremonial) of building up the imperial family as a model of family and civic virtue on the British pattern. *See* also JAPAN: *History.* (R. P. D.)

**MIKHAILOVSKI, NIKOLAI KONSTANTINOVICH** (1842–1904), Russian sociologist and political writer, recognized leader of the *narodnik* (populist) movement in the reign of Alexander II. Born in Meshchovsk, on Nov. 15, 1842, the son of a noble government official, he worked from 1868 to 1884 for the influential journal *Otechestvennye zapiski* ("Fatherland Annals") and from 1892 till 1904 edited *Russkoe bogatstvo* ("Russian Wealth"). He followed his motto: "We must avert the proletarian plague which now rages in Europe and threatens to infect Russia." But he romanticized the stagnant peasant commune as fatally as any official Slavophil, remaining strangely blind to the fact that it blocked one of the improvements which he aimed at, an escape from hopeless poverty. And from the survival of a beautiful but ancient peasant art he drew absurdly flattering conclusions about the modern peasant's character.

In 1874 the government started to arrest and imprison numerous innocent enthusiasts who had gone to live and work in remote villages. This led to the foundation of an extremist *narodnik* group called *Narodnaya Volya* ("The People's Will"), which justified political assassination. While this group had Mikhailovski's support, it was strenuously opposed by the more gradualist Marxian Georgi Plekhanov. Mikhailovski seems to have raised no objection to the various attempts made on the life of Alexander II. But throughout that time the executive committee of "The People's Will" proclaimed that its campaign of terror was merely a drastic method to bring the tsar to reason and compel him to call a constituent assembly. Their objectives remained astonishingly moderate and mild, even when they sanctioned murder as a means.

Alexander III wiped out the organization that plotted his father's death, and hanged its leaders. In fact the end of the *narodnik* revolutionary phase signified for many of its adherents the beginning of new faiths, not always socialist, derived from chastening political experience. According to their temperaments, former *narodniks* after 1881 turned either into sober skeptical progressives like Mikhailovski himself, full-blown Marxians like Plekhanov, or repentant conservatives like Tikhomirov. Mikhailovski died at St. Petersburg on Oct. 24, 1904.

*See* E. Frangian, *N. K. M. als Soziologe und Philosoph* (1913); R. Hare, *Portraits of Russian Personalities Between Reform and Revolution* (1959). (R. Ha.)

**MIKIR,** a tribe in Assam, India, inhabiting the hills between Brahmaputra and Dhansiri and calling themselves Arleng. They speak a Tibeto-Burman language akin to the Naga and Kuki dialects, practise shifting cultivation and live in small settlements of little permanence. The headmen of villages are elected and those of several settlements form a regional council with judicial powers. The tribe is divided into patrilineal, exogamous clans and though in the 1960s all clans were of equal status, there is a tradition that the functions of priests and warriors used to be linked with certain clans. Tribal gods are worshiped with animal sacrifices, and Hindu influence has affected religious belief and practice only superficially. Elaborate ceremonies, including dancing and sacrifices, accompany the cremation of the dead and megalithic monuments are erected for prominent men.

*See* E. Stack, *The Mikirs,* ed. by C. Lyall (1908). (C. V. F.-H.)

**MIKKELI** (Swedish SANKT MICHEL), a frontier *lääni* (county) in southeast Finland. Pop. (1960) 235,214. Area 8,359 sq.mi. It is a heavily wooded region embracing the southern halves of the great Saimaa lake system and of the historic province of Savo (Savolax), the home country of the east-central Finnish people—*Savolaiset.* It is centred on the market town, administrative centre and bishopric of Mikkeli (pop. 19,412). Other towns are Savonlinna (Nyslott) (14,410), the railway junction of Pieksämäki (10,295) and the waterway centre of Heinola (10,681). Savonlinna has the largest of Finland's medieval fortresses. Forestry is important, with livestock farming subordinate. Softwood processing and preparation of foodstuffs are the chief industries. There is small-scale limestone quarrying. (W. R. Me.)

**MIKKELSEN, EJNAR** (1880– ), Danish seaman and explorer, was born at Vester Brönderslev, Jutland, Dec. 23, 1880. His imagination was fired by dreams of polar exploration and at the age of 16 he walked the 320 mi. from Stockholm to Göteborg in an unsuccessful attempt to persuade S. A. Andrée to take him on the latter's arctic balloon flight. In 1900, however, G. C. Amdrup took him on the Danish expedition to east Greenland, where he took part in the remarkable journey in a small rowing boat along the dangerous and unexplored Blosseville coast. In 1901–02 he was a member of the Baldwin-Ziegler expedition to Franz Josef Land. After a few years at sea in merchant vessels as mate and master, Mikkelsen led the Anglo-American polar expedition (1906–08); a sledge journey of several hundred miles over the ice of the Beaufort sea established that, contrary to report, there was no land north of Alaska.

Mikkelsen's most famous exploit belongs to the expedition which he led (1909–12) to northeast Greenland to look for reports left by Mylius-Erichsen in 1907. He found these, including valuable geographical information, but when he and his only companion, I. P. Iversen, returned to the base on the coast they found their ship crushed by the ice and no sign of the remaining members of the expedition, who had in fact returned home on a sealing vessel. The two men survived a further two winters in Greenland

uffering great hardships, and were rescued by a Norwegian sealer fter nearly all hope for them had been abandoned. Mikkelsen ien wrote *Lost in the Arctic* (1913).

After some further years at sea, and as a journalist in Karelia during the Russian Revolution) and South America, Mikkelsen d an expedition in 1924 to establish the Eskimo settlement at coresby sound in east Greenland; great importance has been ttributed to this measure as a factor in The Hague court's deci- on in favour of Denmark in the dispute with Norway over east reenland. Mikkelsen also contributed to the development of ie west Greenland fisheries, and in 1932 led a scientific expedi- on to southeast Greenland.

He later became inspector general for east Greenland (1934–), a post for which he was suited by his deep feeling for the t of the east Greenland Eskimo.

His published works include *Frozen Justice* (Eng. trans. 1922), *Mirage in the Arctic* (Eng. trans. 1955); *Two Against the Ice* Eng. trans. 1957) and a number of studies of the east Green- nders. (P. A. B. G.)

**MIKOYAN, ANASTAS IVANOVICH** (1895– ), Soviet Communist leader of Armenian nationality, one of the few old Bolsheviks" who survived Stalin's purges. He was born on Nov. 25, 1895, at Sanain, then in the Tiflis province, and is said to ave come from a working-class family. After education in the rmenian ecclesiastical seminary at Tiflis he rejected the priest- ood, joined the Bolshevik party in 1915 and became one of the eaders of the revolutionary movement in the Caucasus. While eading the underground organization in Baku in 1918, he was aken prisoner by British troops but was later released. From 920 he worked as a Communist party official in Nizhni Novgorod now Gorki) and two years later in Rostov-on-Don. Entering the entral committee of the Communist party in 1923, he became in 926 a candidate member and in 1935 a full member of the olitburo (later presidium) of the party. In 1926 he was made ommissar for external and internal trade in the Soviet govern- ient, responsibilities he continued to hold under various titles hroughout his career until 1955. From 1942 to 1945, during World War II, he was a member of the state defense committee, harged with the task of supplying the armed forces. For this ork he was honoured as a Hero of Socialist Labour. From 1946 o 1953 he was a deputy prime minister of the U.S.S.R. After talin's death in 1953 he remained in the party presidium and ppears to have been the only senior member of the Soviet leader- hip to side firmly with Nikita S. Khrushchev in the ensuing con- icts. After Khrushchev consolidated his position in 1957 Mikoyan became a close adviser and a first deputy prime minister. He made official visits to the U.S. and Mexico in 1959 and to apan in 1961. In 1963 he represented the Soviet government at he funeral of Pres. John F. Kennedy in Washington, D.C., and in 964 he became chairman of the presidium of the supreme soviet r nominal chief of state of the U.S.S.R. (D. Fd.)

**MIKSZÁTH, KÁLMÁN** (1847–1910), Hungarian novelist, regarded by contemporaries and succeeding generations alike s the outstanding Hungarian writer at the turn of the century. He was born on Jan. 16, 1847, at Szklabonya. He studied law ut soon took up journalism, first at Szeged, later in Budapest. n 1887, already a famous writer, he was elected to the national ssembly. He died on May 28, 1910, in Budapest.

Mikszáth scored his first success with two volumes of short tories entitled *A tót atyafiak* ("The Slovak Kinsfolk"; 1881), nd *A jó palócok* ("The Good Palócs"; 1882). In 1894 he pub- ished his first novel, *Beszterce ostroma* ("The Siege of Besz- erce"), the story of an eccentric Hungarian aristocrat. Mikszáth's early art is romantic, and strongly influenced by Jókai. oward the end of the century he became more realistic. Unlike ókai, who pictured a national fairyland, Mikszáth was the writer f everyday life, which he described with understanding and ympathy, though he did not hesitate to pillory the shortcomings f society with sharp-witted satire.

The plots of his short stories and even of some of his novels re usually based on anecdotes. Only toward the end of his life lid Mikszáth succeed in creating such full-sized novels as his two principal works *Különös házasság* ("A Strange Marriage"; 1900), and *A Noszty fiu esete Tóth Marival* ("The Noszty Boy and Mary Tóth"; 1908). The first is set in early 19th-century Hungary and deals with the fight of two lovers against the oppressive forces of society. The second tells the story of a frivolous young noble who tries to make a fortune by seducing a rich middle-class girl. Mikszáth's last work, *A fekete város* ("The Black City"; 1910), is his finest historical novel. A critical edition of his works has been published, *Mikszáth Kálmán Összes Munkái* (1956 *et seq.*).

*See* M. Rubinyi, *Mikszáth élete és müvei* (1917); I. Király, *Mikszáth Kálmán* (1952); A. Schöpflin, *Mikszáth Kálmán* (1941).
(T. Kv.)

**MIKULICZ-RADECKI, JOHANN VON** (1850–1905), Polish surgeon, was born May 16, 1850, in Cernowicz (then part of Austria, now in Rumania). After taking his medical degree in Vienna in 1875, he became assistant to the great surgeon Theodor Billroth (*q.v.*). In 1882 Mikulicz became professor of surgery at Krakow, moving in 1887 to Königsberg and in 1890 to Breslau, where he remained until his death.

Mikulicz-Radecki was one of the most versatile and imaginative of the European surgical giants credited with the origin and rise of modern surgery; his lifetime spanned the golden age. He is the eponym for diseases he described and for surgical techniques and tools he devised. The most commonly cited are: Mikulicz's disease, a symmetrical swelling of lacrimal and salivary glands due to growth of lymphoid tissue in these organs; Mikulicz resection of intestine, the exteriorization of a diseased segment of colon as a stage in operative removal; Mikulicz pad, a multilayered gauze sponge or pack commonly used in abdominal operations. He is identified with the invention and application of the esophagoscope, the surgical face mask and many surgical instruments. Other subjects of his writings include goitre, cancer, replacement of blood loss, anesthesia and asepsis.

Like Billroth, he was an accomplished musician. He died on June 4, 1905. (J. H. Md.)

**MILAN** (Milan Obrenovich IV) (1854–1901), prince of Serbia from 1868 to 1882 and king from 1882 to 1889, was born at Maraşeşti in Moldavia on Aug. 22 (new style; 10, old style), 1854. He was the only child of the younger Milosh Obrenovich (1829–61; son of Prince Milosh Obrenovich I's youngest brother, Yevrem) and his wife Maria Catargiu (d. 1870) (*see* Milosh). Educated in Paris, with the philosopher François Huet as his director of studies, he was proclaimed prince of Serbia on July 2 (N.S.), 1868, after the assassination (June 10) of Prince Michael. A regency, composed of Milivoje Petrović-Blaznavac, Jovan Ristić and Jovan Gavrilović, governed for him till he came of age in Aug. 1872. The Liberal government for which Ristić stood was dismissed in 1873 but was called back to office in 1875; and from 1876 to 1880 affairs were again in the hands of Ristić. It was only after the recognition of Serbia's independence by the congress of Berlin (1878) that Milan, having decided to lean toward Austria-Hungary instead of Russia, in 1880 dismissed Ristić and began to rule effectively for himself. He then kept the Progressists in office till 1887, though the Radicals, whom he hated, were predominant in the parliament.

Milan was proclaimed king of Serbia on March 6 (N.S.), 1882. An armed rebellion by the Radicals, known as the Timok rising, was suppressed in 1883. Having done much to modernize the army, Milan in 1885 embarked on the ill-judged Serbo-Bulgarian War (*q.v.*): Serbia was saved from disaster by the intervention of Austria-Hungary, with which Milan had in 1881 concluded a secret pact for close co-operation. Internal institutions of this period were the first railways (begun in 1881), the National Bank of the Kingdom of Serbia (1883), a reorganized system of taxation (1884) and the Serbian Academy of Sciences (1886).

Married since July 1875 to Nathalie Petrovna Keshko (1859–1941), Milan, whose private life was notorious, was soon on bad terms with her. When the Progressists took her side, he entrusted the Radicals with the government (Dec. 1887–April 1888), then formed a nonparty administration and proceeded to divorce his wife (October). Finally, to consolidate his son Alexander's posi-

tion, he settled his differences with the Radicals and proclaimed a more democratic constitution before abdicating, in Alexander's favour, on March 6 (N.S.), 1889.

Milan then settled in Paris under the title of count of Takovo. In 1892 he renounced Serbian nationality. Having returned to Serbia in 1893, he left again in 1895, returned again to be commander in chief in 1897 and went definitively into exile in 1900, because of his disapproval of his son's marriage. He died in Vienna on Feb. 11, 1901. Pleasure-loving and ambitious, Milan had yet had a deep sense of Serbia's national interest.

*See* S. Jovanović, *Vlada Milana Obrenovića,* 3 vol., new ed. (1934). (K. St. P.)

**MILAN, LUIS** (*c.* 1500– ? ), Spanish vihuela (lute) player, composer and courtier. Born in Valencia, he seems to have lived there at the brilliant and cultivated court of Germaine de Foix, which he described in a manual of behaviour (1561); he also published a book of parlour games. His fame rests upon *El Maestro* (1536), a collection of pieces for the vihuela and songs with vihuela accompaniment. This was the first of a series of such publications of vihuela music by various composers that continued to appear until 1576; the series is one of Spain's most distinctive contributions to 16th-century culture. The music in Milan's book is arranged in order of increasing difficulty, its apparently didactic purpose being suggested by the title. The songs—Spanish and Portuguese *villancicos, romances* and Italian sonnets—are often of great beauty and the instrumental writing is infinitely varied and resourceful.

*See* J. B. Trend, *Luis Milan and the Vihuelistas* (1925). (N. Fo.)

**MILAN** (Italian Milano, German Mailand, ancient Mediolanum), the capital city of the north Italian province of Milano in the region of Lombardy (*q.v.*), stands on the little Olona river near the centre of the Lombard (Po) plain at a height of 400 ft. above sea level, 482 km. (300 mi.) N.W. of Rome. It is the seat of an archbishop, the chief financial centre of Italy and its wealthiest manufacturing and commercial town. Pop. (1961) 1,582,534.

The surrounding plain is extremely fertile, because of the richness of the alluvial soil deposited by the Po, Ticino, Olona and Adda rivers and the excellent irrigation system. The plain is like a vast garden divided into square plots by rows of mulberry and poplar trees. The summer is intensely hot, and the winter very cold with frequent snow and fog and a temperature often below freezing.

**Architecture and Art.**—*To the End of the Middle Ages.*—The plan of Milan faithfully reflects the city's history. Still clearly traceable are substantial sections of the rectangular street plan of the original Mediolanum (see *History* below) and the roads radiating from its four main gates. It lay in the quarter to the southwest of the cathedral, the two axes intersecting at the Piazza S. Sepolcro, which is the presumed site of the Roman forum. By the end of the 3rd century A.D. the city had long outgrown its early limits and was enclosed within a larger and somewhat irregular circuit, which remained in use throughout the early middle ages. The reconstruction of the city after its sack by Frederick I Barbarossa in 1162 brought important changes. The area was again enlarged, this time to an oval measuring 1,650 by 2,100 yd., enclosed by a wall whose course is now marked by an inner ring of streets following the line of the former moat. The centre of activity, together with the focus of the street plan, shifted to the site now occupied by the Piazza del Duomo, where it still remains. The radiating pattern so established has dominated all subsequent development, first to an outer wall erected by the Spaniards between 1549 and 1569 and now marked by a ring of boulevards; and (since 1859, when the population was 250,000) to an expanding succession of residential and industrial suburbs. The historical centre suffered severely in the air raids of 1943.

The remains of the Roman city still visible include a stretch of the early 4th-century walls; traces of the circus, built by Maximian (286–305); of a theatre and amphitheatre; and of a fortress built to protect a 4th-century imperial mausoleum. The principal remains of premedieval Milan, however, are the churches, which constitute a group comparable in importance and in earliness of date to those of Ravenna and Rome. Of the churches within the city, that of Sta. Tecla (the "Basilica Nova" of St. Ambrose) was destroyed in 1548 to make way for the Piazza del Duomo. Its remains, excavated in 1942 and 1962, were found to consist of a five-aisled basilica 250 ft. in length (probably post-Ambrosian in date), with an enclosed transeptal feature forming two chapels on either side of the chancel in the Greek manner. Immediately to the east of it stood the octagonal baptistery of S. Giovanni alle Fonti. Another such early building is the crypt of S. Giovanni in Conca, spared when the 9th-century church above it (used in modern times by the Waldensians) was destroyed in 1949. Most of the early Christian churches, however, lay outside the walls. The finest of these is S. Lorenzo, outside the Porta Ticinese, which may have been the palatine chapel. Though many times restored, the structure, except for the central dome (perhaps replacing a cross vault), is still that of the original 4th-century building. The plan is a square with four symmetrical lobes, enclosed within an ambulatory and buttressed at the angles by four towers. The colonnade of 16 re-used classical columns facing the street is what remains of the street-frontage of the atrium. Opening symmetrically off the main church are the near-contemporary chapels of S. Aquilino, S. Ippolito and S. Sisto; of which the first named, in the form of an octagonal mausoleum with an apsed antechapel, contains important remains of late 4th- or early 5th-century mosaic decoration. Other early churches lay in the cemetery areas and were originally martyr shrines. S. Nazaro, built as the church of the Holy Apostles by St. Ambrose in 386, opened off a broad, colonnaded street leading to the Porta Romana. Although this church was rebuilt after a fire in 1075 and very badly restored in 1830, excavation and further restoration has revealed the remarkable cruciform plan of the early building, which had a single, narrow, elongated nave and two strongly projecting, lobed transepts. It contains a fine silver casket of the 4th century. The Basilica Martyrum, built by St. Ambrose to house the remains of SS. Gervasio and Protasio, was a simple three-aisled basilica, 175 ft. long. In it, in 397, was buried St. Ambrose himself; and its remains lie directly beneath the present church of S. Ambrogio (12th century). Fragments of the original 4th-century wooden doors are preserved in the adjoining museum. Of the several neighbouring martyr-chapels, the only one surviving is that of S. Vittore in Ciel d'Oro, so called from its important remains of mosaics of the late 5th century. Another church traditionally ascribed to St. Ambrose is that of S. Simpliciano beside the road to Como. An early Christian basilica with lofty, projecting transepts, large windows and distinctive blind arcading, it was long thought to be of the 12th century, but has been shown to have preserved much of its original masonry to roof height.

Of the many recorded buildings of the earlier middle ages few have survived. Apart from the 9th-century campanile of S. Ambrogio and parts of the tower of the Monastero Maggiore (8th–9th century, on earlier work), the principal surviving monument of this period is the chapel of the Pietà in S. Satiro. This was the work of the great archbishop Anspert (868–881); in its cross-in-square plan there are evident signs of contemporary Byzantine influence. Anspert also built an atrium to the church of S. Ambrogio; but this was destroyed to make way for the present building, which dates almost entirely from the 11th and 12th centuries. With its carefully contrived vaulting system, handsome brick exterior, galleried façade and finely preserved atrium, it not only remains the outstanding Romanesque monument of Milan but had also in its own time a profound influence on contemporary building in north Italy; for it represented the full and perfect expression of the Lombard brick architecture of its age. The magnificent silver-gilt altar frontal, with figured panels and enameled mounts, the work of Volfoinus (German) and presented by archbishop Angilbert II (824–859), is a superb example of Ottonian goldsmith's work. Other notable fittings are the carved pulpit and altar canopy, both restored in part from earlier elements in 1196; and an unusually fine 4th-century "city gate" sarcophagus. Many of the earlier churches were rebuilt in the 12th century, and there are good Romanesque details in S. Celso, Sta. Babila and S. Vincenzo in Prato; but the only building of any distinction is the large 12th-century church of S. Eustorgio, vaulted in the

4th century. The adjoining Portinari chapel (1462–68), a graceful early Renaissance structure of Florentine inspiration with frescoes by Vincenzo Foppa, contains the splendid sculptured tomb, borne by eight Virtues, of St. Peter Martyr by Giovanni di Balduccio of Pisa (1339). This is the outstanding masterpiece of Milanese medieval sculpture.

Of the 12th-century walls and gates only the Porta Nuova and the S. Ambrogio postern have survived (the sculptured friezes from the former are now in the civic museum). The Palazzo della Ragione, or Broletto Nuovo ("new town hall"), the seat of the council of the medieval commune, was built between 1228 and 1233 by the mayor, Oldrado da Tresseno, whose equestrian relief occupies the centre of the façade. Together with the Loggia degli Osii (erected in 1316, with two open porticos, one above the other, in black and white marble) it faces on to the Piazza Mercanti, the commercial and administrative centre of medieval Milan. It replaced the Broletto Vecchio, which stood on the site later occupied by the town residence of the Visconti family and later still by the Palazzo Reale. The castle, begun by the Visconti in 1368 and dismantled during the short-lived republic of 1447–50, lay outside the Porta Giovia. This structure was replaced by the Castello Sforzesco, a grandiose brick fortress with angle towers of bossed stonework, more than 200 yd. square, built by Francesco Sforza between 1450 and 1468 to the designs of Giovanni da Milano. The great entrance tower was an addition by Antonio Filarete, the Florentine architect. The castle was much enlarged under Spanish rule in the mid-16th century; it now houses the civic museum and art gallery. Another fine Visconti monument is the octagonal campanile of the church of S. Gottardo (1336), an elegant example of Lombard decorative terra-cotta work; there are also parts of the archbishop's palace and the equestrian statue of Bernabò Visconti (*c.* 1365), now in the Castello Sforzesco.

The most ambitious and original architectural creation of the later middle ages was the cathedral (Duomo), begun in 1386 by Gian Galeazzo Visconti on the site of the 9th-century basilica of Santa Maria Maggiore. When first projected it was the largest church in existence; and it is still, after St. Peter's in Rome and the cathedral of Seville, the largest in Europe, covering an area of 54,000 sq.yd. and capable of holding 20,000 people. The exterior dimensions are: length, 515 ft.; width, 216 ft. (302 ft. at the transept); height of nave, 157 ft.; top of spire 356 ft. Built partly of brick and partly of granite and cased throughout in pink-tinged marble from the Candoglia quarries, the essential structure is a very elaborate Gothic, altogether alien in conception, but modified to Italian taste and highly individual in the detail of its execution. The Duomo took five centuries and the work of many generations of architects, both Italian and foreign, to complete. The high altar was consecrated in 1418, but the church itself not until 1572. The octagonal cupola was completed early in the 16th century, the main spire in 1765–69, the façade (on Napoleon's orders) in 1805–13; and the last of the lesser spires not until 1858. The church is cruciform, with five aisles to the nave, shallow three-aisled transepts and an ambulatory round the choir. Except for the two sacristies, the entire space contained within the outer walls comprises a single vast hall supported on 52 great pillars, which rise uninterrupted to the full height of the vault, with canopied niches for statues instead of the usual capitals. The marble pavement and the elaborate canopy over the high altar are by Pellegrino di Tibaldo de' Pellegrini (Tibaldi; 1567–82); and the richly carved Gothic doors to the sacristies are by Giovanni di Fernach (1393) and Giacomo da Campione (1396). The tombs include those of two early archbishops, Aribert (1045) and Ottone Visconti (1295); and that of Gian Giacomo de' Medici (1555) by Leone Leoni. In the crypt (Pellegrini's) lies the richly clad body of St. Carlo Borromeo in a casket of rock-crystal presented by Philip IV of Spain. The Trivulzio candelabrum, a seven-branched 16-ft.-high candlestick of 13th-century French workmanship, stands in the north transept. The exterior of the church is adorned with a fantastic profusion of turrets, pinnacles and more than 3,000 statues, of all periods from the late 14th century onward. From the tower a visitor may obtain a magnificent view of the surrounding plain and the distant Alps. (J. B. W.-P.)

*From the Early Renaissance to Modern Times.*—During the greater part of the 15th century the Gothic tradition was continued by Giovanni and Guiniforte Solari. Their simple and austere designs have a pleasing Renaissance touch. Noteworthy is Guiniforte's church of S. Pietro in Gessate (*c.* 1460, with baroque portal and the memorial chapel to Sen. Ambrogio Grifo, d. 1493). A project of Filarete was the Ospedale Maggiore, the first municipal hospital, begun in 1456 on the wide "Brolo" (waste ground) between the gates of S. Stefano and Bottonuto. It was carried out by Guiniforte Solari and G. A. Amadeo in a style half-Gothic, half-Renaissance (completed 1465). Extensions in the baroque style were made in the 17th century and in the neoclassical style in the 18th century. The Ospedale now houses the state university. Bramante and Leonardo da Vinci came to Milan in 1480 and 1482 respectively. Characteristic of the full flower of the Renaissance are Bramante's dome of the church of Sta. Maria delle Grazie; and the celebrated "Cenacolo" or "Last Supper" painted by Leonardo (1495–97) in tempera now much damaged on the refectory wall of the adjoining abbey. The rebuilding of the ancient church of S. Satiro (1486), with skilful use of perspective culminating in a false apse of stucco, is also Bramante's work.

At this period Duke Ludovico Sforza designed wide *piazze* in front of the Duomo (1489) and the castle (1492). These anchored the city's layout to the two complexes consisting of the castle on the one hand and of the Duomo, archiepiscopal palace, ducal (later royal) palace and Broletto Nuovo on the other, linked at the elliptical Piazza Cordusio, the city's commercial centre.

Notable 16th-century works are the frescoes by Bernardino Luini in the church of S. Maurizio and those of Gaudenzio Ferrari formerly in the Gothic 15th-century church of Sta. Maria della Pace (now in the Brera picture gallery).

Once Spanish rule had begun, the governor of Milan, Ferrante Gonzaga, undertook the enlargement of the Castello Sforzesco. Gonzaga began by surrounding the castle with ramparts in the shape of a six-pointed star and then built bastions along the line of the Visconti enclosure, 700–900 m. (2,296–2,952 ft.) in front of the earliest (12th-century) city walls. These new walls, corresponding to the modern city's inner ring of boulevards, formed the boundary of Milan until the late 19th century. Only the "lazzaretto" *i.e.*, the plague asylum, lay outside them. The space occupied by the open firing-range running from the castle toward the countryside was subsequently utilized by Napoleon.

Architecture flowered richly between the mid-16th and mid-17th centuries. Examples of this period are the Palazzo Marino (begun 1553 by Galeazzo Alessi) and the façade of Sta. Maria presso S. Celso, a church which contains a wealth of 16th- and early 17th-century Lombard painting. The church of S. Fedele, begun in 1569 by Pellegrini, is Milan's parallel to the Gesù in Rome. The chief baroque church is S. Alessandro on Via Zebedia, begun in 1602 by Lorenzo Binago, continued by Francesco Maria Richini and finished in the 18th century. Richini, whose patron was Cardinal Federigo Borromeo, impressed the whole of Milanese baroque with his austere and classicizing style. The most important example of his work is the Palazzo di Brera, designed in 1651 on the basis of a building begun in 1591, now occupied by the picture gallery (one of the most important in Europe, particularly for north Italian painting), the academy of art and the national library. By the Piazza Pio XI is the Biblioteca Ambrosiana (Ambrosian library), originally built by Fabio Mangone and founded in 1609 by Cardinal Borromeo; it has one of the great collections of Europe, with about 600,000 printed volumes, 2,000 incunabula and 25,000 manuscripts, as well as paintings. All the churches of this period are rich in paintings of the early 17th-century Lombard school. The Poldi-Pezzoli museum, restored after destruction in World War II, houses an art collection. The Leonardo da Vinci Museum of Science and Technology is in the old Olivetan convent rebuilt in 1947–52 after war damage.

Pre-neoclassical 18th-century works include the Palazzo Sormeni (1736, by Francesco Croce; now the city library) and the Palazzi Clerici (1740) and Dugnani, frescoed (1731) by Giovanni Battista Tiepolo. The first prominent neoclassicist was Giuseppe Pier-

marini (1734–1808). He transformed the Palazzo Reale (1773–78); built the world-famous La Scala theatre (1776–78), a great home of Italian opera, and the Palazzo Belgioiso (1773–81); and planned the Via Sta. Radegonda, the Piazza dell' Arcivescovado (now Fontana) and the Corso di Porta Romana (this last, the first paved street in Europe, had a granite footpath and was admired by the French writer Stendhal). Piermarini also planned the Cerso di Porta Orientale (now Corso Venezia), which runs from S. Babila toward Monza; and the "green lung" (the Giardini publici with a zoo, planetarium, natural history museum and Villa Reale) on its left-hand side.

The Parco (park) began with the demolition of the castle's Spanish outworks and the building of the semicircular Foro Bonaparte in front of it and the Piazza d'Armi behind. The layout included Luigi Canonica's Arena (1807) and the Arco della Pace (1807–37) by Luigi Cagnola. The latter made the starting point for Napoleon's great Corso Sempione, which was to have been the first line of a radial expansion of the city beyond the Spanish walls. But this project was superseded, after 1888, by haphazard development combined with thoughtless demolition in the city centre resulting in traffic problems still unsolved by the mid-1960s.

Most 20th-century buildings up to 1945 were tasteless or ugly. Exceptions, however, were the Casa Rustici in the Corso Sempione (by Giuseppe Terragni and Pietro Lingeri, 1931) and Luigi Figini's villa near the Central station. The city centre was heavily bombed in 1942–43, and the rebuilding and subsequent expansion were most unsatisfactory. Many streets of handsome houses of restrained baroque or neoclassic style with fine interior courtyards gave way to skyscrapers and large blocks of offices or flats which sprang up from the 1950s onward and began to transform the appearance of the city.

The regulating plan of 1950 made the first attempt to work out the serious urban problem of "greater Milan" on up-to-date and positive lines. This plan created the metropolitan district, a green zone (for the preservation of monuments) in the south and a business centre in the north. Some of the best architectural achievements are: the Olivetti firm's palazzo in Via Clerici, by Antonio Bernasconi, Annibale Fiocchi and Marcello Nizzoli; the Pirelli skyscraper near the Central station, by Gio Ponti, Pier Luigi Nervi and A. Danusso; and, as an out-of-centre business headquarters, E.N.I's Metanopoli at S. Donato Milanesi, with office building by Nizzoli and Oliveri. (M. Ri.)

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THE PIRELLI SKYSCRAPER

**The Modern City and Province.**—The Milan industrial complex has extended into the plain and has absorbed outlying villages. The province of Milano (area 1,065 sq.mi.; pop. [1961] 3,156,815) is an industrialized region as well as being a rich agricultural territory, so that agricultural pursuits and industrial works are often in close juxtaposition in it. Legnano, Monza and Lodi (*qq.v.*) are major local centres in the province. Industry attracts numerous immigrants from other parts of Italy and Milan's net increase of population approaches 70,000 a year. The severe housing shortage is remedied by intensive slum clearance and building of new estates. The province, too, receives a growing influx of workers: on its outskirts, and into neighbouring Como, sprawls the shanty settlement of Brianza.

*City Transport, Roads and Railways.*—Milan's streetcars, buses and trolley buses are operated by the Azienda Tranviaria Municipale. In the mid-1960s a metropolitan railway (subway) was under construction over a four-line network and a length of about 30 km. (18½ mi.).

Three important trunk roads branch out from the city. The first, the Via Emilia, runs to Rimini and links Milan with the Adriatic Riviera; the second, the Via del Sempione, goes to the Simplon pass; and the third to the Lake Como and the Spluga (Splügen) pass. Both thus connect Milan with Switzerland. Two more highways run across the city: the Genoa-Milan-Como road and the Turin-Venice road. A dense network of lesser roads connects the province with the other provinces to north, east and south. The southwesternmost part is intersected by the "Vigevanese" which then runs into Pavia and Alessandria. Most of Italy's toll motorways or highways (*autostrade*) also branch from Milan; *i.e.*, the Milan-Lakes route with branches to Varese, Como and Sesto Calende; the Milan-Turin route; and the Milan-Bergamo-Brescia-Verona-Vincenza-Padua-Venice. These motorways were constructed in the early 1930s and were widened in the 1960s.

Additional motorways include the Milan-Genoa "dei Fiori" and the most ambitious, the Milan-Bologna-Florence-Rome-Naples, the Autostrada "del Sole." Of the former, the Milan-Serravalle stretch and of the latter the Milan-Bologna stretch are in use.

Milan is linked with the whole of Europe via the transalpine tunnel, and internal mainline services run to Turin, Genoa, Verona-Padua-Venice, Bologna-Rimini-Ancona and Bologna-Florence-Rome-Naples. By 1960 there was need to supplement the Stazione Centrale (Central station) by a second mainline station at Porta Nuova to take over the Simplon Orient Express line. Two smaller stations (Porta Genova and Porta Romana) deal with local traffic; and the Stazione Nord serves the prealpine provinces of Como, Varese and Novara.

*Airports.*—Of these there are two: Linate (Forlanini), 7 km. (4½ mi.) from the centre and used by both internal and continental traffic, and Malpensa, 40 km. (25 mi.) from the city, still used for international flights.

*Industry.*—Many hundreds of thousands of workers are engaged in mechanical engineering, textile manufacture (especially silk), building and electrical, gas and water supply throughout the province of Milan. After 1950 there was a tendency for industries to move out of the city; engineering, in particular, moved northward (to the Sesto San Giovanni district, where there was already a good deal of heavy engineering). Textiles moved northwest; the chemical industry southeast. Milan has understandably become an active centre of trade unionism. As the centre of the silk area, it has developed into a thriving Italian fashion centre.

*Agriculture.*—The great agricultural wealth of Milano province is based on the fodder growing and cattle raising carried on, particularly in the south (with centre at Lodi) and in the east (centre at Melzo). Approximately 85% of the land is under rotated crops

nd fodder; the remainder is used for afforestation, as woodland, c. Crops include wheat, maize (corn) and some rice. The ulberry is cultivated to rear silkworms.

*Administration.*—The city of Milan is governed by a council f 80 members, who choose a mayor and an 18-man committee om among themselves. The council serves a four-year term, though on occasion elections may be delayed a year. The committee consists of the mayor and 17 "assessors" who are in charge f budget and finance; labour and statistics; legal business; personnel; consumer taxes; civil records; city police; food; benefit nd assistance; education; town planning and property; private uilding; public works; sport and tourism; and public utilities nd hygiene.

*Education and Cultural Facilities.*—Milan has three modern niversities, the State university, the Catholic University of the acred Heart and the Luigi Bocconi Commercial university. There also a polytechnic, with faculties in science, engineering and rchitecture. Among institutes of higher studies are the Giuseppe erdi Conservatory of Music, the Lombardic Institute of Science nd Letters, the Brera Academy of Fine Arts, the Enrico Fermi uclear Research institute and the M. Negri Institute of Chemoherapy.

*Sport.*—There are football (soccer) stadiums at the Civica rena in the Parco Sempione and at the suburb of San Siro. The wo Milanese teams, The Milan and The International play at San iro. Horseracing and trotting take place at the Ippodromo San iro and at Monza, about five miles away, there is the well-known otor-racing circuit (*Autodromo*) over which both the Italian uto and motor-cycle *grand prix* are run. (Ao. D.)

## History

The earliest known settlement on the site of Milan was that of he Insubres, a Celtic tribe who established themselves in the egion during the 4th century B.C. The first historical notice of he city dates from 222 B.C., when the Romans took possession of after defeating the Insubres. They had to withdraw from the rea during the Second Punic War, but recovered it shortly afterard. The Roman name, Mediolanum or Mediolanium, is of Celtic erivation. The process of romanization was achieved during the nd century B.C. and it obtained Latin rights in 89 B.C.; in -9 B.C., with the conferment of Roman citizenship on the Transadane province, Milan attained the rank of a *municipium*. Little s known of its history during that period. It appears as a city f second rank in the Peutinger table, but was given the status of *olonia,* possibly as early as the 2nd century A.D. It was the 3rd entury, however, which saw the rise of Milan to a great political entre, as the growing pressure of Germanic tribes gave a new trategical importance to the north of Italy. Under the Roman mperor Aurelian, Milan became the capital of the consular province of Aemilia-Liguria, which then comprised the 9th and the 1th regions of Italy according to Augustus' reorganization including Transpadane Gaul. The city was fortified with walls, which were completed by Maximian. With the reforms of Diocletian, the main administrative centre of the western Roman empire was established at Milan, which remained throughout the 4th century the preferred residence of the Western emperors and the seat of the vicar of Italy instituted by Diocletian and of the *praefectus praetorio* instituted by Constantine. The prosperity of the city, nourished by its position at the crossing of major roads from Gaul, Raetia and Illyricum, was further enhanced by the presence of the government, until the emperor Flavius Honorius for reasons of defense transferred the capital to Ravenna in 404.

Milan, whence Constantine issued the edict of 313 giving official recognition to Christianity, also became an important ecclesiastical centre, especially from the time of St. Ambrose (*q.v.*), bishop from 374 to 397. Ambrose made Milan a centre of the Catholic struggle against the Arian heresy, formulated the Ambrosian rite still in use in the Milanese diocese and gave its church a sense of independence toward Rome which long survived.

With the 5th century came the barbarian occupations of Milan: by the Huns under Attila in 452, by the Heruli under Odoacer in 476 and by the Goths under Theodoric in 493. The invaders selected Pavia as their capital from the time of Odoacer, but Milan seems to have maintained its economic importance until 539, when it was sacked by Uraia the Goth, against whom Bishop Datius had appealed to Byzantium for aid. Narses, Justinian I's general, is reported to have restored the city in 567, but in 569 it was taken by the Lombards who mastered northern Italy and, like their predecessors, established their capital at Pavia.

The rectangular plan of Roman Milan has been traced in the centre of the modern city. Because of successive destructions, very little evidence from the Roman period has survived above the ground. Many archaeological remains (now housed in the Castello Sforzesco) have been found below ground level, and have helped to fix some topographical aspects of the Roman period; but much remains in doubt.

**Ascendancy of the Archbishops.**—In the obscure centuries that followed the Lombard conquest, the archbishops of Milan, champions of orthodoxy against the Arianism of the early Lombards, were the leading figures in the life of the city and the rallying point of its inhabitants. Private deeds and donations to churches dating from the 8th century indicate the presence of a well-to-do element in the city by that time, and the incorporation of the Lombard kingdom into the dominions of Charlemagne in 774 probably gave a fresh impetus to prosperity. With the disintegration of the Carolingian empire toward the end of the 9th century, the freedom of action of the Milanese under their archbishops grew. Civic independence was strengthened by the need to take local action against the inroads of the Magyars in the first half of the 10th century, when refugees from the countryside swelled the population of the city. The counts of Milan, originally Carolingian royal officials, began to lose all effective authority within the walls. The archbishops, though they were never vested with full comitial powers, acquired a temporal authority in the city and diocese through the exercise of the Carolingian office of missus dominicus, to add to their traditional role of spokesmen and leaders of the people. The territorial endowment of their see expanded, reaching as far as the Leventina and Blenio valleys of the Swiss Alps, which were important highways for Milanese commerce. In 983, Archbishop Landolf II resolved the difficulties and opposition which faced him by the enfeoffment of lands of the see and the public power in the countryside, thereby creating a military aristocracy which formed a governing class around the archbishop in the city.

On these foundations Archbishop Arihert, from 1018 to 1045, built the power which enabled him to unite the city in successful resistance to the demands of the emperor Conrad II in 1037–39. But this unity was short-lived. The exercise of temporal authority by the archbishops placed some strain on their relations with the citizens; and at the same time the increasing tempo of trade and industry and the growing wealth of the cities brought new social problems to the fore. The outcome at Milan was a popular movement which found expression in the attack of the Patarines, in alliance with the ecclesiastical reforming circles dominant at Rome in the second half of the 11th century, on the corruption of the aristocratic higher clergy of the city.

**The Commune.**—Milan's problems found temporary issue at the beginning of the 12th century in the formation of a commune, with permanent and autonomous organs of government (*see* COMMUNE [MEDIEVAL]), to replace the more informal control of the archbishop and his advisers. The commune reflected a reconciliation of conflicting social forces which was encouraged by archbishops attached to the reforming party and induced partly by exhaustion, though it was also related to external needs. Rapid economic expansion in a confined space had created intense rivalry among the cities of Lombardy. Milan, the most populous and prosperous among them, naturally played a leading part in these conflicts, subduing Lodi (1111), defeating Como after a prolonged war (1118–27) and threatening other neighbouring towns. Fear of Milanese preponderance in Lombardy caused the city's enemies to appeal to the emperor Frederick I Barbarossa. The Milanese successfully defied him for a time, but in 1162 he captured and destroyed the city after a nine months' siege and dispersed the inhabitants in the countryside. German rule in Lombardy quickly

aroused hostility, and Milan was rebuilt and the population returned in 1167 under the protection of the newly formed Lombard league (*q.v.*), in which the Milanese henceforth took a prominent place, contributing the greater part of the forces which defeated Barbarossa's final attempt to subdue Lombardy at the battle of Legnano in 1176. After the peace of Constance (1183), dislike of Milanese power again began to divide the cities of northern Italy, but it was once more under Milanese leadership that the league was revived to resist Frederick II's attempt to restore imperial power (1226–50).

Milan was governed during this period by the institutions common to the Italian communes and began to create its own municipal law, which formed the basis of later codes of statutes. The institutions were a *parlamento* or assembly of citizens, suspect because open to demagogic pressure and subsequently restricted in number and known as the *consiglio grande;* a small and more wieldy committee of the council, known as the *credenza;* and the executive body of consuls, finally replaced after some years of experiment (1186–1213) by a single foreign official, the *podestà,* in an effort to curb the disorders arising from rivalry for office. The growing industrial activity of the city was organized through the guilds, which began to aspire to political influence. The most important products were (1) fustians and woolen cloth, in the production of which the religious fraternity of the Umiliati played a leading part; and (2) arms, for which Milan acquired a special renown and for which the mineral resources of the Alpine valleys provided readily accessible raw materials. Intensive irrigation, undertaken notably by the new Cistercian monasteries of Morimondo and Chiaravalle, raised the fertility of the countryside to meet the demand of the rising population for food. A charter of Frederick I in 1185 transferred the imperial regalian rights to the commune, thus weakening the claims of the archbishop, and of the feudal class associated with him, to monopolize the government of the city.

All these factors contributed to the renewed social conflicts of the 13th century. Within an essentially fluid social structure, it is possible to discern a challenge, organized by the producing guilds who joined forces under the name of Credenza di S. Ambrogio, to the political dominance of the nobility; while another association of less clear affiliations, possibly formed of the lesser nobles and wealthy merchants, took the name of Motta. The struggle between these forces continued parallel to the conflict with Frederick II, who inflicted a severe defeat on the Milanese and their allies at Cortenuova in 1237, but was unable to press home his advantage and capture the city. Meanwhile oppressions of the people alternated with expulsions of the nobility, who then attached their hopes to the revival of archiepiscopal authority on the election, in 1241, of an archbishop particularly favourable to them, Leone da Perego (d. 1257). Thus the archiepiscopal party in Milan assumed a Ghibelline complexion while the *Credenza,* which found noble leaders in the family of Della Torre, took the name of Guelphs (*see* GUELPHS AND GHIBELLINES). The conflict between these parties eventually merged in a struggle for power between the Della Torre and the Ghibelline nobility, issuing in the victory of the latter, under Archbishop Ottone Visconti, at Desio in Jan. 1277. The subsequent creation of the lordship or *signoria* of the Visconti marked the end of the independent commune of Milan: henceforth the history of the city was largely that of the successive dynasties that ruled it.

Internal conflicts and external wars do not seem to have affected seriously the economic well-being of the city. The population continued to grow, swollen by immigration from the countryside; and the city was largely rebuilt during the 100 years after the peace of Constance. Bonvesin da la Riva was a citizen whose work, *De Magnalibus urbis Mediolani* (1288), described a prosperous and flourishing city with a population of 200,000 (possibly an exaggerated figure).

**Visconti and the Sforza.**—The dynasty of the Visconti (*q.v.*), whose *signoria* became hereditary from 1349 and who received the title of duke of Milan in 1395, offered to Milan, in compensation for its lost autonomy, the position to which it had long aspired of virtual capital of the province of Lombardy. Milanese citizens were prominent in the central organs of government introduced by the ruling dynasty, as well as in official posts in the provincial cities. The Visconti kept in touch with the leading commercial interests of Milan, such as the international banking firm of the Borromei; and though they were not prepared to neglect the interests of other sections of their subjects their policy was generally aligned to the needs of the Milanese market. The introduction of the mulberry plant into Lombardy by Filippo Maria Visconti in the 1430s led to the rapid development of the silk industry in Milan, to supplement that of woolen cloth which was increasingly subject to international competition.

When Filippo Maria died without leaving a male heir in 1447, the hankering for the independent days of the commune, especially among the older civic families, led to the setting up of the Ambrosian republic and the restoration of communal government in Milan. But the other cities of the Visconti dominions, always jealous of the preponderance of the capital, rejected its claims to supremacy over them and went their own way; and the force of political events soon made clear the anachronism of the aspirations of Milan and the incompetence of its leaders. A powerful general, Francesco Sforza, who had married Filippo Maria Visconti's illegitimate daughter, was able to enforce his claim to Milan and to the duchy and restored the governmental system of the Visconti in 1450. Under the dynasty of the Sforza (*q.v.*), Milan became the seat of a magnificent Renaissance court. Ludovico Sforza, in particular, did much to encourage the embellishment of the city, but this did not assuage growing discontent, for the grandiose style and political commitments of the Sforza needed heavy exactions to support them. Thus Milan made no resistance to Louis XII of France (grandson of Filippo Maria's sister Valentina Visconti) when he defeated Ludovico Sforza and annexed the duchy in 1499. The Sforza were finally restored when the Swiss expelled the French from Lombardy in 1512; but this dynasty too became extinct in the direct line in 1535, whereupon Milan was added to the Habsburg dominions of the emperor Charles V.

**Spanish and Austrian Rule.**—In 1540 Charles V invested his son, the future Philip II of Spain, with the duchy of Milan. The Spanish dominion, which lasted until 1706, pressed heavily on Milan: not that it was entirely unenlightened, but because the city, dependent politically on a foreign state and adversely affected by its subordination to the declining Spanish economy, dwindled in importance to the level of a provincial centre. Charles V had reorganized the legal system by the so-called "New Constitutions" of 1541, and the constitution of the province by the ordinances of Worms in 1545, incorporating and consolidating the provisions of previous dynasties. Municipal affairs came largely into the hands of a closed aristocratic caste on the Spanish model. Some families made quick fortunes in the wars of the 16th century, but by the end of the century the industrial production and prosperity of the city had begun to decline. As elsewhere, industry found freer conditions in the countryside, and measures to prevent emigration had little success.

Prince Eugene of Savoy, with an Austrian army took possession of Milan in Sept. 1706, in the course of the War of the Spanish Succession, and the dominion of the Austrian Habsburgs was confirmed, apart from some cessions of territory to Savoy, by the treaty of Utrecht. The first half of the 18th century was a period of general misery and misfortune. During the War of the Polish Succession the city was annexed by Savoy from 1733 to 1736; and during the War of the Austrian Succession it was occupied by a Franco-Spanish army in 1745–46. A severe repression of anti-Austrian elements followed its recovery in 1746; and throughout the period the acute financial needs of the Austrian government frustrated all projects for improving the state of the dominion. After the peace of Aix-la-Chapelle (1748), however, Milan under Austrian rule became a field for the activities of "enlightened" autocracy, which gained the support of the most enterprising commercial and industrial circles of the city. The Austrian government initiated a large program of financial, administrative and judicial reforms. While the wealth and influence of the older nobility declined, the entrepreneurs, backed by the government in their economic activities, flourished and grew wealthy, entered the administration and were ennobled. Neoclassical architecture

began to transform the appearance of the city. The Palazzo delle Scuole Palatine became a major centre of learning. The ideas of the French *Encyclopédistes* circulated in spite of the Austrian censorship. A revival of aristocratic control ordained by the emperor Leopold II in 1790 further helped to prepare the ground for revolution.

**French Revolutionary and Napoleonic Period.**—When Napoleon Bonaparte entered Milan on May 15, 1796, in the course of his first Italian campaign, he was welcomed by many elements of the population, notably among the middle class. The main city of the Cispadane republic and subsequently of the Cisalpine (later Italian) republic into which the Cispadane was incorporated, Milan became the capital of the greater part of the peninsula when Napoleon took the title of king of Italy (being crowned at Milan in May 1805). Eugène de Beauharnais ruled there as viceroy.

Milan received the Code Napoléon, prospered from the enterprise of its citizens and from its revived political importance and drew to itself talents of all kinds from the rest of Italy. But the strain on resources and manpower to meet the demands of Napoleon's last campaigns once more brought disillusion, and though some voices were raised for independence, Milan accepted submissively the fate decreed for it by the victorious allies in 1814.

**Austrian Restoration and After.**—Under Austrian rule again, Milan was made part of the Lombardo-Venetian kingdom constituted in 1815. Experience of the irritations of Metternich's system quickly revived the desire for independence. In the *Cinque Giornate* ("five days") of March 18–22, 1848, still celebrated as one of the most glorious episodes of Milanese history, the people rose in revolt, drove out the Austrian garrison and allied themselves with the forces of Sardinia-Piedmont; but the effort was premature, and the Austrians returned again a few months later (*see* ITALIAN INDEPENDENCE, WARS OF). On June 8, 1859, however, after the battle of Magenta, Victor Emmanuel II and his ally the French emperor Napoleon III entered Milan, so that the city was already Victor Emmanuel's when he became king of Italy in 1861.

By that time Milan had fully embarked on an industrial revolution, in which the production of cotton and metal goods played a prominent part. Heavily damaged by bombing in World War II, it was rapidly rebuilt, with modern skyscrapers as a feature of the skyline. It continued to thrive and expand as a commercial and industrial city—characterized by the annual Sample fair, which became the focal point of its life. *See* also ITALY: *History;* and references under "Milan" in the Index. (D. M. B. DE M.)

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**MILAZZO,** a seaport of Messina province, Sicily, Italy, on the north coast of the island 30 km. (18.5 mi.) W. of Messina by road. Pop. (1961) 24,101 (commune). It is mainly built on the low isthmus of a peninsula 3 mi. long; the old town on a hill above contains a Norman castle dating mainly from the 16th century, with parts from the 13th century. Milazzo is on the railway from Messina to Palermo and is the transit port for the Aeolian Islands. The neighbouring plain yields grapes and early fruit. The town is a tourist centre and has a growing industry. The town, the ancient Mylae, was founded in the 8th century B.C. by colonists from Zancle (Messina). It was taken by the Athenians in 426 B.C.; Gaius Duilius won the first Roman naval victory over the Carthaginians in the bay in 260 B.C.; and on July 20, 1860, Garibaldi defeated the Bourbon forces outside Milazzo. The town suffered from Allied bombing in World War II.

**MILDENHALL,** a market town of Suffolk, Eng., is on the river Lark, 39 mi. N.W. of Ipswich by road. Pop. (1961) 7,132. The town retains its hexagonal market cross dating from the reign of Henry V and now scheduled as an ancient monument. The church of St. Mary is of the 13th to the 15th century with a tower 112 ft. high. It is distinguished for the open timber hammerbeam roof of the nave.

**The Mildenhall Treasure.**—This hoard of Roman silver tableware was acquired by the British museum in 1946, having apparently been discovered four years before in the plowing of a field at West Row, 2 mi. N.W. of Mildenhall, near remains of a 4th-century Roman building. The majority of the pieces, 34 in all, seem to be of 4th-century workmanship, and some are products of Mediterranean factories. Possibly the owners buried their family plate in the troubled days of the Barbarian invasions.

The most impressive piece in the hoard is a great dish, 60.5 cm. in diameter, its outer frieze of relief ornament depicting the triumph of Bacchus over Hercules. The same techniques of naturalistic figures in relief with incised detail are found on two platters with heavy beaded borders. There are also four large and two smaller bowls with flanges ornamented in relief. A large flanged dish and a bowl are decorated in a different style, with incised niello work. The dish is perhaps the earliest item in the hoard, although the lid found with it is obviously of later workmanship. A fluted bowl with swing handles completes the larger items in the collection. The smaller pieces are two unusual goblets with very broad bases, possibly for use as plates, five ladles with dolphin handles and eight spoons, three of which have Christian inscriptions and were probably christening spoons.

*See* J. W. Brailsford, *The Mildenhall Treasure,* 2nd ed. (1955). (R. J. CR.)

**MILESCU, NICOLAE** (1636–1708), Rumanian writer of Greek origin, and a great scholar and traveler, was born near Vaslui in Moldavia in 1636. After studies at the Greek patriarchate college in Constantinople, he returned in 1653 to Iaşi (Jassy), the Moldavian capital, and was appointed secretary to Prince Gheorghe Ştefan. In 1658 Prince Gheorghe Ghica gave him the title of *spathar* (swordbearer). Hoping to be appointed prince of Moldavia, he intrigued against Prince Ilias Alexandru, who in 1668 punished him by cutting his nose. So disgraced, Milescu left his native country, never to return. He revisited Constantinople, where his friend Dositheos, patriarch of Jerusalem, gave him a letter to tsar Alexis (Aleksei Mikhailovich). Through Buda and Warsaw he traveled to Moscow, where he arrived in 1671 and was appointed translator to the *posolski prikaz* (foreign office) as Nikolai Gavrilovich Spafari. He gained the confidence of Prince V. V. Golitsyn and A. S. Matveev, two boyars who had great influence with the tsar, and in 1675 was sent as ambassador to Peking, returning in Jan. 1678. In the meantime Alexis had been succeeded by his son Fedor III, and Spafari-Milescu lost his official position. He was compensated for his mission to China only in 1693, under Peter I. He died in Moscow in 1708.

A highly educated man, who could write in Greek, Latin, Rumanian and Russian, Milescu left many manuscripts. He translated the Bible from Greek into Rumanian, and the Bible printed by the Walachian prince, Şerban Cantacuzino, in 1688 was based on his translation. Among his writings the most valuable is the *Puteshestvie cherez Sibir . . . do Kitaya* ("Journey Across Siberia . . . to China"). It was printed in 1882 (Eng. trans. in J. Baddeley's *Russia, Mongolia, China,* vol. ii, 1919).

*See* E. Picot, "Notice biographique et bibliographique sur Nicolas Spatar Milescu," in *Mélanges orientaux* (1883); P. P. Pănăitescu, "Nicolas Spathar Milescu," in *Mélanges de l'Ecole Roumaine en France* (1925).

**MILETUS** (Byzantine PALATION, Turkish BALAT), an ancient city of Asia Minor, on the southern shore of the Latmic gulf near the mouth of the Maeander (Buyuk Menderes) river. Before the Ionian migration it was inhabited by Carians. Some Bronze Age objects from the Aegean world have appeared on the site, but the Bronze Age settlement has not been located. The Greek city traced its foundation to Neleus and his followers from Pylos. Situated at the mouth of a rich valley, Miletus was the natural outlet for the trade of southern Phrygia. In Egypt it had much to do with the founding of Naukratis (*q.v.*). In the west

it engaged extensively in the wool trade with Sybaris. In the north it founded more than 60 cities between the Hellespont and the Crimea—among them Abydos, Cyzicus, Sinope, Olbia and Panticapaeum. The date of its earliest commercial and colonial expansion remains quite uncertain; but before 500 B.C. it was the greatest east Greek city. It was distinguished also for its literary and scientific figures, among them Thales, Anaximander, Anaximenes and Hecataeus. The three Ionian cities of Caria—Miletus, Myus and Priene—spoke a peculiar dialect of Ionic.

Miletus had tyrants, Thrasybulus and Histiaeus (*q.v.*), at the very beginning and end of the 6th century. Its political constitution at other times up to 500 is very obscure. Its extant list of annual magistrates appears to begin as late as 525. But from the 7th century the Mermnad kings of Lydia found in Miletus a strong adversary. After a long war, Alyattes made peace with Thrasybulus toward 600 B.C. Later, Miletus seems to have acknowledged the rule of Croesus. On the Persian conquest, Miletus passed under a new master. But *c.* 499 B.C. its tyrants, balked by Darius, began the Ionian revolt; and in 494 it was stormed and sacked by the Persians. (*See* IONIA.) After the Persian defeat by the Greeks (479) it joined the Delian league (*q.v.*). The first Athenian tribute lists and contemporary inscriptions (*c.* 450) show that Miletus was then poor and factious. In 442 it lost a local war against Samos and was propped up by Athens. But the Milesians were already rebuilding their city on a new grid plan to the type invented in this very period by the Milesian Hippodamus. In 412 Miletus revolted to Sparta; before 350 it was under Mausolus of Caria, and in 334 it opposed Alexander on his southward march, succumbing only after a siege. Hellenistic princes who competed for influence at Miletus included Antiochus IV Epiphanes and Eumenes II of Pergamum, both about 170 B.C. Miletus remained an important commercial town, and received special attention from Augustus and from Trajan. But, like Ephesus, it was slowly silted up. The sea, which washed it on three sides, has been replaced by the Maeander; and Lade, once an island nearby, is now a hill far inland. The city, already much smaller under Justinian, is now deserted.

The ruins occupy the former peninsula extending northward from the hill of Kalabak Tepe. The site, about a mile long, is half a mile wide at its southern end, but farther north is more pinched and is indented with two good natural harbours. The more easterly of these, the Lion harbour, was guarded by stone lions and was the more important.

The area covered by the archaic city is unknown. An archaic fortification wall south of Kalabak Tepe may show it extended far south of the later town. But one can hardly believe, with some recent authorities, that it did not take in the harbours, even if the central agora did not occupy its later position, just south of the Lion harbour. Only one small archaic temple survives in part, on Kalabak Tepe, a backward building for its date in the later 6th century.

The classical town comprises a southern part; there are extensive remains both of private dwellings and public buildings, ranging from the 5th century B.C. to buildings of Roman imperial times. The Hellenistic council house is especially interesting for its propylon, which has some of the earliest known examples of true pilasters.

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**MILFORD,** a city of Connecticut, U.S., on Long Island sound near the mouth of the Housatonic river, a part of the Bridgeport standard metropolitan statistical area (*see* BRIDGEPORT). Milford was founded in 1639 by the Rev. Peter Prudden and his followers; the land was purchased from the Paugusset Indians for 6 coats, 10 blankets, 1 kettle, 12 hatchets, 12 hoes, 24 knives and 12 small mirrors. The settlement was named for the English city. New Haven colony first rejected Milford's application for membership because six nonchurch members could vote but a later compromise brought Milford into the colony in 1643. In the 1640s Indian attacks threatened the town to such an extent that citizens surrounded the settlement by palisades. During the American Revolution Milford men drove off a small British landing force.

From about 1690 to 1818 shipbuilding flourished. Oyster raising, begun in 1752, continued profitably into the second half of the 20th century. After a lengthy period of slow growth in the 1800s, Milford began to increase rapidly in population after 1910 as it acquired new industries. Leading manufactures include brass goods, electronics and electrical motors, hardware, locks and screw machine products. Milford was a town from its founding until 1959, when it was incorporated as a city. Pop. (1960) 41,662. For comparative population figures *see* table in CONNECTICUT: *Population*. (A. E. V. D.)

**MILFORD HAVEN, LOUIS ALEXANDER MOUNTBATTEN,** 1ST MARQUESS OF (1854–1921), also known as PRINCE LOUIS OF BATTENBERG, British admiral of the fleet, was born at Graz, Austria, on May 24, 1854, the eldest son of Prince Alexander of Hesse, and was naturalized as a British subject in 1868, when he entered the Royal Navy. He had a distinguished career, taking part in the Egyptian campaign (1882) and while still a captain he held the post of director of naval intelligence (1902). As rear admiral he commanded the 2nd cruiser squadron (1905), where he showed great skill as a naval leader and was promoted vice-admiral in 1908. After commanding the Atlantic fleet and part of the Home fleet, he became second sea lord (Dec. 1911). In 1912 he was moved to the position of first sea lord where he was responsible for bringing the fleet to a state of readiness for war. After a test mobilization in July 1914, he ordered the reserve ships to remain in full commission without instructions from the government, so that the whole fleet was ready for action when World War I began on Aug. 4. Two months later, despite his prevision and the work he had done for the navy, notably in signals and tactics, press agitation over his German origin brought about his resignation. In 1917 he relinquished his German titles at George V's request, assumed the surname Mountbatten and was created marquess of Milford Haven. He died in London on Sept. 10, 1921.

In 1884 he married Princess Victoria of Hesse-Darmstadt and had two daughters and two sons, George (1892–1938), 2nd marquess, and Louis, afterward Earl Mountbatten of Burma (*see* MOUNTBATTEN OF BURMA, LOUIS MOUNTBATTEN).

(W. S. CH.)

**MILFORD HAVEN,** an urban district and seaport of Pembrokeshire, Wales, lies on the north shore of the natural harbour and spacious estuary from which it takes its name. Pop. (1961) 12,802. The town was not founded until 1793 though the harbour had been the chief point of embarkation for Ireland from the middle ages until the mid-19th century. Henry II's army sailed from there to Ireland in 1171 and Richard II landed there in 1399 before his surrender to Henry of Lancaster (afterward Henry IV), in whose reign a French fleet sailed to the Haven to support the rebellion of Owen Glendower. Henry Tudor (afterward Henry VII) also landed there from France in 1485. In 1790 Sir William Hamilton (*q.v.*) was authorized by act of parliament to establish a town, docks, etc., at Milford Haven. His nephew, Charles Francis Greville, arranged for approximately 25 American Quaker families to be brought from Nantucket Island in 1793 to establish a whaling community for the supply of spermaceti whale oil for London street lighting. Following the introduction of gas lighting in London (1807) this whaling industry declined. A royal naval dockyard, established at Milford Haven early in the 19th century, was removed with the arsenal to Pembroke Dock in 1814, and about 20 years later the Irish packet service was transferred to Neyland. Toward the end of the 19th century the town recovered much of its prosperity as a fishing port.

The original part of the town is laid out on a gridiron pattern. Modern developments include a large oil refinery on the north shore of the harbour, another refinery began operations after 1964 on the south shore where there is an oil tanker terminal. Milford Haven is now one of the major oil ports of northern Europe. The main imports, aside from oil, are cattle food, potatoes and fertilizers. (A. H. JA.)

**MILHAUD, DARIUS** (1892– ), French composer of a

Jewish Provençal family, who developed the technique of polytonality, was born at Aix-en-Provence on Sept. 4, 1892. He studied at the Paris conservatoire under Paul Dukas, Vincent d'Indy and others and later spent two years (1916–18) at the French legation in Rio de Janeiro, Brazil, where he was secretary to Paul Claudel. On his return to France he became a member of the group of young composers known as "Les Six." He asserted his individuality in a bold dissonant style that is characteristic of his music as a whole, noticeable especially in the early ballets he wrote in collaboration with Jean Cocteau and Claudel, *L'Homme et son désir*, *La Création du monde* and *Le Boeuf sur le toit*, and in the incidental music composed in 1920 for Claudel's *Protée* and the same poet's translations of the Aeschylean tragedies *Agamemnon* (1913), *Choëphores* (1915) and *Les Euménides* (1917–22). Whips and hammers are introduced into the orchestration of this trilogy, a work of remarkable dramatic force, while the chorus is required to groan, whistle and shriek. Other operas include *Le Livre de Christophe Colomb* on a libretto of Claudel (Berlin, 1930) and *David* (Jerusalem, 1954). In 1925 he married his cousin Madeleine Milhaud, who provided the libretto for his opera *Médée* (1939) and, with J. Supervielle, for *Bolivar* (1943).

A prolific composer, Milhaud by the early 1960s had written over 400 works including numerous choral works, light symphonies and 18 string quartets, as well as music for radio and motion pictures. Among works inspired by Jewish subjects are the *Sacred Service* and the *Chants juifs*. The style of his music is largely inspired by his admiration for Berlioz, Bizet and Emmanuel Chabrier. Though it became simplified in later years, its harmonic basis remained predominantly polytonal.

In 1940 Milhaud was appointed professor at Mills College, Oakland, Calif. After 1947 he became professor of composition at the Paris conservatoire.

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**MILINDAPANHA,** a remarkable Buddhist noncanonical work in seven parts written in elegant Pali (the sacred language of the early Buddhists) about the 1st century B.C. in northwestern India or Kashmir by an unknown author (or authors), and since its inception highly esteemed by Buddhists. The title means "Milinda's Questions." Milinda, a Bactrian Greek king, called Menander (*q.v.*) by Greek historians, is represented as questioning Nagasena, an erudite Buddhist monk (possibly not a historical person) on important Buddhist teachings; *e.g.*, the nature of man, whether part of him is reborn, his mental states. After making a deeper study of these teachings, Milinda (in part iv) propounds 82 dilemmas based on seemingly inconsistent statements in them. Nagasena's solutions, still authoritative today, abound in analogies and similes, usually felicitous, sometimes false. Next, Milinda's doubts about the Buddha's existence being dispelled by an elaborate allegory of the City of Truth, there follows an eloquent eulogy of the 13 stricter monastic practices. Finally, the qualities the ideal monk should possess are compared with those of 67 things and animals, 38 now being lost. *Milindapanha* entirely lacks the frequent repetitions of the Pali canonical works. A compilation of great literary charm, it has long been recognized as a masterpiece of Indian literature.

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**MILITARY, NAVAL AND AIR ACADEMIES.** Academies for the training of officers for the armed forces exist in most countries. Their origins date from the establishment in Europe toward the end of the 17th century of permanent national navies and armies with the consequent need to build up a cadre of trained officers for them, though the founding of academies themselves did not begin until the latter half of the 18th century and the beginning of the 19th. Until the 20th century training was in the handling of weapons, drilling and management of men, tactics and strategy, and ceremonial; and, for naval cadets, also in navigation, sailing and naval warfare. In the 20th century separate air force academies were founded in some countries. With the increasing part played by science, technology and organization in modern warfare the content of the academies' courses of instruction was broadened. After World War II the officer cadet received a good deal of instruction in science and also in general subjects. The academic standard of entry became higher and many cadet establishments qualified their students for a college degree or prepared them to proceed to a university. At the same time, cadets were drawn from much wider social strata than hitherto and were usually trained at the state's expense.

## UNITED STATES

**West Point.**—The United States Military academy was established as a part of the corps of engineers with five officers and ten cadets on March 16, 1802, at West Point, N.Y. (*See* also ENGINEERS, MILITARY.) The site, about 50 mi. N. of New York city, was a key Hudson river military fortress during the Revolution.

Several compelling reasons made the formation of a U.S. military academy necessary; first was the Revolutionary War experience, during which the United States had been forced to rely on foreign military technicians; second, military leaders, including George Washington, felt that the mastery of military technology required extended study and could not be acquired by practice alone; and third, some educational reformers felt that the established colleges were not furnishing the type of practical education and scientific skills required for American commercial and industrial development.

Before 1812, the academy was conducted as an apprentice school for military engineers and, in effect, as the first U.S. school of engineering. The act of April 29, 1812, reorganized the academy and increased the authorized strength of the corps of cadets to 250, expanded the staff of the academy, and established a four-year curriculum. This legislative goal was not effective until the superintendency of Col. Sylvanus Thayer, 1817–33, who became known as the "father of the military academy" because of his lasting influence upon the West Point physical plant, the library, the curriculum and the pedagogical method. Under Thayer's leadership the academy produced military technicians whose skills were adaptable to meet the civil engineering needs for the program of internal improvement which accompanied America's westward expansion. The act of congress of July 13, 1866, allowed the selection of a military academy superintendent from branches of the army other than the corps of engineers.

The military academy is under the immediate supervision and control of the department of the army, exercised through the superintendent, in whom is vested the immediate military command of the academy and the military post. The goal of the educational program is to instruct and train the corps of cadets so that each graduate will have the qualities and attributes essential to continued development through a lifetime career as an officer in the regular army. The four-year course of college level education and training leads to a B.S. degree and a commission as second lieutenant in the regular army. The curriculum is balanced between mathematics and engineering sciences (55%) and the humanities and social sciences (45%).

Cadets must be at least 17 years of age but not yet 22, and unmarried. They must have a high school education or its equivalent; they must take scholastic aptitude tests and a medical examination before admission. Enrollment is about 2,500. The great majority of appointments to the academy are made by U.S. senators and representatives. Citizens of the Republic of the Philippines, the various Latin-American republics, Canada and certain other countries, if fully qualified, may also be admitted to the

academy. Admissions information may be obtained from the registrar, United States Military academy, West Point, N.Y.
(S. F.)

**Annapolis.**—The United States Naval academy, an institution of college grade, is located at Annapolis, Md.; its graduates are commissioned in the navy and marine corps. It was established in 1845 by Secretary of the Navy George Bancroft, initially as a five-year course of which three were at sea, but since 1851, with slight modifications, it has had its present structure of a four-year academic course with summer cruises and practical instruction. Under the superintendent are a commandant, who instills military qualities and maintains discipline, and three academic directors who are responsible for instruction.

Midshipmen are selected on the basis of their scores on college entrance examinations and overall evaluation, from among nominees of the U.S. president and vice-president and of members of congress. Additional midshipmen may be appointed each year from the regular navy and marine corps, from the reserve, from sons of service personnel and some from other special sources. Total enrollment is about 4,000. Entrants must be U.S. citizens between the ages of 17 and 22, be secondary school graduates and be of good health and character. They must never have been married.

The course covers mathematics, science and engineering at the level of an engineering college, though without specialization, and English, history, government, economics, one of six foreign languages, meteorology, navigation, naval weapons and operations, hygiene, leadership and physical education. Elective overload courses leading to majors in special fields are available to superior students, and advanced standing is granted for college level work completed prior to entrance. Graduates are awarded the degree of bachelor of science, with a major in special cases. (W. D. B.)

**U.S. Coast Guard Academy.**—Located at New London, Conn., this military institution of higher learning is maintained by the federal government and conducted within the authority of the treasury department. Founded by act of congress in 1876, it embraces a four-year curriculum for the professional and academic training of cadet candidates for commissions in the coast guard.

Prior to World War II, the Coast Guard academy had a cadet corps of between 200 and 300 cadets, but in later years, as the coast guard assumed many new peacetime duties, the academy enrollment averaged between 500 and 600 cadets.

Entrance to the academy is restricted to unmarried U.S. male citizens between the ages of 17 and 22. Appointment is obtained exclusively through nationwide competitive examinations. There are no political nominations. Examinations are held late in February of each year, and application to take the examinations must be made through the coast guard commandant, Washington, D.C.

Coast guard cadets are paid a small allowance for uniforms, equipment, textbooks, food and other expenses incidental to their training. A cadet is required to make a deposit upon entrance to the academy to defray initial clothing and equipment costs. In exceptional circumstances the superintendent of the academy is authorized to waive this requirement in part. A portion of a cadet's allowance is put aside for the purpose of outfitting him at the time of his commissioning.

The new class enters the academy during the summer, usually the first week in July. The "swabs" (fourth classmen) spend their first summer in becoming indoctrinated to military life. They are introduced to small boats, seamanship and military drill and discipline, in addition to attending their first classes, which include mathematics and history.

Instruction during the four-year course includes mathematics, English composition, physics, geography, navigation, seamanship, chemistry, meteorology, ordnance, materials of engineering and strength of materials, thermodynamics, electrical engineering, power engineering, economics and government, naval architecture and ship design, electronics, gunnery, law, communications, administration and leadership. In addition, each cadet makes annual summer training cruises aboard the three-masted sailing bark "Eagle" and escort cutters. Graduates receive the B.S. degree and are commissioned as ensigns in the U.S. coast guard.

The present home of the Coast Guard academy was constructed in 1932 at a cost of more than $2,000,000 and was expanded just prior to World War II at a similar cost. The buildings are of red brick in the Georgian colonial style, and centre around the administration building, Hamilton hall, named after Alexander Hamilton, the first secretary of the treasury, who founded the coast guard in 1790. The academy occupies a 65-ac. tract of land on the west bank of the Thames river.

**U.S. Merchant Marine Academy.**—The U.S. merchant marine corps was established in 1938 and the academy at Kings Point, N.Y., about 20 mi. E. of New York city, was dedicated Sept. 30, 1943. Similar in many respects to the other federal academies, it prepares cadets to serve as officers in the merchant marine.

Graduates are licensed as either deck or engineer officers and receive the degree of bachelor of science. They are also eligible to apply for commissions as ensign in the U.S. naval reserve. A candidate for admission to the academy must be an unmarried U.S. male citizen, must be 17 but not yet 22 years of age on July 1 of the year in which he seeks admission, be nominated by his congressman, take a competitive examination and meet rigid physical requirements.

After the first year at Kings Point, cadets spend a full year at sea before returning to the academy for their second- and first-class years. The curriculum includes courses in nautical science, engineering, mathematics and science, ship management, history and languages, naval science and ship's medicine.

**Air Force Academy.**—Authorized by U.S. congress in 1954, the Air Force academy accepted its first class of 306 cadets on July 11, 1955, at an interim site at Lowry air force base, Denver, Colo. Its permanent site, occupied in Sept. 1958, is 8 mi. N. of Colorado Springs. Enrollment is about 2,500.

The academy's mission is to train and motivate its graduates for lifetime careers as air force officers. Its four-year academic curriculum, a combination of liberal arts and science courses, leads to a baccalaureate degree. Simultaneously, cadets receive a four-year airmanship course leading to a commission as second lieutenant in the air force and the aeronautical rating of navigator. The airmanship program, conducted throughout the year, includes military, physical and flying training. An extensive intercollegiate athletic program is conducted separately. Physically qualified graduates may proceed through a full-scale course in pilot or navigator training.

Cadets receive a small salary, out of which they must purchase uniforms, books and personal needs. Food, quarters, medical and dental care and recreation facilities are furnished by the government. Cadets must be at least 17 and less than 22 years old on July 1 of the year they enter. They must never have been married, must be U.S. citizens of good moral character and must be physically qualified for pilot training. Congressional nominees fill 85% of the vacancies of each class. For further information write the registrar, United States Air Force academy, Colorado.

## GREAT BRITAIN

**Dartmouth.**—British naval officer cadets begin their training at the Royal Naval college, Dartmouth, Devon (H.M.S. "Dartmouth"). From 1863 until 1905 they were trained for 16 months to two years in H.M.S. "Britannia" berthed in the river Dart. In 1905, when the Royal Naval Britannia college was opened, the scheme devised by the first lord of the admiralty, the earl of Selborne, introducing a common entry for all officers of the executive and engineering branches and of the Royal Marines, was put into practice. Cadets spent their first two years at Osborne, Isle of Wight, where a Royal Naval college had been opened in 1903, and the last two at Dartmouth, after which they went to sea as midshipmen. Following the introduction of the special entry scheme in 1911, Dartmouth mainly provided officers for the Royal Marines. From 1921, when Osborne was closed down and Dartmouth enlarged, all cadets (about 550) were trained at Dartmouth until 1942, when the college was bombed. They

then moved to Eaton hall, Chester, returning to Dartmouth in 1946. The naming of the royal yacht H.M. Yacht "Britannia," in 1953, caused the name of the college to be changed to H.M.S. "Dartmouth."

The age limits for entry are about 17–19, academic qualifications required being of university entrance standard. Young officers spend one year in the college (including a cruise in the training squadron) as cadets before joining the fleet for a year as midshipmen. Seamen and supply officers then return to Dartmouth for a further year of academic study; then take specialist courses; and spend another year at sea. Engineer officers study for a London university degree at the Royal Naval Engineering college, Manadon, Plymouth, Devon; or go to Cambridge university.

**Sandhurst.**—Most of the potential regular officers for the British army undergo a course of general and military education as officer cadets at the Royal Military academy, Sandhurst, near Camberley, Surrey. This is heir to the functions performed up to 1939 by both the Royal Military academy at Woolwich (*q.v.*), London, and the Royal Military college at Sandhurst. The latter was established by royal warrant in 1802 at Great Marlow, largely as a result of the efforts of Col. J. G. Le Marchant and Gen. Francis Jarry, an exiled French officer, who had organized a training school for officers at High Wycombe three years earlier. The move to Sandhurst took place in 1812 when the "Old Building" there was completed. The college at first included a senior department for the training of staff officers, but in 1858 this was made entirely separate and in 1862 was transferred to the present staff college building on the same grounds. In 1911 a new building was added to accommodate the increasing numbers of cadets. After World War I (during which it was for a time reduced to four months) the length of the course was fixed at 18 months and officers were trained for commissions in all branches of the British and Indian armies except the artillery, engineers and signals which were separately provided for at Woolwich.

In order to educate and train all regular army officers on a common basis it was planned to amalgamate the Royal Military academy and the Royal Military college at Sandhurst in 1940. World War II intervened and Sandhurst became the location of an O.C.T.U. (Officer Cadet Training Unit) until the present academy came into being in 1947.

Most cadets enter the academy at 18½–19½ years after passing the competitive army entrance examination and doing a short period of army training in the ranks. Other cadets come from Welbeck college, Worksop, Nottinghamshire, established by the war office in 1953 for boys of about 16½ who intend to obtain commissions in technical arms. In the early 1960s about one-tenth of the cadets were from commonwealth overseas territories.

The academy has a major general as commandant and is organized into three colleges, each of four companies, with training and administrative staff. There are also more than 70 civilian lecturers in the four departments of mathematics, science, modern subjects and languages; headed by a director of studies responsible to the commandant. Some cadets are prepared for the mechanical sciences tripos at Cambridge university or the degree course at the Royal Military college of science, Shrivenham, Berkshire; others for the army interpretership examination. Studies include the problems of government, especially within the Commonwealth. The military courses include history, organization and administration, military law, tactics, drill, signals and weapon training. In addition to the usual games and societies, mountaineering, exploration and ocean sailing are officially sponsored.

At the end of the course (comprising six terms of 12–13 weeks each) commissions are allotted in the arms of the service according to existing vacancies. First choice of regiment is usually given to those high up in the order of merit, which is determined by a formula combining educational achievement with an assessment of personal qualities. Each term the Queen's medal is awarded to the first cadet in this order and the Sword of Honour to the cadet considered by the commandant to be the best of the term.

Cadets of Sandhurst receive the pay of their rank during their previous service in the army. The course in military subjects is common to candidates for commissions in all arms; appropriate specialist training is provided for each officer immediately after commissioning. The strength of the academy in the 1960s was nearly 1,000 cadets.

**Cranwell.**—The Royal Air Force college at Cranwell, Lincolnshire, was founded in 1920 by Lord Trenchard (*q.v.*), the chief of the air staff in the years after World War I, who had recognized the need for a counterpart to the colleges of the other services in his plan for the building of the new air arm. The function of the college is to train long-service officers (pilots and navigators) for the Royal Air force. Cadets also come from commonwealth and non-commonwealth countries to be trained for their own air forces.

By the start of World War II more than 1,000 officers had passed through Cranwell.

The college accepts two classes of flight cadets a year, each numbering about 65. Cadets enter usually between the ages of 18 and 20. During the three-year course they learn to fly, first the basic trainer and then an advanced jet trainer, carry out university type academic studies, and develop their potential as officers. A small number of officers are trained for certain ground branches.

Cadets wishing to enter the technical branch of the Royal Air force train at the Royal Air Force Technical college, Henlow, or by means of university cadetships.

## OTHER COUNTRIES

**Canada.**—The Royal Military College of Canada, founded in 1875 at Kingston, Ont., as a military academy and reconstituted in 1948 to provide training for navy and air force as well as army cadets, is administered by the department of national defense. Constituent colleges are Royal Roads, established in 1942 near Esquimalt, B.C., and the Collège Militaire Royal de Saint Jean, dating from 1952, at St. Jean, Que.

**Australia.**—The Royal Military college, commonly known as Duntroon, was founded at Canberra in 1911 to train Australian and New Zealand cadets. Among other military training facilities are the Jungle Training centre, at Canungra, Queensland, and a number of arms and services schools.

**France.**—In 1802 Napoleon founded at Fontainebleau the École Spéciale Militaire (E.S.M.). In 1808 it was transferred to St. Cyr, near Versailles. From its foundation up to 1957 about 51,000 officers graduated from St. Cyr and 11,000 of them were killed in action. After the liberation the E.S.M. was reformed, reorganized and installed, May 23, 1947, at the military training camp of Coëtquidan in Brittany, with the word *interarmes* added to its official name. The new E.S.M.I.A. also absorbed other schools where officers had been trained for the infantry, cavalry, artillery and engineers.

From 1947 the pupils of the E.S.M.I.A. have been divided into three battalions: the 1st and 3rd are known as the St. Cyr division and the 2nd as the *corps de troupe* division. Those of St. Cyr are composed of pupils who had obtained their *baccalauréat* at one of the secondary schools and are 18 to 23 years old; the term of study is two years. Having graduated from the E.S.M.I.A. as second lieutenants they serve a third year in a specialized school of the arm of service they have chosen. Those of the *corps de troupe* are noncommissioned officers coming from the ranks. After a term at a special preparatory school they take an entrance examination and, on passing, study at the E.S.M.I.A. for one year, graduating as second lieutenants.

The École Navale of Brest trains officers for the navy. The candidates must be from 16 to 21 years old, have their *baccalauréat* and be single. They must pass an entrance examination. The course lasts two years, at the end of which those who do not satisfy the examiners may be allowed to stay another year, but no longer.

The École de l'Air was opened at Versailles, Nov. 4, 1935, and in 1937 was transferred to Salon-de-Provence. The course lasts from 1½ to 3 years according to specialization.

**Spain.**—The Academia General Militar was founded in 1882 at the Alcázar of Toledo. Dissolved in 1893, it was restored in 1927. Again dissolved in 1931 it was restored for the second time in 1940. As the Alcázar of Toledo had been destroyed during the civil war, the academy was moved to Saragossa, where it is housed in modern buildings specially erected for this purpose.

Training of the *caballeros cadetes* for all branches of the army and for the Guardia Civil lasts two years and the number of pupils admitted each year is limited to about 300. The entrance is by competitive examination for candidates between the ages of 16 and 21, but the upper age limit is extended for those with previous service. The cadets pay monthly about 518 pesetas for their upkeep, but there are exceptions and reductions for various cases. After two years at the Saragossa academy the cadets, with the rank of *alférez* (second lieutenant), spend a year in a specialized school of the arm they have chosen. Only then are they commissioned with the rank of *teniente* (lieutenant).

In the Escuela Naval Militar at Marin (Pontevedra) the yearly enrollment is limited to 60 and the training lasts five years. At the Academia General del Aire at San Javier (Murcia) yearly enrollment is about 100 and training generally lasts four years.

**Italy.**—Admission to the Accademia Militare at Modena is competitive, with 600 pupils accepted yearly. The academy is open to pupils from military schools, from secondary schools of general education, and also to serving noncommissioned ranks. Candidates must be age 17 and not over 22 (27 for noncommissioned ranks of the carabinieri). A successful candidate has a two-year course of study at the end of which, as *sotto-tenente*, he is appointed to one of the various branches of the army. There follows a further two years of study at specialized military schools.

The naval academy is at Livorno (Leghorn). The course extends over four years with about 100 new students accepted every year. The air academy is temporarily situated on the Island of Nisida and the flying training is given at Pomigliano d'Arco, near Naples. The course extends over four years, with a yearly enrollment of 70.

**Federal Republic of Germany.**—Special schools for training of officers were organized after 1952. There is a Heeresoffizierschule at Hanover. Every candidate starts by spending from six months to one year in the army as an ordinary recruit. He must also have passed a successful *Maturitätsprüfung* (certificate of examination from a secondary school). As a sergeant he passes a special examination and, if accepted, joins the officers' school as a *Fähnenjunker* (an honorary title, not rank). After a successful year at the school, he goes back to his regiment as a *Fähnrich* (ensign) for a short period and afterward to specialized arm schools for nine months. When back at his regiment he passes another test and only when his commander is satisfied with his intelligence, personality and qualities of leadership does he recommend him to be commissioned as *Leutnant*. The training period takes on the average three years. The same system existed in the old German army.

For training of the officers of the navy there is the Marineschule at Mürwik, near Flensburg. For the air force there is the Offizierschule der Luftwaffe at Neuhieberg, near Munich. The general system of training is similar to that of the army.

**Netherlands.**—The Koninklijke Militaire Academie was founded at Breda in 1828. It has a three-year course for cadets between the ages 18 to 21. It trains officers for all arms of the land army including the *marechaussee* (military police). Since World War II it also trains air force officers. The Koninklijk Institut voor de Marine was founded in 1554 at Willemsoord, near Den Helder. For four previous years it was at Breda. From 1803 to 1550 navy officers were trained on board a special ship. The course, entrance methods and age of cadets are the same as for the army. All cadets pay a nominal fee yearly on a sliding scale of relief.

**Belgium.**—The Brussels École Royale Militaire trains officers for army, navy, air force and the *gendarmerie nationale*. The candidates must be at least 17; under certain conditions they are accepted up to 25. The academy is divided into two divisions: at the Polytechnique the course lasts five years; at the Toutes Armes, three years. Cadets are commissioned after two years and stay on as officers.

**U.S.S.R.**—Although the first military academy was founded in Russia in 1698 by Peter I, in the modern sense of the word the first naval academy was founded in 1827 and the first military academy in 1855. The first cadets' corps (*Kadetski Korpus*) or officers' training school was created in 1732. In 1863 the cadets' corps were reorganized as military gymnasiums, but in 1882 their curriculums were revised and they recovered the former name. On the eve of World War I, Russia had about 30 cadets' corps with a total of about 6,000 pupils. Instruction lasted seven years. The graduates were entitled to enter one of the existing military academies.

In 1918, soon after the Communist Revolution, the first Soviet military academy was founded in Moscow. In 1924 its director was Mikhail Vasilievich Frunze (1885–1925), one of the brilliant Red army commanders. After his death the academy was named after him. There are also naval, air, engineering and military political academies. Admission is limited to officers who have not only graduated from specialized military schools but also have had a period of service in the armed forces. There is an entrance examination and only candidates with very high marks are accepted.

There are about 30 junior military schools named after Gen. Aleksandr Vasilievich Suvorov (*q.v.*); the first were opened in 1943. There are also two junior naval schools, in Leningrad and Baku, created in 1944 and named after Adm. Pavel Stepanovich Nakhimov (1802–1855).

In both military and naval schools entry is reserved for sons of men who served in the Soviet armed forces. The candidates must have studied for at least four years in a secondary school. There is an entrance examination. The instruction is entirely at the expense of the state.

*See* also OFFICERS, MILITARY; TRAINING, MILITARY. (X.)

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**MILITARY AFFAIRS (ARTICLES ON).** The survey article WAR discusses the history of warfare in the context of political and social history and international law; it also relates major changes in military theory and practice to industrial and technological developments.

ARMY summarizes methods of organizing, equipping, training and deploying military forces, from the ancient Sumerians to the contingencies created by the 20th-century scientific revolution. Parallel histories are given from specialized points of view in LOGISTICS; STRATEGY; and TACTICS.

The various types of military operation dealt with in individual articles include AIR WARFARE; DESERT WARFARE; ECONOMIC WARFARE; GUERRILLA WARFARE; JUNGLE WARFARE; MOUNTAIN WARFARE; PSYCHOLOGICAL WARFARE; and TRENCH WARFARE. Nuclear weapons, discussed in AIR WARFARE and in articles listed in AERONAUTICS (ARTICLES ON), are treated also in ATOMIC ENERGY and ROCKETS AND GUIDED MISSILES. Other aspects of war are discussed in BIOLOGICAL WARFARE and CHEMICAL WARFARE.

Among articles dealing with special branches of the armed services and activities connected with them are ARMOURED FORCES; ARTILLERY; BRIDGING, MILITARY; CAMOUFLAGE; CAVALRY; COAST DEFENSE; ENGINEERS, MILITARY; INFANTRY; INTELLIGENCE, MILITARY AND POLITICAL; MEDICAL SERVICES, MILITARY; MILITARY GOVERNMENT; MILITARY POLICE; ORDNANCE CORPS; PROCUREMENT, MILITARY; QUARTERMASTER; SANITATION, MILITARY; SIGNAL COMMUNICATION; SIGNAL CORPS; TRANSPORT, MILITARY; and WOMEN'S SERVICES, MILITARY.

Methods employed in the training of professional military officers are discussed in MILITARY, NAVAL AND AIR ACADEMIES; OFFICERS, MILITARY; and WAR COLLEGES. TRAINING, MILITARY, deals with the training of enlisted men and reserve officers. The economic and industrial aspects of military mobilization are described in MOBILIZATION, ECONOMIC; and MOBILIZATION, INDUSTRIAL.

The organization of nonprofessional armies is discussed in CONSCRIPTION; MILITIA; TERRITORIAL ARMY; VOLUNTEERS; and YEOMANRY. Articles on military installations include BARRACKS; CAMP; FORTIFICATION; and PROVING GROUND. Related topics are dealt with in such articles as COLOURS, MILITARY; INSIGNIA, MILITARY; SALUTE; and UNIFORMS.

The systems used for coordination of army commands in various eras and countries are surveyed in STAFF, MILITARY. Similarly, the earlier and present methods for assignment of responsibility and authority to individual military leaders are described in OFFICERS, MILITARY. Articles are devoted to the duties of commissioned and noncommissioned officers—*e.g.*, GENERAL; MAJOR; LIEUTENANT; SERGEANT. The organization of military units is discussed in BATTALION; COMPANY, MILITARY; DIVISION, MILITARY; SQUADRON.

Articles on military equipment include AMMUNITION; ARTILLERY; ARMOUR, TANK AND AIRCRAFT; ARMOURED CAR; ARTILLERY; BAZOOKA; FLAME THROWER; GRENADES; MACHINE GUN; MINE LAND; PISTOL AND REVOLVER; PROPELLANTS; RANGE FINDERS; ROCKETS AND GUIDED MISSILES; SIGHTS, GUN; SMALL ARMS, MILITARY; TANK; etc.

The great wars of history, from ancient to contemporary times, are treated in separate articles—for example, GRECO-PERSIAN WARS; PELOPONNESIAN WAR; PUNIC WARS; THIRTY YEARS' WAR; AMERICAN REVOLUTION; FRENCH REVOLUTIONARY WARS; NAPOLEONIC WARS; CRIMEAN WAR; AMERICAN CIVIL WAR; FRANCO-GERMAN WAR; RUSSO-JAPANESE WAR; WORLD WAR I; WORLD WAR II; KOREAN WAR. Individual articles are devoted also to battles and campaigns of major importance—*e.g.*, MARATHON, BATTLE OF; CANNAE; HASTINGS: *The Battle of Hastings (1066)*; GETTYSBURG: *Battle of Gettysburg*; MARSTON MOOR, BATTLE OF; SAINT MIHIEL: *Battle of St. Mihiel, 1918*. Additional information on the history and organization of armies and the conduct of wars as seen in the historical perspective of individual nations is provided in such articles as FRANCE; GERMANY; GREAT BRITAIN AND NORTHERN IRELAND, UNITED KINGDOM OF; UNITED STATES (OF AMERICA); RUSSIAN HISTORY; etc. Reference to the Index will show the material on any topic available in specific sections of articles, in addition to complete articles.

Military antiquities are treated in such articles as ARMOUR, BODY; CASTLE; CROSSBOW; ENGINES OF WAR; GUARDS AND HOUSEHOLD TROOPS; HELMET; LANCE; SWORD; WEAPONS, PRIMITIVE; etc. Biographical articles summarize the careers of outstanding military leaders, from Alexander III the Great to the leading strategists and tacticians of the Korean war.

Articles on related topics are cited in AERONAUTICS (ARTICLES ON); INTERNATIONAL RELATIONS (ARTICLES ON); and NAVAL AFFAIRS (ARTICLES ON).

**MILITARY GOVERNMENT.** This term may be defined as the administration of occupied territory by an occupying power, including the exercise of executive, legislative and judicial authority. In international law, territory is considered occupied when it is actually placed under the authority of hostile armed forces. The necessity for military government arises from the failure or inability of the legitimate government to exercise its functions. It is immaterial whether the government over an enemy's territory consists of a military or civil or mixed administration; its character and the source of its authority are the same. It is a government imposed by force, and the legality of its acts is determined by the international law of belligerent occupation.

Since it is in connection with belligerent occupation that the general concept of military government was evolved, the definition does not cover cases in which military forces have been stationed in neutral or friendly territory. As a result, the United States and Great Britain make use of the term civil affairs to describe relations between military forces located in a friendly country or area and the civil authorities and people of that country or area. These relations usually involve exercise by the military forces of certain authority normally the responsibility of the local government. In this connotation, military government is but one aspect or degree of civil affairs, although the terms have been used interchangeably.

Military government must be distinguished from military law and martial law. Military law is the code which regulates the conduct of members of the armed forces, but does not apply to civilians. Martial law is the temporary government of the civil population through the military forces without the authority of written law, as necessity may require. It is invoked only in domestic territory, the local government and inhabitants of which are not treated or recognized as belligerents, and is governed solely by domestic law. (*See* MILITARY LAW; MARTIAL LAW.)

Up to the 19th century, a conqueror usually considered himself the absolute owner of occupied lands and substituted his own military convenience for all previously existing rules. The Greeks and Romans did, however, recognize some limitations on the power of the occupying military commander, generally showing respect for local law, customs, traditions and religious uses when not inimical to the mission of their forces. Despite these earlier advances, however, practices in occupied areas reverted to barbaric conduct even after the appearance of Hugo Grotius' *De jure belli ac pacis* in 1625. Grotius urged the adoption of humanitarian principles during military occupation. Later writers took up this theme and by the 19th century limiting principles gradually found recognition in the instructions which nations issued for use of their own armies as a matter of domestic law.

Early indications of the more enlightened practices were the instructions issued to both troops and the civilian population by Gen. Winfield Scott in Mexico in 1847. A significant landmark was the famous document, *Instructions for the Government of the Armies of the United States in the Field*, prepared by Francis Lieber (q.v.) and issued by the war department in 1863. Known as the Lieber code, this was a set of instructions issued to Union forces in the American Civil War to guide their conduct in Confederate territory. But the Lieber code made no provision for any organization specifically designed to administer occupied areas. Military government was conducted in some areas by political appointees and in others by military commanders. Nevertheless, the Lieber code had a widespread effect. It was published without change during the Spanish-American War of 1898, and reportedly many of its provisions were used by Germany during the war with France in 1870. Meanwhile the British had gained considerable experience with military government problems in France after the Napoleonic Wars, in India, Egypt, South Africa and other areas throughout the world.

Following the Franco-German War, several international conventions obligated their parties to observe certain minimum standards in territory under belligerent occupation. Art. 42–56 of the Hague convention of 1907 gained almost universal recognition, and with the Geneva conventions of 1929 and 1949, furnish the modern legal basis for the protection of individual and property rights during military occupation. (*See* also LAWS OF WAR.)

Experience in World War I illustrated only sketchily the principles and techniques which had evolved in the earlier patterns of military government. The Rhineland was untouched by the war; German administrative services were still functioning and continued to operate under orders from the central government. Military government consisted mostly of supervision of local authorities by officers placed in charge of civil affairs at each major headquarters and in each German kreis (the equivalent, roughly, of a British or U.S. county). Its organization was improvised and inadequately prepared for the problems to be faced.

Organizations for civil affairs and military government, planned in advance of tactical operations, were not developed until World War II. Intensive training programs for both U.S. and British military personnel were carried out during the war and it became standard procedure to formulate plans for civil affairs and military government in coordination with tactical plans.

With the invasion of Italy, both U.S. and British military government personnel were included in the first assault forces, and so effective was their work that they won highest praise from tactical commanders in the field. Effective control over the civilian populations and authorities assured the tactical commanders of stabilized conditions in their areas of responsibility.

In addition to the inclusion of civil affairs detachments in all

major tactical units, the importance of having civil affairs officers on the staffs of the tactical commanders become so evident that, when the supreme headquarters, Allied expeditionary forces, was organized for the invasion of northwest Europe, civil affairs was made a section of the general staff and was designated the $G_5$ division. Other theatres of operations followed suit, and headquarters at theatre, army group, army and corps were organized with $G_5$ sections on the general staff.

The advances of Allied armies in all theatres of war during 1944 resulted in great expansion of measures for controlling civilian populations in the battle areas. Civil affairs detachments operated in all countries of Europe as they were released from the grip of Hitler's armies. Carefully planned military governments were set up in captured areas of Germany and Austria. Long-range plans for the control from Berlin of all of Germany had been under discussion since 1943. In Germany, the entire government had to be rebuilt, and the task of feeding, clothing, housing, transporting and furnishing medical care to 6,500,000 displaced persons had to be handled in the process.

Across the world, other civil affairs and military government units accompanied both army and naval forces into recaptured areas in the Pacific ocean areas and into the Philippines, Japan and Korea. Unlike the situation in Germany, the supreme commander for the Allied powers in the Pacific was able to make use of an existing government in Japan, thus making the job primarily one of supervision to see that allied orders were carried out.

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**MILITARY LAW** is that system of law by which the military establishment of a state or nation is governed in whole or in part. Every well-developed state has found it necessary to prescribe special rules for governing the conduct of its military establishment, and the most important are those which provide a special and distinct penal system within the military structure, different in many respects from that which is applicable to the general populace.

Military law finds its source, to a great extent, in the enactments of the same legislative bodies which provide laws for the entire citizenry, such as the congress of the United States and the parliament in Great Britain. In addition there are certain rules of conduct which find their authority in custom, as does the common law in both Britain and the U.S. A further source of military law is international law, both customary and conventional.

Distinct military penal systems have existed from early times. The first known treatise on military law appeared in the 2nd century A.D., and portions of it were included by the Roman emperor Justinian in his *Digest.* Modern military law is often said to have originated in the code of articles of Gustavus Adolphus of Sweden (1621), although articles of war were promulgated in England by Richard II as long ago as 1385. Codes of military law, both in Britain and in the U.S., have traditionally been known as the Articles of War, a term used in the U.S. until 1951 and in Britain until 1957.

Should a soldier commit an offense which is of a nonmilitary nature, he may be tried by a civil court, since the soldier remains a citizen with all attendant rights and duties, although he has other special duties and is subject to criminal sanctions provided by military law. It is generally true, however, that the military authorities may assert a superior claim and hold the military man for trial by a military court. In the United States, for example, a person in the military service may be delivered to the civil authorities for trial if the military authorities so choose, and rarely will the military authorities attempt to interfere if an accused person is first apprehended and charged with an offense by civil authorities.

The Uniform Code of Military Justice, governing all of the armed forces of the United States, was enacted by the congress in pursuance of the provision of the U.S. constitution which empowers the national legislative body to make rules for the government and regulation of the land and naval forces. The system by which military justice is administered in the United States is not a part of the federal judicial system, and it is not controlled by constitutional provisions applicable to ordinary criminal proceedings. Congress, however, provided by express enactment practically all of the procedural guarantees which the ordinary criminal defendant enjoys, and in some cases the defendant in the military system enjoys other and greater guarantees. An example is found in the fact that throughout the appellate process counsel is furnished the accused, without cost even though he possess ample funds.

**Persons Punishable Under the Military Code.**—The military codes of most countries specifically designate those who may be punished for violation of military law. Generally, such codes apply to members of the armed forces and prisoners of war. In some countries offenses of a military nature, such as treason, are tried by military courts even though the accused are civilians. The United States supreme court in 1960 held that civilians cannot be tried by court-martial except in time of war, even tnough accompanying the armed services outside the United States.

There are instances in which the military authorities exercise jurisdiction over all persons in a particular area, but in these instances it is not, strictly speaking, military law which governs. In time of great danger martial law governs all inhabitants within a particular area in which it has been declared, and military government is administered by the occupying military forces in a locality in which the operation of civilian courts has been at least partially suspended because of hostilities.

**Military Offenses.**—Anglo-American law denounces many offenses which are purely military in the sense that they are incident only to military service. The same is generally true in countries which have modeled their law upon the French civil system. For convenience, such prohibited acts usually are styled military offenses. The Uniform Code of Military Justice of the United States lists more than 20 offenses which are of a strictly military nature. These are offenses which have no counterparts in civilian jurisprudence.

Among the offenses so listed are fraudulent entry into the service, unauthorized absence from duty, desertion from the service, failure to obey orders or regulations, misbehaviour before the enemy, disorders and neglects to the prejudice of good order and discipline and, in the case of an officer, conduct unbecoming an officer and a gentleman. The ordinary criminal courts are without authority to try persons for such offenses; trial must be by a military court. As a matter of form, the Uniform Code of Military Justice also enumerates other offenses which may be tried by a military court, such as murder, robbery, assault, etc. One cannot be tried by a military court of the United States except for an offense prescribed by the code.

The situation is generally different in other countries. The military codes of France and Britain, for example, enumerate only the purely military offenses. Although the military court may try a person for a crime other than a military offense, the accused is charged with a violation of the appropriate criminal law of the state. For example, a British or a French soldier who is charged with murder may be tried by a military court if he is serving with the armed forces in the field, but he is charged with a violation of the criminal statute applicable to the entire populace. Unless serving with the military forces outside the borders of his country, the British or French soldier ordinarily will be tried by a civilian court for a civilian-type offense.

**Military Trial.**—The court by which military justice is administered is known as the court-martial. In the United States there are three types of courts-martial. The general court-martial is composed of at least five members, and in addition there is a law officer who is analogous to a judge; it may adjudge any punishment authorized by military law. The special court-martial is composed of three or more members, and may adjudge punishment which includes punitive discharge (under certain conditions), confinement of not more than six months and a forfeiture of two-thirds pay for not more than six months. Members of general and special courts-martial are usually officers, but, if an accused enlisted man,

requests inclusion of enlisted men, at least one-third of the court must be so composed. The summary court, which consists of one officer, is not permitted to try officers or certain other specified classes of individuals, and it may not pass a sentence of confinement at hard labour of more than a month, or restriction to a specified area of more than two months or forfeiture of two-thirds pay for more than one month. The court-martial is convened by the commander of a military unit or installation, and in the case of a general court-martial authority to convene the court is limited to commanders of major units designated by congress, or of other units or installations specifically authorized.

British military law provides for a general court-martial consisting of not less than five officers which may adjudge any punishment authorized by law; a district court-martial, which shall consist of not less than three officers and which may not try officers or adjudge a sentence which includes confinement of more than two years; and a field general court-martial, which may be convened outside the United Kingdom when it is impracticable to try an accused by the ordinary general court-martial. The field general court-martial is ordinarily composed of not less than three officers, and may adjudge any sentence authorized by law, including death; such a court, however, may be convened with only two members, in which case imprisonment in excess of two years may not be adjudged.

The French military code provides for only one type of court-martial, which within France proper is a somewhat permanent structure rather than one in which the personnel is frequently changed, as is the case under the military law of the United States. The French court-martial consists of seven members; six are military officers, and the presiding member of the court is a civilian judge of the locality in which the court is convened. During active military operations, however, the French court-martial convened in the field is composed entirely of military officers.

**Punishment.**—The kinds of punishment authorized by military law generally include those authorized by civilian penal codes; *i.e.*, death, imprisonment and monetary fine. In addition, however, punishment peculiar to the military service is authorized, such as restriction to a specified area for a prescribed period of time, total or partial forfeiture of a convicted person's pay and punitive separation from the service. The latter is known by various terms. In the United States, an officer may be sentenced to be dismissed from the service, and an enlisted man may be sentenced to either a dishonourable discharge or a bad conduct discharge, the latter supposedly having less stigma attached to it. Cruel and unusual forms of punishment are specifically prohibited by the Uniform Code of Military Justice. Other permissible punishments include loss of rank, admonition and reprimand. Reduction in rank usually results upon conviction of an enlisted person of a serious offense, and in time of war an officer may be reduced to enlisted rank.

British military law generally provides the same forms of punishment as those prescribed by the Uniform Code of Military Justice, but a notable addition, in the case of an officer, is that of cashiering. This is a more ignominious form of punishment than dismissal from the service, and normally an officer who has been cashiered cannot thereafter hold an appointment under the crown.

**Disciplinary Powers of Commanders.**—Almost all military codes of the world provide that a commanding officer may administer punishment to a limited extent which usually is specific in its limitation, without resort to trial by court-martial.

A commanding officer of the United States forces was given increased authority to impose nonjudicial punishment by 1962 legislation. An officer now may be restricted to a specified area for 30 days and forfeit half his pay for two months if the punishment is imposed by a commander authorized to convene general courts-martial. Other offenders may be restricted to a specified area, reduced in grade, forfeit part of their pay; those in the lower grades may be placed in correctional custody, which does not have the stigma of penal confinement. A company officer may impose a forfeiture of pay and correctional custody for seven days. A commander of higher rank may impose a forfeiture of half the offender's pay for two months and correctional custody for 30 days.

The military law of Britain authorizes a commanding officer to impose upon a soldier, but not upon an officer or warrant officer, such nonjudicial punishment as detention not exceeding 28 days, forfeiture of pay for a period not exceeding 28 days or, in the case of drunkenness, a fine of not exceeding £2. French military law authorizes a commanding officer to impose confinement not exceeding 60 days without trial by court-martial, but the extent of confinement which may be imposed depends upon the command of the officer imposing the punishment, 60 days being the maximum.

In the Soviet military forces, the extent of nonjudicial punishment which may be imposed upon a soldier is dependent upon the grade of the offender. The Disciplinary code of the Soviet army, issued in 1940, provided that in the case of privates a disciplinary penalty might include ordinary confinement not to exceed 20 days, strict confinement not to exceed 10 days, restriction to quarters of up to six weeks, extra detail or reprimand. In the case of a non-commissioned officer, the maximum periods of confinement were reduced, but demotion and partial loss of pay added. Disciplinary punishment could be imposed upon Soviet officers, including generals.

**Procedure.**—The determination of whether an accused shall be tried by court-martial rests with a commanding officer, usually the commander of an organization in which the accused is serving, or the commander of a higher military unit.

The military codes of the United States, Great Britain, France and most other countries provide that there shall be a thorough and impartial investigation before an accused can be brought to trial by court-martial. This investigation, under the law of the United States, is somewhat analogous to a proceeding before a grand jury, although the accused is given more rights than in a grand-jury proceeding. If the investigation reveals that there is sufficient evidence of guilt and that trial is indicated, the case is referred to an appropriate court-martial.

In the actual conduct of a trial by court-martial, the rules of procedure and evidence are similar to those of civilian criminal trials. The court hears the evidence, and determines innocence or guilt; it also adjudges the sentence, a function which in many civilian jurisdictions is performed by the judge.

The Uniform Code of Military Justice provides that following a conviction the sentence must be approved by a reviewing authority, who is either the commander who convened the court or some other commander authorized to convene a court-martial of the type by which the accused was convicted. The reviewing authority may disapprove findings of guilt in whole or in part, and may reduce the sentence, but cannot increase it; a finding of not guilty is binding upon him and cannot be disturbed. One who has been convicted and whose sentence includes a punitive discharge which is not suspended, or a year or more of confinement, enjoys an automatic appeal to a tribunal in Washington, D.C. (or in an overseas theatre, headquarters), composed of qualified lawyers; this tribunal is known as a board of review, and must include at least three members. If the conviction is affirmed by the board of review, the accused may seek a further review by petition to the court of military appeals, which consists of three civilian judges.

In Great Britain, under an act of 1951, a person convicted by court-martial might appeal to the courts-martial appeal court, a judicial body composed of civilian jurists and headed by the lord chief justice. In exceptional cases, a further appeal could be taken to the house of lords.

Canadian military law provided for an appeal to the court-martial appeal board, a civilian body established by legislation of 1950. The French military code permits an appeal to the highest court in the land on a question of interpretation of law and in time of war, an appeal may be made to an intermediate appellate military court. The U.S.S.R. likewise permits, in exceptional cases, an appeal from a conviction of a military offense to the highest court in the land.

**Later Legislation.**—With the enactment of the Uniform Code of Military Justice, which became effective in May 1951, the United States brought into effect a code uniformly applicable to all of the armed services, replacing the Articles of War which had

previously governed the army and the air force, the Articles for the Government of the Navy and the Articles for the Discipline of the Coast Guard. In Canada a uniform code of justice applicable to all of the armed services was enacted as a portion of the National Defense act of 1950. In most other self-governing countries of the commonwealth, military law follows the general principles of procedure laid down for United Kingdom forces, although varying considerably in detail.

British military law applicable to the army and the air force was governed by the Army and Air Force (Annual) act until 1955, when a constitutional change dispensed with the need of an annual act. This amended Army act, according to its terms, was enacted to consolidate the Army Discipline and Regulation act, 1879, and the subsequent amendments thereto and also the Army and Air Force (Annual) act. It became effective Jan. 1, 1957. The French military code was enacted in 1928 but a number of amendments were added, particularly after the close of World War II.

Soviet military law is found in the penal codes of the republics which constitute the Soviet Union, but the Disciplinary code of the Soviet army, promulgated in 1940, provided uniformity with respect to a portion of the Soviet military law. *See* also COURT-MARTIAL.

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(J. K. G.)

**MILITARY MUSIC.** From ancient times musical instruments were used in war as an incentive to courage, to excite the troops in action and to dismay the enemy, as well as to convey orders and information to troops in battle. Woodwind and brass instruments, stringed instruments and percussion appear in ancient pictorial representations of warriors and battle scenes.

Many ancient military wind instruments, such as the Egyptian trumpet, the Hebrew shofar and the early medieval European short horn, the oliphant, were capable of producing only a few notes and their use was restricted to sounding military calls.

In Europe during the middle ages military music, modeled on contemporary Moorish practice, was provided by such essentially outdoor instruments as the shawm, trumpet, bagpipe and nakers (small kettledrums). During the Renaissance the shawm was developed in several sizes, from treble to double bass, and shawm bands, sometimes also including trombones, became the mainstay of 16th- and 17th-century ceremonial and military music.

By the 16th century the fife and side drum, introduced by the Swiss mercenaries, were established throughout Europe as infantry instruments for sounding military calls and for providing music for marching, while the same function was provided for the cavalry by the trumpet and kettledrums (*see* also DRUM).

The military march, designed to promote marching in step, dates from the 16th century. Surviving examples of military marches from this time include two for fife and drum (a combination that persisted until the 20th century) by Thoinot Arbeau and several pieces, including "The March before the Battell," "The Irishe Marche" and "The Marche to the Fighte," in a programmatic suite for virginal by William Byrd.

Many 17th- and 18th-century military marches originated in contemporary vocal or instrumental music or, on the other hand, passed from military use into the wider concert or operatic repertory. Handel's "Dead March" in *Saul* was later used for army funerals and the march in his opera *Scipio* became the parade march of the Grenadier guards.

Military music was greatly developed by Louis XIV and Frederick the Great. Lully and other composers introduced oboes to replace the louder shawms in the band of Louis XIV, and the military bands of Frederick the Great included clarinets, horns and bassoons. In 1763 the military band of the Prussian army was standardized by Frederick the Great to consist of two oboes, two clarinets, two horns and two bassoons, a combination that served 18th-century composers in works for wind octet. Similar combinations were used in 18th-century British bands. In 1795 Haydn wrote two military marches for the Derbyshire yeomanry, scored for trumpet, horns, clarinets, bassoons and serpent. In 1799 the U.S. Marine band consisted of two oboes, two clarinets, two horns and one bassoon.

About the middle of the 18th century Negro drummers were introduced into military bands and later "Turkish music" or "Janissary music" was added. This music imitated that of the life guards of the Turkish sultan. (The Janissaries were the sultan's bodyguard.) The instruments used for "Turkish music" in European bands included the triangle, cymbals, tambourine, bass drum, crescent (called in England "Jingling Johnny," in France *chapeau chinois*) and other percussion instruments (*q.v.*). The drummers, who were often slaves, wore exotic clothes, a fashion that persisted until the 20th century, when the drummers of British bands still wore leopard skins. The "Turkish music" of military bands had a wide influence and there are "Turkish" effects in works of Mozart and Beethoven, notably in the section for tenor solo and male chorus in the finale of the latter's Ninth Symphony, and early 19th-century pianos were fitted with devices for reproducing the sounds of percussion instruments.

The democratic open-air functions of the period of the French Revolution and of Napoleon encouraged the formation of much larger military bands. The clarinets in these bands took the place of the violins in the orchestra, allowing military music of a much more lyrical nature to be written, and clarinets continued to predominate in military bands until the 20th century. Sixteen clarinets were used in Napoleon's infantry regiments; in 20th-century bands there were sometimes as many as 30. About the middle of the 19th century the style of military music deteriorated. At the outbreak of the Crimean War many British bandsmen applied for discharge with the result that in 1857 a training school was established at Kneller hall, Twickenham, near London, to maintain the older traditions of military music. Much of the music later written for military bands, however, was either light and somewhat trivial or it consisted of arrangements of well-known operatic works made in a conventional manner and played with a severely restricted sense of expression. In the 20th-century novel instrumental effects of the military band were explored in works by leading composers, among them Strauss, Stravinsky, Holst and Vaughan Williams. At the same time the military band movement in the U.S. was greatly developed in schools and colleges where, as the result of competitions, a high standard of performance was reached.

From ancient times orders and commands were proclaimed in the armed forces either to the accompaniment of instrumental flourishes, fanfares and other short pieces of music, or by means of these instrumental pieces alone, which then symbolized a particular duty. In 1527 Machiavelli stated that drumbeating should accompany the commands of officers. Trumpet and kettledrum calls are incorporated in C. Jannéquin's programmatic *chanson*, *La Bataille*, in the form of a description of the battle of Marignano (1515), and other calls are described in several military manuals of the 17th century. Since most of these calls, usually for fifes and drums, trumpets and drums or, in Scottish regiments in later times, bagpipes, were devised for particular functions of the time they later fell out of use. Well-known calls used until the 20th century were "La Retraite," used by Berlioz in the *Damnation de Faust*, "Reveille," "Last Post" and "Tattoo." In *Carmen* Bizet uses a French cavalry call, "À cheval." In the first half of the 20th century military calls in the British army were classified as regimental calls, field calls and routine calls.

*See* H. G. Farmer, *Military Music* (1950).

**MILITARY POLICE** is the name given to soldiers who exercise police and other functions in armies. From the very beginning of military history armies have had men to perform military police duties.

**United States.**—Military police in the United States comprise a separate branch of the U.S. army known as the military police corps. They are distinguished from other soldiers by a blue and white armband with the letters "MP." The insignia of the corps is crossed pistols modeled from the Harpers Ferry arsenal army flintlock pistol, model 1807, calibre 54.

The mission of the military police corps is to maintain law and order, to prevent and investigate crime within the army and to operate confinement facilities. This mission includes the apprehension and return to military control of unauthorized absentees and escaped military prisoners; the retraining and rehabilitation of military prisoners; the control of traffic on military reservations; the physical security of posts, camps and stations; and the protection of the welfare of fellow soldiers. Additional functions, in time of war, include responsibility for the care, custody and documentation of prisoners of war; and evacuation and movement of refugees. The secondary mission of the military police is to engage in combat as infantry when required. The chief of the military police corps, the provost marshal general, is the principal law enforcement authority on the department of the army staff. He formulates military police policies and supervises the technical training and functioning of the military police corps.

In the U.S. army there was no regularly constituted military police corps before 1941, but the traditions of duty, service and security date back as far as Jan. 1776, when a "Provost Martial" was appointed by General Washington "to the army of the United Colonies." Two years later, by congressional resolution, a provost corps was established. In Sept. 1862 a provost marshal general was appointed for the duration of the Civil War. His primary function was the operation of the draft laws, but his subordinates throughout the country were charged also with apprehending deserters, arresting disloyal persons, seizing stolen government property and detecting spies. In 1917 a provost marshal general was again appointed in the war department to administer the selective service law. A provost marshal also was appointed in the American expeditionary forces and on Oct. 15, 1918, a military police corps was activated in the A.E.F. After the Armistice the corps was dissolved and between 1919 and 1941 military police duties were performed by individuals designated for that purpose at military installations.

The rapid expansion of the army during 1940–41 made obvious the need for a unified, centrally directed military police organization. On July 31, 1941, a provost marshal general of the army was again appointed and the military police corps was established on Sept. 26, 1941. From three battalions and four separate companies, the corps grew to a strength of about 210,000 which included military police organizations for tactical units of the ground and air forces, communications zones, and the zone of interior; escort guard companies for handling prisoners of war; prisoner of war processing companies; and criminal investigation detachments. Although a majority of military police units were disbanded following World War II, the corps built up to 42,000 during the Korean War.

On June 28, 1950, public law 581 authorized the establishment of the military police corps as a basic branch of the army. Its responsibilities are worldwide, wherever U.S. army forces are stationed. Each army in the United States, each overseas command, and every post, camp and station, as well as each major subordinate unit of the field forces, such as division, corps and field army, has a provost marshal who acts as a staff officer to the commander and supervises military police activities.

Training for the officers and enlisted men of the military police corps is provided at the Provost Marshal General's school, Fort Gordon, Ga. In addition to the basic courses, the school provides instruction for its specialized functions. (W. H. Ms.)

**Great Britain.**—In Great Britain the military police are organized as a combatant corps in the army, 15th in the order of precedence and known since 1946 as the corps of royal military police (R.M.P.). At the head of the corps is the provost marshal, one of the most ancient appointments in the army. The provost marshal and his assistants hold offices which date back probably to the 12th and 13th centuries. The earliest certain record of a provost marshal is in 1511, when Henry VIII appointed Sir Henry Guildford to the office. Since then the provost marshal and his assistants have been basically concerned with the preservation of good order and military discipline, but their responsibilities have evolved with the changing tasks of the army itself, and now are much wider and more varied.

In June 1855 a permanent corps of mounted police was raised at Aldershot and designated military mounted police in May 1877. The word "police" was an innovation in the British army. In July 1855 the military foot police was separately raised; this division continued until Feb. 1926, when the two corps were merged as the corps of military police. Considerable expansion took place in World Wars I and II; in World War II various specialized wings were formed but since 1945 only four have survived: provost ("red-caps"); special investigation branch (S.I.B.); vulnerable points (V.P., reserve army only); and women's royal army corps (W.R.A.C.) provost.

Provost companies are self-contained and self-accounting, completely mobile and equipped with radio. The basic provost formation is the section consisting of 17 other ranks commanded by a sergeant. Provost companies are formed of a varying number of sections depending on the mission. Field-force companies are included in all major formations; *e.g.*, brigades and static companies in all commands and districts. Specialized companies for duties with dogs, horses and in ports for docks and embarkation work are formed as needed.

Military police duties include the preservation of discipline outside unit lines; road patrols and traffic control; escorts; and antivice duties. In war, in addition to these, there are the duties of prisoner-of-war control; control of stragglers; manning of information posts; refugee control; and prevention of looting. The special investigation branch investigates all serious crime in the army while the women's royal army corps provost has disciplinary duties with the W.R.A.C. The royal military police derive powers of arrest from the Army act, 1955 (s. 74 (4) and 209, and the fifth schedule) and have reciprocal powers of arrest with the royal navy and royal air force police. They have no powers of punishment under the act.

**British Commonwealth Countries and Others.**—Commonwealth countries have formed military police on the British model; in all, the emphasis is on a military policeman being a soldier first and a policeman second. This is at variance with the French and Netherlands armies where the *gendarmerie* and *marechaussée* are more closely concerned with security and whose work in the United Kingdom would largely be carried out by the civilian police.

*See* S. F. Crozier, *The History of the Corps of Royal Military Police* (1951). (R. J. R. W.)

**MILITARY SCIENCE:** *see* MILITARY AFFAIRS (ARTICLES ON).

**MILITARY TRANSPORT:** *see* TRANSPORT, MILITARY.

**MILITIA.** This term is more easily traced to its classical roots than defined. It derives from the Latin words *miles* ("soldier") and *militia* ("military service"). The definition employed here, selected as the best from among many in use, is: that portion of the manpower of a society which is enrolled on military rosters and at least partially trained for local defense in short terms of service. "For local defense in short terms of service" must be stressed as it sharply distinguishes militia from professional military forces.

**Early History.**—Up to the middle of the 5th century B.C. the Greek city-states (except Sparta, which was a militaristic society) required military service of all free, able-bodied male citizens, but did not expect long tours of duty in wartime, nor the greater part of a citizen soldier's time for training during years of peace. Such forces were true militia. Then came the wars between the city-states during the 5th and 4th centuries B.C. in which the militia was gradually replaced by professional armies.

Later, Rome followed the same progression; at first, a universal military obligation provided short-term soldiers for the republic, but these were gradually replaced by regulars as the republic turned into an empire. By the end of the 2nd century B.C. the replacement was complete.

Next came the development of feudal military obligation. Although submerged in this, the militia did not die out. On the contrary, in certain quarters it became the forebear of modern systems. Thus, the militias of Britain and the United States stem from the Anglo-Saxon fyrd, a sort of pre-Norman militia. Similarly, Switzerland's unique militia organization began to develop

toward its modern form in the 14th century. The wapenshaw (Middle English for "weapon-show") was a periodical muster or review of troops held in Scotland to satisfy the military chiefs that the arms of their retainers were in good condition.

In the middle ages the familiar progression reappeared. The national states during and after the 13th century set up standing armies and relied on them more and more. The increase in the variety and complexity of weapons which took place after the introduction of firearms in the 14th century tended to make those armies permanent; and since the militia found it harder to work with the new weapons, its position deteriorated.

Other factors related to the procurement of men contributed to the deterioration. The standing armies of peacetime were seldom large enough to carry the whole burden of a war, but when expanding their forces for war, rulers sought to avoid the militia because of its short-term and local-use limitations. For long, distant campaigns they called for volunteers and thus weakened the militia. Harder yet on the militia was the development of national conscription. Here was no draft of citizen soldiers carried out by local authorities, but a national levy operated by a national government. Revolutionary France undertook the first such conscription (*see* CONSCRIPTION) because of the imperative need for greater numbers of men than had been required in the wars of the early 18th century and than could be procured by volunteering.

Most other European powers sooner or later followed the example of France. Prussia, in 1814, made a new departure when it extended national conscription into peacetime. By this innovation it developed and maintained a mighty national reserve force which could be mobilized swiftly in time of war. When neighbouring nations saw the strength of the Prussian army demonstrated during the wars of the 1860s and 1870s, they followed that lead. Thereafter, only those nations which were strongly defended by geographical barriers or neutralized by political action dared continue to rely on militia.

Early militia service was based on the theory that all men owed a duty to defend their societies, a theory that endured without much change into the 20th century. But by 1870 the application of the idea had changed. It gradually ceased to be the basic concept upon which the militia rested, and became instead the foundation for national conscription. The militia slowly shifted from it to volunteering.

In summary, in nearly all times and places where it has existed, militia has been local in character, short in service, and usually defensive in activity. Made up largely of land forces, it has also included naval elements and, in the 20th century, air militia as well. It has traditionally consisted of citizen soldiers who regarded themselves, and were so regarded, as citizens first and soldiers second. The emphasis has been on the "citizen" part of "citizen soldier" in Switzerland but not in Germany, and that is why the armed forces of the former remained a true militia, whereas the Landsturm and Landwehr of Germany, as they existed from the 1860s to 1945, were not.

**The Militia in Great Britain and in the United States in Modern Times.**—Because of the notable parallel between the militias of Great Britain and the United States, the histories of the two are examined together.

When British settlement began in North America, the militia in Britain was inactive. It was otherwise in America, where the colonists could defend themselves only by banding into militias. To direct training and to help make the earliest bands efficient the leaders of each colony brought a few professional soldiers with them. The smallness of the initial settlements and the steady pressure of danger made co-operation relatively simple and contributed to efficiency. The greater the danger the higher the efficiency. Also, the denser the settlement and the stronger the local government the higher the efficiency. But, efficient or not, all the colonies except Pennsylvania established militias soon after their founding; Pennsylvania, because of its Quaker leadership, passed no militia law for 65 years.

In England the Civil War (1642–52) temporarily stimulated the militia. More important, it brought the first English standing army into being. That army very soon created a fear among Englishmen that it could put an end to their personal liberty. This fear crossed the Atlantic, took root in the new world and added strength to the inherited idea that militia was the true bulwark of liberty. It did not, unfortunately, improve the organization and training of American citizen soldiers.

Less than a century after the first settlements in North America the intermittent wars between France and Britain (1690–1763) put the colonial militias to a test. The 13 separate organizations proved to be poor agencies for the waging of imperial conflict. Even so, they were indispensable, for they were the only partially organized, semiorderly sources from which the colonies could draw manpower for war. They could, if need be, draft men, but drafting often failed to achieve the desired results. When colonials were needed for distant enterprises, such as the assault on Louisburg in 1745, officials had to call for volunteers, who more often than not came from the militia.

In spite of efforts made by William Pitt to reform the militia in 1757, the wars of empire produced few lasting improvements. Consequently, the militias of both Britain and the colonies were in a flabby condition when the American Revolution began. Since the colonials could not threaten English soil, the British militia remained unexercised. In contrast, dire necessity soon infused some vitality into the American militia. Faulty as it was, without it the colonials could not have kept a force in the field.

George Washington was frequently driven to despair by the limitations of militia: ". . . (they) come in," he said, "you cannot tell how; go, you cannot tell when, and act, you cannot tell where, consume your provisions, exhaust your stores, and leave you at last at a critical moment." Even though distressed by them, he continued throughout the war to call on the militias, a reliance which demonstrates that they were indispensable.

All through the French Revolution, in contrast to the American, it was necessary for British militiamen to guard their coasts, and to continue their watch until the end of the Napoleonic Wars. But their organization and strength were so poor that had Napoleon been able to cross the English channel they could not have repulsed his assault.

During the years when British militia kept watch against French invasion, American leaders were building reliance on militia into the military policy of the new republic. Most of the states regarded the militias as primarily state forces, but they saw the need to give some power over them, under specified conditions, to the central government. Accordingly, the framers of the constitution in 1787 gave congress the right to call forth militia to suppress insurrections, repel invasions and enforce the law. In addition, congress received authority to organize, arm and discipline the militia, while the states retained the right to officer and train it in accordance with the discipline established by congress. The effect of the military provisions of the constitution was to give the central government authority to maintain professional forces and to grant the states authority to keep a compensatory power in their militias. Like the other powers of government, the military was checked and balanced, authority over the militia being divided between federal government and the states. When the first Militia act was passed in 1792 to implement the provisions of the constitution, it gave ultimate control to the states. As a result, for 111 years a national militia could not exist, nor could the nation use the state militias unless permitted by state authorities.

The War of 1812 was a turning point in the history of U.S. militia. Throughout it, the New England states, denying that the conditions for federal use of the militia, as prescribed in the constitution, existed, refused to send their citizen soldiers in answer to the president's calls. This stand showed that the militia was an uncertain instrument to use in national conflicts, but did not much reduce the use of it during the war. Militia provided the majority of U.S. soldiers. This had two contradictory effects. Because of failures of militia troops, as at Bladensburg, U.S. arms suffered several dangerous defeats. Conversely, because of achievements of militia, as at New Orleans, certain brilliant victories were gained. The end result on postwar policy was likewise contradictory. The militia was glorified in theory but never again used to the same extent in a national war.

After 1815 the militia declined in both Great Britain and the United States. The relative security of the two nations and their preoccupation with economic development perhaps explain the decline. In any case, an important change was in progress. Training and discipline fell off in the militia units in which service was compulsory, but Volunteer units (the capital V will be used hereafter to distinguish this sort from "war volunteers") made up of men who enjoyed military exercise increased in number and efficiency. As a result, in the United States, some states, beginning with Massachusetts in the 1840s, repealed their compulsory laws and relied on Volunteer units.

Similarly, in Britain in 1852 the basis of the militia was changed. Before that date it had been universal obligation backed by conscription; afterward it became volunteer service supplemented in rare crises by conscription (*see* VOLUNTEERS). In the United States most of the Volunteer units were a part of the militia, but in Britain they were formed into separate forces, the volunteers and the yeomanry or cavalry. In the mid-19th century both bodies drew their membership largely from the upper classes, which tended to set them apart from the militia.

Another category of volunteers came into wider and wider use. It was made up of individuals, "war volunteers," who came forward for a specific conflict. The use of such volunteers grew up because of the need to circumvent the time limitation and local limitation which rendered the militia unfit for national wars. Impelled by that need, commissioners of array had sought war volunteers in England from time to time since the late middle ages. War volunteers were used in America during the Revolution and during the Indian wars of the 1790s. Their employment lagged in the second war with Britain, but was important in the war with Mexico 30 years later. The trend toward their use continued, and, as a result, they composed the bulk of the forces on both sides during the American Civil War.

Of course, war volunteers often came from the militia system and from the Volunteers. A common procurement method was to assemble a militia unit, announce that there had been a call for soldiers and then ask for volunteers. By the time of the American Civil War this method alone could not produce the men required. Accordingly, both belligerents resorted to conscription. Ineffective in practice, conscription was significant as a precedent, for it caused many men to offer themselves as war volunteers. It must be stressed that Civil War conscription was not the traditional draft of militias which the state governments already had the power to operate. On the contrary, it was national conscription.

The Civil War, like the War of 1812, demonstrated that militias controlled by the several states could not be relied on to wage national war. They provided only a semiorganized pool of manpower for both belligerents. Even in this role militia was not perfectly reliable. For example, the governor of Georgia refused the call of the Confederacy for Georgia militia in 1864 because he needed it for defense of the home state.

Meanwhile, in Britain, the militia, which received no such stimulus as the Civil War gave in the United States, made some long-needed improvements. During the 1870s and 1880s, as a result of reforms begun by Edward Cardwell, the regular army was organized for service throughout the empire. Regular regiments were located at a home depot in Britain, at which one battalion remained while another served overseas. The militia, drawn into closer association with the regulars for home defense, supplied third and fourth battalions to each regular regiment. The status of the Volunteers and yeomanry was not clear.

During the 1880s militiamen who agreed to enter the regular forces in a national emergency were allowed small pay in time of peace. Although this inducement turned the militia into a reservoir of manpower for the regulars, it tended to weaken it as a home defensive force. All the while, Volunteers and yeomanry were growing less patrician, and in time, as the militia changed into an army reserve, they gradually took over much of the militia's old task of local defense.

In the United States after the Civil War some Volunteer units grew in strength and attained the name of "organized militia." The states used them not infrequently during the 1870s and 1880s to suppress strikes by labour, and so they became strongly representative of the propertied portion of the population. At the same time the organized militia acquired yet another name, national guard, and by 1890 all but three of the states used this term. The mass of men of military age not in the guard, although known as the unorganized militia, were not really militia at all.

**20th-Century Changes.**—Relatively minor overseas wars at the turn of the century brought alterations so profound to the militias of both nations that they did not stop until the militias were completely transformed 50 years later. The South African War (1899–1902) started the reaction in Britain. From it resulted the remarkable reforms instituted about 1908 by Lord Haldane, the secretary of state for war. Haldane's changes made the regular army into a small but effective expeditionary force which could be mobilized and transported to the continent within two weeks, and also created a reserve and a special reserve to fill out the expeditionary force when required. The militia was absorbed in these two. Behind the reserves was the territorial army made up mainly of Volunteers and yeomanry. The territorial army resembled what the national guard in the United States later became. It had local roots like the guard, but became a part of the national manpower reserve for war more easily than in the U.S. because the heritage of split control over the militia that persisted in the United States did not exist in Britain.

The war with Spain in 1898 did for the United States what the South African War was to do for Britain. It revealed dangerous weaknesses in U.S. arms and called forth a talented civilian, Elihu Root, who as secretary of war brought about a set of sweeping reforms. Root's changes, like Haldane's, were based on the need to supplement the regular forces in time of war. The first step was the repeal of the Militia act of 1792 and the enactment of a new one in 1903. The new law gave the initiative to the states. If requested by the governor, the secretary of war could issue arms to the militia, detail regular officers to duty with it, cause inspections by regulars, permit joint maneuvers of army and militia and even pay the costs of training under certain conditions. The broad significance of the new law was that it made a beginning toward forming the state militias into a national reserve force.

Following these reforms tension developed between the national guard and the regular army. The latter sought to procure a reserve force responsible to the national government alone. The guard on the other hand (supported by the National Guard association, founded in 1879 and since grown politically powerful) strove to gain financial support from the federal government, and recognition as an integral part of the national military reserve. In a series of compromise measures both gained their objectives, but with reservations. The army had to accord to the guard an enlarged role in the defense system; the guard, in return, was subject to increased federal control. Under that very important enactment, the National Defense act of 1916, the war department began to pay guardsmen for drills, provided that their units conformed to federal requirements, stood inspections by regular officers, and conducted a specified number of training periods every year.

In addition, under the National Defense act, when congress declared a national emergency the president was authorized to draft members of the national guard into federal service. He did so during World War I, breaking up in the process the proud old units of the guard. By this time, of course, the traditional geographical limitation on militia was abandoned and guardsmen could be used outside the U.S. With the World War I draft of the national guard a full circle was completed; that portion of the militia which had survived because it had abandoned compulsory service in favour of volunteering was once again subjected to draft.

In 1920 the act of 1916 was amended and federal control of the national guard was extended. Thenceforth extension of federal control became the pattern. By the time of the 1933 amendment to the act of 1916 the guard was virtually nationalized. For the first time, it became an integral part of the national military reserve. Now the U.S. paid at least nine-tenths of the cost of maintaining it. Now, too, it had a dual personality. Guard units that conformed to standards set by the war department became

part of the "National Guard of the United States." This was the first side of the dual personality. As such they were subject to call by the president without regard to any governor. Here was an advance for the guard since its units now could enter federal service intact and so avoid the dismemberment that had been their fate in World War I.

The National Guard of the United States scarcely resembled the traditional militia, but the second side of the dual personality did. When not in federal service the units were parts of the national guards of the several states. Nor was there any restriction upon the uses to which the governors could then put them. In consequence, governors on a few occasions used their guards to prevent federal officials from carrying out U.S. projects.

Because of the absence of the federal system in Britain, no counterpart to the dual nature of the militia developed there. Otherwise the relationship of the territorial army to the British government is about the same as that between the U.S. government and the National Guard of the United States.

The nationalized national guard hardly seems connected with the traditional American militia. But the guard itself, the federal government and the states all consider it to be descended from that ancient institution. As militia it has two commanders, one state, the other national. To which commander must its final allegiance go? Since the federal government pays most of the guard's expenses, and since the units of the guard become part of the army as soon as the president calls them into service, and, finally, since the constitution of the U.S. and all laws passed under it are the supreme law of the land, the guard looks to the nation as its ultimate sovereign.

*See* also NATIONAL GUARD; TERRITORIAL ARMY.

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**MILK,** the fluid secreted by the mammary glands of the mammalia as food for their young in the period immediately after birth. Milk and products derived from milk, such as butter and cheese, have been used as food for human beings of all ages throughout the time of recorded history. The unqualified term, milk, is considered to refer usually to cows' milk, since most milk destined for human consumption is from the cow. However, approximately half of the milk consumed in India is from the buffalo, and buffaloes of local types produce milk that is used for food in China, Egypt and the Philippine Islands. Goats' milk is produced in countries bordering the Mediterranean sea and in small quantities in many other parts of the world. The milk of the reindeer is used as food in northern Europe; sheep's milk is used in southern Europe in making cheese.

Cows' milk and its products have become important articles of commerce, most of the research on the chemistry, bacteriology and technology of milk being carried out in relation to it. Of the principal milk products, butter, cheese and ice cream are discussed elsewhere; evaporated, condensed and dried milks are discussed in this article. (*See* BUTTER; CHEESE; ICE CREAM.)

**History.**—The milk of animals was used as food by man much earlier than the beginning of recorded history. Soured milks, butterlike products, and cheese were probably common foods of the peoples roaming the grasslands of Asia with their sheep and cattle thousands of years ago. In the biblical narratives, Abel, son of Adam, was a "keeper of sheep," and Abraham served milk to the three divine beings who appeared to him at Hebron (Gen. xviii). Canaan was described as "a land flowing with milk and honey" and cheese is mentioned in the Book of Job. The Hindu Vedas, written prior to 1400 B.C., mention the use of butter as food. In all these instances the mention of milk or its products is incidental and implies much earlier use.

The ancient Greeks, Romans and Scythians did not use butter as food but applied it to skin injuries and to the hair; the soot from burned butter was applied to sore eyes. Butter was used as oil for lamps in Scotland as recently as the 19th century.

Prior to the 17th century, whey was employed widely in Europe as a medicine for many real and imagined ills. Milk sugar (lactose) seems to have displaced whey as a panacea subsequent to its isolation from whey in 1628. In the 20th century, the medicinal use of lactose has been limited to its function of aiding the growth of desirable bacteria in the intestinal tract.

Commercial processes for making concentrated and dried milks were developed after 1850, although the principle was known earlier; apparently the Tatars in the time of Genghis Khan prepared concentrated milks in paste, and probably in dry form, and used them as food during their raids. The original United States patent for "the concentration of milk" was granted to Gail Borden in 1856, and the utility of canned concentrated milk was demonstrated by its use in army rations during the Civil War. F. S. Grimwade's British patent for producing dried milk was issued in 1855, but large-scale production of dried milks did not begin until 50 years later.

**Composition.**—The same constituents are present in the milks of all mammals but the proportions differ both among species and within a species. The above typical analyses, which are from many sources, include the major components in the milks used as food for man.

| Species | Water % | Protein % | Fat % | Milk sugar % | Ash % |
|---|---|---|---|---|---|
| Cow | 87.0 | 3.5 | 3.9 | 4.9 | 0.7 |
| Goat | 87.0 | 3.5 | 4.3 | 4.3 | 0.9 |
| Sheep | 82.0 | 5.8 | 6.5 | 4.8 | 0.9 |
| Indian buffalo | 82.7 | 3.6 | 7.4 | 5.5 | 0.8 |
| Chinese buffalo | 76.8 | 6.0 | 12.6 | 3.7 | 0.9 |
| Egyptian buffalo | 82.1 | 4.2 | 8.0 | 4.9 | 0.8 |
| Philippine carabao | 78.5 | 5.9 | 10.4 | 4.3 | 0.9 |
| Reindeer | 63.3 | 10.3 | 22.5 | 2.5 | 1.4 |

Many factors influence the composition of milk, including breed, the genetic constitution of the individual cow and the interval between milkings. Since the last milk to be drawn at each milking is richer in fat than the rest, the completeness with which the mammary apparatus is emptied influences the composition of the sample. The age of the cow, the stage of lactation and certain disease conditions are among other factors affecting composition. In general, the kind of feed has slight effect on the composition of milk, but feed of poor quality and insufficient quantity causes both a low yield and a low percentage of nonfat solids.

The milk of each species seems to be a complete food for its own young for a while after birth, but in the natural state small quantities of other foods are usually taken early in life. Milk protein is of high nutritional value, since it contains all the essential amino acids; *i.e.*, those that man cannot synthesize in quantities sufficient for his needs. In the stomach of the young it is precipitated as a soft curd in which the globules of fat are enclosed. Digestion can thus proceed smoothly without the disturbance which the ingestion of fatty foods often causes. The mineral content includes calcium and phosphorus adequate for normal skeletal development, but little iron. Milk contains the fat-soluble vitamin A and carotene, its precursor, but the amount varies considerably with the food of the lactating animal. Since green food is the main source of this vitamin in the diet of cows, summer milk usually has more than winter milk. The fat-soluble vitamin D and the water-soluble B complex and C are also present. Because cows' milk contains proportionally more casein and less lactose than women's milk, it is usually recommended that, for babies' formulas, water be added to cows' milk to decrease the percentage of casein, and that lactose be added. Pediatricians often prescribe formulas based on evaporated or dried milk, and may suggest substituting the more rapidly assimilated glucose for lactose. It has been shown that one pint of English summer milk contributes to the daily requirements of a moderately active man about 90% of the calcium, 30%–40% of the riboflavin, 25%–30% of the protein, 10%–20% of the calories, vitamins A and B, and less than 10% of the iron and vitamin D. Although it would supply a higher proportion of the daily needs of a five-year-old child for calories, protein, vitamins A, $B_1$ and $B_2$, the contribution to the calcium needs would be reduced to about 70%.

In most countries in which milk is an article of commerce,

standards of composition of milk for retail sale are established by law or local regulations. The minimal standard for fat is usually some value between 3.0% and 3.5%, that for nonfat solids usually 8.5%.

**Sanitation.**—Raw milk, which is milk that has not been heated, contains microorganisms that eventually cause it to become sour to the taste and to curdle. During the milking, handling and transportation, it may become contaminated with organisms that cause disease in man. In many countries, regulations specify requirements relating to the health and care of cows, the health and personal cleanliness of persons who handle milk, methods of cleaning and sterilizing pails and other equipment, construction and cleanliness of buildings in which milk is produced and stored, and the temperatures of milk in storage. The effectiveness of such regulations is usually insured by periodic inspection of farms and dairies and by bacteria counts made on milk delivered to dairies and on milk delivered to consumers. Cooling of milk to temperatures slightly above the freezing point markedly reduces the rate of multiplication of the bacteria and the amount of chemical change they produce, and, consequently, increases the length of time milk continues to be palatable.

**Pasteurization.**—Even sanitary regulations are not considered in many countries to be adequate protection against transmission of disease by milk and, hence, pasteurization of milk for retail sale is a requirement in some areas, and pasteurization or boiling a recommendation in others. Pasteurization, properly carried out, kills all disease-producing organisms and a large proportion of those causing souring. If milk is pasteurized in closed containers and kept from contamination thereafter, it will continue to be a safe milk. It should be kept refrigerated to minimize the growth of remaining harmless bacteria which can produce unpleasant flavours. Pasteurization has been defined by the United States public health service as "the process of heating every particle of milk to at least 145° F. and holding at such temperature for at least 30 minutes, or to at least 161° F. and holding at such temperature for at least 15 seconds." After pasteurization, milk should be cooled rapidly to refrigerator temperatures.

**Homogenization.**—Much of the milk sold for beverage purposes is homogenized. In this process, the milk is forced under very high pressure through small openings to break up the clusters of globules of milk fat and to reduce the size of the globules. The milk fat then remains evenly distributed throughout the milk rather than rising to form a layer of cream. Vitamin D, supplied in solution in oil, is incorporated in milk by homogenization. This process is employed also to prevent separation of milk fat from cream, evaporated milk and ice cream mix.

**Separation of Cream.**—If milk, which has not been homogenized, is allowed to stand undisturbed, the milk fat will rise gradually to form a layer of cream. This was the only method known for producing cream until the cream separator was invented in the second half of the 19th century. This device is a high-speed centrifuge modified for the purpose. It can be adjusted to produce either 18% to 20% coffee cream, 30% medium cream or 36% to 40% whipping cream in one passage. By repeated passages, cream can be produced to contain as much as 80% fat, a product known as plastic cream.

**Evaporated and Condensed Milk.**—Of the concentrated milks on the market, the most important in volume is evaporated milk. This is whole milk that has been concentrated in a ratio of approximately 2.1 to 1.0, sealed in cans, and sterilized by heating at 240° F. for 15 to 20 minutes. It may contain added vitamin D and a fraction of a percent of stabilizing salts. It has a cooked flavour and a brownish colour. The evaporated milk produced in the United States is marketed at retail mostly in cans containing 14½ fluid ounces each, this quantity being equivalent in solids and food value to one quart of fluid milk. Other countries use containers of different sizes, usually based on the metric system. Minimal standards of composition are, for example, 25.9% total milk solids and 7.9% fat in the United States, and 31.0% total milk solids and 9.0% fat in Great Britain, the percentage of total milk solids includes in both instances the percentage of fat.

Plain condensed milk is a concentrated whole milk of a composition similar to that of evaporated milk, but not sterilized. It is sold to bakers and confectioners in bulk containers and must be used within a few days after manufacture to avoid spoilage. Plain condensed skim milk, containing at least 20% milk solids, is another product sold only in bulk for use in bakery products and ice cream.

Sweetened condensed milk is whole milk that has been concentrated in a ratio of 2.2 to 1.0 or greater, and contains more than 40% of sugar, which prevents bacterial spoilage. It is not sterilized and therefore does not have the brownish colour and cooked flavour associated with evaporated milk. For consumer use it is sealed in 14-oz. cans, or in baby-size 6-oz. cans. For use by food manufacturers it is packed in 10-gal. milk cans or in barrels. The standards for sweetened condensed milk require at least 28.0% total milk solids and 8.5% fat in the United States, and 31.0% total milk solids and 9.5% fat in Great Britain. Sweetened condensed skim milk, containing a minimum of 20% milk solids, is marketed in bulk containers for use in bakery products and, especially, ice cream.

Other concentrated dairy products, not sold directly to consumers but used in food and confectionery manufacture or for animal feed, are condensed buttermilk, concentrated sour skim milk, plain condensed whey and sweetened condensed whey.

**Dried Milks.**—The first commercially dried milk was malted milk powder. This product consists of approximately half milk solids and half solids from a mash prepared from barley malt and wheat flour. It usually contains about 8% milk fat. Dried whole milk, which contains at least 26.5% of fat and at least 95% of total milk solids, is produced principally for food manufacture, but is available in drug stores in the United States and in chemists' shops in Great Britain. Dried skim milk, or nonfat dried milk as it is designated in the United States, is used extensively as a constituent of bread and other bakery products and of dry mixes for home baking. A rapidly soluble nonfat dried milk is available in food stores for reconstituting into beverage skim milk in the home. Dried ice cream mix, containing approximately 60% milk solids (of which half is milk fat) and 40% added sugar, is another available dried product. Others, made in relatively small quantities and in only a few countries, are dried cream, dried buttermilk and dried cheese whey. Butter oil, which is a dry butterfat, produced in quantity in Australia, New Zealand and Argentina, has, since World War II, been reconstituted with dried skim milk, mostly from the United States, to produce a whole milk in plants built for the purpose in areas of milk shortage, such as eastern Asia and the Pacific islands.

**Other Milk Products.**—Soured milks of several varieties, such as kefir, yogurt and Bulgarian buttermilk, are made and consumed in countries near the eastern end of the Mediterranean sea. Cultured buttermilk and chocolate-flavoured milks are available in western Europe and North America. These products are usually made from skim milk or partially skimmed milk. Cultured buttermilk, acidophilus milk and Bulgarian buttermilk are skim milks that have been soured by lactic acid produced from milk sugar by bacteria. They differ in the bacteria used, the degree of sourness and in that acidophilus milk contains added milk sugar. (*See* BUTTERMILK.) Yogurt (*q.v.*) is a sharply sour, semisolid, fermented milk containing lactic acid and made from whole milk concentrated to two-thirds of its original volume. It is commercially available in western Europe and the United States. The fermenting culture contains bacteria of three species. Kefir is a self-carbonated, fermented milk containing both lactic acid and alcohol. Kefir grains, which are small lumps of milk protein carrying both bacteria and yeasts, are the fermenting agents. Chocolate-flavoured milks contain sugar, cocoa or chocolate liquor and a stabilizer, such as gelatine. Chocolate-flavoured nonfat dry milk is available for reconstituting in the home.

**Consumption.**—Differences in the level of consumption of milk and its products are attributable to many factors; among these are economic level, food habits, knowledge of nutritional values, price and availability. In western Europe, Oceania and Canada, milk and milk products account for 25% to 30% of total food expenditures of wage-earners, but in the British West Indies

and Japan for less than 10%. The distribution of consumption among dairy products differs considerably among countries, but, for Europe, North America and Oceania at mid-century, about 30% of the total milk produced was consumed as fluid milk, about 35% as butter, 11% as cheese, 4% as concentrated and dried milks and 3% as ice cream and other products.

**Marketing.**—The marketing and distribution of fluid milk are complex and highly organized. Care has to be taken not only of physical and hygienic aspects but also of the great seasonal differences in volume of supply and day to day irregularities in demand. The so-called "flush" season of milk supply is in the months of May and June in the northern hemisphere and in the corresponding late spring months in the southern hemisphere. The winter months are those of shortest supply. Since fluid milk is perishable, the surplus of the spring months must be converted into products that can be stored and placed on the market at a later time. Chiefly butter and, to a lesser extent, cheese are the dairy products that have served as a means of carry-over, but, since World War II, the skim milk that is a by-product of butter manufacture has been converted to nonfat dried milk and stored for later marketing. The heaviest demand for fluid milk in cities is during the weekend. The midweek surpluses are converted into such products as cream for home consumption, cream for ice cream, cottage cheese and cultured buttermilk.

Since fluid milk is both highly perishable and very bulky for its content of solids, it is supplied to cities and villages from farms within a well-defined, close, surrounding area. It is transported from farms to dairy plants within the cities in 10-gal. cans or in tanks. After the milk is pasteurized and bottled or put in cardboard containers, it is delivered to the consumer. In countries in which homes do not generally have refrigerators, milk deliveries are made daily. In countries such as the United States in which nearly every home has a refrigerator, deliveries are usually made on alternate days or three times a week. An increasing proportion of fluid milk is being marketed in the United States through food stores having refrigerated cabinets.

The price paid to farmers for milk for fluid consumption is greater than that paid by manufacturers of milk products. In some areas of the English-speaking countries, the producer receives the market-milk price for a fixed quantity of milk throughout the year and the lower manufacturing-milk price for all milk delivered in excess of the fixed quantity. In other areas, a regional pooling arrangement is operated under which each producer receives a price related to the average price realized for sales in both markets, irrespective of the purpose for which his own supply was used. Countries specializing in the production of milk for manufactured dairy products (*i.e.*, New Zealand and Denmark) also have highly organized marketing arrangements.

Producers who supply factories making cheese, concentrated milks, dried milks and casein (*q.v.*) deliver whole milk. Before the demand for dried skim milk began its remarkable increase, butter factories received mostly cream produced by the use of cream separators on the farms. Since before 1940 there has been an increasing tendency for whole milk to be delivered to butter factories in Australia, New Zealand, and the butter-producing areas of the United States. Payment is made for cream on the basis of its fat content. Payment for whole milk is on a weight basis, with additional payment for fat above a standard percentage.

**Production.**—Milk and its products are produced in the largest quantities in the United States, Australia, New Zealand, and the countries of western Europe, especially Denmark, the Netherlands, France and West Germany.

*See* also Dairy Industry and references under "Milk" in the Index.

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**MILKING MACHINE:** *see* Dairy Industry: *Dairy Machinery and Manufacturing Processes.*

**MILK RIVER.** The headwaters of Milk river are in the Blackfoot Indian reservation in the rolling foothills of the Rocky mountains in northwestern Montana, U.S. The north and south branches of the river flow northeastward through dry grassland and ranching country into Alberta, Can., where they join. The river flows east through southern Alberta and then bends southeastward into north-central Montana; it joins the Missouri river a few miles northeast of the Fort Peck dam and reservoir. In its total length of 625 mi., slightly more than 100 mi. are in Canada. Some water from its north branch is diverted into St. Mary river for use in irrigation. Milk river is entrenched about 100 ft. below the level of the flat, dry plains of southern Alberta. Winter pasture and feed grains are grown in the valley flats for the cattle-ranching industry. East of the town of Chinook, Mont., much of its water is used for irrigation farming; strips of irrigated green in the valley bottom contrast with the brown grasslands of the rolling hills above. The main line of the Great Northern railway follows the Milk river valley; it serves several towns, of which Malta and Glasgow are the largest. (J. L. R.)

**MILK TREE:** *see* Cow Tree.

**MILKWEED** (Silkweed), the name given to plants of the genus *Asclepias*, of the milkweed family (Asclepiadaceae; *q.v.*), comprising about 100 species, natives mostly of the western hemisphere, about 55 of which are found in North America. Many species have a milky juice, and all have silky downy seeds. Well-known species of the eastern U.S. and Canada are the common milkweed (*A. syriaca*), often a troublesome weed; the swamp milkweed (*A. incarnata*); and *A. exaltata*, a tall perennial.

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RIPENED PODS OF A BUTTERFLY OR ORANGE MILKWEED (ASCLEPIAS TUBEROSA)

The orange milkweed (*A. tuberosa*), usually called butterfly weed or pleurisy root, common on sandy soils, has rough hairy foliage and contains a resinous juice. Some species, notably the desert milkweed (*A. subulata*), contain small quantities of rubber. *Asclepias* species contain variable amounts of resinoids and other substances of a toxic nature that sometimes prove fatal to livestock. *A. galioides* and *A. verticillata* are especially dangerous in this regard. Earlier, the drug asclepias, derived from the resinous juice of *A. tuberosa*, served as a diaphoretic, diuretic and expectorant.

The seed floss of *A. syriaca* is very buoyant and has been used in life belts and vests. Noteworthy species of the western U.S. are the showy milkweed (*A. speciosa*) and the narrow-leaved milkweed (*A. mexicana*). Some species are cultivated for ornament, such as *A. curassavica*, but many are weeds, effectively controlled only by chemical spraying.

*See* also Butterfly Weed. (N. Tr.)

**MILKWORT,** the common name for plants of the genus *Polygala* (family Polygalaceae), comprising about 500 species, which are widely dispersed in temperate and tropical regions. The genus is represented by about 50 species in North America and a few species in Great Britain. The name *Polygala* is from the Greek *polys*, "much," and *gala*, "milk," the plant being supposed to increase the yield of milk in cows. The common milkwort (*P. vulgaris*) is a small wiry perennial found on heaths and in meadows throughout the British Isles and warmer parts of Europe, in western Asia and northern Africa. The stems are two to ten inches long and bear narrow rather tough leaves and small, one-sixth to one-third inch long, white, pink, blue, lilac or purple flowers. The flowers are peculiar in form and arrangement of parts; they have five free sepals, the two inner of which are large, petaloid and winglike, forming the most conspicuous part of the flower; the

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MILKWORT (POLYGALA PAUCIFOLIA)

petals are united below with the sheath of the eight stamens forming a tube split at the base behind; their form recalls that of the pea family.

Some species with showy flowers are known in cultivation as greenhouse or hardy annual or perennial herbs or shrubs. The root of *P. senega*, snakeroot, a North American species, is officinal. The fringed milkwort or flowering wintergreen (*P. paucifolia*) of the northeastern U.S. and adjacent Canada is a delicate woodland plant with handsome purple flowers. The yellow or orange milkwort (*P. lutea*) of the eastern U.S. is suited for the bog garden. Sea milkwort is the common name for *Glaux maritima*, a small succulent herb found on northern ocean shores, and occurring on the Atlantic and Pacific coasts and locally in the interior of North America and also in the British Isles; it belongs to the primrose family (Primulaceae).

**MILL, HUGH ROBERT** (1861–1950), British geographer and meteorologist who exercised a great influence in the reform of geography teaching and on the development of meteorology, was born at Thurso, Scot., on May 28, 1861. He was educated at Edinburgh university, graduating in chemistry (1883) and specializing in the chemistry of sea water for his doctorate (1886). Love of the sea and of boats led to his famous pioneer survey, *The English Lakes* (1895). Indifferent health and physique—he became totally blind in later life—prevented his becoming an explorer, but from 1892 on (when he was appointed librarian of the Royal Geographical society and settled in London), he became an acknowledged world expert in oceanography and antarctic exploration. It was through *The Realm of Nature* (1891) that he influenced the reform of geography teaching. As director of the British Rainfall organization (1901–19), editor of *British Rainfall* and *Symons' Meteorological Magazine*, honorary secretary of the Royal Meteorological society from 1902 until 1907 when he became president, he had a profound influence on the development of meteorology which was recognized by the institution of a Hugh Robert Mill medal by the society, with Mill as first recipient. He served as vice-president of the Royal Geographical society from 1927 to 1931, but was compelled by ill-health to refuse the presidency in 1933. His autobiography was in proof when he died at Dormans park, East Grinstead, Sussex, on April 5, 1950.

Mill's other publications include: *Hints . . . on the Choice of Geographical Books . . .* (1897); *New Lands* (1900); *The Siege of the South Pole* (1905); *The Life of Sir Ernest Shackleton* (1923); *Hugh Robert Mill: an Autobiography*, with introduction by L. Dudley Stamp (1951); he also edited *The International Geography* (1911) and was geographical editor for the 11th edition of *Encyclopædia Britannica* (1911). (L. D. S.)

**MILL, JAMES** (1773–1836), British historian, economist and philosopher, prominent as a representative of "philosophical radicalism," was born on April 6, 1773, at Northwater Bridge, in the parish of Logie-Pert, Forfarshire, the son of James Mill, a shoemaker. His mother, Isabel Fenton, of a good family which had suffered from connection with the Stuart rising of 1745, sent him to the parish school, to the Montrose academy and then to the University of Edinburgh, where he distinguished himself as a Greek scholar. He was licensed as a preacher in Oct. 1798 but occupied himself with occasional teaching and with historical and philosophical studies. In 1802 he went to London in company with Sir John Stuart, M.P. for Kincardineshire, and devoted himself to journalism. In 1804 he wrote a pamphlet on the corn trade, arguing against a bounty on the exportation of grain. After his marriage (1805) with Harriet Burrow, he took a house in Pentonville, where his eldest son, John Stuart Mill (*q.v.*), was born in 1806. About the end of 1806 he began his *History of British India*.

Mill became acquainted with Jeremy Bentham in 1808 and was for many years his chief companion and ally. He adopted Bentham's principles in their entirety and did more to propagate them and to oppose the beginnings of romanticism than anyone else. He was a regular contributor (1806–15) to the *Anti-Jacobin Review*, the *British Review*, the *Eclectic Review* and the *Edinburgh Review* (1808–13). In 1811 he co-operated with William Allen (1770–1843) in a periodical called the *Philanthropist*. He contributed largely to every number—his principal topics being education, the freedom of the press and prison discipline (under which he expounded Bentham's "Panopticon"). He took part in the discussions which led to the foundation of London university in 1825.

In 1814 Mill undertook various articles—including, eventually, "Government," "Jurisprudence," "Liberty of the Press," "Prisons and Prison Discipline," "Colony," "Law of Nations" and "Education"—for the supplement to the 4th, 5th and 6th editions of the *Encyclopædia Britannica*. These were reprinted and enjoyed an extensive circulation. Although the article "Government" was the target of some very able articles by Thomas Babington Macaulay, it had a considerable influence on public opinion in the 1820s and did a good deal to prepare the ground for the passage of the first Reform bill in 1832. It provides perhaps the most succinct statement of the political theory of the philosophical radicals. It also had the merit of stimulating the production of such diverse political theories as those of John C. Calhoun and John Stuart Mill. (*Cf.* Sir Ernest Barker's introduction to the Cambridge reprint of 1937.)

*The History of British India*, three volumes (1817), appeared at the beginning of 1818; and in 1819, though his *History* contained drastic criticisms of British rule in India, Mill was appointed an official in the India house. He gradually rose till he was appointed head of the examiner's office in 1830. His *Elements of Political Economy* appeared in 1821 (3rd and revised ed., 1826).

From 1824 to 1826 Mill contributed to the *Westminster Review*, started as the organ of the philosophical radicals, articles attacking the *Edinburgh Review*, the *Quarterly Review* and ecclesiastical establishments. In 1829 appeared the *Analysis of the Phenomena of the Human Mind*, two volumes. From 1831 to 1833 Mill was largely occupied as the spokesman of the court of directors in the defense of the East India company, during the controversy attending the renewal of its charter. His last published book was the *Fragment on Mackintosh* (1835). He died June 23, 1836.

Mill's greatest literary monument is *The History of British India*. The materials for the history of the conquest of India were put into shape for the first time; political theory was brought to bear on the delineation of the Hindu civilization; and the conduct of the successive stages of the conquest and administration of India was subjected to severe criticism. The work itself and the author's official connection with India for the last 17 years of his life effected a complete change in the system of governing that country.

Mill played a great part in English politics. His writings on government and his personal influence among the radical politicians of his time determined the change of view from the French Revolutionary theories of the rights of man and the absolute

equality of men to the claiming of securities for good government through a wide extension of the franchise. His *Elements of Political Economy* shows all the author's precision and lucidity. Its interest is mainly historical, as a summary of the views of the philosophical radicals based mainly on David Ricardo. Mill maintained: (1) that the chief problem of political reformers is to limit the increase of population, on the assumption that capital does not naturally increase at the same rate as population (II, sec. 2, art. 3); (2) that the value of a thing depends entirely on the quantity of labour put into it; and (3) that what is now known as the "unearned increment" of land is a proper object for taxation. The enunciation of the second of these propositions is important in view of the use made of it by Karl Marx.

In his *Analysis of the Phenomena of the Human Mind* Mill developed the psychological side of Benthamism. It was a more systematic attempt than that already made by David Hartley to explain all mental phenomena by the association of ideas.

All the writings of James Mill—economic, political and psychological—should be regarded as contributions to the program of the philosophical radicals. Élie Halévy provides much the best account of that movement in his *Growth of Philosophical Radicalism* (Eng. trans. Faber and Faber Ltd., London, 1928; page 6): "Given a science of the mind and a science of society which exhibit the qualities both of the experimental and of the exact sciences analogous to the physics of Newton, should it not be possible to found on these new disciplines a moral and legal theory which would be scientific—the achievement of the universal practical science? Such is the problem which exercised thinking people in England throughout Bentham's century. What is known as Utilitarianism, or Philosophical Radicalism, can be defined as nothing but an attempt to apply the principles of Newton to the affairs of politics and of morals. In this moral Newtonianism the principle of the association of ideas and the principle of utility take the place of the principle of universal attraction."

**MILL, JOHN STUART** (1806–1873), British philosopher and economist, prominent as a publicist in the reforming age of the 19th century and of lasting interest as a logician and as an ethical theorist. The eldest son of James Mill (*q.v.*), he was born on May 20, 1806, in his father's house in Pentonville, London. He was educated exclusively by his father, who was a strict disciplinarian. By his eighth year he had read in the original Aesop's *Fables*, Xenophon's *Anabasis* and the whole of Herodotus and was acquainted with Lucian, Diogenes Laërtius, Isocrates and six dialogues of Plato. (*See* his *Autobiography*.) He had also read a great deal of history in English. A contemporary record of Mill's studies from 8 to 13, published in Alexander Bain's sketch of his life, shows that the *Autobiography* rather understates the amount of work done. At the age of eight he started Latin, Euclid and algebra and began to teach the younger children of the family. His main reading was still history, but he went through all the Latin and Greek authors commonly read in the schools and universities and, by the age of ten, could read Plato and Demosthenes with ease. About the age of 12, he began a thorough study of the scholastic logic, at the same time reading Aristotle's logical treatises in the original. In the following year he was introduced to political economy and studied Adam Smith and David Ricardo.

The training which the younger Mill received has aroused amazement and criticism. The important part of it was the close association with the strenuous character and vigorous intellect of his father. From his earliest days he spent much time in his father's study and habitually accompanied him on his walks. He thus inevitably acquired many of his father's speculative opinions and his father's way of defending them. But he did not receive the impress passively and mechanically. "One of the grand objects of education," according to the elder Mill, "should be to generate a constant and anxious concern about evidence." The duty of collecting and weighing evidence for himself was at every turn impressed upon the boy. His childhood was not unhappy, but there is no doubt that it was a strain on his constitution and that he suffered from the lack of natural unforced development.

From May 1820 till July 1821 Mill was in France in the family of Sir Samuel Bentham, brother of Jeremy Bentham. Copious extracts from a diary kept by him at this time are given by Bain; they show how methodically he read and wrote, studied chemistry and botany, tackled advanced mathematical problems and made notes on the scenery and the people and customs of the country. He also gained a thorough acquaintance with the French language. On his return in 1821 he added to his work the study of psychology and that of Roman law, which he read with John Austin, his father having half decided on the bar as the best profession open to him. This intention, however, was abandoned; and in 1823, when he had just completed his 17th year, he entered the examiner's office of the India house. After a short probation he was promoted, in 1828, to assistant examiner. For 20 years, from 1836 (when his father died) to 1856, Mill had charge of the East India company's relations with the Indian states, and in 1856 he became chief of the examiner's office.

In 1822 Mill had read P. E. L. Dumont's exposition of Bentham's doctrines in the *Traités de législation*, which made a lasting impression upon him. The impression was confirmed by the study of the English psychologists and also of Condillac and Helvétius; and in 1822–23 he established among a few friends the "Utilitarian" society, taking the word, as he tells us, from John Galt's *Annals of the Parish*.

Two newspapers were open to him—the *Traveller*, edited by a friend of Bentham's and the *Morning Chronicle*, edited by his father's friend John Black. One of his first efforts was a solid argument for freedom of discussion, in a series of letters to the *Chronicle* on the prosecution of Richard Carlile. He seized every chance for exposing departures from sound principle in parliament and courts of justice. Another outlet was opened up for him (April 1824) by the starting of the *Westminster Review*, which was the organ of the philosophical radicals. In 1825 he began work on an edition of Bentham's *Rationale of Judicial Evidence*, 5 vol. (1827). He discussed eagerly with the many men of distinction who came to his father's house and engaged in set discussions at a reading society formed at George Grote's house in 1825 and in set debates at the Speculative society, formed in the same year.

The *Autobiography* tells how in 1826 Mill's enthusiasm was checked by a misgiving as to the value of the ends which he had set before him. At the Speculative debating society, where he first measured his strength in public conflict, he found himself looked upon with curiosity as a precocious phenomenon, a "made man," an intellectual machine set to grind certain tunes. The elder Mill, like Plato, would have put poets under ban as enemies of truth; he subordinated private to public affections; and Landor's maxims of "few acquaintances, fewer friends, no familiarities" had his cordial approval. These doctrines the younger Mill now felt himself forced in reason to abandon. Too much in awe of his father to make him a confidant, he wrestled with his doubts in gloomy solitude. He emerged from the struggle with a more catholic view of human happiness, a delight in poetry for its own sake, a more placable attitude in controversy, a hatred of sectarianism and an ambition no less noble and disinterested but moderated to practical possibilities. Gradually the debates in the Speculative society attracted men whose society was invigorating and inspiring, among others J. F. D. Maurice and John Sterling. Mill ceased to attend the society in 1829, but he carried away from it the conviction that a true system of political philosophy was "something much more complex and many-sided than he had previously had any idea of, and that its office was to supply, not a set of model institutions but principles from which the institutions suitable to any given circumstances might be deduced."

Mill's letters in the *Examiner* in the autumn of 1830 after a visit to Paris, where he made the acquaintance of the younger liberals, may be taken as marking his return to hopeful activity; and a series of articles on "The Spirit of the Age" (ed. with introduction by F. A. von Hayek, Chicago, 1942) appeared in the same paper in 1831. During the years 1832 and 1833 he contributed many essays to *Tait's Magazine*, the *Jurist* and the *Monthly Repository*. In 1835 Sir William Molesworth founded the *London Review*, with Mill as editor. It was amalgamated with

the *Westminster* (as the *London and Westminster Review*) in 1836, and Mill continued as editor (latterly proprietor also) till 1840. In and after 1840 he published several important articles in the *Edinburgh Review*. Some of the essays written for these journals were reprinted in the first two volumes (1859) of Mill's *Dissertations and Discussions* and give evidence of the increasing width of his interests. Among the more important are "Thoughts on Poetry and Its Varieties" (1833), "Writings of Alfred de Vigny" (1838), "Bentham" (1838), "Coleridge" (1840), "M. de Tocqueville on Democracy in America" (1840), "Michelet's History of France" (1844) and "Guizot's Essays and Lectures on History" (1845). The twin essays on Bentham and Coleridge (together reprinted with introduction by F. R. Leavis, London, 1950; New York, 1951) are perhaps the finest things that Mill ever wrote and indicate very clearly the new spirit that he tried to breathe into English radicalism.

During these years Mill also wrote his great systematic works on logic and on political economy. His reawakened enthusiasm for humanity had taken shape as an aspiration to supply an unimpeachable method of proof for conclusions in moral and social science: Auguste Comte had some influence here but the main inspiration undoubtedly came from Newton, whose physics had already been accepted as a model of scientific exposition by Locke, Hume, Bentham and James Mill. But he was determined that the new logic should stand in no antagonism to the old. In his *Westminster* review of Richard Whately's *Logic* of 1828 he was already defending the syllogism against the Scottish philosophers who had talked of superseding it by a supposed system of inductive logic. He required his inductive logic to "supplement and not supersede." For several years he searched in vain for the means of concatenation. Finally, in 1837, on reading William Whewell's *Philosophy of the Inductive Sciences* and rereading J. F. W. Herschel's *Preliminary Discourse on the Study of Natural Philosophy*, Mill at last saw his way clear both to formulating the methods of scientific investigation and to joining the new logic onto the old as a supplement. *The System of Logic*, 2 vol., was published in 1843 (3rd–8th editions, introducing many changes, 1851–72).

Mill distinguished three stages in his development as a political economist. In 1844 he published the *Essays on Some Unsettled Questions in Political Economy*, which he had written several years earlier; and four out of five of these essays are solutions of perplexing technical problems—the distribution of the gains of international commerce, the influence of consumption on production, the definition of productive and unproductive labour and the precise relations between profits and wages. Here for the most part Mill appears as the disciple of Ricardo, striving after more precise statements and reaching forward to further consequences. In his second stage originality and independence become more conspicuous as he struggles toward the standpoint from which he wrote his *Principles of Political Economy*. This was published in 1848 (2 vol.; 2nd and 3rd editions, with significant differences, 1849, 1852), and at about the same time Mill was advocating the creation of peasant-proprietorships as a remedy for the distresses and disorder in Ireland. Thereafter Mill made a more thorough study of socialist writers. He was convinced that the social question was as important as the political question. He declined to accept property devised originally to secure peace in a primitive society as necessarily sacred in its existing developments in a quite different stage of society. He separated questions of production and distribution and could not rest satisfied with the distribution which condemned the labouring classes to a cramped and wretched existence, in many cases to starvation. He did not come to a socialist solution, but he had the great merit of having considered afresh the foundations of society. This he called his third stage as a political economist; and he says that he was helped toward it by the lady, Mrs. Taylor (Harriet Hardy), who became his wife in 1851.

It is generally supposed that Mill writes with a lover's extravagance about this lady's powers. He expressly says, indeed, that he owed none of his technical doctrine to her, that she influenced only his ideals of life for the individual and for society and that the only work which was directly inspired by her is the essay on the "Enfranchisement of Women" (*Dissertations*, vol. ii). Nevertheless Mill's relations with her have always been something of a puzzle. It is noticeable that in his *Autobiography* Mill first introduces her name in a passage in which he closes his account with Thomas Carlyle, and it is possible that the clue to their relationship lies here. "I felt," he says of Carlyle, "that he was a poet and that I was not; that he was a man of intuition which I was not; and that as such he not only saw many things before me, but that it was highly probable he could see many things which were not visible to me even after they were pointed out. I knew that I could not see round him and could never be certain that I saw over him; and I never presumed to judge him with any definiteness until he was interpreted to me by one [that is, Mrs. Taylor] who was greatly the superior of us both—who was more a poet than he and more a thinker than I—whose own mind and nature included his and infinitely more."

It would appear from this passage that Mrs. Taylor played something like the same role in Mill's life as Carlyle had done, and we know that Carlyle took over this role from Sterling. Each of these three, Sterling, Carlyle and Mrs. Taylor, seemed to provide some nourishment for Mill's perpetual love of loving—"the need," as he defines it, "of a sympathising support or of objects of admiration and reverence"; and at the back of his mind there was always the terrible fear of the stifled melancholy that had visited him in his early manhood. It was to Sterling that he made the pathetic confession that "there is now no human being (with whom I can associate on terms of equality) who acknowledges a common object with me"; and he was even more explicit to Carlyle a few years later. "You wonder," he writes, "at the boundless capacity man has of loving, but I also wonder, judging from myself, at the narrowness of that capacity in others. That seems to me the only really insuperable calamity in life—the only one which is not conquerable by the power of a strong will. It is hard to have no aspiration and no reverence but for an Ideal towards which striving is of no use." The fact is that there were two distinct strains in Mill: the sensitive temperament that craved for sympathetic support and responded so delicately to every trend of the age was balanced, or almost balanced, by a strong and thoroughly trained will which was never content simply to absorb influences but insisted on systematizing them. The latter trait drew him to his father, the former to his wife; and it was perhaps inevitable that the conflict was only resolved at the cost of a good deal of suffering for all concerned.

During the seven years of his marriage Mill became increasingly absorbed in the work of the East India company and in consequence published less than at any other period of his life. In 1856 he became head of the examiner's office in the India house; and for two years, till the dissolution of the company in 1858, his official work kept him fully occupied. It fell to him as head of the office to write the defense of the company's government of India when the transfer of its powers was proposed. Mill opposed the transfer, and the documents in which he defended the company's administration are models of trenchant and dignified pleading. On the dissolution of the company Mill was offered a seat in the new council, but declined it and retired with a pension of £1,500. His retirement from official life was followed almost immediately by his wife's death at Avignon. He spent most of the rest of his life at a villa at St. Véran, near Avignon, returning to his Blackheath house only for a short period in each year.

Mill sought relief by publishing a series of books on ethics and politics which he had meditated and partly written in collaboration with his wife. The essay *On Liberty* appeared in 1859 with a touching dedication to her and the *Thoughts on Parliamentary Reform* in the same year. In his *Considerations on Representative Government* (1861) he systematized opinions already put forward in many casual articles and essays. Lord Lindsay remarked how Mill combined enthusiasm for democratic government with pessimism as to what democracy was likely to do; practically every discussion in these books exemplifies this. (*See* further R. B. McCallum, introduction to his edition of *On Liberty* and *Considerations on Representative Government*, Oxford, 1946;

New York, 1947.) His *Utilitarianism* (in Fraser's *Magazine*, 1861; separate publication, 1863; reprint with study of the English utilitarians by J. P. Plamenatz, Oxford, New York, 1949) was a closely reasoned attempt to answer objections to his ethical theory and to remove misconceptions about it. He was especially anxious to make it clear that he included in "utility" the pleasures of the imagination and the gratification of the higher emotions.

Mill also began to write again on the wider philosophical questions that had occupied him in the *Logic*. In 1865 he published both his *Examination of Sir William Hamilton's Philosophy* and his *Auguste Comte and Positivism*; but in both cases his motives for writing were largely political. "The practical reformer," he writes in his *Autobiography*, "has continually to demand that changes be made in things which are supported by powerful and widely-spread feelings, or to question the apparent necessity and indefeasibleness of established facts; and it is often an indispensable part of his argument to show how those powerful feelings had their origin, and how those facts came to seem necessary and indefeasible. There is therefore a natural hostility between him and a philosophy which discourages the explanation of feelings and moral facts by circumstances and association, and prefers to treat them as ultimate elements of human nature." It was because he regarded the writings and sayings of Sir William Hamilton as the great fortress of intuitional philosophy in Great Britain that Mill undertook to counter his pretensions. In dealing with Comte, Mill distinguished sharply between Comte's earlier philosophical doctrine of positivism and his later religion of humanity. The doctrine he commended (as he had frequently done previously) because he regarded it as a natural development of the outlook of Berkeley and Hume; the religion he attacked because he saw in it merely another attempt to foist a priestly hierarchy upon suffering humanity. It is noticeable that Mill's language in these books is much closer to the language of Bentham and James Mill than it had been since his boyhood; and it was as an act of piety that in 1869 he republished his father's *Analysis of the Phenomena of the Human Mind* with additional illustrations and explanatory notes.

While mainly engaged in these years with theoretical studies, Mill did not remit his interest in current politics. He supported the North in the American crisis of 1862, using all his strength to explain that the real issue at stake in the struggle was the abolition of slavery. In 1865 he stood as parliamentary candidate for Westminster, on conditions strictly in accordance with his principles. He would not canvass or pay agents to canvass for him, nor would he engage to attend to the local business of the constituency. He was with difficulty persuaded even to address a meeting of the electors, but was elected. He took an active part in the debates on the Reform bills of 1866–67 and helped to extort from the government several useful modifications of the bill for the prevention of corrupt practices. The reform of land tenure in Ireland (*cf.* his *England and Ireland*, 1868, and his *Chapters and Speeches on the Irish Land Question*, 1870), the representation of women (*see* below), the reduction of the national debt, the reform of London government and the abrogation of the declaration of Paris were among the topics on which he spoke. He took occasion more than once to enforce what he had often advocated, England's duty to intervene in foreign politics in support of freedom. As a speaker Mill was somewhat hesitating, but he showed great readiness in extemporaneous debate. Elected rector of St. Andrews university, he published his *Inaugural Address* in 1867.

Mill's subscription to the election expenses of Charles Bradlaugh and his attack on the conduct of Gov. E. J. Eyre in Jamaica were perhaps the main causes of his defeat in the general parliamentary election of 1868. But his studied advocacy of unfamiliar projects of reform had made him unpopular with "moderate Liberals." He retired with a sense of relief to Avignon. His villa was filled with books and newspapers; the country round it furnished him with a variety of walks; he read, wrote, discussed, walked, botanized. He was extremely fond of music and was himself a fair pianist. His stepdaughter, Helen Taylor (d. Jan. 1907), was his constant companion after his wife's death. Mill was an enthusiastic botanist all his life and a frequent contributor of notes and short papers to the *Phytologist*. During his last journey to Avignon he was looking forward to seeing the spring flowers and completing a flora of the locality.

Mill did not relax his laborious habits or his ardent outlook on human affairs. The essays in the fourth volume of his *Dissertations* (1876; vol. iii had appeared in 1867)—on endowments, on land, on labour and on metaphysical and psychological questions—were written for the *Fortnightly Review* at intervals after his short parliamentary career. In 1867 he had been one of the founders, with Mrs. P. A. Taylor, Miss Emily Davies and others, of the first women's suffrage society, which developed into the National Union of Women's Suffrage Societies; and in 1869 he published *The Subjection of Women* (written 1861), the classical theoretical statement of the case for women's suffrage. His last public activity was concerned with the starting of the Land Tenure Reform association, for which he wrote in the *Examiner* and made a public speech a few months before his death: the interception by the state of the unearned increment on land and the promotion of co-operative agriculture were the most striking features in his program, which he regarded as a timely compromise in view of the impending struggle between capital and labour in Europe. His *Autobiography* (see *Bibliography*, below) and *Three Essays on Religion* (1874) were published posthumously.

Mill died at Avignon on May 8, 1873. A bronze statue of him stands on the Thames embankment in London, and G. F. Watts's copy of his original portrait of Mill hangs in the National gallery there.

**Influence and Significance.**—Mill was a man of extreme simplicity in his mode of life. The influence which his works exercised upon contemporary English thought can scarcely be overestimated; nor can there be any doubt about the value of the liberal and inquiring spirit with which he handled the great questions of his time. Beyond that, however, there has been considerable difference of opinion about the enduring merits of his philosophy. At first sight he is the most lucid of philosophers. Many people have spoken of the marvelous intelligibility of his writing; some have even mentioned the intellectual ecstasy produced in them by the exact and ordered sequence of his reasoning. Usually, however, it is not long before doubts begin to creep in. Although the lucidity remains, its span is seen to be somewhat limited, and one sometimes has the uneasy feeling that he is being equally lucid on both sides of a question. Hence it has often been held, since W. S. Jevons first made the discovery, that Mill's mind was "essentially illogical" and that his philosophy was notable mainly for its "intricate sophistry."

Oddly enough, however, this judgment has not led to any neglect of Mill. Little attention is now paid to Hamilton or to Whewell; but Mill's name continually crops up in philosophical discussions. This is partly due to the fact that Mill offers a body of doctrine and a set of technical terms on many subjects (notably on induction) which have proved extremely useful in the classroom. But a more important reason is that he has come to be regarded as a sort of personification of certain tendencies in philosophy which it is regarded as continually necessary to expose. Thus he is, or says he is, a utilitarian; yet nothing, it is pointed out, could tell more strongly against utilitarianism than certain passages in his writings. Then again he is said to be an empiricist (although he says himself that he is not), and his theories of the syllogism and of mathematics are constantly used to demonstrate the fatal consequences of this way of thinking.

Now we are, of course, paying a considerable compliment to any man when we link his name in this way with some important doctrine, but at the same time we also run a considerable risk of misunderstanding him. It has been generally acknowledged in the case of more than one philosopher—Locke's is a particularly pertinent case here—that a traditional label, applied as often as not in the interests of party politics, has resulted in a very distorted view of the philosopher's teaching; and this appears to be at least as true of Mill as of Locke.

Thus it has been pointed out that the theory of the syllogism usually associated with Mill's name is an empiricist theory, while the theory of induction is not. "The characteristic feature of the former is the assertion that we can never attain certainty in our

reasonings, because we must always argue from particulars to particulars. The underlying assumption is that we can never establish any real connection between particulars by way of universals because universals are merely collections of particulars. The theme of the latter, on the contrary, is that we can obtain certainty by way of scientific experiment because the particulars we are dealing with there are merely collections of universals. It is on this assumption that the problem of induction is reduced by Mill to the formal one of determining what universals in one particular are connected with what universals in another; and it is this problem which he solves by means of his Canons of Induction" (R. P. Anschutz, *Philosophy of J. S. Mill*, The Clarendon Press, Oxford, 1953).

It is equally misleading to speak without qualification of Mill's utilitarianism. If we do, we immediately suggest that there is a degree of agreement between the ethical and political doctrines of Bentham and those of Mill which does not on the face of it exist. Nor is it sufficient to add that Mill modified the utilitarianism that he inherited from Bentham and from his father in one way and another, in order to meet the criticisms which it encountered in Victorian times. He does, it is true, sometimes give that impression (as in his essay on *Utilitarianism*); but elsewhere (as in his essay *On Liberty*) he scarcely attempts to conceal the fact that his premises are completely independent of Bentham's. Thus, contrary to the common belief, it appears to be very hazardous to characterize offhand the precise position of Mill on any major philosophical topic. All his theories, like Locke's, are extremely complex and unstable structures, prone to fall to pieces at the first inconvenient question. Nevertheless one or two points about Mill leap to the eye, and with their aid it is possible to unravel to some degree the tangled skein of his thought.

For one thing, Mill was not the paragon of the middle-class virtues that he is sometimes represented as being. As in the case of his marriage, he sometimes behaved with a reckless disregard of consequences more suitable to a romantic than to a utilitarian. He is thoroughly romantic, again, and thoroughly representative of his age in the eagerness with which he seeks out and endeavours to assimilate every last exotic line of thought which shows any signs of vitality. He himself claimed to be superior to most of his contemporaries in "ability and willingness to learn from everybody"; and indeed, for all his father's careful schooling, there was never anybody less buttoned up against alien influences than Mill. Somewhere or other in his writings there can be discerned traces of every wind that blew in the earlier part of the 19th century.

On the other hand there was another strain in Mill which was perpetually at war with this: he was an inveterate systematizer and, search as he might, he never succeeded in finding a system which had anything like the appeal of the one in which he had been brought up. Looking back upon the stormy period of his youth, Mill said: "I found the fabric of my old and taught opinions giving way in many fresh places and I never allowed it to fall to pieces but was incessantly occupied in weaving it anew"; and this is a description that never really ceased to be applicable to him.

*See* also references under "Mill, John Stuart" in the Index

BIBLIOGRAPHY.—The primary source for Mill's life is his *Autobiography*, ed. by Helen Taylor (1873), of which two new editions appeared in 1924, one with an appendix of previously unpublished speeches, a preface by H. Laski and a good index; the other, ed. by J. J. Coss, including passages omitted from the original edition. There are collections of his letters ed. by Hugh Elliott, *Letters of John Stuart Mill*, 2 vol. (1910); by E. d'Eichthal, *Correspondance inédite de J. S. Mill avec Gustave d'Eichthal* (1898); by L. Lévy-Bruhl, *Lettres inédites de J. S. Mill à Auguste Comte* (1899); and by F. A. von Hayek, *John Stuart Mill and Harriet Taylor: Their Friendship and Subsequent Marriage* (1951). *See* further the *Bibliography of the Published Writings of J. S. Mill*, ed. by N. MacMinn, J. R. Hainds and J. McCrimmon (1945).

For biography and criticism *see*: A. Bain, *John Stuart Mill, a Criticism, With Personal Recollections* (1882); Sir Leslie Stephen, *The English Utilitarians*, vol. iii. (1900); E. E. Neff, *Carlyle and Mill, an Introduction to Victorian Thought*, 2nd ed. (1926); Elie Halévy, *Growth of Philosophical Radicalism*, Eng. trans. (1928), essential for an understanding of the background of his thought; M. A. Hamilton, *John Stuart Mill* (1933); R. P. Anschutz, *The Philosophy of J. S. Mill* (1953); K. Britton, *J. S. Mill* (1953); M. S. Packe, *The Life of John Stuart Mill* (1954). (R. P. A.)

**MILLAIS, SIR JOHN EVERETT** (1829–1896), English painter and illustrator, and a founder member of the Pre-Raphaelite brotherhood, was born at Southampton on June 8, 1829, of Jersey extraction. In 1838 he went to London and on Sir Martin Archer Shee's advice entered first Henry Sass's school, Bloomsbury, then the Royal Academy schools in 1840. Extremely precocious, Millais won all the academy prizes, including a gold medal for "The Young Men of the Tribe of Benjamin Seizing Their Brides" (1847). His first academy picture "Pizarro Seizing the Inca of Peru" (1846; Victoria and Albert museum, London) was influenced by William Etty. In 1847 his painting "The Widow's Mite" (fragments at Christchurch priory, Hampshire) went unrewarded in the competition for decorating the houses of parliament. The next year, 1848, Millais joined with Holman Hunt and D. G. Rossetti to form the Pre-Raphaelite movement, and his "Isabella" (1849; Walker art gallery, Liverpool), from Keats's "Isabella; or the Pot of Basil," was a remarkable tour de force in the new manner. At the next year's academy, Charles Dickens led the violent attack on Millais's "Christ in the House of His Parents" (Tate gallery, London), which many considered blasphemous. The storm gradually abated. "The Return of the Dove to the Ark" (1851; Ashmolean museum, Oxford) was admired by both John Ruskin and Théophile Gautier, and "The Order of Release" (1853; Tate gallery), which included a portrait of his future wife Effie Gray (then married to Ruskin), was praised by Eugène Delacroix in 1855 and earned for its artist his associateship to the Royal Academy in 1853. Thus was set the seal of respectability upon a former rebel.

In 1863 Millais became full academician, and by this time his style had noticeably broadened and his subject matter considerably altered. "The Black Brunswicker" (1860; Lady Lever art gallery, Port Sunlight) marks the transition toward a more deliberately popular, less didactic approach, although he executed illustrations for George Dalziel's *Parables* (1864) and E. Moxon's edition of Tennyson's poems, and contributed to *Once a Week*, *Good Words* and other periodicals. Millais's later work is undoubtedly of poorer over-all quality—a deterioration of which he was fully aware. In 1871 appeared the first of his pure landscapes, "Chill October," which makes interesting comparison with the jewellike landscape background (a view of Winchelsea, Sussex) of "The Blind Girl" (1856; Birmingham art gallery), a painting whose tender sentiment contrasts sharply with the banality of "Bubbles" (Messrs. Pears). Many of these landscapes are of Perthshire, where Millais also shot and fished in the autumn. Among the better products of this period may be noted "A Yeoman of the Guard" (1877; Tate gallery) and "The North West Passage" (1874; Tate gallery), the model for which was Edward Trelawny, a friend of Lord Byron. Many portraits belong to this date, including those of Gladstone, Tennyson, Cardinal Newman and Mrs. Bischoffsheim. Millais was created a baronet in 1885 and was elected president of the Royal Academy in 1896. He died on Aug. 13, 1896, and was buried in St. Paul's cathedral.

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**MILLAY, EDNA ST. VINCENT** (1892–1950), U.S. poet, immensely popular in her day, something of an unofficial feminine laureate, and a personification of the Byronic spirit of the 1920s, was born in Rockland, Me., on Feb. 22, 1892. She graduated from Vassar in 1917 and supported herself in New York city by writing short stories under pseudonyms and as an actress and playwright with the Provincetown Players. In 1923 she married Eugen Boissevain and spent the rest of her life, except for occasional travels, on a farm in the Berkshires. She died there on Oct. 19, 1950.

Miss Millay first attracted attention with a long poem, "Renascence," published in *The Lyric Year* anthology (1912) and written when she was only 19. This was incorporated in 1917 into *Renascence and Other Poems*, a volume full of the romantic and independent temper of youth. *A Few Figs From Thistles* (1920) did not maintain the level of quality of her first work, but

*Second April* (1921) marked a return to her earlier mood and craftsmanship. In 1921 she also published three plays: *Two Slatterns and a King, The Lamp and the Bell* and *Aria Da Capo. The Harp-Weaver and Other Poems* (1923) revealed a new maturity, the title poem having been awarded a Pulitzer prize for poetry in 1922. In 1925 she was commissioned by the directors of the Metropolitan Opera company to write the book for an opera, the music of which was to be composed by Deems Taylor; the result of their collaboration, *The King's Henchman*, first presented in 1927, was a greater success than any previous American opera. Works of succeeding years were: *The Buck in the Snow and Other Poems* (1928), introducing a more sombre tone to her poetry; *Fatal Interview* (1931), a highly acclaimed sonnet sequence; *Wine From These Grapes* (1934); *Conversation at Midnight* (1937), an unsuccessful attempt at an intellectual discourse involving masculine speakers; *Huntsman, What Quarry?* (1939), a return to personal lyricism; *Make Bright the Arrows* (1940); and *The Murder of Lidice* (1942); the latter two are verse commentaries on the contemporary political upheaval.

Critical judgment of Miss Millay's work remains divided. Its frequent romantic extravagance and inflated rhetoric is undeniable; many of her shorter poems, however, particularly the early ones, are models of lyric beauty and emotional restraint. Her *Letters* were edited by A. R. Macdougall (1952).

*See* E. Atkins, *Edna St. Vincent Millay and Her Times* (1936).

**MILLENNIUM,** literally (from Latin) a period of 1,000 years; commonly used of a period when, in the belief of some Christians, Jesus Christ will return and establish his kingdom on earth. Among early Christians the idea of millenarianism, or chiliasm (from the Greek *chilioi*, "a thousand"), was derived chiefly from Jewish eschatological expectations and usually implied the nearness of the triumph of Christians over the world; in later times it has often been used in support of minority groups in opposition to churches regarded as too closely identified with the world. Within the New Testament the existence of this doctrine has sometimes been inferred from an apparent allusion to the "kingdom of Christ" in I Cor. xv, 23–25, but it is clearly present only in Rev. xx. Other passages which speak of the establishment of the reign of God on earth are not clearly millennial, and in II Peter iii, 8 it is explicitly stated that "with the Lord one day is as a thousand years, and a thousand years as one day."

The more general use of the term to include expectations of material benefits to be enjoyed on earth in the near future means that a number of early Christian writers, especially those close to Jewish Christianity, can be called millenarians. Among such writers are the author of the Epistle of Barnabas (*see* Apostolic Fathers), Papias, Justin and Irenaeus, not to mention the Jewish-Christian Gnostic Cerinthus. Many Christians first became aware of the dangers of this kind of doctrine only with the rise of the movement known as Montanism (*q.v.*). The Montanists believed that the heavenly Jerusalem would soon be manifested in Phrygia and that their leader was the Paraclete promised in the Gospel of John. At the same time, more orthodox teachers continued to share a similar hope; Hippolytus tells of bishops in Syria and Pontus who led their flocks out into the desert to await Christ's coming (contrast Matt. xxiv, 26).

By the time of the triumph of the church in the reign of Constantine such hopes were on the wane. Eusebius in his *Church History* indicates that they are in process of fulfillment in the life of the church, and in describing Montanism he makes no mention of its millennial aspects. His older contemporary Victorinus wrote a millenarian commentary on the Apocalypse, but most manuscripts of the work have been interpolated in favour of more orthodox views. The great western theologian Augustine was a millenarian early in his career, but he came to recognize the error of such a view. At the Council of Ephesus (431) millenarian views were not condemned, but they were mentioned only to be ignored. In later times they arose sporadically when they could be used against the authority of the church; thus they flourished among spiritual enthusiasts during the middle ages and particularly at the time of the Reformation, when social and religious ferment worked together, especially among the various groups loosely denominated Anabaptist (*see* Anabaptists). The more conservative Reformers shared the Catholic view that these hopes were illusory. Like Augustine, they tended to speak of the coming of Christ as primarily past rather than future and to identify the Kingdom of God on earth with the church, even though such an identification was hardly ever regarded as complete.

In the history of religions such minority movements have not been uncommon. A conspicuous instance is provided by the group near Qumran by the Dead sea, which combined hostility toward the existing priesthood at Jerusalem with expectation of divine assistance in a coming "war of the Sons of Light against the Sons of Darkness" (*see* Dead Sea Scrolls). In the final battle, soon to take place, no prisoners would be taken; only the Sons of Light would survive in order to rule the world. There is a complete fusion of sociological and religious motifs. Both in Judaism and in Christianity, as well as in Islam, ideas of the millennium have flourished because of the strong emphasis on the future which is to be found in all these religions. The basic problem concerns the extent to which such ideas can be balanced by other aspects perhaps more central in the religions involved. (R. McQ. G.)

**Periods of Several Millennia.**—Though millenarianism is essentially a form of Judaeo-Christian eschatology, periods of one or more millennia have had special significance in other religions. According to Herodotus the ancient Egyptians believed that the human soul, after death, had to pass through various forms of incarnation for a period of 3,000 years; the statement is contradicted by the evidence of Egyptian texts. Empedocles reckoned the period of the soul's transmigration as "thrice 10,000 seasons." Plato in the *Phaedrus* set the period at 10,000 years, which the philosophic soul could reduce to 3,000. In the *Republic*, however, he says that the departed souls had to spend 1,000 years before returning to this world; Virgil expresses a similar belief in the *Aeneid*. In such estimates a millennium was probably used only as a convenient figure signifying an immense period of time. In Hindu astronomical speculation millennia were employed in a similar manner (*see* Chronology; *Hindu;* Hinduism: *Cosmology*). A chronological system was elaborated, according to which a *maha yuga* lasted 12,000 "years" (each "year" being one year of the gods and equaling 360 human years). In turn 1,000 *maha yugas* equaled one *kalpa*, which represented one day of Brahma. In Buddhism millennia form the basis of attempts to calculate the "incalculable" periods of cosmic evolution.

In Iran it was believed that the present world order would last for 12,000 years from the time of its creation (*see* Zoroastrianism: *Cosmology*). This period was divided into four periods of 3,000 years, each of which was characterized by a particular phase in the struggle between good and evil, personified respectively as Ormazd (Ohrmazd) and Ahriman. The antiquity of this chronological scheme can only be surmised; the earliest recorded reference (mentioning two periods of 3,000 years) is by Theopompus (4th century B.C.). The final period of 3,000 years is especially important for the comparative study of eschatology. According to the Zoroastrian work called the *Bundahishn* (Greater Iranian version; 9th century A.D., but embodying earlier material), each millennium in this period would be presided over by one of the three posthumous sons of Zoroaster, Oshetar, Oshetarmah and Saoshyans. The first two of these millennia constituted the prelude to the restoration of the world after the depredations of Ahriman and his evil forces; during this period all noxious animals, created by Ahriman, would be destroyed. The final millennium was to be ushered in by the virgin birth of Saoshyans (*i.e.*, the Saviour). The dead would then be raised to life and have to endure the ordeal of passing through molten metal, which would not harm the just but be a punishment and purification to the wicked. Finally the forces of evil were to be destroyed, and Ormazd would reconstitute the world according to his will.

The interrelations of this Persian eschatology and Judaeo-Christian eschatology still remain a problem for specialist research. Manichaean eschatology was certainly influenced by Persian ideas. (S. G. F. B.)

*See* also Apocalyptic Literature; Eschatology; Kingdom of God; Messiah. For the modern religious bodies that place em-

phasis on millenarianism, *see* ADVENTISM, JEHOVAH'S WITNESSES.

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**MILLER, ARTHUR** (1915– ), U.S. playwright, was born Oct. 17, 1915, in New York city and attended public schools there and then the University of Michigan. He began to write plays in college, but his first public success was with *Focus* (1945), a novel about anti-Semitism. Miller's first important play was *All My Sons* (1947), an Ibsenian drama about a manufacturer of shoddy war materials. *Death of a Salesman* (1949) won the Pulitzer prize in drama and became one of the two or three most famous American plays of its period. *The Crucible* (1953), about the Salem witch trials, was originally misinterpreted by critics as an allegorical version of the investigations that Sen. Joseph R. McCarthy was conducting at the time. In 1955 two short plays, *A View From the Bridge* and *A Memory of Two Mondays*, were staged on the same bill. In 1963 Miller's finest play, *After the Fall*, inaugurated the repertory theatre of the Lincoln Center in New York city. This play came closest to fulfilling Miller's expressed aim, "to bring to the stage the thickness, awareness and complexity of the novel." Miller also wrote a screenplay, *The Misfits* (1961), for his second wife, the actress Marilyn Monroe (1926–62). (R. G. St.)

**MILLER, DAVID HUNTER** (1875–1961), U.S. international lawyer and expert on treaties, was born in New York city on Jan. 2, 1875. Graduating from New York Law school, he practised in New York, 1911–29. Between 1917 and 1919 he served on the Inquiry (a body of experts who collected data for the Paris peace conference) conducted by Col. Edward M. House (*q.v.*), was legal adviser to the American commission to negotiate peace at Paris and collaborated in the drafting of the League covenant. Subsequently he published in limited edition *My Diary at the Conference of Paris, with Documents*, 21 vol. (1924–26). As an officer of the U.S. department of state, 1929–44, Miller headed the U.S. delegation to the 1930 Hague conference for the codification of international law and compiled *Treaties and Other International Acts of the United States of America*, 8 vol. (1931–48). Miller died in Washington, D.C., on July 21, 1961. (G. B. N.)

**MILLER, HENRY** (1891– ), U.S. writer, is best known as the author of *Tropic of Cancer* and *Tropic of Capricorn*, episodic narratives published in Paris in the 1930s, and because of their uninhibited relation of sexual experiences, banned in Great Britain and the United States until the 1960s. Miller's prose, frequently autobiographical, ranges from the earthy and colloquial to the lyric and surrealistic in language, and is notable for its candor and vitality.

Miller was born on Dec. 26, 1891, in New York City, and was brought up in Brooklyn. In 1924 he left his job with Western Union in New York to devote himself to writing. In 1930 he went to France, launching a decisive decade in his career. *Cancer* (published in 1934) is based on these years, while *Capricorn* (published in 1939) draws on the earlier New York phase.

Miller's visit to Greece in 1939 inspired his travel book *The Colossus of Maroussi* (1941). In 1940–41 he toured the United States extensively and wrote a sharply critical account of it, *The Air-Conditioned Nightmare* (1945). After settling in Big Sur on the California coast, he produced his *Rosy Crucifixion* trilogy, an ongoing autobiographical opus, and wrote prolifically, combining homely insights with metaphysical exhortations. The publication of the *Tropics* in the United States (*Cancer* in 1961, *Capricorn* in 1962) provoked a series of obscenity trials that culminated in a 1964 Supreme Court decision favourable to the author.

*See* Alfred Perles, *My Friend Henry Miller* (1956); George Wickes, ed., *Henry Miller and the Critics* (1963). (A. K. B.)

**MILLER, HUGH** (1802–1856), Scottish geologist and lay theologian remembered for his work on fossil fishes in the Cromarty region of Scotland and for his antipatronage campaign in the Presbyterian Church. He was born at Cromarty on Oct. 10, 1802, and his apprenticeship to a stonemason turned him toward practical geology. After early literary ventures and a period (1834–40) as a bank accountant in Cromarty, he went in 1840 to Edinburgh as editor of the newly founded *Witness*. This newspaper, which presented the views of those opposed to patronage in the Church of Scotland, gained a wide reputation through Miller's leading articles. Miller also wrote for it a brilliant geological series, part of which, published in book form as *The Old Red Sandstone* (1841), described his discoveries in the district of Cromarty. Of his remaining works on geology, *Footprints of the Creator* (1849) was the most original. It recorded his reconstruction of the extinct types of fishes which he had discovered in the Old Red Sandstone and contended, on theological grounds, that their perfection disproved the doctrine of evolutionary succession. Miller died at Edinburgh on Dec. 23, 1856.

*See The Centenary of Hugh Miller* (1902). (C. E. T.)

**MILLER, JOAQUIN** (CINCINNATUS HINER [HEINE] MILLER) (1837–1913), U.S. poet who made a significant early attempt to celebrate the west. He was born near Liberty, Ind., on Sept. 8, 1837. He went west with his family and led a picaresque early life in California among miners, gamblers and Indians. He attended Columbia college (Eugene, Ore.) briefly in 1858–59 and was admitted to the bar in 1860 in Oregon. In 1862 he established a pony express; in 1863 he bought the *Eugene Democratic Register*. For it he wrote an article defending the Mexican brigand Joaquin Murietta, whose given name he later used as an author; he also presumably adopted the more "poetic" name "Heine" for the same purpose. He became a county judge in Canyon City, Ore., in 1866. His first volumes of poems, *Specimens* (1868) and *Joaquin et al.* (1869), attracted little attention.

In 1870 he traveled to England, where his exotic manners and flamboyant western costume made him a great favourite with the literati. *Pacific Poems* (1871) was privately printed there. *Songs of the Sierras* (1871), upon which his reputation mainly rests, was loudly acclaimed in England, while generally derided in the United States for its excessive romanticism. Productions of succeeding years included *Songs of the Sunlands* (1873), *The Ship in the Desert* (1875), *The Baroness of New York* (1877), *Songs of Italy* (1878), *Memorie and Rime* (1884) and the *Complete Poetical Works* (1897). In 1886 he settled in Oakland, Calif., where he died Feb. 17, 1913.

Whitmanesque in temper, his work is frequently bombastic and artificial. Because of his fondness for Byronic posturings, his autobiographical writings are untrustworthy.

*See* M. S. Peterson, *Joaquin Miller, Literary Frontiersman* (1937); M. Marberry, *Splendid Poseur: Joaquin Miller, American Poet* (1953).

**MILLER, JOE** (JOSEPH or JOSIAS) (1684–1738), English actor, first appeared in the cast of Sir Robert Howard's *Committee* at Drury Lane in 1709 as Teague. Trinculo in *The Tempest*, the First Grave-digger in *Hamlet* and Marplot in *The Busybody* were among his many favourite parts. He died on Aug. 15, 1738. He is remembered chiefly for the association of his name with a book brought out after his death by John Mottley (1692–1750). Called *Joe Miller's Jests, or the Wit's Vade Mecum* (1739), it was a collection of contemporary and ancient coarse witticisms, only three of which were told of Miller. Any timeworn jest came, somewhat unjustly, to be called "a Joe Miller."

**MILLER, SAMUEL FREEMAN** (1816–1890), associate justice of the U.S. supreme court, was foremost in sustaining measures taken for the preservation of the union—notably in upholding the validity of the legal tender legislation. Born at Richmond, in central Kentucky, on April 5, 1816, after a common school education he studied medicine at Transylvania university at Lexington, and practised at Barbourville, near the Cumberland gap, in southern Kentucky.

While caring for patients he read law, and in 1847 was admitted to the bar of Knox county. When the movement for gradual emancipation of slaves was lost in the Kentucky constitutional convention of 1849, Miller decided to seek a home in free territory, and in 1850 moved with his family to Keokuk, Ia. He soon be-

came a leader in the Iowa bar and in the organization of the Republican party in that state. In 1862, with the very active support of the Iowa delegation in congress, he was appointed by President Lincoln to the supreme court. Throughout his 28 years of service he was assigned to the 8th circuit, extending from the Mississippi river to Colorado. His work in first instance, as he coped with the practical problems of this circuit, was marked by zeal for justice and impatience with mere technicality.

Miller spoke for the majority of the court in the Slaughterhouse cases in which, in 1873, the court first construed the 14th amendment. The amendment was first invoked to resist a monopoly on butchering granted by the carpetbag (*q.v.*) legislature of Louisiana. In holding that no federal right had been abridged by this malodorous legislation, Miller stressed what a distortion it would work in the federal system if the amendment were so read as to make the court "a perpetual censor upon all legislation of the States." Ever a believer in effective and responsible government, he was loath to see the court interpose even at moments when legislative power seemed lost to reason. His opinion in *Kilbourn v. Thompson*, in 1880, is, however, the classic rebuke to vagrant congressional investigation. He set himself, unavailingly, against a strong judicial movement to sustain public grants to railroad corporations, notwithstanding well-founded contentions that the grant was unconstitutional.

A bold and self-confident magistrate who moved directly to the controlling issues, a statesman whose judgments were infused with a strong sense of public policy, Justice Miller remains one of the court's heroic figures.

He died in Washington, D.C., on Oct. 13, 1890.

*See* Charles Fairman, *Mr. Justice Miller and the Supreme Court, 1862–1890* (1939). (C. Fs.)

**MILLER, WILLIAM** (1782–1849), U.S. religious enthusiast, leader of a movement called Millerism that sought to revive belief in the bodily, imminent Advent of Christ, was born Feb. 15, 1782, at Pittsfield, Mass. In 1786 his family moved to Low Hampton, N.Y. Miller was a farmer, but also held such offices as deputy sheriff and justice of the peace. In the War of 1812 he served as a captain of the 30th infantry. After years of Bible study he began to preach in 1831 that the present world would end "about the year 1843." He based this belief primarily on Dan. viii, 13, 14. He published a 64-page pamphlet in 1833, and a book of lectures in 1836, the first of many publications. Principal organs of the Millerite movement were the *Signs of the Times* (Boston) and the *Midnight Cry* (New York). Miller estimated that between 50,000 and 100,000 believed in his views. When 1843 passed, some of his associates set Oct. 22, 1844, as the date of the second coming. This date brought the movement to a sharp climax. There is no historical foundation for stories that the Millerites engaged in such fanatical excesses as ascending hills, housetops and trees in ascension robes. The last general conference met at Albany, N.Y., April 1845. Belief in the imminence of the Advent was restated, but no date was set and no church organization created. Miller died at Low Hampton, Dec. 20, 1849.

There are two principal Adventist bodies today—the Advent Christian church, organized in 1861, and the much larger body of Seventh-day Adventists, organized in 1863—and several small Adventist bodies. *See* also ADVENTISM.

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**MILLER, WILLIAM EDWARD** (1914– ), U.S. political figure, was born in Lockport, N.Y., on March 22, 1914. Following his graduation from the University of Notre Dame, Notre Dame, Ind. (1935), and Albany (N.Y.) Law school (1938), he practised law in Lockport and in 1940 was appointed U.S. commissioner for the western district of New York. In 1942 he entered the U.S. army and, after serving with the military intelligence branch, attended officer candidate school. Assigned as a first lieutenant to the war crimes section of the judge advocate general's office in 1945, he served as assistant prosecutor at the Nürnberg war crimes trials. After his return to civilian life, Miller served as assistant district attorney and district attorney of Niagara county, N.Y., and in 1950 was elected to the U.S. house of representatives. Reelected six times, he became a spokesman for the conservative wing of the Republican party and was known for his effective, often biting, criticism of the Democratic opposition. As chairman of the national Republican congressional committee in 1960, Miller played an important part in the campaigns of that year which resulted in an increased Republican house membership despite the election of a Democratic president. In 1961 Miller was named chairman of the Republican national committee and in 1964 he became the Republican vice-presidential nominee on the ticket headed by Sen. Barry M. Goldwater. After a campaign, described as one of the bitterest in modern U.S. history, the Goldwater-Miller ticket was overwhelmingly defeated.

**MILLERAND, ALEXANDRE** (1859–1943), French lawyer, politician and president of the republic, was born in Paris on Feb. 10, 1859. He was educated for the bar, and made his reputation by his defense of the instigators of the strike at Decazeville in 1883. He was elected to the chamber of deputies for the *département* of the Seine in 1885 as a Socialist. He became chief of the Socialist left, which then mustered 60 members, and edited until 1896 their organ in the press, *La Petite République*. When in June 1899 he entered Waldeck-Rousseau's cabinet of "republican defense" as minister of commerce he limited himself to practical reforms, devoting his attention to the improvement of the mercantile marine, to the development of trade, of technical education, of the postal system and to the amelioration of the conditions of labour. He was bitterly denounced by many Socialists as a traitor, for agreeing to participate in a nonsocialist government along with men hated by the workers.

He was a fierce opponent of the Combes ministry, which succeeded that of Waldeck-Rousseau, for he objected to its narrow anticlericalism. In July 1909 he became minister of public works in Briand's first cabinet, his principal achievement being the reorganization of the state railways. Together with Briand he took strong measures to suppress the railway strike of Oct. 1910. In Jan. 1912 he was appointed minister of war under Raymond Poincaré. He reorganized the higher command, and gave a definite status to military aeronautics for the first time. On Aug. 25, 1914, he was invited by Viviani to become minister of war. Accused, however, of being too slow in providing the necessary heavy artillery, he resigned with the other members of the Viviani cabinet at the end of Oct. 1915. In 1918 he was elected a member of the Académie des Sciences Morales et Politiques.

On the resignation of Clemenceau, Jan. 18, 1920, Millerand formed a cabinet, and became prime minister and minister for foreign affairs. His main activities were in regard to the application of the treaty of Versailles. He was present at the inter-Allied conferences at San Remo and Spa in 1920. In May 1920 he frustrated attempts to organize revolutionary strikes. He did much to supply matériel to Poland during the Polish-Soviet war.

In Sept. 1920 Deschanel, president of the republic, was forced by ill-health to resign. Millerand was elected as his successor. During his candidature he made no secret of his wish to strengthen the power of the president by a revision of the constitution. Millerand's conception of the role of president of the republic brought him into collision with the Radical and Socialist majority, which, under the name of the *cartel des gauches*, was successful in the elections of May 11, 1924. He was violently attacked by the Radical and Socialist press, which accused him of having exceeded his powers by intervening in the party struggle, and called for his resignation. Herriot, the leader of the *cartel des gauches*, when asked by Millerand to succeed Poincaré as premier, announced that he would do so only on Millerand's resignation.

Millerand therefore invited the senator François-Marsal, who had been his minister of finance in 1920, to form a cabinet. His government, however, was immediately defeated; and Millerand tendered his resignation.

In Jan. 1927, at the senatorial elections in the *département* of the Seine, Millerand was defeated. Several months later he stood for a by-election in the *département* of the Orne, in Normandy. He was elected and resumed his place in the senate. He remained a controversial figure in French politics, too independent in mind

to please any party. Among his published works are *Le Socialisme réformiste* (1903) and *Pour la défense nationale* (1913). He died at Versailles, France, April 7, 1943.

*See* R. Persil, *A. Millerand* (1949). (D. Ts.)

**MILLERITE,** a mineral consisting of nickel sulfide, NiS. It is a minor ore of nickel. Millerite crystals belong to the rhombohedral system and have the form of slender needles arranged in divergent groups or of delicate fibres loosely matted together ("hair-pyrites"). The colour is brass yellow and the lustre metallic. Millerite was named for mineralogist W. H. Miller.

**MILLER'S-THUMB,** any of several small fishes of the genus *Cottus*, abundant in rivers and lakes of northern and central Europe and North America where there is clear water and gravelly bottom. Unlike most members of the sculpin family (Cottidae), miller's-thumbs are confined to fresh water. The names bullhead (more properly applied to certain catfishes) and sculpin (usually given to marine cottids) are often used for miller's-thumbs. The head is broad and flat; the body rounded and scaleless with large pectoral and narrow pelvic fins, and two dorsal fins. The gill cover is armed with a spine.

The European species (*C. gobio*) is usually three to five inches long. The common species of eastern North America, *C. bairdi*, *C. carolinae* and *C. cognatus*, also called mottled, banded and slimy sculpins, respectively, seldom exceed four inches. The prey consists of small aquatic animals, upon which the fish pounces from some refuge. The female deposits her eggs in a cavity under a stone, and the male watches and defends the eggs until the young are hatched. (C. Hu.)

**MILLES, CARL** (originally Vilhelm Carl Emil Andersson) (1875–1955), Swedish-U.S. sculptor, designer of decorative fountains and memorial monuments in Sweden and the United States, was born in Uppsala, Swed., June 23, 1875.

In 1902, during student years in Paris, Milles won recognition through the competition for the Sten Sture monument at Uppsala (completed 1925). His style, at first impressionistic under Auguste Rodin's influence, became more abrupt and formal under successive influences of medieval art and early Greek art, and later showed more fluent patterns within individual figures and among the parts of his elaborate compositions. Milles worked in clay (for casting into bronze), stone and wood. His first major fountain, "Europa" in Halmstad, Swed. (1926), has the elements of spacious design, subtle water effects and inventive figure types (such as the fusion of classical triton or faun with Nordic goblin or troll) which also characterize his "Orpheus" fountain in Stockholm (1936) and the "Meeting of the Waters" in St. Louis, Mo. (1940). Milles' reputation spread with exhibitions at the Tate gallery, London (1926–27), and the City Art museum, St. Louis (1931). In 1931 he became head of the department of sculpture at Cranbrook Academy of Art, Bloomfield Hills, Mich. He became a U.S. citizen in 1945.

CARL MILLES' FOUNTAIN "EUROPA AND THE BULL," MILLES VILLA, LIDINGÖ, NEAR STOCKHOLM

Milles' works were collected at Cranbrook, his home for 20 years, and at the Milles villa, now a museum, in Lidingo, near Stockholm. Stockholm has over 20 Milles monuments, and notable examples of his work are in Detroit, Mich., Chicago, Ill., St. Paul, Minn., Harrisburg, Pa., Falls Church, Va., Wilmington, Del., and New York city. His "Agnippe" fountain was set up in the New York Metropolitan Museum of Art shortly after his death at Lidingo on Sept. 19, 1955.

*See* Meyric R. Rogers, *Carl Milles, an Appreciation of His Work* (1940). (Ja. W. F.)

**MILLET, FRANCIS DAVIS** (1846–1912), U.S. painter, illustrator and writer, was born at Mattapoisett, Mass., on Nov. 3, 1846. He was a drummer boy with the Union forces in the Civil War, graduated from Harvard college in 1869, and in 1871 entered the Royal Academy of Fine Arts, Antwerp. During the Russo-Turkish War of 1877–78 he was a correspondent for several newspapers, and was decorated twice by the Russian government. On his return he was made a member from the United States of the international art jury at the Paris exposition of 1878. He was director of decorations at the Columbian exposition, Chicago, 1893, and in 1898 went to Manila as war correspondent. Millet was a passenger on the "Titanic" when it sank on April 15, 1912; he was last seen urging women and children into lifeboats.

In 1850 Millet became a member of the Society of American Artists, and in 1885 was elected to the National Academy of Design, New York. He was a trustee of the Metropolitan Museum of Art, secretary of the American Academy in Rome and vice-chairman of the Fine Arts committee. His work as a decorative artist may be seen at Trinity church, Boston; the Bank of Pittsburgh, and the capitol at St. Paul, Minn. His pictures are in many public collections, among them being "A Cosy Corner" in the Metropolitan Museum of Art, New York, and "Between Two Fires" in the Tate gallery, London. Millet also wrote essays and short stories, and an English version of Tolstoi's *Sebastopol* (1887). Among his publications are *The Danube* (1891), *Capillary Crime and Other Stories* (1892) and *Expedition to the Philippines* (1899).

**MILLET, JEAN FRANÇOIS** (c. 1642–1679), commonly called Francisque, was born at Antwerp about 1642. He is generally classed among the painters of Flanders because of the accident of his birth, but his father was a Frenchman, who, while on service with the prince of Condé in Antwerp, apprenticed his son to a painter named Laurent. With Laurent Francisque left Antwerp for Paris, and there settled in 1660 after marrying his master's daughter. He was received a member of the Academy of Painting at Paris in 1673, and after gaining consideration as an imitator of the Poussins he died in 1679, bequeathing his art and some of his talents to one of his sons.

Francisque's paintings of Italian and Arcadian scenery were graceful and effective, although as he had not traveled his impressions of them were gained at secondhand. Twelve of his most important landscapes in the Tuileries were destroyed by fire; and though many of his pieces may still be found catalogued, a great number remain unknown and unacknowledged.

**MILLET, JEAN FRANÇOIS** (1814–1875), the French peasant who became a celebrated Barbizon painter and etcher, was born at Gruchy, near Gréville (La Manche) on Oct. 4, 1814. He spent his youth working on the land, but by the age of 19 he was

EWING GALLOWAY

"THE GLEANERS" BY JEAN FRANÇOIS MILLET. IN THE LOUVRE, PARIS

studying under Mouchel (real name Bon Dumoucel), a former pupil of J. L. David. These studies were interrupted by the death of his father in 1835, but in the spring of 1836 Millet was again at Cherbourg, studying now with J. C. Langlois (a pupil of A. J. Gros), who at the end of the year persuaded the authorities to finance Millet's further studies. In Jan. 1837, Millet arrived in Paris with an allowance of 1,000 francs and eventually enrolled in the studio of Paul Delaroche, where he seems to have remained until 1839. It was here that Millet came into contact with P. de Marolle, who introduced him to the works of La Fontaine and J. B. L. Gresset, which provided subjects for "Le Lutrin Vivant" and "Vert-Vert."

After the rejection of one of his entries for the Salon of 1840, Millet returned to Cherbourg where he remained during most of 1841. Here he painted a number of portraits including those of M. and Mme. Feuardent and that of his first wife, Pauline Virginie, whom he married in Nov. 1841. Rejected at the Salon of 1842, Millet achieved his first success in 1844 with "The Milkmaid" and a large pastel, "The Riding Lesson." The pastel shows the type of work which was to occupy a large part of his production during the 1840s, and which has a sensual character somewhat reminiscent of N. V. Diaz, J. H. Fragonard and Correggio. The "Offering to Pan" (1845) and "Oedipus Taken From the Tree" (1847) are important examples of this type. With the death of his first wife in April 1844, Millet again returned to Cherbourg, remaining in that area until 1845. Among portraits painted at this time are the "Antoinette Hébert" and the "Officer of Marine." The technical variety of his work up to this time indicates the range of Millet's interests and enthusiasms—Italian primitives, Michelangelo, Poussin, Ribera, Titian and Rembrandt. From 1845 dates Millet's union with Catherine Lemaire, a union which was legalized in 1853.

The peasant subjects, which from the early 1850s were to be Millet's principal concern, made their first important appearance at the Salon of 1848 with "The Winnower." The first version, later destroyed by fire, was purchased by A. A. Ledru-Rollin, who also secured for Millet a state commission for which the artist painted "The Haymakers at Rest" (1848–49, Louvre). After the Salon of 1849 ("The Seated Peasant Girl," Boston), Millet left Paris for Barbizon, a small hamlet in the forest of Fontainebleau. Barbizon was to become Millet's home for the remainder of his life; it was there that he died on Jan. 20, 1875. The Salon of 1850 included "The Sower" and "The Binders" and it was these paintings which first roused hostile critics to accuse Millet of being a socialist. This charge Millet refuted, but in a letter of Feb. 1851, he admits, "at the risk of appearing even more socialist, that it is the human, the frankly human side which moves me most in art." The same letter indicates a wish to have done with the "Nudes and Mythologies" for which he had acquired a reputation, but during the course of 1851 such works, if not produced, were still being offered for sale by Millet's friend and biographer, A. Sensier. The Salon of 1853 included "The Reapers" (now at Boston) which is probably identical with a "Ruth and Boaz," mentioned by Millet in a letter of 1851. This doubt concerning the real subject of the work may be indicative of Millet's idealistic attitude toward his subjects and his desire "to make the trivial serve to express the sublime." Major works of the following years, conceived in much the same spirit, are "A Peasant Grafting a Tree" (1855), "The Gleaners" (1857), "The Angelus" and "Death and the Woodcutter" (1858–59), "Sheep Shearing" (1860), "Sheepfold by Moonlight" (1861), "The Potato Planters" (1862) and "The Man With a Hoe" (1863). This last painting again raised the accusation that Millet was a socialist, and letters of the period defending Millet's position underline the fundamentally classical nature of his approach to painting.

In 1860, Millet entered into contract with two picture dealers, Arthur Stevens and Ennemond Blanc. The agreement, which was to provide him with a fixed income for three years, did not work out very satisfactorily. It did, however, ensure a regular showing of those works which had come into the possession of Blanc. By the middle of the 1860s, Millet's work was beginning to be in demand; official recognition came in 1868, after nine important paintings had been shown at the Exposition of the previous year. Important collections of Millet's pictures are to be found in the Museum of Fine Arts, Boston (68 pastels and paintings) and in the Louvre (23 pictures).

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(R. A. Dv.)

**MILLET** is the name applied to various small-seeded grasses that were probably first cultivated in Asia or Africa. All are annual, warm-season plants with small edible seeds. Important millets are pearl or cattail millet, called bajri in India (*Pennisetum glaucum*), foxtail millet (*Setaria* [*Chaetochla*] *italica*), proso, common or broomcorn millet (*Panicum miliaceum*), and finger, or coracan millet, also called ragi, (*Eleusine coracana*). Others include Japanese millet (*Echinochloa crus-galli* var. *frumentacea*), koda or ditch millet (*Paspalum scrobiculatum*), browntop (*Panicum ramosum*) and little millet (*Panicum miliare*). The finger, koda and little millets are not grown in North America. Sorghum (*q.v.*) is erroneously called millet.

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FOXTAIL MILLET (SETARIA ITALICA)

With the exception of pearl millet, these grasses range from one to four feet in height. The heads of pearl and foxtail millets are rather dense cylindrical spikes; those of finger and koda are racemes; and other millets bear panicles. Flowers are largely cross-pollinated. All seeds except pearl millet remain enclosed in hulls after threshing. Hulled seeds are mostly creamy white.

Pearl millet, a popular food crop in India and Africa, is well suited to soils of low fertility and limited moisture. Its stalks are five to ten feet tall and up to one inch or more in thickness. It provides abundant pasture and hay in the southeast U.S.

Proso, grown chiefly in Soviet Russia, Manchuria and China, has hairy stems and compact to loose panicles. The hulls on the seeds are red, light to very dark brown, gray, greenish-gray, yellow or white. The leading U.S. varieties are Yellow Manitoba, Turghai and Early Fortune. Proso ripens 60 to 80 days after sowing. The grain is used in birdseed and chick feed mixtures and as livestock feed in the United States, and as food in Asia and eastern Europe.

Foxtail varieties, including German or Golden, Common, Hungarian, Siberian, White Wonder and Kursk, have yellow, orange, green or gray hulls. Foxtail millets are grown for hay in North America and western Europe, but the small pointed seeds are important foods in China and other Asiatic countries.

Finger millet is an important food grain in southern Asia and parts of Africa. Japanese millet is grown chiefly for hay in Japan, the United States and some other countries. The little millet is grown for food chiefly in India. Browntop is grown in the southeastern United States for hay, pasture or feed for game birds.

Millets are sown in drills or cultivated rows in late spring or early summer after the weather is warm. The grain is harvested by the same methods used for wheat, barley or rice. Hulled millet grains, either whole or cracked, are cooked into porridge called *kasha* in Russia and Poland. Some grain is ground and made into unleavened breads. The composition of millet grain is similar to that of wheat, maize (corn) or rice.

About 26,000,000 tons of millet are produced annually, chiefly in China, India, Manchuria, U.S.S.R., countries of western Africa and Korea. In these countries the millets are used chiefly as food grains, but in western Europe and the United States millets are grown mostly for hay and pasture.

*See* also W. A. Wheeler and D. D. Hill, *Grassland Seeds* (1957); A. S. Hitchcock, *Manual of the Grasses of the United States*, U.S. Dept. Agri. Misc. Pub. 200 (1950). (J. H. Mx., X.)

**MILL HILL FATHERS** (Societas Missionariorum S. Josephi de Mill Hill), a Roman Catholic society of common life founded by Herbert Vaughan at Mill Hill, London, in 1866. The priests, all British or Dutch, serving as missionaries chiefly in Africa and southeast Asia, numbered about 1,000 in the 1960s. *See* Orders and Congregations, Religious.

**MILLIKAN, ROBERT ANDREWS** (1868–1953), U.S. physicist, recipient of the 1923 Nobel prize in physics for his study of the elementary electrical charge and the photoelectric effect, was born at Morrison, Ill., on March 22, 1868. He graduated from Oberlin college (1891) and obtained his doctorate at Columbia university in 1895; later he was in residence at the universities of Berlin and Göttingen. In 1896 he was appointed to an assistantship in physics at The University of Chicago, where he became a full professor in 1910.

Millikan's earliest outstanding investigation was an accurate determination of the charge $\epsilon$ carried by an electron, followed by evidence that this charge was not merely a statistical mean but a definite constant. In this investigation he improved upon the method of the falling cloud (already employed, in several forms, at the Cavendish laboratory at Cambridge) by substituting for the indefinite cloud a single falling drop whose motion in the gravitational field could be easily measured and whose motion in the electrical field could be controlled. For this work Millikan was awarded the Comstock prize by the National Academy of Sciences in 1913; and in 1915 he was elected to membership in the academy. During the year 1916 he took up with the same skill the experimental verification of Einstein's well-known photoelectric equation $\frac{1}{2}mv^2 = Ve = h\nu - p$, and the evaluation of Planck's constant $h$. The result was a thorough confirmation of Einstein's equation and a value of $6.57 \times 10^{-27}$ for Planck's constant. (*See* Electron; Photoelectricity.)

In 1921 he resigned his chair at The University of Chicago to accept the directorship of the Norman Bridge Laboratory of Physics of the California Institute of Technology, at Pasadena, and became chairman of the executive council of the institute, a post he held with marked success until his retirement in 1945. He represented the United States for ten years (1922–32) on the League of Nations committee for intellectual co-operation and served as chairman of the board of directors of the Huntington Library and Art gallery, San Marino, Calif.

Millikan's research at the California Institute of Technology considered the cosmic rays (*q.v.*) ranging from the stratosphere to the bottoms of deep melted-snow lakes.

Following many honours—degrees, prizes, medals—that came to him during half a century of professional life, he died Dec. 19, 1953, in San Marino, Calif.

Millikan's publications include *The Electron*, 2nd ed. (1924, abridged ed. by J. W. M. Du Mond, 1963), *A First Course in Physics for Colleges* (with H. G. Gale and C. W. Edwards; 1925), *Evolution in Science and Religion* (1927), *Time, Matter, and Values* (1932), *Cosmic Rays* (1939), *Autobiography* (1950). *See* also references under "Millikan, Robert Andrews" in the Index.

*See* L. A. Du Bridge and P. S. Epstein, "Robert Andrews Millikan," in *National Academy of Sciences: Biographical Memoirs* (1959). (H. Cw., X.)

**MILLIN, SARAH GERTRUDE** (née Liebson) (1889– ), South African writer, whose most outstanding novels, concerned with the problems of South African life, are remarkable for impartiality, vividness and clarity of style. Born of Jewish parentage in Lithuania, she was taken to South Africa as a baby. Her childhood on the diamond fields at Kimberley and on the river diggings at Barkly West, among the white, Coloured and black community, provided the background for much of her writing. In 1912 she married Philip Millin, who became one of South Africa's most distinguished supreme court judges, and thereafter her home was in Johannesburg.

Her first novel, *The Dark River* (1920), was set around Barkly West. Others followed, but it was *God's Stepchildren* (1924), dealing with the half-caste Coloured community, that made her famous. With *Mary Glenn* (1925), a study of a mother's reaction to her child's disappearance, she became recognized as one of the leading modern novelists in the English language, with her nervous, sharp, vivid, often almost staccato, style. *The South Africans* (1926; revised as *The People of South Africa*, 1950), a fair and realistic account of the mixed races and cultures of her country, was a venture in a new direction. Her biography of Cecil Rhodes (1933) was a work of great power, though criticized by those who knew him. For her life of Gen. J. C. Smuts (1936) she had access to private papers, but it suffered from appearing before his dramatic closing years. In some novels she used events in South African history; *e.g.*, *The Coming of the Lord* (1928), about a black "prophet" in the eastern Cape; and *King of the Bastards* (1950), on the life of the white chieftain Coenraad Buys. *Men on a Voyage* (1930) is a collection of essays, and a series of impressive war diaries (1944–48) was inspired by the sufferings of mankind in general and of the Jewish people in particular. She wrote two autobiographical books, *The Night Is Long* (1941) and *The Measure of My Days* (1955).

*See* J. P. L. Snyman, *The Works of Sarah Gertrude Millin* (1955). (Ed. R.)

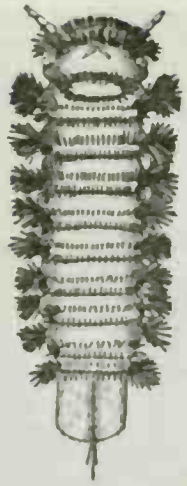
**MILLING:** *see* Flour.

**MILLING MACHINE:** *see* Machine Tools.

**MILLIPEDE,** a common name for a group of many-legged, air-breathing arthropods having cylindrical segmented bodies and now recognized as a distinct class, Diplopoda. They were formerly placed as an order or subclass under Myriapoda (*q.v.*) until accumulated evidence made it impossible to regard the latter as a homogeneous or wholly natural assemblage. Millipedes, many of which are brightly coloured, are worldwide in distribution, their numbers, species and sizes being greatest in the tropics and decreasing notably toward the polar regions. Geologically they were among the most ancient of land animals. Millipedes, or forms closely related to them, occurred in the swamps of Carboniferous times, some of them one foot in length and probably amphibious. Fossils of other forms have been found in rocks of Silurian age.

## STRUCTURE AND FUNCTION

**Body Form.**—The head segment is as distinct as it is in insects, whereas the remaining segments follow each other in rather monotonous succession, to form a continuous trunk or body. The name Diplopoda is derived from the fact that most of the apparent segments of the body bear two pairs of legs resulting from a complete or partial fusing of the primary segments in couples, each couple having a single dorsal plate (tergite) while retaining two sterna. One or two of the posterior (caudal) segments and usually four of the most anterior segments remain single. Of these four, three bear only a single pair of legs, while the other—usually the



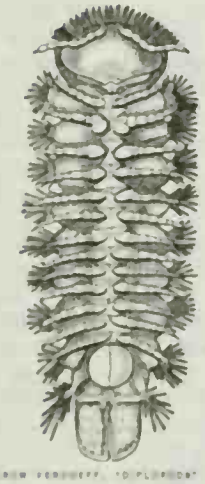


FIG 1.—POLYXENUS LAGURUS DORSAL AND VENTRAL VIEWS

first—remains legless. In some forms the number of segments in the body is invariable. Thus in the large order Polydesmida hundreds of species invariably have 20 segments, though in some this number holds only for the female, the male having 19. In millipedes consisting of more than 32 segments the number is variable not only from group to group and from species to species but also to a certain extent within a species itself. The number of segments approaches 200. Millipedes vary in length from about 2 mm. to almost 300 mm.; the width ranges up to 50 mm., as in some of the family Sphaerotheridae.

The often cylindrical body of millipedes may be modified to hemicylindrical or may even appear more flattened through a lateral extension of the segments. Millipedes, when disturbed, generally curve the body into a spiral or, in the broader forms, into a ball. Although in rare cases (*e.g.*, *Polyxenus*) the body is soft, in most species it is covered by a crustaceous shell or armour, the skin (integument) consisting of a strong base of chitin stiffened by a rich deposit of lime salts. Millipedes, like many other arthropods, grow between molts; as each old integument is discarded the new soft one is exposed. Since the animal is particularly vulnerable at this time it usually retires to a concealed nest or retreat.

**Stink Glands.**—With the exception of the crustaceous integument, stink glands comprise the only protection of most millipedes. These glands discharge their product through pores located along the sides of the body. The secretion is sometimes exuded as a gas, but more frequently as a liquid which may be colourless or may range from white to yellow, brown or red. In composition it varies considerably from group to group but in many common forms has been found to contain hydrocyanic acid, iodine and quinone. It has a pungent odour and is toxic enough to kill certain insects. Injury to the human skin may result from accidental contact, as when the animals find their way into bedding or clothing. The secretion is extruded when the millipede is disturbed, especially when it is in the process of rolling up, at which time the secretion may be squirted a considerable distance.

**Sense Organs.**—The head of millipedes bears a pair of relatively short antennae, each composed of seven or eight sections of which the terminal one bears four or more sensory cones. The eyes in most forms are composed of one or many simple ocelli on each side but they may be absent, as in the large order Polydesmida. A pair of mandibles are present. These are typically fitted for biting or chewing and have a terminal lobe with combs used in scraping off the soft portion of food tissues. Only one pair of maxillae are developed, the first pair in adults being absent or represented merely by rudiments. The second pair of maxillae form a large, complicated plate termed the gnathochilarium, which varies much in detail in different groups. This plate is generally accepted as homologous with the labium of insects, but is more highly evolved. Poison jaws, characteristic of centipedes, are never present.

FIG 2.—GLOMERIDESMUS MEXICANUS

**Respiratory and Circulatory Systems.**—Millipedes breathe by means of tracheae, one pair on each segment bearing one pair of legs, and two pairs on each fused double segment. The opening (stigma) of each trachea lies in the corresponding sternum. Each stigma opens into a pocket from which branches proceed. Each

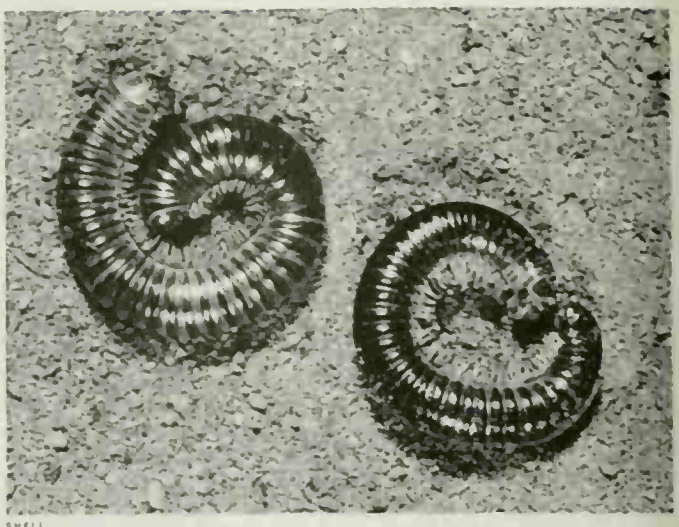


FIG. 3.—BLACK MILLIPEDES (TACHYPODOIULUS NIGER)

tracheal system is independent and shows no fusion (anastomosis), in this respect contrasting with the systems of insects and centipedes. The alimentary canal is a short, almost straight tube, which at most shows only an S-shaped flexure posteriorly. The canal has three divisions: a narrow foregut (esophagus), a thicker midgut and a narrow hindgut into which open two or four Malpighian tubules. Salivary glands open into the mouth. The heart is a tube running lengthwise above the alimentary canal. The lateral openings into the heart (ostia) occur in double pairs in each double segment. The nervous system consists of a ventral nerve cord, which has ganglionic swellings in each segment—two pairs of them in each double segment. In the head the nerve cord is joined by a ring with the small brain lying above the esophagus. The paired reproductive organs lie between the intestine and the ventral nerve cord, their ducts opening through the coxae of either the second legs or those directly behind.

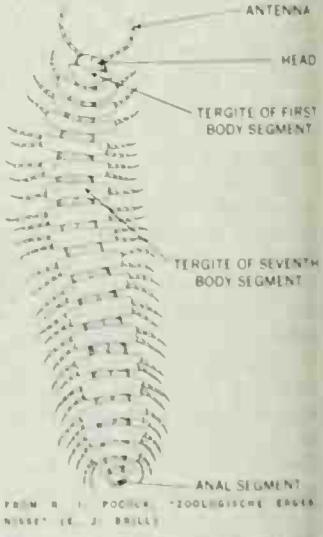
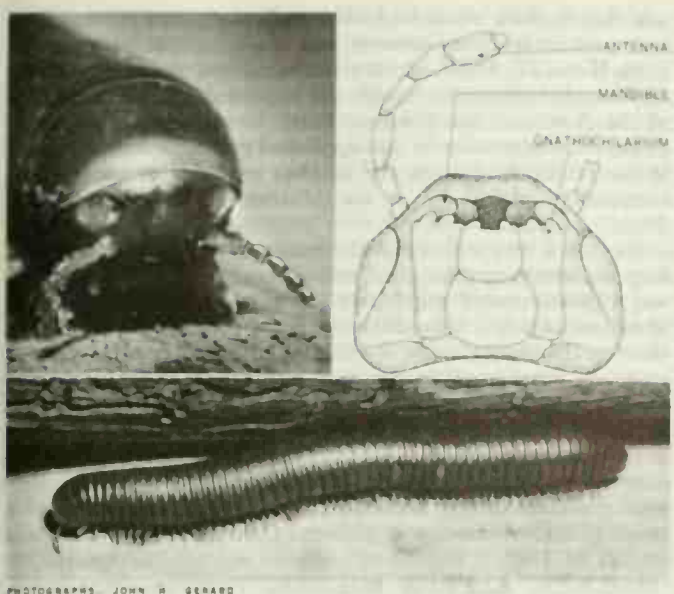



FIG 4.—PLATYRHACUS MIRANDUS A SUMATRAN SPECIES OF POLYDESMIDAE, SHOWING THE FORM CHARACTERISTIC OF THE ORDER POLYDESMOIDA

## NATURAL HISTORY AND REPRODUCTION

**Habitat.**—In contrast with the centipedes, which are carnivorous, the millipedes are inoffensive creatures living primarily upon decaying vegetable—or, rarely, animal—matter. A few forms feed upon the rootlets or other delicate tissues of living plants, sometimes damaging vegetable crops. They live in damp localities under decaying logs and leaves, and in dry seasons may be found at considerable depths in the soil where they have followed the retreating moisture. In comparison with other ground-dwelling animals such as beetles and spiders, millipedes occur only sparsely in a given area. Occasionally, however, they appear suddenly and in great numbers—for some reason not fully understood—often migrating in swarms, entering houses and becoming a nuisance (because of their crushed bodies) on roads and railroad tracks. Generally, millipedes are subject to factors of isolation; as a result they are among the most useful animals in studies of geographical distribution.

**Life Cycle.**—The eggs of millipedes are most commonly laid below the surface of the ground in clumps of from 25 to 50, the clumps being enclosed in an earthy capsule or sometimes, as in *Polydesmus*, in a capsule made of pellets of excrement. The fe-




PHOTOGRAPHS, JOHN H. GERARD

FIG. 5.—(TOP LEFT) CLOSE-UP OF HEAD OF NARCEUS SHOWING SIMPLE EYES PRESENT IN SMALL AGGREGATES. (TOP RIGHT) HEAD OF JULUS FROM BELOW. (BOTTOM) NARCEUS MILLIPEDE AT APPROXIMATELY ACTUAL SIZE

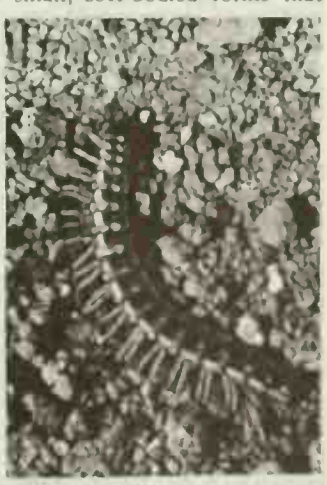
male often remains with the eggs until the young hatch out. In the course of development the embryo usually leaves the egg in a quiescent, pupoidal form. Soon emerges a larva resembling a wingless insect with three pairs of legs, behind which lie four footless segments. Following this first stage new segments are added in groups of one, two, three or more double segments. The development is thus anamorphic. The attainment of each new stage is preceded by a pause or rest period. The animal occupies a retreat or nest while undergoing the molting process as mentioned earlier. More rarely the first free larva possesses four (*e.g.*, Polyzonium) or even more pairs of legs. The new segments are invariably produced between the last leg-bearing segment and the final, or anal, segment.

Millipedes that breed and lay their eggs in the autumn commonly die out by early winter, the males disappearing first. In these types a new generation emerges from the eggs in early spring, the life cycle being completed within a year's time. Other millipedes may live two years and some are estimated to live as long as seven years.

## CLASSIFICATION

The class Diplopoda embraces two subclasses: the Pselaphognatha and the Chilognatha.

I. The Pselaphognatha include small, soft-bodied forms that bear bristles (setae) of several kinds arranged in rows and bundles (fascicles). Copulatory organs (gonopods) are lacking and the gnathochilarium is abortive or poorly developed (*e.g.*, Polyxenidae).



SHELL

FIG. 6.—FLAT-BACKED MILLIPEDE (POLYDESMUS ANGUSTUS)

II. The Chilognatha include the great majority of millipedes. In these the integument forms a hard shell which bears setae only singly, never grouped in fascicles, and the gonopods are always well developed. The major subdivisions of this subclass may be listed as follows:

1. Superorder Pentazonia (Opisthandria): the gonopods are at the tail end of the body, being modified from the last two pairs of legs; tracheae two-branched (*e.g.*, orders Glomerida and Glomeridesmida).

2. Superorder Colobognatha: first legs of seventh segment of males not modified; eight pairs of legs in front of the gonopods; head small, mandibles usually much reduced; labrum without teeth; tracheae unbranched (*e.g.*, orders Platydesmida and Polyzoniida).

3. Superorder Helminthomorpha: first legs of seventh segment of male always modified; seven pairs of legs in front of the gonopods; head not reduced; mouthparts of normal size; labrum usually with three teeth; tracheae unbranched (*e.g.*, orders Polydesmida, Chordeumida, Julida, Spirobolida, Cambalida and Spirostreptida).

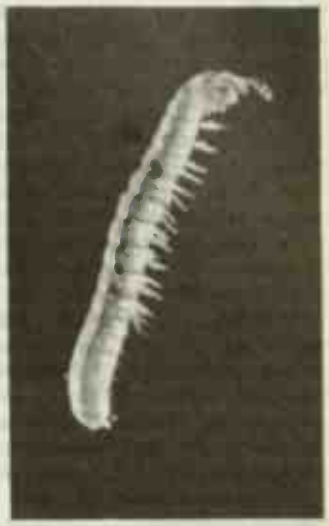


FIG. 7.—YOUNG SPOTTED SNAKE MILLIPEDE (BLANIULUS GUTTULATUS)

In contrast with the Pentazonia (Opisthandria), the second and third superorders are often placed as the Proterandria, because of their agreement in having the copulatory organs on the seventh segment and in not having the tracheae branched.

BIBLIOGRAPHY.—The best accounts of the Diplopoda as a whole are in German and French. To be mentioned specially are the following: Carl Graf Attems' treatment in Kukenthal and Krumbach's *Handbuch der Zoologie*, vol. iv (1926); Karl W. Verhoeff in Bronn's *Klassen und Ordnungen des Tierreichs*, vol. v (1910–1914, 1926); H. W. Brolemann, "Myriapodes Diplopodes," in *Faune de France*, 29 (1936 *et seq.*). Many excellent papers and monographs on particular regions and groups have appeared by these and other authors. For the diplopods of North America a complete bibliography is given in R. V. Chamberlin and R. L. Hoffman, "Checklist of the Millipedes of North America," *Bull. U.S. Nat. Mus.*, 212 (1958). (R. V. C.)

**MILLS, ROBERT** (1781–1855), the first strictly professional architect of U.S. birth, was born on Aug. 12, 1781, in Charleston, S.C. Mills generally followed the principle enunciated by Thomas Jefferson, that classical architectural forms best befitted a reincarnation of ancient republics, *i.e.*, the new United States, but he used those forms with originality, both in plan (*e.g.*, his auditorium type of evangelical church) and structure (*e.g.*, his ideas about fireproofing and acoustics). Mills's more than 50 major works included colleges, prisons, hospitals, houses, canals, bridges and breakwaters. His most famous buildings, however, were public—the Treasury (1836–42) and Patent office (1839) in Washington, D.C., the wings of Independence hall in Philadelphia (1807) and, best known of all, the monuments to George Washington in Baltimore (1814) and Washington, D.C. (designed 1836, completed 1884).

Mills died on March 3, 1855, at Washington, D.C.

*See* H. M. Pierce Gallagher, *Robert Mills* (1935); T. F. Hamlin, *Greek Revival Architecture in America* (1944). (AN. G.)

**MILNE, ALAN ALEXANDER** (1882–1956), English humorist, poet of childhood and minor playwright, best-known for his children's stories about Christopher Robin and his animals—"Pooh," "Piglet," "Kanga," "Roo" and "Eeyore"—was born on Jan. 18, 1882, in London, and educated at Westminster school and Trinity college, Cambridge. In 1906 he joined the staff of *Punch*, writing humorous verse and whimsical essays in a style that has become dated. He wrote his first published play (*Wurzel-Flummery*) while serving with the Royal Warwickshires in 1917, and achieved considerable success with light comedies, of which the best are *Mr. Pim Passes By* (1919), *The Dover Road* (1922) and *Michael and Mary* (1929). He also attempted the novel, but his detective story, *The Red House Mystery* (1921), is the only memorable one.

Although his fifth play was the brilliant extravaganza for children, *Make-Believe* (1918), he stumbled into his true literary kingdom by chance with some verses written to order, about his son, Christopher Robin. These grew into the collections *When We*

*Were Very Young* (1924) and *Now We Are Six* (1927), some of the best light verse for children ever written. But they were surpassed by two sets of stories about Christopher Robin's toy animals, *Winnie-the-Pooh* (1926) and *The House at Pooh Corner* (1928), the most-quoted children's classics since Lewis Carroll's *Alice's Adventures in Wonderland* (1865). *Toad of Toad Hall* (1929), a play based on Kenneth Grahame's *The Wind in the Willows*, retains its popularity but falls far short of its original. Milne will be remembered for his nursery verse, and as the creator of "Pooh Bear," whose sayings and doings have become a part of the language. He died at Hartfield, Sussex, on Jan. 31, 1956.

*See* his autobiography, *It's Too Late Now* (1939). (R. L. Gr.)

**MILNE, EDWARD ARTHUR** (1896–1950), English mathematician, astrophysicist and cosmologist, best known in his later years for his original researches in relativity and cosmology, was born at Hull on Feb. 14, 1896. He was educated at Hymers college, Hull, and at Trinity college, Cambridge, where he was elected to a prize fellowship in 1919. In 1920, he became assistant director of the Solar Physics observatory. Four years later, he was elected professor of applied mathematics at Manchester university.

In 1928 Milne was appointed first Rouse Ball professor of mathematics at Oxford. He became a fellow of the Royal society at the age of 30, and was awarded a Royal medal in 1941. He died suddenly in Dublin on Sept. 21, 1950.

Milne first became internationally known for his pioneer work on the theory of stellar atmospheres. He showed, in collaboration with R. H. Fowler, that the pressures of the levels of stellar atmospheres where absorption lines are formed are considerably lower than previously imagined. He also found that atoms can be ejected from the sun at about 1,000 mi. per second. In 1929, Milne turned his attention to problems of stellar constitution and became an acute critic of A. S. Eddington's hypothesis that the interior of a star obeys the perfect gas law throughout. He did much work on the highly dense white dwarf stars which afterward stimulated S. Chandrasekhar to develop the now generally accepted theory.

Milne's theory of the expanding universe was easier to visualize physically than that based on Einstein's theory of general relativity. In place of expanding curved space, Milne considered a cloud of particles expanding into a vacuum in flat space. In studying such a system, he was led to develop a new form of relativity, called kinematic relativity, based on a deep analysis of time measurement. Milne's works include *Thermodynamics of the Stars* (1930); *The White Dwarf Stars* (1932); *Relativity, Gravitation and World-Structure* (1935); *Kinematic Relativity* (1948). (G. J. Ww.)

**MILNE, JOHN** (1850–1913), British seismologist and mining engineer who was largely responsible for the establishment of seismological observation stations throughout the world, was born at Liverpool on Dec. 30, 1850, and educated at King's college, London, and the Royal School of Mines. He worked as a mining engineer in Newfoundland and Labrador, and in 1874 went as geologist with C. T. Beke's expedition to Egypt and northwestern Arabia. In 1875 he was appointed professor of geology and mining in the Imperial Engineering college at Tokyo, where he remained for 20 years. Milne was recognized as a leading authority on seismology. He traveled widely in the east, and about 1880 established the seismic survey of Japan, with 968 stations. He invented various forms of the seismograph (*q.v.*). In 1894 he returned to England and established a private observation station near Newport, Isle of Wight. It was as secretary of the seismological committee of the British association that he organized a world-wide network of observation stations. He died at his home on the Isle of Wight on July 30, 1913.

He published two standard works, *Earthquakes* (1883) and *Seismology* (1898), besides many books on mining and crystallography and papers in scientific journals.

**MILNE-EDWARDS, HENRI** (1800–1885), Belgian zoologist prominent in comparative anatomy, comparative physiology and general zoology, was born at Bruges on Oct. 23, 1800, the son of British parents settled in Belgium. He studied in Belgium and then in Paris where he took a medical diploma in 1823. He soon gave up medicine, however, and taught natural history at the *lycée* Henri IV, where in 1827 he introduced the theory of the division of physiological labour. In 1838 he was elected a member of the Académie des Sciences, Paris, in succession to Georges Cuvier. Subsequently he was appointed professor of entomology at the Jardin des Plantes and in 1844 professor of zoology and comparative physiology at the Muséum d'Histoire Naturelle, Paris.

He took a very active part in organizing courses in natural history and was a member of several government commissions. He was a prolific writer and keenly interested in the popularization of natural history. Milne-Edwards also made important contributions on the shore animals of France and Sicily, especially on the anatomy, physiology, classification and habits of Crustacea and Coelenterata. He was the author of various textbooks, the most important being *Leçons sur la physiologie et l'anatomie comparée de l'homme et des animaux*, 14 vol. (1857–81). He was one of the most outstanding of those zoologists who refused to accept Darwin's evolution theory, and explained zoological distribution as a result of special creation in different centres. He died in Paris on July 28, 1885. (Ed. He.)

**MILNER, ALFRED MILNER,** Viscount (1854–1925), imperial administrator who played a decisive role in the history of South Africa, was born at Giessen, Hesse-Darmstadt, on March 23, 1854, of English and German descent; his father, Charles Milner, was a medical doctor and a teacher of English literature. Milner's childhood was spent alternately in Germany and in England; he entered the Tübingen *gymnasium* in 1866 and after his mother's death in 1869 moved to King's college, London. He won a scholarship in 1872 to Balliol college, Oxford, where he had a brilliant career. He was president of the Oxford union, took first classes in classical moderations and Greats, won the Hertford, Craven, Eldon and Derby scholarships, and in 1876 became a fellow of New college. At Oxford he also became an ardent advocate of imperialism and social reform.

Milner left Oxford for London in 1879 and two years later was called to the bar of the Inner Temple. As legal work was scarce he turned to journalism and worked for the *Pall Mall Gazette* under John (later Viscount) Morley and W. T. Stead. He stood for Harrow as a Liberal candidate in the general election of 1885, but was defeated. His public career started in 1887, when he was appointed official private secretary to G. J. (later Viscount) Goschen, chancellor of the exchequer. He served with distinction under Sir Evelyn Baring (afterward Lord Cromer) in Egypt from 1889 to 1892 and wrote *England in Egypt* (1892), an analysis of the problems of Egyptian administration and a vindication of British intervention. He then became chairman of the board of inland revenue, where he was responsible for formulating Sir William Harcourt's celebrated death duties. His services were rewarded with a knighthood in 1895.

**High Commissioner in South Africa.**—Joseph Chamberlain, colonial secretary in Lord Salisbury's cabinet, selected Milner in 1897 as governor of Cape colony and British high commissioner in South Africa, the cardinal imperial appointment of the time. Relations between Britain and the South African republic were already strained. Britain regarded the republic as falling within its exclusive sphere of influence and as being subject to its suzerainty. The republican government of Pres. Paul Kruger denied that British suzerainty existed under the London convention of 1884 and was striving to preserve Boer supremacy over the republic in the face of the challenge presented by the influx of many British and other *uitlanders* to the Witwatersrand gold fields (*see* Transvaal: *History*). Boer suspicions of Britain had recently been intensified by the Jameson raid which was a plot to coerce the republic back into the empire.

During his first ten months in South Africa Milner held his hand, touring Cape colony and picking up the threads of its politics; but Kruger's alliance with the Orange Free State, his military preparations and his re-election as president for a fourth term in Feb. 1898 led Milner to consider that Britain should intervene to assert its paramountcy. First, he hoped to secure a government

in Cape colony that would support his plans. Accordingly, in a speech at Graaff Reinet in March 1898 he criticized the Cape Afrikaners for espousing the cause of the South African republic and made it clear that his sympathies lay with the imperialistic Progressive party. Nevertheless the Afrikaner Bond and its allies obtained a narrow majority in a general election, and in Oct. 1898 W. P. Schreiner formed a ministry which included Bondsmen and depended on Bond support.

At the end of 1898 Milner went to England for consultation with the colonial secretary and after his return to South Africa in Feb. 1899 he and Chamberlain put persistent pressure upon Kruger. In March, Milner ensured that a Cape ministerial proposal for a conference of South African states and colonies should come to nothing. In response to Chamberlain's request for a statement for publication, he dispatched a vigorous telegram on May 4 describing the *uitlanders* as being "in the position of *helots*" and asserting that the case for British intervention was "overwhelming." Between May 31 and June 5, in conference with Kruger at Bloemfontein, he demanded full citizenship rights for *uitlanders* after five years' residence, and abruptly terminated the discussions when Kruger refused to grant so much. When the republican *volksraad* adopted a law making considerable concessions in July, Milner criticized it as inadequate. And when J. C. Smuts, the republican state attorney, offered in Aug. 1899 more than Milner had demanded at Bloemfontein, the latter advised Chamberlain to reject the offer on account of the conditions attached to it. By then, indeed, Milner had determined that British supremacy should be asserted by force and he was content when war broke out on Oct. 11, 1899, following an ultimatum from the two republics. (*See* SOUTH AFRICAN WAR.)

During the war Milner was created baron (1901) and viscount (1902). While retaining the high commissionership, he handed over the governorship of Cape colony to Sir Walter Hely-Hutchinson in 1901 and became administrator (later governor) of the former republics; he was also primarily responsible for the post-war settlement. His plans were far-reaching. The Witwatersrand gold-mining industry was to provide a surplus to stimulate the rapid expansion of the entire South African economy. It was also to attract a large number of British immigrants, while British settlers were to be assisted to establish themselves on the land, so that a permanent British majority would be created in the white South African population. The Boers were to be weaned from their cultural and racial isolation not only by the effects of economic change and British immigration but also by a vigorous educational program, with all teaching in the English language. The Transvaal and the Orange River colony were to be ruled as crown colonies for an indefinite period and Cape colony was to forfeit its constitution and be reduced to the same status. Only when his economic, immigration and educational policies had borne fruit would it be safe and desirable to create a federal dominion of British South Africa, which would have full internal self-government and, Milner hoped, be so loyal that it would support his broader project of imperial federation, under which an imperial council or parliament would be formed, with powers over the defense and the trade of the empire. To assist him in these tasks he recruited a group of bright young men from Oxford, known as "Milner's kindergarten," including Patrick Duncan, Lionel Curtis, Robert Brand and Philip Kerr, to occupy the key posts in the Transvaal administration.

**The Period of Settlement.**—Milner and Lord Kitchener represented Britain in the negotiations that led to the signing of the treaty of Vereeniging on May 31, 1902. It was Milner who made sure that the treaty specified no date for the introduction of self-government in the Transvaal and the Orange River colony and included no promise that the Dutch language would rank equally with English. In return he yielded completely to the colour consciousness of the Boers, in the clause that made no concessions to the African and Asian inhabitants of the new colonies and provided that no "native" would be given the vote before the introduction of self-government. At about the same time, however, he failed to persuade Chamberlain to suspend the constitution of Cape colony.

For the next two years Milner's administration was largely concerned with re-establishing the Boers on the land, and this work was efficiently and generously performed. But in other respects his policy was not a success. Although his schools gave young Afrikaners unprecedented educational opportunities, his insistence upon the use of English provoked organized Afrikaner opposition. The gold-mining industry was expanding quite rapidly and Milner persuaded the colonial secretary to alleviate the shortage of unskilled labour by allowing the importation of Chinese on short-term contracts, terminating in compulsory repatriation. This decision evoked widespread opposition in South Africa and reports of ill-treatment of the Chinese labourers gave Milner's opponents in England a powerful weapon. There was also a considerable emigration of British people from Cape colony and Natal during the postwar depression, while the scale of British immigration to the Witwatersrand was not so great as Milner had hoped; his land settlement schemes produced only about 1,000 settlers, so that Afrikaners continued to form a substantial majority of the white South African population.

In 1904, in an attempt to stave off more radical changes, Milner persuaded Alfred Lyttelton, Chamberlain's successor, to sponsor a constitution that would have given the Transvaal representative, but not responsible government. But by then Milner was being opposed by some British South Africans as well as by most Afrikaners, and in Britain the reaction against him and against the Unionist government was becoming powerful. He resigned from his South African appointments in April 1905 and returned to England, hoping that his successor, Lord Selborne, might be able to inaugurate the Lyttelton constitution and save something of his work. However, the Lyttelton constitution was stillborn. Sir Henry Campbell-Bannerman's Liberal cabinet took office in Dec. 1905, was confirmed in power at the polls in Jan. 1906 and proceeded, to Milner's acute dismay, to grant full self-government to the Transvaal and the Orange River colony, with electoral provisions that enabled predominantly Afrikaner governments to obtain control of both colonies in 1907.

**Last Years.**—For several years after his return from South Africa Milner remained out of public employment and out of sympathy with the British government. In the house of lords he vehemently opposed the "people's budget" of 1909, the Parliament act of 1911 and Irish Home Rule. Early in World War I, however, he presided over committees on food production and coal production and in 1916 he became a member of Lloyd George's war cabinet, where his administrative gifts were used to full advantage. He also undertook missions to Rome and St. Petersburg (Leningrad), and in the military crisis of March 1918 he went to France and secured unity of command under Gen. Ferdinand Foch. Milner became secretary for war in April 1918 and then in December moved to the colonial office. As colonial secretary he attended the peace conference and signed the treaty of Versailles. Later he spent four months in Egypt and recommended that it should be given a qualified form of independence, but the cabinet rejected his advice and in Feb. 1921 he resigned. Three weeks later he married Violet, the widow of Lord Edward Gascoyne-Cecil. He died of sleeping sickness at Sturry court, near Canterbury, on May 13, 1925.

The most significant part of Milner's career was his South African high commissionership, which was the crest of the late-19th-century wave of British imperialism. To it he brought great administrative talents, a clear-cut idealism and an inflexible will. However, his attempt to destroy Afrikaner nationalism proved to be a boomerang, for Afrikaner nationalism came to thrive upon a tradition of "Milnerism" which, though exaggerated, was not entirely false. His constant appeal to British racial fervour misled British South Africans into nourishing unattainable aspirations. And his failure to raise the status of the non-white inhabitants of the Transvaal and the Orange River colony removed the strongest vindication that might have existed for the war that his diplomacy had done so much to bring about. *See also* SOUTH AFRICA, REPUBLIC OF: *History*.

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(L. M. T.)

**MILNER, JOHN** (1752–1826), English antiquary and Roman Catholic controversialist, had great influence in the campaign to obtain the parliamentary relief of Catholics from legal disabilities. Born in London on Oct. 14, 1752, and educated first at Sedgeley Park school, near Wolverhampton, and later at the English college at Douai, in France, Milner was ordained priest in 1777 and returned to pastoral work in England, chiefly at Winchester. His *The History, Civil and Ecclesiastical, and Survey of the Antiquities of Winchester*, two volumes (no date [1798–1801]), was very well received and achieved a third edition in 1839. Even more famous was his *The End of Religious Controversy*, published in 1818. In 1803 Milner became titular bishop of Castabala and vicar-apostolic of the Midland district. He died on April 19, 1826.

Milner's chief political success was to prevent parliament's granting relief to Catholics from the penal laws of an earlier age on terms unduly restrictive of papal power. In this he was unsuccessfully opposed by influential Catholic laymen and even bishops who were prepared to take oaths incompatible with Catholicism and to grant the English government a power of veto over the appointment of Catholic bishops. Milner's resistance was sustained in numerous published writings marred, however, by a too great asperity of style.

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(E. McD.)

**MILNGAVIE** (locally pronounced "Milguy"), a small burgh of Dunbartonshire, Scot., 6 mi. N.N.W. of Glasgow. Pop. (1961) 8,894. Industries include light engineering and the making of paper, cardboard boxes, bedding, scientific instruments and spectacle frames; but the town is largely a residential quarter for Glasgow. Mugdock and Craigmaddie reservoirs store water from Loch Katrine. Bardowie castle is 1¼ mi. E.S.E. and Mugdock castle, 1¾ mi. N. of Milngavie, is an old stronghold of the Grahams; in Baldernock parish, about 2 mi. E., a megalith called the "Auld Wives' Lift" stands on a hill 400 ft. high.

**MILO** (Milon), of Crotona, Greek athlete, lived about the end of the 6th century B.C. He was six times crowned at the Olympic games and six times at the Pythian for wrestling, and was famous throughout the civilized world for his feats of strength—such as carrying an ox on his shoulders through the stadium at Olympia. In his native city he was much honoured, and he commanded the army which defeated the people of Sybaris in 511.

The traditional account of his death is often used to point a moral: he found a tree which some woodcutters had partially split with a wedge, and attempted to rend it asunder; but the wedge fell out, and the tree closed on his hand, imprisoning him till wolves came and devoured him. His name became proverbial for personal strength.

**MILO, TITUS ANNIUS** (d. 48 B.C.), Roman politician from Lanuvium, was the son of C. Papius Celsus, but was adopted by his mother's father, T. Annius Luscus. He supported Pompey, and organized bands of mercenaries and gladiators against P. Clodius (*q.v.*). Milo was tribune of the plebs in 57. He actively promoted the recall of Cicero from exile, in spite of Clodius. He tried to prosecute Clodius and prevent his election to the aedileship; in 56 Clodius attempted in turn to prosecute Milo. Milo was praetor in 55. In 53 Milo was candidate for the consulship and Clodius for the praetorship; strife continued until the two leaders met at Bovillae and Clodius was murdered (Jan. 52). Milo was impeached, his guilt was clear, and his enemies took every means of intimidating his supporters and his judges. Cicero was afraid to speak, and the extant speech *Pro Milone* is an expanded form of the unspoken defense. Milo went into exile at Massilia (Marseilles). He was the only man excepted from Caesar's general amnesty. He joined M. Caelius Rufus in 48 in his rising against Caesar, but was killed near Thurii. His wife was Fausta, daughter of the dictator Sulla.

**MILORADOVICH, MIKHAIL ANDREEVICH** (1771–1825), Russian army officer who distinguished himself in the French Revolutionary and Napoleonic Wars. Having had early experience under Gen. A. V. Suvorov in the wars against Turkey and against Poland, he won some reputation as a commander of advanced troops in Suvorov's campaign in 1799 in Italy and Switzerland. In 1805, having attained the rank of lieutenant general, he served under Gen. M. I. Kutuzov in the campaign that ended disastrously at Austerlitz. When war with the Turks broke out again, he commanded the army corps that took Bucharest in Dec. 1806 and won two victories on the Danube in 1807. In 1810 he was promoted to the rank of general of infantry. When the French invaded Russia in 1812 he commanded a corps at Borodino and subsequently a rear guard covering the Russian army's retreat toward Kaluga; and when the French began their retreat his corps was active in pursuit of them. In 1813, however, the Russians and their allies sustained some defeats in central Europe, and Miloradovich found himself again in command of a rear guard; but on the recovery of the allies he led a Russo-Prussian corps at the battle of Leipzig and in the campaign of 1814. He was appointed military governor of St. Petersburg in 1818 and remained in command until he was shot in the rising of the Dekabrists there on Dec. 26 (new style; 14, old style), 1825.

**MILOSH** (Milosh Obrenovich I; originally Milosh Teodorovich) (1780–1860), prince of Serbia from 1815 to 1839 and from 1858 to 1860, the founder of the Obrenovich dynasty. He was born at Srednja Dobrinja on March 18 (new style; 7, old style), 1780, the first child of a poor peasant, Teodor Mihailovich (d. 1802), by his wife Vishnya (d. 1819), who already had three children by her former husband Obren Martinovich. In early life a herdsman, Milosh worked at Brusnica for his half brother Milan (d. 1810). In 1807 he married Lyubitsa Vukomanovich (1788–1843), by whom he eventually had two daughters and two sons, Milan and Michael.

During the first Serbian rising (1804–13), Milosh distinguished himself and was appointed commander (1805). After his half brother's death, he changed his name from Teodorovich to Obrenovich. Being in opposition to Karageorge (*q.v.*), he was arrested in 1811 but immediately pardoned. After the Bucharest treaty of 1812, Karageorge took refuge in Austria, but Milosh remained behind and was appointed by the Turks to be *knez* (prince) of three central Serbian districts. He used his influence to pacify the country and protect the population. When Haji-Prodan's rebellion broke out (1814), Milosh helped the Turks to restore order; but when they started large-scale massacres he proclaimed to the assembled leaders outside Takovo church on Palm Sunday 1815: "Here am I; there you are: war to the Turk!" He routed the Turkish regulars at Palez (now Obrenovac), Ljubic and Dublje. The Turks, fearing Russian intervention, preferred to settle their differences with the Serbs amicably, and Marashli Ali Pasha concluded a gentleman's agreement with Milosh, who styled himself "supreme prince and ruler of the Serbian nation," the title being recognized (1815) by a national assembly. He rid himself of all his rivals and secured his own position. The Turkish regime was relaxed and Serbian autonomy enlarged until a *hatti-sherif* (1830) recognized Milosh as hereditary prince, besides granting Serbia other concessions and, in order to limit Milosh's powers, making provision for a council. Milosh enlarged Serbia by six districts (1833), paid a visit to the sultan and suppressed Mileta's rebellion but had to accept a constitution (1835). Considering this constitution too liberal, Austria, Russia and Turkey protested, and Milosh was glad to abolish it. In the meantime he decreed that land belongs to those who cultivate it. He wanted a council whose members would depend on him, whereas Russia wanted the members to be independent and appointed for life. Milosh tried to secure British help, but Russian pressure was decisive, and in 1838 Turkey granted Serbia a constitution agreeable to Russia. Milosh tried to abolish it by force but failed and was compelled to abdicate on June 13 (N.S.; 1, O.S.), 1839, in favour of his sickly son Milan Obrenovich II, who died 25 days later and was succeeded by his brother Michael (*q.v.*).

Milosh, who had made himself one of the wealthiest men in the

Balkans, went into exile. Michael followed him into exile in 1842, and Alexander Karageorgevich then became prince. Finally, however, when Alexander was compelled to abdicate Milosh, "the Old Master," was recalled to the throne on Dec. 23 (N.S.), 1858. After having spent nearly 20 years in exile, he had only enough time to show that his ideas remained unchanged. He died at Topchider, near Belgrade, on Sept. 26 (N.S.), 1860.

Whereas Karageorge had aimed at independence, Milosh, an illiterate political genius, was content with autonomy. In a period of transition he was the best man to bring this about. He owed everything to his political skill against the Turks and to his tyrannical energy. In the next stage, when justice, written laws, education and a good administration were essential, he could not adapt himself.

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(K. ST. P.)

**MILOVANOVIC, MILOVAN** (1863–1912) Serbian statesman, prime minister in 1911–12 and an architect of the Balkan alliance, was born in Belgrade on March 1 (new style; Feb. 17, old style), 1863. He was the first Serb to qualify as doctor of laws in Paris. He was then elected professor at Belgrade university and, though only 25 years old, was mainly responsible for drafting Serbia's liberal constitution of 1888. Appointed undersecretary for foreign affairs in 1890 he kept that post until 1894 with a short interruption. He became minister of justice in 1896, but was dismissed in 1897. As a prominent Radical, he was sentenced *in absentia* to two years' imprisonment (1899). In 1900, however, he was appointed minister to Bucharest. As minister of national economy in 1901 he was one of the drafters of the new constitution. Having been minister to Rome from 1902 he represented Serbia at the second Hague conference in 1907 and was then elected a member of the Permanent Court of Arbitration. In 1908 he became foreign minister of Serbia. Finally, on July 8, 1911, he was appointed prime minister, retaining the portfolio of foreign affairs.

Milovanovic guided Serbian foreign policy through the crisis that followed Austria-Hungary's annexation of Bosnia-Hercegovina (1908); and he cleverly succeeded in raising internationally the question of Serbian national unification without provoking war with Austria-Hungary. Though a confirmed Russophil, he initiated the negotiations that led to a trade agreement with Austria-Hungary (1910). He was one of the chief founders of the Balkan alliance of 1912 insofar as it was he who negotiated the first Serbo-Bulgarian alliance of that year, though he died in Belgrade on July 1 (N.S.; June 18, O.S.), 1912, before a more substantial alliance could be concluded (*see* BALKAN WARS I.). He was the ablest statesman that Serbia had had since Prince Michael Obrenovich. Milovanovic published *Les Traités de garantie au XIX^e siècle* (1888), *Srbi i Hrvati* (1895) and *Srbi i Bugari* (1898).

*See* S. Jovanovic, *Milovan Milovanovic* (1962); D. Djordjevic, *Milovan Milovanovic* (1962).

(K. ST. P.)

**MILTIADES** (MELCHIADES), **SAINT,** pope probably from July 2, 311, to Jan. 10, 314, was born in Africa and was pope when edicts of toleration were published by Galerius, Constantine and Licinius. Constantine had him and bishops of Gaul and Italy judge the Donatists' charges against Caecilian, bishop of Carthage. (*See* DONATISTS.) Miltiades is considered a martyr because of earlier sufferings under Maximian; his feast is Dec. 11.

(W. M. K.)

**MILTIADES,** the name of two Athenian statesmen and generals of a family (the Philaidae) of Aeginetan origin, which claimed descent from Aeacus.

MILTIADES (6th century B.C.), the son of Cypselus, a prominent opponent of Pisistratus (*q.v.*). He founded an Athenian colony in the Thracian Chersonese (Gallipoli peninsula) at the request of the native Doloncians. He became tyrant of the Chersonese, which he fortified by a wall across the isthmus from Cardia to Pactya. He was captured by the people of Lampsacus, but released on the intervention of Croesus of Lydia. He was succeeded by Stesagoras, son of his half brother Cimon.

MILTIADES (d. *c.* 488 B.C.), the victor of Marathon, was another son of the Cimon mentioned above. He was probably archon in 524/523. On the death of Stesagoras, he was sent to the Chersonese (*c.* about 518–516) by Hippias—no doubt to support Hippias' half brother Hegesistratus at Sigeum. He imprisoned the chief men of the Chersonese, which was then in a turbulent condition, and married Hegesipyle, daughter of the Thracian prince Olorus. He led a contingent in the Scythian expedition of Darius I of Persia (*c.* 513) and, according to Herodotus, he advised the destruction of the Danube bridge, which would have cut off Darius' retreat. Since Miltiades was not at once expelled by the Persians, the story is doubtful and may have been invented for his trial. While ruling the Chersonese he seized the islands of Lemnos and Imbros for Athens. He supported the Ionian revolt from Persia and when it collapsed fled to Athens, where he was impeached (?493) by his political enemies for tyranny.

When the Persians sailed against Athens Miltiades was made one of the ten generals, and it was on his advice that the polemarch Callimachus decided to give battle at Marathon (*q.v.*). Subsequently he obtained a fleet of 70 ships from the Athenians, with a commission, according to Cornelius Nepos, to regain control over the Aegean. Herodotus says that, having besieged Paros unsuccessfully for nearly a month, he made a secret visit to Timo, a priestess of Demeter in Paros, with a view to the betrayal of the island, and being compelled to flee wounded himself severely in attempting to leap a fence. In any case, the siege was raised for some reason, and the Alcmaeonidae had him impeached on his return. All that is known is that he died of his wound (489/488), without paying the fine, which was paid subsequently by his son Cimon (*q.v.*). He appears to have been a man of strong determination and great personal courage, of a type characteristic of the time before the new constitution of Cleisthenes. His absence from the Chersonese during the first years of the new democracy (508–493?) and his aristocratic descent account naturally for the difference that existed between him and the popular leaders Themistocles and Aristides.

*See* Herodotus, vi, 34 ff. and Cornelius Nepos, *Miltiades*, and general histories of Greece. On the Parian expedition and the trial, R. W. Macan, *Herodotus iv–vi*, vol. ii, appendix xi (1895).

**MILTON, JOHN** (1608–1674), who ranks next to Shakespeare among English poets, was born in London, in Bread street, Cheapside, on Dec. 9, 1608.

**Family.**—Milton's grandfather, an Oxfordshire yeoman, had been a staunch Roman Catholic who disinherited his son, the poet's father, for turning Protestant. John Milton senior, going to London, made his way to prominence and a comfortable fortune as a scrivener or notary and through the collateral business of private banking or moneylending. Possibly the poet inherited a disposition toward religious independence, certainly he was given the best education, then six years of leisure and finally a continental tour. Milton paid repeated tributes, in verse and prose, to his father's generous concern. Another debt was in the way of music. The father was a composer, not of the first rank but still of enough repute to be a contributor to Thomas Morley's famous collection, *The Triumphs of Oriana* (1601); the poet's lifelong devotion to music is attested by the warmth of his own allusions and by his early biographers. Of his mother (d. 1637) Milton said only that she was well esteemed and known for her charities. He had an older sister Anne who married in 1623, and a younger brother Christopher who became a lawyer and, though a royalist, continued on good terms with him.

**Education and Early Poems.**—The conventional date given for Milton's admission to St. Paul's school, 1620, has no authority; it may have been as early as 1615. In addition to his regular schoolwork in Latin, Greek and—later—Hebrew, the boy had instruction at home, perhaps partly in modern languages, from private tutors, to one of these, the Scottish Thomas Young, he later wrote two letters and the Latin Elegy IV (1627), in which he gratefully recalled Young's introducing him to Latin poetry. Milton was from childhood a voracious student; he traced the initial

cause of his blindness to his having, from his 12th year, rarely quitted his books before midnight.

Along with a couple of Latin exercises that have survived, his earliest attempts at verse, made when he was 15, were rhymed paraphrases of Psalms 114 and 136. Milton's closest friend, at school and later, was Charles Diodati, the son of a prominent physician of Italian origin, who went from St. Paul's to Oxford; a less intimate friendship, which also lasted beyond school, was with Alexander Gill, the son of the headmaster.

On April 9, 1625, Milton matriculated at Christ's college, Cambridge; he received his B.A. degree in March 1629, his M.A. in July 1632. Young men of future distinction whose Cambridge careers more or less overlapped Milton's were Roger Williams, Thomas Fuller, Thomas Randolph and Jeremy Taylor and, at Christ's, John Cleveland and Henry More. Milton's experience at Cambridge can be partly gathered from his abundant Latin verse and his seven Latin prolusions (these were public speeches expected to display the speaker's learning and rhetorical and argumentative powers). The occasion of his first Latin elegy, addressed to Diodati, was his rustication, after a clash with his tutor, apparently in March 1626; at home in London, he compared his exile to that of his beloved Ovid and rejoiced in the opportunity to read the books (here classical plays) "that are my life" and to see beautiful girls while strolling. Evidently the college authorities did not find serious fault, since on his return he was assigned to another tutor and graduated in the normal time.

The nickname Milton acknowledged, "the Lady," no doubt referred to his handsome and delicate features and to a purity of mind and behaviour that disdained the diversions of his coarser fellows. During his seven years at Cambridge he seems to have moved from some unpopularity to general respect and, among dons and cultivated students, high esteem. He did not love the scholastic logic which largely dominated the university curriculum and which, in prolusions and later in *Of Education*, he denounced as barren. In his last prolusion (1631–32?) he proclaimed the fervent creed and dream of a young Renaissance humanist who was at once a Christian, a Platonist and—whether or not he had yet read Francis Bacon—a Baconian: it was in man's power to master all fruitful knowledge, to become an oracle of nations, a godlike ruler of nature.

Meanwhile Milton had been learning his art and sometimes revealing his inner self in writing Latin verse. Neo-Latin poets, such as George Buchanan or the contemporary Hugo Grotius (whom Milton later met in Paris, and whom posterity remembers as a jurist), enjoyed European fame; and college students commonly celebrated academic and national events in what was the normal language of the university world.

Milton's Latin poetry, with all its conventional rhetoric, sometimes attained higher levels than that of any other English practitioner. His small anti-Catholic epic of 1626, "In Quintum Novembris" (*i.e.*, on Guy Fawkes day), gives a vigorous if crude sketch of Satan and hell, and even formal obituaries on bishops inspire the Miltonic vision of heaven. Elegy V (1629), a picture of awakening spring, is aflame with the sexual imagery of an intense though innocent paganism. In Elegy VII (1627–28?) Milton presents himself as a confident foe of Cupid who is overcome by the beauty of a girl he encounters. The young poet's sensuous instincts were further displayed, along with his mastery of Italian, in six Italian sonnets (1630?), with which may be linked his first English sonnet, "O Nightingale."

*"On the Morning of Christ's Nativity."*—Early in 1628 Milton wrote the earliest of his extant English poems (apart from the two psalms), "On the Death of a Fair Infant," an elegy, in the Elizabethan vein, on his baby niece, Anne Phillips. In part of an academic prolusion in English couplets ("At a Vacation Exercise," July 1628) he declared his devotion to his native language, a style free from eccentricity, and exalted themes concerning nature and man. And in the Latin Elegy VI, addressed to Diodati in the festive Christmas season of 1629–30, he praised the light verse kindled by wine and love but turned from that to celebrate the ascetic purity of the heroic poet. The elegy ended with a reference to a poem he had just written, his first great poem in English, "On the Morning of Christ's Nativity." Such a poem, composed shortly after his 21st birthday, may be taken as a kind of announcement of his poetical coming of age and future direction, both in its religious theme and in its mastery of conception and form and image and rhythm. A short prelude enunciates, in terms of light, the supreme paradox of the Incarnation and leaps over time and space to link the poet's humble ode with the gifts of the three wise men. Then the hymn unfolds itself in three movements: the universal peace of the Roman world and all nature's awareness of its defects on the eve of its Creator's birth; the angelic song which, in symbolizing the new bond between heaven and earth, recalls the celestial music that attended creation and anticipates the trump of doom and the bliss of eternity; and, finally, the overthrow and flight of the pagan gods with the earthly advent of the true God. The last lines quietly reaffirm the central theme of divine order and harmony.

*"L'Allegro," etc.*—Probably in the long vacation of 1631 Milton wrote the companion poems, "L'Allegro" and "Il Penseroso." Less ambitious in theme than the "Nativity," they have their own complexity, concealed beneath a unique grace and charm. These celebrations of mirth and melancholy (really contemplation) transcend the traditions they belong to, the traditions of the encomium, the emblem, the prose "character" and the pastoral. The representative of mirth observes people, in pastoral sunshine or bright and crowded interiors; the contemplative solitary communes with himself and nature in twilight and with books through the night. But the "man" in each case is only a thread for the varied scenes and times and seasons that evoke or reflect the quality of the experience, and the descriptions are quite rightly generalized. The twin poems are related through abundant parallel and contrast; and the couplets, in trochaic and iambic lines of seven or eight syllables, trip and flow and pause with expressive ease. If the imagery and tone of the "Nativity" partake in some degree of the Italianate and Spenserian manner, these poems may be said to embody—and excel—the urbane, civilized decorum of Jonson's lyrical and reflective pieces—a quality already manifested in the tiny ceremonial "Song: On May Morning" (1629–30?) and the "Epitaph on the Marchioness of Winchester" (1631). In "L'Allegro" the learned Jonson is joined with "sweetest Shakespeare," the unlearned author of outdoor comedies (the plays that would appeal to the mirthful man). Milton had lately (1630) written the lines "On Shakespeare" which had the honour—the circumstances are not known—to be printed in the Shakespearian Second Folio (1632). The two elegies on Hobson the Cambridge carrier—whose death (1631) occasioned much student wit—were on a different level, of jocose punning.

Milton's scholarly and literary gifts had from childhood marked him out in the minds of his family and teachers for the ministry; in his later prose he said he had refused to "subscribe slave" in a church governed by prelacy, but the date of his negative decision is not known. As his academic career approached its end, the problem of an occupation would come up, and the poem "Ad Patrem"—though some scholars link it with *Comus* (1634)—may well have been written in 1631–32. In this piece, with a mixture of filial gratitude, firmness and confidence in poetry and himself, Milton assumes or urges that he would not be pushed into some basely lucrative profession by a father who has fostered his literary pursuits and is himself a devotee of the muses.

**Horton Period (1632–38).**—On taking his M.A. in July 1632, Milton retired to his father's house—perhaps first at Hammersmith, then the country estate at Horton, near Windsor, Berkshire—and proceeded to give himself the liberal education Cambridge had not provided. It was in these years that he laid the foundation or set the direction of his liberal thinking. With the humanistic zeal that had fired the seventh prolusion, he sought to digest the mass of history, literature and philosophy ancient and modern, to gain the "insight into all seemly and generous arts and affairs" needed by the citizen-poet who would be, no less than the cleric, a leader and teacher. At times he suspended his labours to visit London in quest of books or something new in mathematics or music.

An important landmark in Milton's early development is the

sober sonnet, "How soon hath Time," written on his 24th birthday, Dec. 9, 1632. During recent years he had become a figure in the small university world; now he writes this sonnet while his contemporaries are forging ahead and he has had six months of studious and outwardly unfruitful obscurity at home. But any uneasiness about his present and future is quieted in the earnest dedication of his life to his great Taskmaster's will. What might be called the first pledges toward the fulfillment of this self-consecration were two short religious poems, "On Time" and "At a Solemn Music" (1632–33). They have the form of a madrigal, a stanza of a *canzone*, and the irregular lines are powerfully modulated, so that every word has weight. The poems are early renderings of the beatific vision that always kindled Milton's imagination. Both, in different sequence, contrast the grossness of temporal life, the jarring discord of sin, with the eternity and harmony of heaven and good.

*Comus.*—The same contrast is sounded in the opening lines and carried through the whole of the masque known as *Comus*. During 1630–33, perhaps in 1632, Milton had, at the invitation probably of the musician Henry Lawes, written *Arcades*, a miniature masque of Jonsonian courtliness designed as a tribute to the dowager countess of Derby. *Arcades* presumably led to a request from Lawes for another masque. *Comus* was presented on Sept. 29, 1634, before the earl of Bridgwater at Ludlow castle in Shropshire, in honour of his becoming lord president of Wales. Lawes, the producer, acted the role of the Attendant Spirit; the parts of the Lady and the two Brothers were taken by the earl's children, of whom the eldest, Lady Alice Egerton, was only 15. The acting version, though somewhat shorter than the text familiar to readers, in length and elevated seriousness went far beyond the limits of the usual court masque, which emphasized lavish costumes, spectacle, music and dancing. Milton did provide such elements in some degree, and also, in Comus' rout of monsters, the "antimasque" often used as a grotesque contrast to ordered beauty, but his aim was not merely decorative. *Comus* was his first dramatizing of his great theme, the conflict of good and evil.

The Homeric and Ovidian Circe, whose power of changing men to beasts had long been allegorized as sensuality, becomes Comus ("revelry"), the son of Circe and Bacchus. Many sources have been suggested as contributing to Milton's mythological and pastoral fable—George Peele's *Old Wives' Tale*, Spenser's *Faerie Queene*, John Fletcher's *Faithful Shepherdess*, Jonson's *Pleasure Reconciled to Virtue*, William Browne's *Inner Temple Masque*, Erycius Puteanus' *Comus*, Tasso's *Aminta*, Italian musical dramas. But, from the first lines of the Attendant Spirit (who is a fusion of Neoplatonic daemon and Christian angel) to the incantatory epilogue, the conception and the poetry bear the clear impress of the author; they embody the crystal purity of his vision of perfection. The chastity the Lady represents is not mere abstinence; it is the positive love of the good that is both Christian and Platonic. Comus, who is projected with a dramatic irony that anticipates the treatment of Satan, puts forth specious naturalistic arguments which the Lady answers first on the rational level; then, with a conscious change of tone, she rises to an impassioned religious affirmation of "the Sun-clad power of chastity," and the epilogue celebrates the love of virtue which alone brings freedom and joy and the help of heaven. The best commentary on *Comus* is the personal passage in Milton's antiprelatical tract, *An Apology for Smectymnuus* (1642), where he tells how early reading had nourished his faith in chastity: he had loved and imitated the erotic poetry of Ovid and his fellows, but, while continuing to cherish their art, he had turned away from their sensuality to the idealism of Dante and Petrarch; then came the romances of knighthood (doubtless these included "our sage and serious poet Spenser"); and finally "the divine volumes of Plato" taught the true love of the good; and prior to and beyond all were "those chaste and high mysteries" glorified by St. Paul and the Book of Revelation.

*"Lycidas."*—If *Comus* was in a way a song of innocence, "Lycidas" (written in Nov. 1637) was a song of experience. Milton's first attempt to justify the ways of God to himself and to men. His former fellow collegian, Edward King, was drowned in a shipwreck in the Irish sea in Aug. 1637, and Milton was asked to contribute to a volume of elegies. "Lycidas," signed "J. M.," appeared at the end of an undistinguished collection of pieces in Latin, Greek and English (1638). The pastoral convention had, from its Greek beginnings, proved its value as a dramatic vehicle or mask for almost anything, public or private, that a poet wished to say, and Milton, working as usual within a venerable tradition, as usual re-created it. The pastoral devices—the lament of nature, the procession of mourners and so on—were accommodated to the Italian *canzone*, with its paragraphs and lines of irregular length and irregular rhyme. Dr. Johnson, in complaining of the absence of grief and the presence of pastoral artifice and a mixture of Christian and pagan allusion, missed the point entirely. Milton had no reason to feel deep personal sorrow for King had not apparently been an intimate friend; but the drowning of a virtuous and promising young man, on the threshold of service in God's church, brought home the whole enigma of life and death, of the rightness of things in a world where such events could happen. What if his own talents—which during his years of study at Horton he has been nurturing under his great Taskmaster's eye—should be cut off? Thus the "digressions" on fame and hireling clergy are not digressions but quite central in the emotional dialectic. In the end, God's justice and providence and the conditions of earthly life are vindicated not by reason, but by the beatific vision of Lycidas' soul received into heaven. A few bald sentences, however, cannot approach the complexities and depths of the poem, its reverberating solidity of reference, its rich variety of pace and tone, the artistic control that dominates turbulent emotions and ends with the high serenity of victory won. "Lycidas" may be the greatest short poem in the language.

**Italian Tour (1638–39).**—In May 1638, a year after his mother's death, Milton set off—with one servant—on a visit to Italy. He sojourned chiefly in Florence, Rome and Naples. Milton and some of his early poems—not those in English—were cordially welcomed among men of letters and patrons and their academies. The experience, which he described at length in the *Second Defence of the English People* (1654) and alluded to elsewhere, warmed his heart and nourished his self-confidence. (It may be remembered that at home he had very little literary acquaintance and, outside a small circle, no poetic reputation; his only writings in print were "On Shakespeare," *Comus*—published anonymously by Lawes in 1637—and "Lycidas," which was buried in the volume on King.) To his distinguished host in Naples, Baptista Manso, marquis of Villa, who had been the patron of Tasso and Marino, Milton wrote a bread-and-butter epistle, "Mansus" (1638–39), which is one of his best Latin poems, a graceful apologia for English culture and a no less graceful statement of his own poetic standing and hopes. He wrote also an epistle to a Roman poet, Salzilli, and several epigrams in praise of the singing of the famous Leonora Baroni. Though he mingled happily with Catholics, and was a guest at a grand entertainment given by Cardinal Barberini, the stout Protestant did not remain silent on matters of religion. He made a call—recorded in *Areopagitica*—on Galileo in his semicaptivity. Milton felt obliged to forgo a visit to Sicily and Greece because of news of mounting tensions in England, although, as he says, he lingered some time longer in Italy.

*Epitaphium Damonis.*—In Aug. 1638 Milton's friend Diodati (who had become a physician) died. Milton no doubt learned of his loss while in Italy; on his way homeward he stopped to see Diodati's uncle, John Diodati, professor of theology at Geneva. He returned to England in July 1639, and proceeded to settle in a house in London and prepare to take in pupils; the first ones were Edward and John Phillips, the sons of his sister Anne. His elaborate pastoral elegy on Diodati, *Epitaphium Damonis*, was written apparently late in 1640 and privately printed. This has commonly been ranked at the head of Milton's Latin poetry, though dissenters may ask if the fact of its commemorating his dearly loved friend has not heightened its intrinsic merits. There are expressions of heartfelt loneliness which are especially moving from a man often regarded as proudly self-sufficient; but in the poem as a whole Milton seems unable, perhaps because of the reality of his grief, to unify and re-create his pastoral material as

he had done so powerfully in "Lycidas."

**Prose Works.**—In his denunciation of hireling clergy in "Lycidas," Milton had virtually declared his Puritan allegiance, and the years 1641–60 he gave almost wholly to pamphleteering in the cause of religious and civil liberty. He had returned to England with anxiety about that cause, and also with plans for an Arthurian epic (plans set forth briefly in "Mansus" and *Epitaphium Damonis*); like other ambitious poets of the Renaissance, he hoped to write the great modern heroic poem. As he shows in the important personal passage in his fourth tract, the *Reason of Church-Government Urged against Prelaty* (1642), it was a heavy sacrifice to put aside his craving for poetic immortality and his cherished studies to "embark in a troubled sea of noises and hoarse disputes," but he could not be deaf to God's summons. And, as his work went on, he was sustained by the conviction that in his many and varied defenses of liberty he was, in another way, fulfilling his epic and patriotic aspirations.

The large bulk of Milton's prose—which fills four times as many volumes as his poetry—is read only by scholars, but much of it is important for several reasons. In an age of great prose, Milton's, at its best, has a very individual if often undisciplined greatness, and *Areopagitica* at least is a classic document and possession of the race. Then, even if he had never written any poetry, his prose works, though they had small influence in their own time, would remain a valuable interpretation of the Puritan revolution, and they have their place in modern histories of political thought. Finally, as the record of Milton's growth (a leftward growth, in religion and politics) and of his dreams and disillusionments, they are the essential introduction to *Paradise Lost*, *Paradise Regained* and *Samson Agonistes*, the bridge between the radiant idealism of youth and the much-tried faith and fortitude of age.

*Antiprelatical Tracts.*—In Nov. 1640 what was to be the Long parliament met and began its reform of abuses; it was soon confronted with a popular agitation against the bishops. During 1641–42 Milton contributed five pamphlets to the attack on prelacy made by the "Smectymnuus" group of Presbyterian divines (the word was composed of their initials, *ty* being Thomas Young, Milton's old tutor). The main issue was what had been the main issue since the emergence of Puritanism early in the reign of Elizabeth I: that the Church of England with its episcopal hierarchy and Prayer Book and ritual was a compromise with Rome (as it had been), and that the Reformation must be completed with a drastic purge of Romanism and a return to the democratic simplicity and purity of the apostolic church. Milton has all the Puritan emphasis on the inward spirit of biblical faith in contrast with outward show and spurious tradition; thus in the opening of his first tract, *Of Reformation Touching Church-Discipline in England* (1641), the Anglican service, so beautifully described in "Il Penseroso," has become "the new-vomited paganism of sensual idolatry." The tract ends with a vehement and magnificent prayer which proclaims Milton's glowing vision of a new and grand Reformation; he touches on his own role as the poet-singer of God's mercies and judgments, and his share in the millenarian dreams of his time appears in the apostrophe to "the eternal and shortly-expected King" who will reward his champions. All the main points come up in this pamphlet, though the *Reason of Church-Government* (1642) is a more ordered argument. It contains the memorable passage in which, with characteristically sublime naïveté, Milton explains his religious conception of poetry and the deferment of his projected epic because of public duty. The fifth and last tract, known under its abbreviated title *An Apology for Smectymnuus* (1642), lives chiefly in the passage cited above in connection with *Comus*, a self-defense that rises far above the refuting of opponents' charges of immorality.

*Tracts on Divorce; Marriage.*—Milton's first real notoriety came with his *Doctrine and Discipline of Divorce* (Aug. 1643; enlarged edition Feb. 1644), which was buttressed by three more tracts, *The Judgment of Martin Bucer, concerning Divorce* (Aug. 1644) and *Tetrachordon* and *Colasterion* (March 1645). Marriage—a prime concern of men in all ages—had been a signal concern of Reformation thought and one that Milton had reflected on in the Horton period (as entries in his Commonplace Book indicate). His discussion was presumably hastened by his own marital disaster. About May 29, 1642, several months before the outbreak of the Civil War, Milton had married Mary Powell, the daughter of a royalist squire of Oxfordshire who owed money to his father. Success could hardly be predicted for the marriage of a scholar and poet of 33 and an uneducated girl of half his age from a large, easygoing household. The young wife, visiting her family a little later, declined—doubtless with their backing—to return. The shock of the experience must have been especially severe for a man who—as one may infer from the anguished cries that recur in the *Doctrine*—had approached marriage not only with high hopes (and an unblemished past) but with earnest prayers; and there was no release from such a tragic mistake. In the tracts, Milton argued that the sole cause admitted for divorce, adultery, might be less valid than incompatibility, that the forced yoke of a loveless marriage was a crime against human dignity. Both religious and philosophic tradition and the way of the world (including the usually meagre education given to girls) kept woman inferior to man; Milton, without denying that view, upheld a personal and Puritan ideal of marriage as an active bond of mutual love and mental companionship, an ideal that exalted women and wives far above the level they occupied, say, in Cavalier poetry. He was, however, assailed as a new libertine by royalists and Presbyterians alike. In 1645 friends brought about a reunion between Milton and his wife; and in 1646, when the Powells had been ruined by the war, he took into his house, for nearly a year, the whole noisy family of ten. Three daughters, Anne, Mary and Deborah, were born in 1646, 1648 and 1652 (a son died in infancy); Mrs. Milton died a few days after Deborah's birth.

*Of Education and Areopagitica.*—In 1644 Milton published what are for modern readers his best-known pamphlets, *Of Education* (June) and *Areopagitica* (November). The former, written at the request of Samuel Hartlib, a man active on many progressive fronts, was one of the last in the long line of European expositions of Renaissance humanism. Milton's aim was the traditional aim, the molding of boys into enlightened, cultivated, responsible citizens and leaders. His proposed academy, which would take the place of both secondary school and college, was to be the model for many others. The main material was the ancient classics, in due subordination to the Bible and Christian teaching. The traditional role of physical and martial exercise was perhaps heightened by Milton's concern over the war in progress. Several points suggest some affinity with the especially Puritan movement toward practical education. While Milton could not share its illiberal hostility to the classics, he did want less gerund-grinding; also, objecting to a premature excess of logic, he planned a graduated advance from sense experience to abstract ideas; and, most conspicuously, he gave a large place to all kinds of science. If his program now seems unduly strenuous it must be compared, not with modern schools and colleges, but with contemporary practice and with the programs of earlier humanists, such as Rabelais.

*Areopagitica* (1644) is of course one of those tracts for the times that transcend their occasion. In 1637 the Star Chamber, reinforcing traditional censorship, put control of the press virtually in the hands of Archbishop Laud and the bishop of London. While the Long parliament abolished the hated Star Chamber, it was disturbed in its turn by the rising flood of unlicensed books, and, in order to maintain or regain its authority, it issued a new ordinance on licensing (June 14, 1643). In Aug. 1644 the Stationers' company (the guild of master printers) demanded stricter enforcement of this ordinance, naming Milton among transgressors. He had written his antiprelatical tracts as a Presbyterian, but in *Areopagitica* he saw the new censorship as only an exchange of episcopal for Presbyterian tyranny. Notwithstanding this disillusionment, he expresses a boundless faith in the Englishmen whom God has chosen to complete the Reformation Wycliffe had begun. With a still larger vision, Milton writes as a scholar and poet and lover of books, above all as a resolute believer in the power of truth to win its way through free inquiry and discussion.

(While this grand plea deserves its classic status, it is not the plea for complete freedom that modern libertarians sometimes make it; in vehemently denouncing censorship before publication Milton freely admits censorship afterward, since for him as for other liberals there must be safeguards for religion and morality.) Themes so near Milton's heart inspire soaring, richly figurative eloquence and also homely, richly figurative satire. In the whole work, cast in the form of a classical oration and addressed to parliament (as if to the Athenian assembly) with more than Milton's usual tact, the organization of topics and sentences alike has more deliberate order and clarity than his hurried prose commonly achieved. *Areopagitica* seems to have had very little effect in its own time—partly, perhaps, because the main theme of pamphlet controversy in 1644–45 was the problem of religious toleration raised by a group of Independent divines who sought congregational freedom from Presbyterian uniformity.

*Political Tracts and Secretaryship.*—In the next few years Milton may have been working chiefly on his *History of Britain* and his large treatise on Christian doctrine. By Feb. 13, 1649, two weeks after King Charles's execution, appeared his first political tract, *The Tenure of Kings and Magistrates*. In his first tract of 1641, Milton had written as a good monarchist, intent only on freeing the crown from the incubus of prelacy. By 1649 he had moved far enough to the left to expound the more or less democratic doctrine of Renaissance liberals, that power resides always in the people, who delegate it to a sovereign but may, if it is abused, resume it and depose or even execute the tyrant. Milton obviously rejected the Stuart claim of divine right; and his view of that abstract theorem, the social contract, was directly opposed to the view of such absolutists as Thomas Hobbes, who held that the people surrendered all rights. In the *Second Defence of the English People* (1654), surveying his earlier writings on liberty, Milton said that he wrote the *Tenure* to reconcile the public mind to Charles's execution, though the terms of his reference suggest the possibility that his own mind was not entirely at ease.

In March 1649, a month after the appearance of the *Tenure*, Milton was invited to become secretary for foreign languages to Cromwell's council of state. Hitherto a detached observer, Milton, in spite of his private studies, was doubtless eager to have a hand in the workings of government (his official experience has often been thought to have contributed to the realism of the fallen angels' debate). He was not on the policy-making level, but he had the easy command of Latin needed for foreign correspondence. Also, as a publicist of demonstrated sympathy with the revolution, he was expected to continue his defense of the cause against the multiplying attacks on the Commonwealth regicides.

Milton's first effort in this line was *Eikonoklastes* (Oct. 1649), one of a number of answers to *Eikon Basilike*, a book edited from the king's papers by his chaplain, John Gauden; this ostensible self-portrait of the royal saint and martyr, catching the public in its first shock of horror over the execution, was one of the most potent pieces of propaganda in English history, and not even Milton could prevail against it.

During 1651 Milton was censor and supervisory editor of the chief Commonwealth newspaper, *Mercurius Politicus*, edited by Marchamont Needham. In this year he became an actor on the European stage, with the publication of his Latin *Defence of the English People*. Charles II, in exile, had engaged Claudius Salmasius (Claude Saumaise), the most eminent of classical scholars, to arraign the regicides (*Defensio Regia pro Carolo I*, 1649). Milton was less effective in legal argument than in discrediting Salmasius by personal abuse; like some other crusaders, he tended to see opponents as monstrous enemies of a sacred cause who must be destroyed by any means. If he was, then and later, uplifted by the vanquishing of a renowned antagonist, he was inevitably and profoundly depressed by the loss of his eyesight; it had been failing for years and blindness became complete in the winter of 1651–52. Milton was only 43, and the great poem was still unwritten. Blindness reduced his strictly secretarial duties, though he continued through 1659 as a translator of state letters.

The *Second Defence of the English People* (1654)—also in Latin, since it also was addressed to Europe at large—was much more worthy of its subject and its author. It was a reply to an anonymous attack, *Regii Sanguinis Clamor ad Coelum adversus Parricidas Anglicanos* (1652), which Milton insisted on ascribing to Alexander More, though it was written by Peter Du Moulin (More had had a share in the business). Milton celebrated the achievements of the Commonwealth leaders in the heroic mood of his sonnets on some of them (Fairfax, Cromwell, Vane)—though he was bold enough to warn Cromwell against one-man rule; and, replying to the charge that he had brought on his blindness by immorality, he linked himself with the blind poet-seers of ancient myth in a passage that approaches the invocation to light in *Paradise Lost*. In *Pro Se Defensio* (1655), answering More's self-exculpatory attack, Milton tacitly accepted his denial of authorship but piled up evidence for his general responsibility and personal depravity.

Two tracts on church and state were published in 1659. In *A Treatise of Civil Power in Ecclesiastical Causes* (February), Milton argued that "it is not lawful for any power on earth to compel in matters of religion"; from such large toleration Roman Catholics were exempted, since Catholicism had shown itself a danger to national security. *Considerations touching the Likeliest Means to Remove Hirelings out of the Church* (August) reasserted, against an establishment and its tithes, the ideal of a clergy of apostolic simplicity of life. Much later, in *Of True Religion, Heresy, Schism, Toleration, and . . . the Growth of Popery* (1673), Milton pleaded for Protestant harmony and unity.

His last political pamphlet, *The Ready and Easy Way to Establish a Free Commonwealth*, was published in March 1660 and again, enlarged, in April. It was an act no less courageous than futile, since machinery was patently moving to bring back Charles II (he made his triumphal entry on May 29). Though Milton's outline of a republican constitution has historical interest, the modern reader's chief reaction is emotional. The tract is a cry of incredulity and despair from the last champion of "the good Old Cause." The glories of the Commonwealth, to which he himself had given 20 years and his eyesight, are being swept away by a nation of slaves "now choosing them a captain back for Egypt"—the "noble and puissant nation" whose faith and love of freedom he had so celebrated in his early pamphlets. The Restoration was the last and heaviest of Milton's many disillusionments.

Many things might be said of his religio-political thinking (and of its effects on later times), but only two can be here. The dynamic centre of his creed was "Christian liberty," a Reformation doctrine which he deepened and widened beyond its common limits. The superseding of the Covenant of Works by the Covenant of Grace is expounded in the *Christian Doctrine* (I, xxvii) and in a grand passage at the end of *Paradise Lost* (xii, 285–306). In brief, the Mosaic law was a primitive moral and ceremonial discipline imposed from above upon an untutored people; it is abrogated for the Christian, who, with the illumination of grace, is a self-governing agent, "freed from the yoke of human judgments, much more of civil decrees and penalties in religious matters." The revolutionary implications of such a creed are obvious—though one must not forget Milton's constant stress on inward discipline. A second point is that the revolutionary radical was not a democrat in the modern sense. He was a classical or "aristocratic" republican in whose ideal vision Platonic philosopher-kings coalesced with the Puritan "saints," and who found historical approximations in ancient Athens and Rome and some modern counterparts.

*De Doctrina Christiana.*—Milton's very large treatise, *On Christian Doctrine*, though now read only by students, held a central place in his thoughts and labours. He seems to have finished it by *c.* 1658–60. It was first printed and translated by Charles Sumner in 1825. But Milton apparently hoped that it might, in his own time, provide a solid basis of strictly biblical doctrine on which all Protestants could unite. For such a compendium he had special models in the work of Johannes Wollebius and William Ames. Granted his premises (which of course long ago lost their validity), Milton's treatise contains much acute argument; its modern importance is that it spells out with clear precision the

theology that operates in *Paradise Lost*. Viewed in a large perspective, most of Milton's essential beliefs are those of traditional Christianity, but—always on authority he finds in the Bible—he departs from orthodoxy on some notable points (not to mention polygamy): God created the world, not out of nothing, but out of his own substance; God the Father, the Son and the Holy Ghost are not a coequal Trinity but a descending order; man's soul dies with his body, until revived at the resurrection (this "mortalist" heresy, which is put into the mouth of the despairing Adam, had other adherents in Milton's England). The significance of the first point is that, in *Paradise Lost* (v, 469 ff.) as well as in the treatise (I, vii), Milton expounds a monistic and "optimistic" metaphysics, a sort of Christian materialism: since the one first matter of God's own substance is good, since all creation proceeds from God and, if not depraved from good, returns to him, matter is not essentially different from spirit but is forever in the process of becoming spirit. Milton's conception of the Trinity, which in itself and its background is too complex for summary, is apparent to alert readers of *Paradise Lost*, though the poem did not disturb generations of the orthodox. More basic for the poem is Milton's denial of Calvinistic predestination (which of course is not a heresy). Brought up, like most Anglicans of his time, as a Calvinist, he regarded himself as one at least until 1644, but his final belief was in the Arminian doctrine—the salvation, not of a predestined few, but of all believers, who constitute the true "elect." As one would expect of a man who had absorbed classical and especially Platonic ethics, Milton insisted on man's rational freedom and responsible power of choice (a main premise and theme of *Areopagitica*). His conception of "Christian liberty" was noticed in the preceding section. While the *Christian Doctrine* is an invaluable gloss on the epic, Milton the poet was well aware of the gulf between biblical truth and imaginative illustration; in the treatise Satan and the war in heaven received only a few lines.

**Sonnets and Other Poems (1642–58).**—Milton's early poems, English, Latin, Greek and Italian, were published at the beginning of 1646 (dated 1645). The loss of a gift copy on its way to the Bodleian library, Oxford, prompted an urbane Latin poem (1647) to John Rous, the librarian, a wartime meditation on poetry and culture that is somewhat akin to the sonnet of Nov. 1642, "Captain or Colonel." During the 20 years given to public affairs Milton was mostly cut off from poetry, but he wrote 17 occasional sonnets, versified a number of psalms and began the composition of *Paradise Lost*. Some of the sonnets on public men and events—for which Tasso had set an example—have been mentioned already; these, although so different in form, have the heroic tone of Horace's loftier odes (in Milton's hands, as Wordsworth said, the sonnet became a trumpet), and the leaders he salutes are invested with the large dignity of ancient heroes. "On the Late Massacre in Piedmont" (1655) is a tremendous imprecation that suggests the Hebrew prophets. Milton is sometimes consciously Horatian in the urbane geniality of addresses to young friends like Edward Lawrence and Cyriack Skinner; and the sonnets to Lady Margaret Ley and Henry Lawes further attest his genius for friendship. Several sonnets on the Presbyterian reception of his divorce tracts and on Presbyterian rigidity, are roughly colloquial journalism. At the opposite pole are the deeply personal sonnets, two on his blindness (1651?–55) and one on the death in 1658, some months after childbirth, of Milton's second wife, Katherine Woodcock, whom he had married in 1656. The major sonnets have much poetical as well as autobiographical interest, and as a group they illustrate (with "Lycidas") both in texture and rhythm the beginnings of the grand style which Milton may have learned partly from Della Casa and Tasso and which was to have full scope in the epic. One is less conscious of the sonnet structure and of rhymes than of a single massive unit which approaches a paragraph of Milton's blank verse.

**Later Life (1660–74).**—The Restoration government executed Sir Henry Vane and exhumed and hanged at Tyburn the bodies of Cromwell, Ireton and Bradshaw—acts of revenge apparently recalled in lines 693–696 of *Samson Agonistes*. Milton himself, as the noted defender of the regicides, was in real danger. In the summer of 1660, when a warrant was out for his arrest, he was kept in hiding by friends; and, though not excepted for punishment in the Act of Oblivion (August), he was later taken into custody (and released on Dec. 15). According to different early stories, his life was spared through the intercession of the poet Andrew Marvell, who in 1657 had become a fellow secretary and was now a member of parliament, or of the royalist playwright Sir William Davenant, whose life Milton had earlier been the means of saving. It may have been thought that the blind writer was now harmless and that nominal proceedings against him were enough; he was even said to have been offered a Latin secretaryship under Charles II. Milton's 14 remaining years were on the whole outwardly and in part inwardly peaceful, although, along with sombre or uplifting thoughts of past and present, there were concrete troubles, a frugal domestic economy necessitated by greatly diminished resources; blindness, and what was sometimes a more severe affliction, the pains of gout; and a degree of friction with his daughters, due probably to faults on both sides. Apart from the publication of books, the chief events of these years were Milton's marriage (1663) to a third wife, a young and amiable Elizabeth Minshull, who survived him, and the removal, during the plague of 1665, to a house at Chalfont St. Giles, Buckinghamshire (now a Milton museum). One cannot catalogue the 11 houses, including temporary lodgings, that Milton occupied in London.

Early biographers give pictures of a quiet daily routine. Milton got up at 4 A.M. and had the Hebrew Bible read to him. Meditation, reading and dictation filled the time till midday dinner. Milton's late and long poems were of course composed in his head, especially at night, as famous allusions in *Paradise Lost* indicate (according to his nephew, Edward Phillips, his vein flowed happily only from the autumnal to the vernal equinox); when he was ready "to be milked," he would dictate, often with one leg flung over the arm of his chair. The taking of dictation, the correcting of copy, and reading aloud in various languages were services performed by paid amanuenses, his two nephews, his daughter Deborah and friends and disciples. After dinner, says John Aubrey, "he used to walk 3 or 4 hours at a time (he always had a garden where he lived)." In the evening there was reading of poetry and he went to bed about 9, after a pipe and a glass of water. One refreshment was music, playing on the organ or viol and singing; "he would be cheerful even in his gout fits, and sing" (Aubrey). And there were many, sometimes too many, callers—foreigners (who came to see the conqueror of Salmasius, not the poet) and English friends, old and young, such as men already mentioned and the young Quaker, Thomas Elwood, whom Milton helped with his Latin. He was, Aubrey reports, "Extreme pleasant in his conversation, and at dinner, supper, etc.: but satirical"; "He pronounced the letter R (*littera canina*) very hard ('A certain sign of a satirical wit'—from John Dryden)." In religion Milton had moved from the low-church Anglicanism of his parents to Presbyterianism to Independency to independence. In the latter part of his life, said John Toland, "he was not a professed member of any particular sect among Christians, he frequented none of their assemblies, nor made use of their peculiar rites in his family." But, as Dr. Johnson observed, suspending his Anglican hostility, "his studies and meditations were an habitual prayer." Milton died on Nov. 8, 1674, "of the gout struck in" (Aubrey), a month short of his 66th birthday. His burial in St. Giles's, Cripplegate, was attended by "All his learned and great friends in London, not without a friendly concourse of the vulgar" (Toland).

The publications of Milton's late years were: *Paradise Lost* (1667), for which he received £10; textbooks of simplified Latin grammar (1669) and logic (1672); the *History of Britain* (1670); *Paradise Regained* and *Samson Agonistes* (1671); the second, enlarged edition of the *Poems* of 1645 (1673); the second, revised edition of *Paradise Lost* (1674); and *Epistolae Familiares* with the *Prolusiones Oratoriae* (1674). *A Brief History of Moscovia* appeared in 1682. A Latin dictionary on which Milton had long worked was completed by others and published in 1693. Edward Phillips translated *Letters of State, written by Mr. John Milton* (1694), with a life.

**Paradise Lost.**—Milton gave up the idea of a British epic described in "Mansus" and *Epitaphium Damonis*. Among nearly 100 biblical and historical subjects for dramas that he set down *c.* 1640, he chose the most momentous event, next to the life and death of Christ, in the world's history. He outlined dramatic treatments of this theme in four short drafts which suggest Italian allegorical representations of biblical story, such as G. Andreini's *L'Adamo* (1613). Edward Phillips recorded that part of Satan's address to the sun (*Paradise Lost*, iv. 32–41) was written early as the opening speech of a drama. In shifting to the epic Milton may have been impelled by the supreme place that form held in Renaissance theory and by his own need for larger scope. It is not known when actual composition began; guesses have centred on 1655–58. Clearly the lines on the poet's having fallen on evil days, in the prelude to book vii, were composed after the Restoration, and presumably the whole was done pretty much in the order in which it stands. It was finished by 1665. The first edition of 1667 was in ten books; this was reissued in 1668 and 1669, and in one of the 1668 issues Milton added the prefatory note on his use of blank verse and the arguments. In the second edition (1674), along with some small revisions, books vii and x were each split into two; and the arguments, formerly grouped together, were placed at the head of the respective books.

The fall of man had for many centuries received copious theological commentary and innumerable imaginative treatments, narrative and dramatic, so that the simple tale in Genesis and the more shadowy role of Satan in heaven, earth and hell had acquired a good deal of interpretative and concrete embellishment. One late, long and popular example which Milton had known in boyhood is the crudely vigorous poem on the creation and the fall by the Huguenot Guillaume Du Bartas, which, translated by Josuah Sylvester as *The Divine Weeks and Works* (1605), held sway in England until superseded by *Paradise Lost* (line 373 in book iii is identical with a line in Sylvester). And Milton would surely have read Grotius' drama, *Adamus Exul* (1601). His knowledge of both the theological and the literary tradition was probably extensive but can seldom be pinned down; from time to time this or that work has been claimed as his "source," yet the inevitable family resemblance among the numerous poetic versions negates or discounts most such claims. The general fact is that the main motives and events of *Paradise Lost* had more or less precedent, though they were handled with powerful originality; Milton, like a Greek dramatist, was reworking a story familiar in outline to his audience. His story, moreover, was one of unique truth, sacredness and universal and eternal import, and it gave the poet the advantage of immemorial belief and association in the minds of his earlier readers, an advantage that no longer operates in the same way—although, for modern readers, the fable possesses the immemorial and universal import of archetypal myth.

Notwithstanding the accumulated embellishments, and the anthropomorphic nature of the nonhuman personages, the story had little of the solidity and variety of character and action of the classical epics, and Milton the classicist naturally took over much in the way of form and style and epic convention. While he was said to have known the Homeric poems by heart, and often echoed them, the great neoclassical model was the *Aeneid*, with which *Paradise Lost* has some inner as well as surface affinities. As Virgil, with his partly abstract theme, re-created what he imitated from the concrete Homer, so Milton, with his far more abstract theme—the assertion of Eternal Providence, the justification of God's ways to men—re-created what he borrowed from both. Thus invocations of the muse, which in Milton mark new stages in the story or changes of scene, become addresses to the heavenly muse, Urania, and prayers for the aid of the creative spirit of God. As artist, he links himself, both proudly and humbly, with the ancients, especially Homer and the blind bards of Greek myth, but he regularly ranks his Christian theme above the themes of the pagan poets. As he had said long before, in explaining why he must postpone his epic, it was a work not "to be obtained by the invocation of Dame Memory and her Siren daughters, but by devout prayer to that eternal Spirit who can enrich with all utterance and knowledge, and sends out his seraphim with the hallowed fire of his altar, to touch and purify the lips of whom he pleases."

Some other large features of the classical and especially Virgilian pattern must be mentioned. Milton makes daring use of the prescribed plunge *in medias res*, since he gives the magnificent first two books to his "villain." Virgil has a roll call of the Italian chiefs who gather to oppose the heaven-sent Aeneas; Milton's roll call of the leaders of the fallen angels, in making them individuals, also becomes a survey of the spread of heathen idolatry over the eastern world. The realistic power of the debate in hell dwarfs all other epic councils. Epic accounts of Hades and of funeral games are combined in Milton's pictures of hell, with Christian lore, but the lurid and dismal scenes and the physical and mental diversions of the fallen angels symbolize their spiritual death and futile striving. The wars of gods and Titans and giants supply details for the war in heaven, which is a large metaphor for the anarchy of sin. The story of events that preceded the opening of the poem, which Odysseus recapitulated at the court of Alcinous and Aeneas at the court of Dido, becomes the archangel Raphael's account of Satan's revolt and war and the Son's creation of the world; and the great object lesson for Adam is underlined by a discourse on astronomical uncertainties which contrasts humble righteousness with the prideful quest of external knowledge. Finally, while a prophetic picture of human history might figure in stories of the fall, Michael's revelation to Adam (books xi–xii) recalls Anchises' revelation to Aeneas; but whereas Aeneas learns of the divinely destined Roman *imperium*, Adam is shown supernal grace contending with the sinfulness of men and the eventual triumph of love with the advent of man's Redeemer—though he is shown too how the gospel of salvation becomes corrupted.

The prime example of this kind, though it goes far beyond classical parallel and contrast, is the characterization of Satan, who is one of the supreme figures in world literature. Satan has, on a superhuman scale, the strength and courage and capacity for leadership that belong to the ancient epic hero, but these qualities are all perverted in being devoted to evil and self-aggrandizement. Satan's character is presented partly through narrative and comment and heroic or—later—animal simile (and many of our most vivid visual memories of the poem are of Satan in his various postures and settings). But there is also the full dramatic self-revelation familiar from Shakespeare's villains, and Satan's speeches at moments remind the reader of Richard III, of Iago and Edmund, of Macbeth. Thus in his first grand speech to his lieutenant Beelzebub, Satan's defiance of God manifests in every phrase his egoistic pride and passion, his false conception of freedom, his alienation from all good, and his other public harangues reinforce and amplify our sense of power that is religiously and morally corrupt and blind. Against the background of hell, Satan maintains (up to the final, wholesale metamorphosis that follows his return from earth) the false magnificence of his "heroic" stature; outside of hell he loses even that. In his soliloquy addressed to the sun he reveals, like Dr. Faustus or Macbeth, his despairing consciousness of his own evil and damnation, a consciousness that gives him potentially tragic dimensions, though he is not allowed to become, like Macbeth, a truly tragic figure. Thus Satan (in his usual public role) and his fellows are enveloped in dramatic irony, because—though the corruption of man is achieved—they fight and scheme in ignorance of the issues at stake, in ignorance of the unshakable power of God and goodness.

Adam and Eve are enveloped in a partly parallel kind of irony. The picture of Eden is a symbolic rendering of Milton's vision of perfection, but it is presented when the reader accompanies Satan into the garden, so that idyllic innocence and happiness are seen only under the shadow of evil. Though the pair have had warnings, Eve is beguiled by an appeal to her vanity and ambition, by the hubristic dream of attaining godlike knowledge and power; and Adam, whose stronger reason is aware of the issues, allows his love for Eve to oversway his love for God. Both, far from attaining godlike knowledge, succumb to animal lust; yet, when grace and penitence begin to work in them, they have a strength

beyond the reach of Satan. On the other hand, though there is promised redemption for the faithful, and though the poem is, logically, a divine comedy with a happy ending, Milton's panorama of human history gives little ground for hope on earth. Irony, profoundly compassionate irony, pervades the simple, complex and moving last lines which describe Adam and Eve as they depart from Eden—not now the majestic lords of creation but two frail human beings beginning life anew in the world of sin and sorrow and death, though "with Providence their guide" and the hope of achieving a "paradise within."

The more one reads *Paradise Lost* the more one recognizes Milton's powers of imagination and organization. Everywhere, on the largest or the smallest scale, in abstract idea or concrete act, theme and material are closely knit through parallel and contrast. The central conflict and contrast between good and evil are reflected and intensified in the contrasts between heaven and hell, light and darkness, order and chaos, love and hate, humility and pride, reason and passion. In the council in hell, Satan alone volunteers for the perilous journey to earth to bring about the fall of man; in the council in heaven, the Son alone volunteers to suffer on earth for man's salvation. Satan and Sin and Death, at the gates of hell, constitute a monstrous and abhorrent parody of the Trinity; when Sin and Death build a bridge from hell to earth, their new domain, they hover upon the waters, like the spirit of God at the creation. Satan unlooses the destructive anarchy of war; the Son creates the world. Eve and Adam reenact the sin and fall of Satan. The boundless scene of *Paradise Lost* is indeed only a backdrop or magnified reflection of the drama that goes on in the hearts of the human protagonists; and when they fall, the ideal world of eternal spring and eternal life becomes the world we live in.

To speak of the setting in more literal terms, Milton's imagination fills space so immense that the created universe—the Ptolemaic one—hangs from heaven like one of the smallest stars close by the moon. Milton showed his awareness of the Copernican universe but the Ptolemaic had the advantages of traditional familiarity and of keeping earth and man at the focal centre. In his handling of vast space Milton's imagination and language work with a suggestive vagueness (mixed with the substantial and concrete) that is very different from the minute particularity of Dante's world. He is excited by the starry dance of the cosmic order, and likewise by the fecundity of Eden; and the account of creation is alive with the sense of movement and growth. The poem is rich in its appeal to the eye—and other senses—as well as to the ear.

Milton's preface stressed the novelty and rightness of blank verse for a heroic poem, and his manipulation of rhythm and sound is of course one of his supreme achievements. The continuous flow of his long sentences and paragraphs is naturally unlike the dramatic blank verse of Shakespearian dialogue, and it builds up a continuous onward pressure. Some main elements of Milton's technique had been conspicuous in his sonnets, in spite of their pattern of rhyme. While the iambic pentameter line remains in one's ear as the norm, there may be extra syllables, and there is endless variety in the number, weight and position of stresses. At the same time there is a secondary and still more fluid system of rhythmic units, which flow from the caesura in one line to the caesura in the next. The principle stated thus baldly means in practice, an infinity of permutations and combinations. As a modern master of rhythm, T. S. Eliot, has said, Milton's blank verse is never monotonous. And the pattern of sound is so wedded to the pattern of sense that each is essential to the other.

Milton's frequently Latinate syntax and diction have sometimes been censured, especially by modern poets and critics for whom colloquial speech and rhythm are the only acceptable medium (though this is in fact no less "artificial" than the grand style). Milton had both ancient and modern (especially Italian) tradition on his side. Homer and Virgil were, in their different ways, thoroughly stylized, and such moderns as Tasso had practised and critically expounded the various ways of achieving the elevation required by a lofty theme. Miltonic elevation is rarely inflation; and it is intermixed with pure simplicity. Latinate syntax or structure, freedom in the placing of phrases and clauses, does not obscure the sense and greatly enlarges and enriches the poet's range of emphasis, the means of economy, contrast, suspension, all the devices of forceful utterance—devices often really colloquial. Many other and likewise functional elements of the grand style could be noted: periphrasis, epic similes, geographical, historical and mythological allusions, etc.

**Paradise Regained.**—In *Paradise Lost* (ix) Milton spoke of "patience and heroic martyrdom" as themes unsung, though nobler than martial prowess, and this "better fortitude" was celebrated in *Paradise Regained* and *Samson Agonistes* (1671). Presumably both works were composed after *Paradise Lost*. In the *Reason of Church-Government* (1642) Milton had named the Book of Job as a model for a brief epic, and its influence is clear in both. *Paradise Regained* is a logical sequel to the long poem since Christ, the second Adam, wins back for man what the first Adam lost. But Milton did not, as his title and theological tradition might suggest, deal with the Crucifixion; instead he showed Christ in the wilderness overcoming Satan the tempter, thereby proving (by God's design) his fitness for his ultimate trial and, in his human role, proving what man in general might achieve through strong integrity and humble obedience to the divine will. Milton followed Luke's version. The first temptation, to change stones into bread, would imply distrust of Providence. The second temptation, that of the kingdoms of the world, Milton extended into a series—a gorgeous banquet, wealth, glory, the delivery of Israel from the Roman yoke, alliance with Parthia or Rome, the imperial throne and, finally, the wisdom of Greece. Christ is proof against all of these. "To the utmost of mere man both wise and good." Dramatic tension has been built up by Satan's tormenting doubts of his antagonist's identity and mission, and also by Christ's own deepening knowledge of both and by our mounting sense of his isolation. The third temptation, that of standing on the pinnacle of the temple, is a challenge which, with dramatic suddenness, reveals Christ's divinity to both Satan and himself. This poem, less of an epic than a drama with elaborate stage directions, is cast in a style of almost gospel simplicity. The mass of readers and critics seem to have found it cold, though it has all the fire of Milton's religious and moral passion, his reverence for true heroism. Many, too, have been upset by Christ's repudiation of the Greek culture which Satan praises in language that seems to come, and does come, from the poet's own heart; but Milton had always, like other Christian humanists, ranked the literature and natural wisdom of antiquity below the Bible and Christian faith. There is a scale of values.

**Samson Agonistes.**—That Christ's rejection of Greece is relative, not absolute, is shown by the fact that *Samson*, in the same volume with *Paradise Regained*, is in the pattern of Greek tragedy, which (along with Italian) Milton extols in his preface. *Samson*, by far the greatest English drama on the Greek model—and, for some readers, the most powerful and completely satisfying of Milton's major works—has affinities with all three of the Greek masters because the poet did not "get up" the technique for the occasion; he wrote out of lifelong saturation and as the Christian peer of the ancients. But the drama recalls especially Aeschylus' *Prometheus Bound* and Sophocles' *Oedipus at Colonus*. Always a strict observer of "decorum," Milton admits no specifically Christian idea, attitude or allusion; his hero, to be sure, is not at all the brawny barbarian of the Book of Judges, but he remains Hebraic—with touches, toward the end, of a calm reasonableness that reminds one of Socrates in prison. The action, up to the reported catastrophe, is wholly psychological; it is the process by which Samson, "Eyeless in Gaza at the mill with slaves," moves from preoccupation with his misery and disgrace to selfless humility and renewed spiritual strength, so that he can once more feel himself God's chosen champion. Still more clearly than the Christ of *Paradise Regained*, Samson is isolated; not even his father or the chorus perceives the true inwardness of his experience. The whole drama is charged with more than Sophoclean irony. Every scene has an effect different from that expected by

the interlocutor; and countless details, from the title and the first line onward, are potently ambiguous. Though the subject had long been in Milton's mind, the drama must owe a good deal of its power to his sense of kinship with his hero; he has been eyeless in London among a nation of slaves. But nowhere does the classical impersonality and restraint of Milton's art show itself so strongly; there is nothing in the drama that does not belong to the story of Samson. And Milton's classical style appears in a new phase, in a rugged, sinewy, colloquial texture and in irregular rhythms of new expressiveness. Altogether, if *Samson* was his last work, it was a grand testament. Like Samson, Milton was able to conquer despair, or to sublimate it in his last three poems. These expressed, not his earlier revolutionary faith in men and movements, but a purified faith in God and the regenerative strength of the individual soul.

**Miltonic Criticism.**—Much of the older criticism, down into the 20th century, is mainly of historical interest and may give modern readers less insight into the poet than into the critic and his cultural climate; but Milton's fame and influence are part of the history of English literature and culture (and libertarian thought). Since criticism in the modern sense was only being created by his young contemporary, Dryden, there is little early testimony: Sir Henry Wotton's praise of *Comus* (in the letter prefixed to the *Poems* of 1645), Marvell's commendatory lines on *Paradise Lost* (1674), Dryden's epigram linking Milton with Homer and Vergil and his more restrained comments in prose, and a few anecdotes. Of special interest is Dryden's report (preface to the *Fables*): "Milton has acknowledged to me that Spenser was his original"—*i.e.*, general model. But Milton's growing eminence is attested by the series of early biographies (*Early Lives of Milton*, ed. by H. Darbishire, 1932): the anonymous manuscript first printed in 1902 (assigned by Miss Darbishire to Milton's nephew, John Phillips, but claimed by W. R. Parker for Cyriack Skinner); the notes, printed in 1813, of the lively and careful John Aubrey; and the lives by Anthony à Wood (1691), who has next to no original value, Edward Phillips (1694), John Toland (1698) and Jonathan Richardson (1734).

Patrick Hume's annotated edition of *Paradise Lost* (1695)—one of Jacob Tonson's five editions of 1688–98—was the first scholarly edition of any English poet. Richard Bentley's edition (1732) was the disastrous attempt of a great classical scholar to emend a supposedly corrupt text. Better evidence of Milton's classical standing was Bishop Newton's variorum edition of the poems (1749–52) and Thomas Warton's edition of the early poems (1785; rev. 1791). Criticism proper began with Addison's papers on *Paradise Lost* in *The Spectator* (1712) in which, accepting Milton as the peer of the ancients, he applied neoclassical theory, noted classical parallels and praised "beauties." Addison was a prime agent in extending Milton's fame on the continent. Dr. Johnson's treatment (*Lives of the Poets*, 1779) suffered from his political and religious prejudice and from some critical failures of understanding, but it retains the value of its author's massive honesty and genuine if limited insight. Milton's enormous influence on 18th-century verse is traced by R. D. Havens, *The Influence of Milton on English Poetry* (1922).

The 19th century opened with H. J. Todd's variorum edition of the complete poems (1801; rev. 1809; 5th ed., 1852), which is still useful, and may be said to have closed with David Masson's important edition (1890). Masson's *Life* (6 vol., 1859–80, with revised editions of the first 3 vol. and an Index, 1881–96) is subject to correction on many things, but it was a great achievement and remains of much value for Milton's life and times.

Nineteenth-century criticism includes many notable names, such as Hazlitt, Coleridge, Keats, Landor, Macaulay, Emerson, Bagehot, Arnold, up through the larger and more professional studies of Mark Pattison (1879) and Sir Walter Raleigh (1900). A brief summary may divide criticism of the 19th and the early 20th century into two main streams. First, the revolutionary romantics, Blake and Shelley, launched the "Satanist" misinterpretation of *Paradise Lost* and its author which is summed up in Blake's saying that Milton was of the Devil's party without knowing it; that is, Milton—as a rebel like Blake and Shelley—projected himself into Satan, his real hero. The other main attitude, also focused on the epic, was also a product of 19th-century liberalism: its exponents threw Milton's beliefs and ideas overboard as long-dead fundamentalism and listened only to the organ voice.

Milton's influence, which had worked from about 1650 up through the romantic poets, largely waned in the Victorian age. In the 20th century the new poetry and criticism inaugurated by Ezra Pound and T. S. Eliot was strongly anti-Miltonic and pro-Donnian, but in the 1940s and 1950s critical activity shifted markedly from Donne back to Milton. Scholarship, going its own way, had already discovered "the new Milton." The movement in scholarship and scholarly criticism which began about 1920 and which (in the late 1950s) showed no sign of exhaustion, produced a vast and varied array of general and special studies; these placed the thinker, the publicist and the poet firmly and significantly in the history of ideas, exterminated the romantic notions touched on above, and brought a new refinement of perception and analysis to the aesthetic study of the poetry (though a poet steeped in the classics may have fared better, in that area, with the older critics). A conspectus is provided in James Thorpe, *Milton Criticism: Selections From Four Centuries* (1950).

*See* also references under "Milton, John" in the Index.

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A large body of scholarship and criticism digested in a 3-vol. variorum commentary on all the poems (the first since Todd), vol. i (1960); the most compendious small digest is *A Milton Handbook*, 4th ed. (1946), by J. H. Hanford, a leader in the modern reinterpretation of Milton. Some general and miscellaneous studies are: Robert Bridges, *Milton's Prosody*, rev. ed. (1921); E. M. W. Tillyard, *Milton* (1930), *The Miltonic Setting* (1938) and *Studies in Milton* (1951); D. Bush, *English Literature in the Earlier Seventeenth Century*, ch. 12 (1945); I. Samuel, *Plato and Milton* (1947); S. E. Sprott, *Milton's Art of Prosody* (1953); D. C. Allen, *The Harmonious Vision* (1954); K. Muir, *John Milton* (1955); K. Svendsen, *Milton and Science* (1956); D. Daiches, *Milton* (1957). T. S. Eliot's essays of 1936 and 1947 are reprinted in *On Poetry and Poets* (1957).

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(D. Bu.)

**MILTON,** a town of Norfolk county, Mass., U.S., located on the Neponset river 7 mi. S. of Boston on hilly terrain that falls gently down to the river from the Blue hills in the south. Settled in 1636 as a part of Dorchester and known by the Indian name of Unquity-quisset, the town of Milton was incorporated in 1662. It soon grew into a mill town and in the 18th century was an important small industrial centre. Industrial activity decreased during the 19th century with the important exception of stone cutting. Stone for the Bunker Hill monument was quarried in Quincy, cut in Milton and transported by the Granite railway, the first railroad chartered in the U.S.; motive power was furnished by horses and oxen.

In the late 19th century Milton became a wealthy suburb of Boston. The large estates were gradually broken up after 1930 and Milton became a suburban community with a small amount of manufacturing. Milton academy (boys) and Milton Academy Girls' school are located there. Blue Hill observatory was established in 1885. For comparative population figures *see* table in MASSACHUSETTS: *Population.* (L. G. Ba.)

**MILWAUKEE,** the largest city of Wisconsin, U.S., is located on the west shore of Lake Michigan, 85 mi. N. of Chicago; a port of entry and seat of Milwaukee county. Population (1960) city 741,324; standard metropolitan statistical area (Milwaukee and Waukesha counties) 1,194,290, to which Ozaukee county (1960 pop. 35,441) was added in 1963. (For comparative population figures *see* table in WISCONSIN: *Population.*)

The city proper is entirely within Milwaukee county and almost wholly hemmed in by incorporated suburbs, including Wauwatosa and West Allis (*qq.v.*). The altitude of 580 ft. at lake level rises 75 to 125 ft. to the west. Three rivers cut the city into natural divisions: the Milwaukee river, entering from the north, is joined half a mile from its mouth by the Menomonee flowing from the west, and nearer the lake by the Kinnickinnic from the south; it empties into Milwaukee bay, about 6 mi. wide. Commercial and industrial property lines the banks of these streams in their navigable, downtown sections. A large part of the lake front was reclaimed or redeveloped for parks and municipally owned outer harbour facilities, including Lincoln Memorial drive. The Court of Honor, a broad park space dedicated to participants in U.S. wars, extends for three blocks on Wisconsin avenue, past the public library and museum. In the heart of the city lies the City centre, a municipal redevelopment area dominated on the west by the massive neoclassical courthouse, made of Indiana limestone, and extending to lake-front Juneau park. Side by side on its north are the municipal auditorium and arena, whose halls can seat 24,500 persons and provide 140,000 sq.ft. for exhibits; on the south the city hall (1894) suggests a Flemish Renaissance town hall. The county's parks and river parkways cover more than 9,100 ac. and provide for all the popular games and recreations, including an extensive zoological garden, botanical gardens and golf courses. County stadium (capacity 43,110) is the home of the Milwaukee Braves, baseball team of the National league.

**History.**—In 1673 Jacques Marquette and Louis Jolliet skirted the west shore of Lake Michigan in their canoes, and Milwaukee bay is distinctly marked on a map attributed to Marquette. La Salle and his party probably stopped there on their way south in 1679, and the name (spelled Melleoiki) first appears in missionary records of that year. Occasional French fur traders may have visited there in the late 17th century. By the time of the American Revolution British traders also were stopping. Jacques Vieau used the Milwaukee post annually for the North West Fur company (British) from 1795 to 1818, when he was superseded by his French-Canadian son-in-law Solomon Juneau (1793–1856), representing Astor's American Fur company. The settlement, sporadically occupied by Indians, was on the route from Fort Dearborn (Chicago) to Green Bay, and as soon as Indian titles in southeastern Wisconsin were extinguished by treaties with the Menomini and others, 1831–33, land seekers appeared. In 1833 Morgan L. Martin (1805–87), a Green Bay land speculator of New York birth, visited Milwaukee, mapped the harbour, and conceived of townsite speculation. In association with Michael Dousman he entered into an agreement with Juneau for a half interest in the latter's pre-emptive claim to the east side. The next year Connecticut-born Byron Kilbourn (1801–70) and a Virginian, George H. Walker (1811–66), planned a similar promotion of the west and south sides. Platting of the townsite occurred in 1835, with completion of the survey and opening of the land to public sale. Two of the villages, officially Milwaukee East Side and Milwaukee West Side, were popularly known as Juneautown and Kilbourntown; rivalry between them, especially over bridges, streets and finances, survived their union as two wards of the town of Milwaukee in 1839 and the addition of Walker's Point (to the south) in 1845. In 1846 the three wards, each of which up to that time had retained complete financial and administrative autonomy of its own affairs, were incorporated as the City of Milwaukee, with Juneau the first mayor.

The first newspaper, the *Milwaukee Advertiser*, began publication on July 14, 1836. In the same year a public school district was formed but a free school system awaited incorporation of the city. In 1839 George Smith and Alexander Mitchell established the Wisconsin Marine and Fire Insurance company, which, despite its name, served as one of the strongest banking houses west of the Alleghenies for over 40 years. The first brewery was built in 1840. Harbour development, advocated as early as 1834, soon permitted Milwaukee's emergence as a major grain and flour port, draining the wheat-raising hinterlands to the Mississippi by plank road and rail. Commerce dominated the city's early decades, but in post-Civil War years industry developed, especially meatpacking, tanning, brewing and iron- and steelmaking.

**Population Characteristics.**—About 1840 the Yankee village received the first German migration; by 1900, 72% of the population had Germanic origins which marked the city's society and culture. Modest Irish and Scandinavian migrations dwindled late in the 19th century before a Polish influx, which impressed the city's south side as much as the Germans on the north. Additional east and south European elements joined a Negro migration from the south in swelling the city's population in the 20th century. An 1850 population of 20,061 reached 285,315 by 1900 and 578,249 by 1930, after which growth was slower.

**Government.**—The city operates under an 1874 charter, providing for a "weak" mayor and a "strong" board of aldermen representing 20 wards and elected every four years. A charter convention of 1908 failed to bring reform but a home rule amendment to the state constitution in 1924 permitted revision by simple council ordinance. Frank P. Zeidler served as mayor from 1948 to 1960, the third member of the Socialist party to become the city's chief executive (Emil Seidel 1910–12, Daniel W. Hoan 1916–40). Henry W. Maier became mayor in 1960.

A Progressive era reform movement brought Milwaukee a reputation for clean and efficient government. Nonpartisan elections (1914), law enforcement free from politics, long tenure for able career administrators and civic support of expanded government services on a pay-as-you-go basis characterized the city. But in the 1960s tension with the 18 suburbs in the county—eight newly incorporated and several sparsely settled—had replaced the provision and maintenance of water supply and sewage disposal facilities and other housekeeping functions as the city's major concern. Programs for an expanded water supply, expressways, public housing, renewal and redevelopment of the city's core, downtown parking and cultural and recreational facilities not only represented municipal maturity but also entailed new relationships to suburban, county, state and federal governments.

**Commerce, Industry and Transportation.**—Milwaukee is

the commercial metropolis of the state and a major industrial centre of the United States in the value of its manufactured products. Its fine harbour, open during most of the year and accessible to the largest ships using the Great Lakes-St. Lawrence seaway, is the most important gateway to the northwest for traffic across Lake Michigan. Water-borne commerce in the second half of the 20th century amounted to 7,500,000 to 9,000,000 tons annually. For more than a century Milwaukee has been one of the great grain ports of the Great Lakes. A small but increasing portion of its port tonnage is overseas. Wholesale trade covers the upper Mississippi valley; retail trade suffers from nearness to Chicago.

The leading manufactured products are electrical machinery, construction and mining machinery, castings and forgings, general industrial machinery and autos and auto parts. Dependence on such capital goods somewhat obscures important consumer products—small gasoline engines, batteries, locks, motorcycles, outboard motors, beers, shoes and meats. The largest firms do not dominate the local economy nor is military buying so important as in other heavy industry centres. Local, and in many instances family, ownership of substantial concerns has persisted longer than was usual in other places. The labour force is highly skilled and well paid.

Several federal highways enter and pass through Milwaukee. Railways connect the city with Chicago and with the Twin cities of Minneapolis and St. Paul, Minn., and with the west; some eastern rail traffic goes by car ferry across Lake Michigan. Milwaukee county's General Mitchell air terminal on the south is a regular stop for commercial airlines; it handles both passengers and freight. The Lawrence J. Timmerman airport to the northwest is for feeder use. Numerous motor coach, truck and lake steamship lines serve the community. Electric and gas buses have superseded trolley cars within the city, while expressways violate a checkerboard street pattern to facilitate auto flow from central city to suburbs.

**Education and Welfare.**—The public school system includes elementary and junior, senior and technical high schools and a vocational school, founded in 1912, which offers apprenticeship; continuation, adult vocational and recreational; and accredited high-school and junior-college programs. There are also Roman Catholic and Lutheran elementary and high schools. The central library services a number of neighbourhood branches and some of the suburbs. The museum of natural and human history has a special collection of prehistoric American Indian materials. Its typewriter collection appropriately reflects the Milwaukee invention of the first practical instrument in 1869 by C. Latham Sholes. The Milwaukee Art centre, housed in the War memorial on the lake front, combines collections of the former Milwaukee Art institute and Layton Art gallery. The Layton School of Art became a degree-granting institution in 1951, the Wisconsin Conservatory in 1930. Marquette university, a Roman Catholic coeducational institution founded in 1864, provides liberal arts, business, engineering, dental, medical, law and journalism curricula. The University of Wisconsin-Milwaukee combines the former facilities of the Milwaukee State (Teachers) college and the University of Wisconsin's Milwaukee extension division, merged in 1956 as an autonomous unit under a provost responsible to the president and regents of the university. It awards degrees in education, letters and science, commerce and engineering. Milwaukee-Downer college, a private college formed in 1895 by consolidation of Milwaukee college and Downer college of Fox Lake, instructs women in liberal arts, home economics and occupational therapy. Alverno (1887), Cardinal Stritch (1937) and Mount Mary (1872) are Roman Catholic colleges for women; St. Francis seminary (1856) prepares Catholic priests; and Concordia college (1881) offers a Lutheran preseminary two-year course. Milwaukee School of Engineering (1903) is internationally known for electrical and mechanical training. In suburban Wauwatosa, county welfare institutions care for the aged, dependent, diseased and insane, while at Wood there is a U.S. veterans administration hospital on the site of one of the nation's three original post-Civil War soldiers homes. Civic programs for public health, traffic safety and fire and crime prevention have brought many records and awards since the 1920s.

The *Milwaukee Sentinel* (morning; founded 1837, daily since 1844) and the *Milwaukee Journal* (evening; founded 1882) are augmented by a German and a Polish daily, the survivors of a once thriving foreign language press, and by numerous church, suburban and foreign language weeklies. Several television stations, one of them an educational outlet of the vocational school, and several radio stations transmit local and network programs to the area. (F. I. O.)

**MILYUKOV, PAVEL NIKOLAEVICH** (1859–1943), Russian historian and liberal leader who became minister of foreign affairs in the first provisional government after the March revolution of 1917, was born in Moscow on Jan. 27 (new style; 15, old style), 1859. He had a distinguished academic career, specializing in Russian history and teaching it at Moscow university. He surpassed his master V. O. Klyuchevski in the comprehensiveness of his vision and soon won a nationwide reputation as a historian. His frank public speaking on contemporary issues, however, led to his imprisonment in 1901, but it also brought him invitations to teach in the United States (1903–04). Milyukov was a convinced westernizer, seeing in absolutism the main obstacle to Russia's progress toward parliamentary democracy. Under the influence of British radical thought he strove to make Russian liberalism a mass movement committed to social reform. Milyukov was a better judge of abstract ideas than of human nature and was too inflexible to be successful in politics.

As a contributor to the clandestine journal *Osvobozhdenie* ("Liberation"), founded in 1902, Milyukov advocated a freely and democratically elected national assembly and did much to swing the incipient liberal movement to the left. In the revolutionary year 1905 he returned to Russia to become the guiding spirit of the Constitutional Democratic, or Kadet, party and editor of its daily newspaper *Rech*. On three occasions in 1905–06 he had private talks with government representatives (S. Y. Witte, D. F. Trepov and P. A. Stolypin); but he refused to compromise on the essentials of the Kadet program, and no agreement resulted.

As the revolutionary tide ebbed Milyukov took a more moderate stand. In the third and fourth dumas (1907–17) he emerged from the wings to become the Kadet party's acknowledged leader. He condemned bureaucratic abuses and championed the rights of non-Russian nationalities within the empire. When World War I broke out he soon adopted a patriotic attitude. He considered that Russia's national interests made the acquisition of the Turkish straits a legitimate war aim, and he advocated the formation of a ministry enjoying public confidence to unite the country in prosecuting the war. This latter demand was unwelcome to reactionaries at court and in the bureaucracy. Milyukov endeavoured to overcome their obstruction by gentle pressure from the duma, in which he organized the moderate parties into a Progressive bloc (Aug. 1915). His overcautious tactics proved ineffective, and in the autumn of 1916 he abruptly changed course. On Nov. 14 he delivered a powerful speech in the duma implying that the government was guilty of treason. His charges had no real substance, but were effective in stimulating revolutionary sentiment. Once again he had miscalculated.

In March 1917 Milyukov sought to preserve the monarchy as a stabilizing influence. But the tide was running strongly against him; and in the provisional government under Prince G. E. Lvov, though intellectually he towered above his colleagues, he was soon outmaneuvered by the Socialist A. F. Kerenski. As foreign minister he clung to the demand for the Turkish straits and stubbornly resisted popular pressure for a democratic peace without territorial annexations. When on May 1 he reluctantly sent to the Allies a note in the sense desired by the Petrograd soviet he deliberately phrased it in ambiguous terms. Disturbances broke out and he had to resign (May 15). He then attempted unsuccessfully to counter the provisional government's swing to the left, which he had himself involuntarily facilitated. After the Bolshevik revolution of Nov. 1917 he served as political adviser to Gen. A. I. Denikin. After emigrating to Paris he reverted to his early radicalism, trying to unify the various currents on a common

republican democratic platform. He remained politically active, as a staunch liberal, until his death at Aix-les-Bains, Fr., on March 31, 1943.

Milyukov's works include *Istoriya vtoroi russkoi revolyutsii* ("History of the Second Russian Revolution"; 2 vol., 1921), *Rossiya na perelome* ("Russia's Great Change"; 2 vol., 1927) and *Outlines of Russian Culture* (3 vol., 1942). His *Vospominaniya* ("Reminiscences," 2 vol.) appeared in New York in 1955.

(J. L. H. K.)

**MILYUTIN, DMITRI ALEKSEEVICH,** COUNT (1816–1912), Russian army officer and statesman, generally regarded as his country's greatest minister of war, was born in Moscow on July 10 (new style; June 28, old style), 1816, of a family of the lesser nobility. After completing his training at the Nicholas military academy in 1836, he served in the Caucasus from 1838 to 1845. Subsequently he was a professor in the Nicholas academy till 1856, when he was appointed chief of staff of the Caucasian army operating against Shamil. During his years at the academy he had published a series of military studies: the best known of these, *Istoriia voiny Rossii s Frantsii*, five volumes (1852–53), dealt with A. V. Suvorov's campaign of 1799. In 1860 he entered the war ministry as deputy minister and in Nov. 1861 became minister of war, a position he held for 20 years. Milyutin inaugurated a series of radical reforms throughout the entire Russian military system. He greatly modified the code of harsh discipline and brutal punishments; he improved the military education of both officers and regular troops; and he reorganized and strengthened the administration of the army. The period of regular service was reduced and, most important of all, he introduced universal military service through the statute of 1874. Henceforth all young men reaching the age of 20 were liable to six years of active service and nine in the reserve. These measures were part of the great reforms of the emperor Alexander II's reign. Milyutin was made a count in 1878.

After the congress of Berlin (1878) Milyutin was a proponent of the League of the Three Emperors linking Russia, Austria-Hungary and Germany. He retired in 1881 when his policies came into conflict with those of the new emperor, Alexander III. He died at Yalta on Feb. 7 (N.S.; Jan. 25, O.S.), 1912. His diaries were published in Moscow in 1947–50. (B. J.)

**MILYUTIN, NIKOLAI ALEKSEEVICH** (1818–1872), Russian statesman remembered for his role in the emancipation of the serfs under the emperor Alexander II, was born in Moscow on June 18 (new style; 6, old style), 1818, the younger brother of D. A. Milyutin.

Educated at Moscow university, he entered the ministry of the interior at the age of 17 and advanced rapidly in the service. He was responsible for the reform of the administration of St. Petersburg, Moscow and Odessa, to which he imparted elements of self-government, and was in charge of the preparation of statistical manuals bearing on social and economic developments. In 1856 he became identified with the preparatory work for the emancipation of the serfs.

His program of reform was deemed too liberal by powerful reactionary circles, but he had influential supporters, among them the grand duchess Elena Pavlovna, widow of the late emperor Nicholas I's brother Michael. Appointed assistant minister of the interior in 1859, Milyutin took a leading part in the framing of the emancipation acts of March 3 (N.S.; Feb. 19, O.S.), 1861, from which he succeeded in eliminating some of the more objectionable features advocated by the ultraconservative groups. He was forced to retire in April 1861, but after the Polish insurrection of 1863 he was appointed secretary of state for the Russian part of Poland, where in 1864 he carried out a land reform favouring the peasantry at the expense of the Polish landowners, who were considered as the core of Polish nationalism. Milyutin was also instrumental in the russification of the Polish schools and administration and in the abrogation (1866) of the concordat with the Holy See. He suffered a stroke in 1866 and died in Moscow on Feb. 7 (N.S.; Jan. 26, O.S.), 1872.

*See* A. Leroy-Beaulieu, *L'n homme d'état russe* (1884); M. T. Florinsky, *Russia. History and an Interpretation*, vol. ii (1953). (M. T. F.)

**MIME,** a dramatic-literary form of Greek and Roman origins. The word is derived from the Greek *mimeisthai* ("to imitate or represent") and refers to both the play and the actor. The Greco-Roman mime was a farce that stressed mimetic action. The preliterary form can only be guessed at, and even the surviving fragments of the playlets of Epicharmus (*q.v.*), a 5th century B.C. writer of comedies, yield only the scanty information that the mimes to which he had given literary stature were concerned with scenes of daily life or with mythological travesty. Other Greek writers of mimes were Sophron (fl. *c.* 430 B.C.) and Herodas (3rd century B.C.) (*qq.v.*).

It can hardly be assumed that early Italian life was deprived of mimetic performances. The existence of a native Italian form of mime may safely be postulated; the Latin word *planipes*, "with bare feet," points to a mime actor who wore no shoes in performance. The first to give literary form to the Roman mime was the knight Decimus Laberius (*c.* 105–43 B.C.) (*q.v.*), who was eclipsed by the ex-slave Publilius Syrus (*q.v.*). The presentation of mimes was a traditional feature of the annual *Floralia* festival, which, being licentious in spirit, opened the popular stage to naked mime actresses (*see* FLORA).

Though only fragments exist, it is clear that the usual mime plot, while free to indulge in biting topical allusion, centred principally around scenes of adultery and other vice. Evidence exists that acts of adultery were actually performed on the mime stage during the Roman empire. Execution scenes with convicted criminals in place of actors are on record. When condemning the Roman theatre, the early Christian writers attacked primarily the mimes in this state of degeneracy. Stock characters and situations of the classical mime found their way into the comic drama of Plautus and Terence and reappeared greatly modified in the *commedia dell'arte* (*q.v.*), a Renaissance extempore entertainment with roots in the Roman theatrical tradition.

Modern mime developed into a purely silent art whereby meanings are conveyed solely through gesture, movement and expression. Its influence was felt strongly in ballet, where the formal posturing of classic style modulated into the descriptive silence of modern dramatic dance movement. In the United States, silent film mimes like Charles Chaplin and Ben Turpin, television entertainers like Sid Caesar and circus clowns like Emmett Kelley were masters in the ancient tradition. The high art of modern mime, however, was templed in France, where its practice was ennobled philosophically by Étienne Decroux, Jean Louis Barrault and Marcel Marceau. Marceau defined mime as "the art of expressing feelings by attitudes and not a means of expressing words through gestures."

*See* also DIALOGUE; DRAMA: *Greek Drama: Origins;* GREEK LITERATURE: *Comedy;* PANTOMIME; THEATRE: *Supplementary Arts: Mime, Pantomime, Vaudeville and Music Hall.*

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**MIMETITE,** a mineral consisting of lead chloroarsenate and closely resembling the lead chlorophosphate pyromorphite (*q.v.*) in appearance and general characters. The arsenic in mimetite is usually partly replaced by equivalent amounts of phosphorus; thus, there may be a gradual passage from mimetite to the isomorphous pyromorphite. The two species can, as a rule, only be distinguished by chemical analysis and because of their close resemblance, the less frequently occurring chloroarsenate was named mimetite or mimetesite, from the Greek word for imitator. Like pyromorphite, mimetite is found in the upper parts of veins of lead ore, where it has been formed by the oxidation of galena and mispickel (arsenopyrite). When found in large amount it is important as an ore of lead. Its composition can be represented by the formula $Pb_5(AsO_4)_3Cl$ and it crystallizes in the hexagonal system. Crystals of pyromorphite though usually optically uniaxial are sometimes biaxial, but in mimetite this anomalous character is almost always present; a cross section of a hexagonal prism of mimetite shows a division into six optically biaxial sectors or a complex lamellated structure. Mimetite is usually yellow or brown, rarely white or colourless; the lustre is resinous to adamantine. The hardness is

3.5, the specific gravity, 7.0–7.25. The best-crystallized specimens are those from Johanngeorgenstadt in Saxony, Wheal Unity in Cornwall, and Tsumeb in South-West Africa. In the United States mimetite has been found in Pennsylvania and in Arizona, California, Nevada and Utah. It was formerly found in considerable amount at Drygill, Cumberland, as six-sided, barrel-shaped crystals of a brownish-red or orange-yellow colour; this variety has been called campylite from a Greek word meaning curved, because of the remarkable curvature of the faces of the crystals.

**MIMICRY,** as used by naturalists, refers to certain advantageous resemblances chiefly between animals or, in a few cases, between plants (e.g. the common dead-nettle and the stinging nettle). These resemblances may exist between species of very different degrees of relationship, generally distant but sometimes near; they are such as appeal to the senses of enemies, especially to the sense of sight, not uncommonly to hearing and occasionally to smell and touch. They differ from the much larger class of protective resemblances that bring about concealment by a likeness to some object of no interest to enemies. The true mimic resembles a conspicuous "model" that is feared or disliked by its enemies; thus the mimic gains protection.

Mimetic resemblances also differ from similarities that are an incidental result of similar functions, such as the general likeness in form between the race horse and the greyhound or between the true moles and the molelike species among the rodents and marsupials. Moreover, the incidental likeness between species that resembles a common part of their surroundings—sand, bark, leaves, etc.—is not considered mimicry. The emphasis has been on the study of animal mimics rather than of plant mimics, a stress that will be followed in this article.

## ORIGIN AND EXTENT OF MIMICRY

Several views as to the origin of mimetic resemblances are that they are due: (1) to the direct influence of the environment acting similarly on different species; (2) to a physiological response to constant mental experience such as colour sensation; (3) to sexual selection, modified by the presence of other types of colour (this suggestion, attributed to Fritz Müller, is weakened by the fact that female butterflies are far more commonly mimetic than males); (4) to the same gene and its mutation in mimic and model; and (5) to a restricted range of possible animal colour patterns and shapes, so that the mutation of different genes, having different effects, will sometimes bring about approximately the same appearance in distinct species.

These resemblances are no mere coincidence, for they are geographically linked. Mimics are found in the same localities as their models and when the latter are modified, the mimics change with them. There are exceptions when the mimics are greater wanderers than their models, and in one remarkable example two butterflies in western China appear to be mimics of a model very common south of the Himalayas; in this case selection by migratory insectivorous birds may be influenced by their remembered experiences of the tropics.

Although mimetic resemblance is believed to exist in mammals, birds and fishes, the number of examples is small and their interpretation often doubtful. Among reptiles, poisonous snakes are mimicked by harmless species. Even the English grass snake will often, when cornered, poise itself and strike like an adder.

But, for the study of mimicry, the insects are supreme: small proportions survive and generations swiftly follow one another, so that the results of natural selection are evident in a short time.

The most formidable of all models are the bees and wasps, striking examples of which are the carpenter bees (Xylocopidae) and their fly mimics. Mimicry and protective resemblance is also found in the Homoptera which, in addition to the cicadas, aphids and others, include also the Membracidae, a cosmopolitan family of small insects with a concentration in tropical America. They have on the body ring behind the head a projection which grows backward and expands into a shield covering every part except the head, wings and legs. This is so marked as to represent protected insects and other natural objects. Certain groups of butterflies that are particularly rich in examples of mimicry have long been studied.

### BUTTERFLY MODELS AND MIMICS

Much about mimicry in butterflies is meaningful only in the light of natural selection and consistent with the view that it is an advantageous resemblance and has been developed for its own sake. The butterflies most generally mimicked by species of other groups and by day-flying moths belong to a few predominant tropical subfamilies, many of whose members are unpalatable to prey, the Danainae, Acraeinae and the genus *Atrophaneura* of the Papilioninae in the old world, and, in the new, the Ithomiinae allied to the first, and the Heliconiinae allied to the second, together with very few Danainae and many Acraeinae. Now, however widely the types of pattern vary within each of these subfamilies, they are still mimicked by butterflies of other groups and often by moths. The South American acraeines have very different patterns from those of the African acraeines, yet both are extensively mimicked.

**Danaine Butterflies.**—The most striking evidence, however, is supplied by the divergent colours and patterns of the danaine models, of which a few examples are figured. The oriental *Hestia* and its allies are large, black-and-white butterflies with thin, papery wings. A characteristic example is *Hestia lenconoe* from the Philippine Islands and its swallowtail mimic (*Papilio idaeoides*) from the same locality. In the same part of the Malay peninsula the male of *Euploea midamus*, an example of a far commoner and widespread danaine type, that of the blue *Euploeas*, mimics another swallowtail (*Papilio paradoxus*). In Africa the danaines, though far fewer, are the chief models for mimicry. Most of the species belong to the genus *Amauris*, black butterflies with white or yellowish markings, very unlike the oriental Danainae.

An entirely different type of danaine pattern is borne by a series of nearly related species in the oriental region, probably the original home of the group. One of those bearing the pattern has migrated westward and become the chief model for mimicry in Africa, while two others have traveled eastward and become the ancestors of American species mimicked by indigenous American butterflies. The best-known invader, the monarch (*Danaus plexippus*), is mimicked by a nymphaline butterfly, the viceroy (*Limenitis archippus*). The viceroy is closely related to the British white admiral and is itself so recently descended from a North American white admiral that the two will interbreed and produce hybrid offspring. In all the earlier stages of its life history the mimic remains a white admiral, the mimetic resemblance being restricted to the final colour and pattern. If mimetic likeness were the result of local influences, the invader would have come to resemble the native rather than that the native should mimic the invader. This is clearly not so in certain butterflies with many forms of female. Thus, three Uganda females of the African swallowtail *Papilio dardanus* mimic, respectively, three very different danaine patterns, and the fourth an acraeine; in other parts of Africa where the danaine patterns alter, and one of them or the acraeine model is absent, the corresponding female is similarly modified or wanting. In another African swallowtail, *Papilio cynorta*, the females mimic an acraeine, changing geographically with the changes of the model. But in Ethiopia, where there is no appropriate model of this group, the female mimics a danaine.

In butterflies the female is the more commonly mimetic. When both sexes mimic, the female's likeness to a model is often the more complete, perhaps because she needs special protection while laying eggs, when she is especially vulnerable to sudden attack and unable to escape by speed. Sight also plays some part in sexual stimulation in butterflies, so that a common male pattern helps to preserve the species—indeed, male butterflies are polymorphic much less often than are the females, quite apart from mimicry.

**Atypical Mimicry.**—The species of the great tropical groups of largely unpalatable butterflies are not only mimicked by butterflies of other families but also mimic each other. Thus, several African acraeines mimic danaines, while in both groups the species of one genus sometimes mimic those of another; the same is true of the oriental danaines. In tropical America the few danaines and many of the heliconines mimic species of an abundant group, the ithomiines. This last mimetic association has caused much confusion, for the superficial resemblance between the ithomiines and an important section of the heliconines is so strong that both

groups were united under the family Heliconiidae by the older naturalists. But their true relationship is now recognized and the two sections are placed far apart, the Ithomiinae next to the Danainae and the Heliconiinae next to the Acraeinae. In the many mimetic associations between the two groups, the Ithomiinae, with rare exceptions, are the models, the Heliconiinae the mimics.

## BATESIAN AND MÜLLERIAN MIMICRY

**Definition.**—It is obvious that the resemblance between the butterflies of distasteful groups is, as H. W. Bates recognized, a different thing from mimicry as he defined it: the likeness of a harmless or palatable species to a formidable or nauseous one that advertises its qualities by warning characters, especially colours, but often by movement, attitude or sound. The mimic gains advantage by the display of false warning characters. This is called Batesian mimicry after its discoverer. The resemblance between the distasteful species themselves was explained later by Müller as an adaptation that economizes life: if two distasteful species are alike, they will share between them the lives collectively lost before the enemies have learned to associate the warning characters with their special means of defense. If they are unlike, the lives must be contributed by each of them independently. These resemblances, a form of common or combined warning, are called Müllerian mimicry. A Batesian mimic may be compared to an unscrupulous merchant who copies the advertisement of a successful firm. Müllerian mimicry may be thought of as a union of firms to adopt a common advertisement and share the expense.

**Relative Efficiency.**—The qualities of Müllerian mimics differ widely in effectiveness, and the species differ immensely in their relative numbers and in their capacities for variation. Hence, models and mimics exist among them no less than in Batesian mimicry and in both there is the same evidence of the development of a mimetic from a different nonmimetic appearance still retained by allied species and often by the nonmimetic male. But while Batesian mimicry is never an advantage, and may be a disadvantage, to its model, Müllerian mimicry is never a disadvantage to the model. This criterion, though simple, is difficult to apply because of our imperfect knowledge of mimics and their enemies. More or less conclusive, indirect evidence is therefore often adduced, and opinions differ widely as to the relative importance of the two kinds of mimicry.

The resemblance of a Batesian mimic to its model is closely related to protective resemblance. In fact, Bates originally included both resemblances under mimicry. A. R. Wallace and nearly all later writers on the subject have differed with Bates in this, because although the two classes are so near akin, the species in one are conspicuous, in the other well concealed. They may, however, be conveniently grouped together under deceptive (or apatetic) resemblance. Both classes include palatable species, much sought after by the enemies of the group to which they belong. Any evidence supporting the conclusion that a mimic has been developed from a species with concealing colours would be evidence that it is a Batesian and not a Müllerian mimic. Such evidence may be obtained by comparison with its closest nonmimetic allies, and in butterflies often by comparing a mimetic female with its nonmimetic male, noting especially the undersurface, where concealing colours are particularly developed. In the tropical American butterfly *Protogonius*, conspicuously mimetic on the upper surface and dead-leaflike on the under, Kaye has noted that the wing is so transparent that when the insect is sailing with expanded wings above the observer, he can see the colours of the upper side only.

## ADAPTIVE VALUE OF MIMICRY

**Avoidance by Predators.**—The mimics score an advantage because they are avoided by predators that mistake them for species of unpleasant taste or smell. In butterflies the models usually exhibit warning coloration. This is easily learned and remembered by birds, for it involves patterns of a simple and conspicuous kind. These are usually the same on the upper and under surfaces of the wings, so that they can be recognized from whatever point of view the insects exhibiting them are seen, in flight or even when they are resting with the wings closed. Such species fly slowly, displaying themselves in a way that would make them easy prey, and, in fact, they may be attacked by young birds that have not yet learned to associate a particular butterfly pattern with unpalatability. Although these butterflies may be pecked at, they do not suffer permanent damage because their bodies are soft and flexible, unlike the bodies of most other insects, including their mimics.

Though it has long been believed that these distasteful models are avoided by insect-eating birds, there was little experimental evidence to support this contention until L. and J. Brower reported their studies on approximately 3,000 butterflies. Using North American species, they chose as models the monarch, a danaine, and the pipevine swallowtail (*Battus philenor*), a black and blue form belonging to the Polydorus group of the Papilionidae. The scrub jay (*Cyanocitta coerulescens*) was used as a predator. The birds found the monarch invariably unpalatable and never ate one. When a jay occasionally pecked at a specimen, it would drop the monarch, wipe its beak vigorously on its perch, ruffle its feathers and shake itself—a series of reactions that the mere sight of the butterfly would subsequently initiate. Having learned to avoid the monarch, the birds were then offered its mimic, the viceroy. This butterfly was palatable to those jays that had no experience of the monarch, but was avoided by those that had. Indeed, the birds reacted to the sight of a viceroy in the same way as to a monarch, by wiping the bill and shaking the feathers. Clearly, therefore, the mimicry was effective in this association. So, too, it was when the pipevine swallowtail was the model used. This species was regarded as extremely distasteful by the birds, and they subsequently reacted to its palatable mimic, the spice-bush swallowtail (*Papilio troilus*), as if it were distasteful too, though one out of the three birds used showed some capacity to distinguish it. To jays that had not discovered the distasteful qualities of *Battus philenor*, *P. troilus* was highly palatable.

**Ratio of Mimics to Models.**—The Browers also studied the numerical proportions of model to mimic that were needed for effective mimicry. Working in England, they used the starling (*Sturnus vulgaris*) as a predator and the yellow mealworm (*Tenebrio molitor*) as prey. These mealworms are normally eaten with great avidity by the starlings. Artificial "models" were produced by making the mealworms conspicuous and distasteful by giving them warning coloration, consisting of a striking band of green cellulose paint, and dipping them into a strong solution of quinine. The mealworms were similarly banded to produce "mimics," but these were dipped only into distilled water. The starlings were given different proportions of models and mimics, which were presented in a random order. With the mimics 10%, 30% and 60% of the total, most of them (80% or more) escaped being eaten. Even when the mimics were nine times commoner than the models, 17% of them were refused. The uneaten ones were those encountered immediately after the birds' unpleasant experience in tasting quinine, showing that the escape of the mimic was related to the distasteful flavour of the model. As the Browers remark, "mimicry can operate to a significant extent under conditions which have long been incorrectly assumed to give no advantage to the mimic." As a control, before or after each model or mimic was offered, an orange-banded (i.e. nonmimetic) mealworm dipped into distilled water was offered to the birds, and this was always eaten. So, too, were the green-banded "mimics" when given to birds that had no experience of specimens dipped in quinine; thus, cellulose paint on the mealworm did not make it less palatable.

**Occurrence of Predation.**—The criticism that birds seldom attack butterflies often is made by those who judge the situation in temperate regions and have not seen the immensely more crowded life and stringent competition of tropical forests. It is there that mimicry is so widespread and there, too, that the intense contrasts of light and shade favour so much the earlier stages of the resemblance. Mimicry occurs both in temperate latitudes and in open country, but it is much less common there. The frequent occurrence of beak marks on the wings of butterflies is indirect evidence of the attacks by birds. It may be the print of the beak on the wing surface or a V-shaped tear from the margin, often identical on two corresponding wings. An observed attack of a bird on a butterfly produced just such damage. Marks also occur

An example of Batesian mimicry: the monarch butterfly (left), subfamily Danainae, a distasteful species, is mimicked by the viceroy (right), subfamily Nymphalinae, a palatable species

An otherwise defenseless fly, family Bombyliidae, is protected by its resemblance to the honeybee

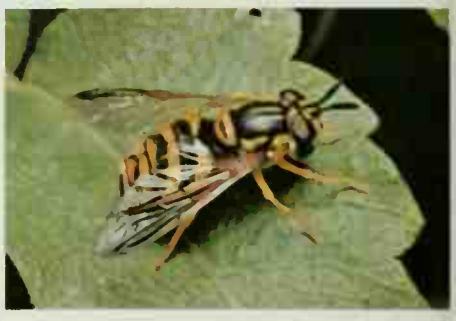
A Colombian spider that resembles an ant

An example of Müllerian mimicry: three distasteful Peruvian insects, a spider wasp (left), a leaf hopper (above) and a moth (right), resemble one another and thus "share" the pressure of predation

TYPES OF MIMICRY

PHOTOGRAPHS: (TOP LEFT) JOHN H. GERARD; (TOP RIGHT) [illegible]

# MIMICRY



A wasp model (left) and two mimics: (above) a locust borer (a beetle) and (right) a hover fly

A Peruvian net-winged beetle (above) and its mimic, a beetlelike moth (below)

The stingerless bumblebee moth (above) is avoided by birds because of its resemblance to the true bumblebee (below)

## MODELS AND THEIR MIMICS

when a distasteful species with warning colours has been attacked and subsequently released because it was found inedible.

H. B. D. Kettlewell's work on industrial melanism (*see* MELANISM), though carried out on cryptically-coloured moths resting upon tree trunks, is important here because it shows how easily some aspects of bird predation may be overlooked. Ornithologists and entomologists were agreed that birds seldom or never selectively prey upon resting moths. Kettlewell has shown that many species of birds readily prey upon those resting moths that contrast with their backgrounds. This was earlier overlooked, for the act of predation takes place in a flash and requires carefully planned experiments to detect it, even though it is so frequent. It is likely, therefore, that the selective elimination of flying or resting butterflies, especially in tropical forests, has similarly been minimized.

As a Batesian mimic increases in numbers relative to its model, so the advantage of its mimicry wanes. Finally, it becomes a disadvantage when predators begin to link a given conspicuous pattern with something edible rather than inedible. It may be desirable, therefore, for the same species to copy several distinct models. Some Batesian mimics exhibit polymorphism (the occurrence of different forms of a species). The mimetic phases must be clear-cut, since an appearance intermediate between that of different models would provide no protection. Not only may these exist together in the same region but they may be replaced by others elsewhere. In addition, mimics must correspond with the various races of their models found from one part of their range to another. Moreover, a nonmimetic form of a butterfly may persist quite commonly with the mimetic ones. It does so because the various polymorphic phases of a species in the same habitat will be adjusted in frequency by natural selection until all receive equal protection. On the other hand, polymorphism is not to be expected among Müllerian mimics, since these aim at uniformity.

## GENETIC BASIS OF MIMICRY

**Theories.**—As is usual with polymorphism, the switch-reaction converting one to another clearly distinguishable mimetic (or nonmimetic) form is genetically controlled by a single-factor difference giving sharp segregation (*see* GENETICS). Different states of the same gene (allelomorphs) arise suddenly, though very rarely, by mutation. Therefore, it has been suggested in the past that the distinct mimics controlled by genes also arose suddenly, that they appeared, with all their marvelous adaptations, complete and fortuitously, without evolutionary adjustment. This is quite incredible. Mimicry involves accurate resemblances of different features, such as colour, pattern and sometimes shape; such multiple adaptations are known in many species.

A much sounder solution is provided by a theory given by R. A. Fisher and developed later. A mutant arises by chance; if it gives some slight resemblance to a model, its effects later can be improved gradually by natural selection acting on the total gene-complex. Although the switch-genes controlling polymorphic mimics arose suddenly, their effects did not immediately produce a full-blown mimic. On the contrary, a slow evolutionary process is required for the perfection of a mimic. This view is supported by the existence of mimetic species whose models are very rare. Here the resemblances accurate elsewhere break down, as with the African *Papilio dardanus* in the mountains near Nairobi.

**Experimental Support.**—C. A. Clarke and P. M. Sheppard used *P. dardanus* to put the evolution of mimicry on a sound basis. They succeeded in breeding this species, primarily a citrus feeder from Africa, in great numbers in England. By hand-pairing, they reared successive generations from known parents and crossed the different races and subspecies so as to obtain a fairly complete picture of the evolutionary genetics of the mimetic forms.

*P. dardanus* belongs to one of the palatable genera of swallow-tail butterflies, as opposed to the poisonous Polydorus group that does not occur in continental Africa. The males are tailed and are yellow with black markings. Only the females are mimetic. Except in Ethiopia and the adjacent regions, they have lost the tails to resemble their tailless models. A number of the mimetic forms are known, several flying in the same locality, and they are astonishingly dissimilar from one another and from the males, while they resemble their respective models very accurately. Yet, they may segregate together in the same brood, normally preserving their distinctions without the occurrence of intermediates. In the wild, they vary in proportion from one region to another depending on the abundance of their models.

Clarke and Sheppard showed that these mimics are controlled genetically on a unifactorial basis (i.e., by a single gene). The mimic form *hippocoides* is recessive to the others (e.g., *cenea*), their respective models are *Amauris niavius* and *A. echeria*. These models are Danaidae, as are the majority of those copied by *P. dardanus*, but one of its forms, *planemoides*, mimics *Bematistes poggei*, a butterfly of an entirely different family, the Acraeidae. A few of the rare forms of *P. dardanus* are due to a combination, as heterozygotes, of the genes of two of the dominant mimics.

Clarke and Sheppard also obtained specimens from Madagascar, where all the females are malelike; they are tailed, therefore, and nonmimetic. They were able to cross these with the mimetic races from the mainland; when they did so, the similarity of the different forms segregating among the offspring broke down, though each of these was unifactorial. This result supports the statement made earlier that the mimicry did not arise complete with the mutation of the controlling genes.

R. Goldschmidt considered the well-known situation in which a mimic adjusts to the different races of its models. His argument assumes that for biochemical reasons distinct genes may produce an apparent similarity of effect in different species. He therefore expects that the differences between geographic races of mimics (and models) will be of a multiple allelic character involving the locus (position of a gene on the chromosome) controlling the mimetic pattern. Clarke and Sheppard's findings contradict this view: *Amauris niavius* is recognizably different in western and eastern Africa and the forms of *P. dardanus* that copy it are modified correspondingly; these they were able to cross and show that the distinction between them is multifactorial, not allelic. The similarity of mimic and model is not chemical but wholly superficial of appearance and no more; corresponding colours in mimic and model are produced by chemically distinct pigments.

A good example of a mimetic resemblance attained in many ways occurs in the large tropical American association of diverse butterflies and day-flying moths that have developed transparent areas on their wings in mimicry of dominant ithomiine models. Transparency has been produced by the following different alterations of scales in different mimetic species or groups of species: (1) they may be so reduced in size that the light passes between them; (2) they may remain the same size but become much fewer; (3) they may stand up on edge, thus allowing more light to pass; (4) they may remain in the usual overlapping position but become themselves transparent. Furthermore, in the models themselves, the scales of the transparent parts have become minute vestiges, reduced much more in one of the two genera to which the species belong. The wings of many moths that mimic bees are, on emergence from the chrysalis, covered with loosely attached scales that are blown off during the first flight. That there are among different groups such diverse means of attaining the same end is further evidence that natural selection produces these variations.

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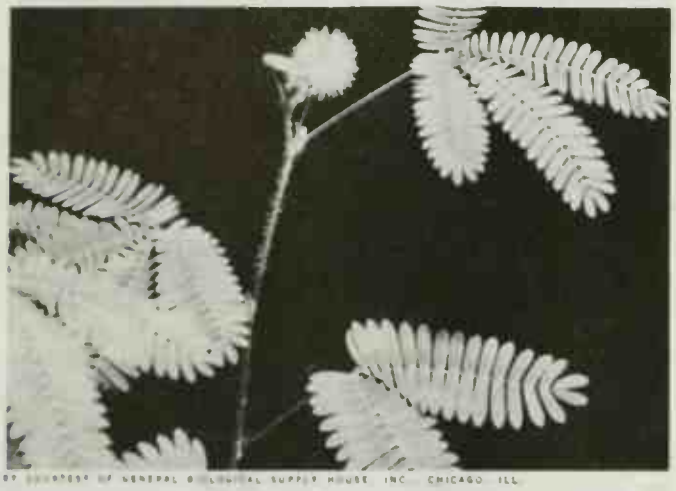
(E. B. FO.; E. B. F.)

**MIMNERMUS** (fl. *c.* 630 B.C.) of Colophon, early Greek elegiac poet. One of his extant fragments refers to the struggle of the Ionians against Lydia. His most important poems were a set of elegies addressed to a flute player named Nanno. Quota-

tions in later writers show that mythological narratives figured largely in these poems; but Propertius' remark *plus in amore valet Mimnermi versus Homero* (I, ix, 11) seems to suggest that the erotic element was yet more important than the mythological. He took a gloomy view of the onset of old age and prayed for death at 60, for which the more optimistic Solon sternly reproved him.

*See* edition by T. Bergk, *Poetae lyrici Graeci*, vol. 2 (1915); *see* also C. M. Bowra, *Early Greek Elegists* (1938). (JN. A. D.)

**MIMOSA,** so named from the movements of the leaves in those species that "mimic" animal sensibility, a genus of 400 species of the pea family (Leguminosae; *q.v.*), which gives its name to the large subfamily Mimosoideae (characterized by usu-



SENSITIVE PLANT (MIMOSA PUDICA)

ally small regular flowers with valvate corolla), to which belongs the nearly allied genus *Acacia* (*q.v.*). They are distributed throughout almost all tropical and subtropical regions, the acacias preponderating in Australia and the true mimosas in America. The acacias are of considerable importance as sources of timber, gum and tannin, but the mimosas are of much less economic value, though a few, like the talh (*M. ferruginea*) of Arabia and central Africa, are important trees. Most are herbs or undershrubs, but some South American species are tall woody climbers. They are often prickly. The roots of some Brazilian species are poisonous, and those of *M. pudica* have irritating properties. The mimosas, however, owe their interest and their extensive cultivation partly to the beauty of their usually bipinnate foliage, but still more to the remarkable development in some species of the sleep movements manifested to some extent by most of the pinnate Leguminosae, as well as many other (especially seedling) plants.

In the so-called "sensitive plants" these movements not only take place under the influence of light and darkness, but can be easily excited by mechanical and other stimuli (*see* TROPISM; PLANTS AND PLANT SCIENCE: *Plant Movements*). When stimulated—say, at the axis of one of the secondary petioles—the leaflets move upward on each side until they meet, the movement being propagated centripetally. It may then be communicated to the leaflets of the other secondary petioles, which close (the petioles, too, converging), and thence to the main petiole, which sinks rapidly downward toward the stem, the bending taking place at the pulvinus (swollen base of the leafstalk). When shaken in any way, the leaves close and droop simultaneously, but if the agitation be continued they soon cease to respond to the shock. The common sensitive plant of hothouses, called also humble plant, is *M. pudica*, a purple-flowered native of tropical America, now naturalized in corresponding latitudes of Asia and Africa, but the hardly distinguishable *M. sensitiva* and others are also cultivated. Species of the closely allied genus *Schrankia* are known as sensitive brier in the southern United States.

**MIMULUS,** the generic name for monkey flowers, comprising about 115 species of showy, hardy or half-hardy, herbaceous, rarely shrubby plants of the figwort family (Scrophulariaceae). They are natives of the extratropical or mountainous parts of both old and new worlds excepting Europe, but are most numerous in western North America, 45 species occurring in California.

The plants have opposite, undivided leaves, and axillary, generally solitary flowers with a two-lipped, gaping corolla. The herbaceous species thrive best in damp situations; the shrubby species, of which *M. aurantiacus* (bush-monkey flower), is best known, are adapted for pot culture in the greenhouse. *M. guttatus* (common monkey flower), widespread in western North America, has become naturalized by riversides in many parts of Britain. *M. moschatus* (musk plant), a native of northwestern America, with small, nearly regular, yellow flowers, diffuse hairy stem and hairy scented leaves, is a well known and favourite perennial for pot culture and outside borders. Several other species are cultivated for their attractive flowers.

**MINAHASA** (MINAHASSAN, MINAHASSEN) are a proto-Malayan people of the northern Celebes. They are often called Menadonese from their principal port and city. Today most of the 500,000 Minahasa are Christian, but early accounts depict them as headhunters who also practised human sacrifice. A highly developed form of spiritualism was associated with mediums, the idea of multiple souls, soul catching, the cutting of the umbilical cord with a bamboo knife, tooth filing, bridewealth (*q.v.*) and other traits that are widespread among the pagan tribes of Malaysia. Like the Batak of Sumatra and the people of Nias they had a highly developed megalithic cult, and Minahasa country is dotted with great stone tombs and burial urns. House fronts also present some of the remarkable carvings and paintings which characterized this people when they were pagan.

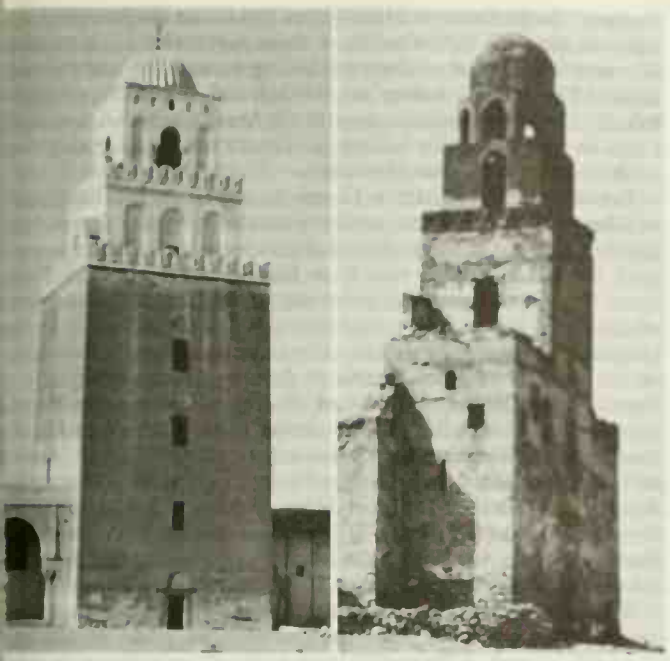
R. Kennedy links the Minahasa with the nearby Gorontalo, a people who practise a form of head flattening similar to that found in Borneo. Linguists have called attention to similarities of the language to those of the southern Philippines, but in general their closest relationships, both ancient and modern, appear to be in Indonesia. Survivals from pagan times have been noted; the modern dress of men and women approximates that of Java, as do most elements of material culture. Viewed against their pagan background this people presents an interesting study in acculturation. *See* also CELEBES.

*See* R. Kennedy, *Bibliography of Indonesian Peoples and Cultures* (1962); W. A. Kaudern, *Ethnographical Studies in Celebes*, 5 vol. (1925–38). (F.-C. CE.)

**MINAMOTO YORITOMO** (1147–1199), one of the most influential shōguns in Japanese history. At a time when the power of the imperial court was declining in the face of continual usurpation by local military lords, he brought order out of the near chaos and gave the country a new form of government which for a century and a half provided a high degree of public order and a considerable degree of humane justice. Yoritomo was himself a member of the military class whose depredations were depriving the imperial government of power. He succeeded in building a large armed following in eastern Japan, and in the late 12th century fought a series of bloody wars with the Taira family, then the dominant military faction in the country. The heroic and gory events of these wars are recounted in Japanese history and legend. Yoritomo was less a field general than a brilliant planner and coordinator; his younger brother and a cousin led his troops in the field most of the time. Upon their complete victory over the Taira in 1185, Yoritomo's forces were the only power in the country capable of bringing peace and orderly government. Instead of making himself emperor, however, Yoritomo was content to rule as shōgun, or the highest military commander of the imperial court. At Kamakura in eastern Japan he established a headquarters for his armed vassals, who were distributed throughout the country to keep order, collect taxes and administer justice. He died in 1199 as the result of a fall from a horse.

*See* also JAPAN: *History*. (T. C. SH.)

**MINARET,** the tower from which the call to prayer is given for Muslims five times a day. In the time of Mohammed no such thing as a minaret was known; when he and his followers first came to Medina they prayed without any preliminary call to prayer. But, having heard that the Jews used a horn and the Christians a *naqus* or clapper, they wanted an equivalent. Mohammed there-



BY COURTESY OF KEPPEL CRESWELL

(LEFT) MINARET OF THE MOSQUE AT KAIROUAN, TUNISIA. (RIGHT) MINARET OF THE MOSQUE OF AL-GUYUSHI (1085), CAIRO, U.A.R.-EGYPT

fore ordered Bilal to give the call to prayer from the highest roof ear the mosque.

The first minarets in Islam were the four square towers at the corners of the *temenos* or sacred enclosure of the pagan god (perhaps Hadad), who was worshiped at Damascus. This *temenos* was the enclosure which is now the Great Omayyad mosque. Ibn al-Faqih (903) refers to these towers, saying, "The minarets which are in the Damascus Mosque were originally watch towers in the Greek days." Al-Masudi (943) says, "Then came Christianity and it [the *temenos*] became a church, then came Islam and it became a mosque . . . and the *Sawami'* [the four corner towers] were not changed; they serve for the call to prayer at the present day." A square tower became the Syrian type of minaret and remained so until after 1200.

In north Africa the oldest minaret, that of Kairouan, is likewise a square tower with a small second story set back upon it; the third story is later. This became the regular type in north Africa and Spain; *e.g.*, at Córdoba, in the mosque of Hassan at Rabat, the Koutoubiya at Marrakech and the Giralda at Seville, the last three dating from the end of the 12th century.

In Iran and central Asia the earliest minarets preserved date from the end of the 11th century. They are all tall, cylindrical, tapering shafts with a gallery near the top, and are often decorated with geometrical patterns in the brickwork, or with faience (*see* A. U. Pope, *Survey of Persian Art*, plates 358–364). They are sometimes built in pairs, generally flanking a monumental entrance, or placed at opposite ends of the main façade; *e.g.*, at Tabriz. Turkish minarets are derived from this type, but they generally have two or even three galleries, and terminate in a tall tapering lead-covered cone. Turkish mosques usually have at least two, sometimes four and, in one case, six minarets (Sultan Ahmed, 1615). Of existing Egyptian minarets, the earliest are those of the mosque of al-Hakim (1013), of which one is a tall, cylindrical stone shaft on a nearly cubical base, the other minaret is a tall, square shaft surmounted by a series of receding octagonal stories. In both cases the original top part is gone. The minaret of al-Guyushi (1085) consists of a square shaft of brick with a stalactite cornice, surmounted by a little cube, an octagonal drum and a dome.

In subsequent minarets this upper part was elaborately decorated, and elongated at the expense of the square shaft, until a type evolved consisting of a square shaft surmounted by an octagonal and a circular story; examples are those of Sangar al-Gawli (1303) and Kusun (1336). After Kusun, the square shaft suddenly shortens so much that only its beveled top corners show above the roof of the mosque, and the visible part consists of a tall octagonal shaft, which has two galleries and terminates in an open domed pavilion; *e.g.*, Shaikhun (1355), Sarghitmush (1358) and Sultan Hasan (1362). *See* also INDIAN ARCHITECTURE; ISLAMIC ARCHITECTURE; MOSQUE.

*See* K. A. C. Creswell in *Burlington Magazine* (May 1936).

(K. A. C. C.)

**MINAS,** capital of the department of Lavalleja in southeast Uruguay, was founded in 1753 and named for the surrounding mines (Spanish *minas*). In the second part of the 20th century Minas became increasingly attractive to tourists, since it is only 75 mi. from Montevideo and offers hills and forests, both unusual in Uruguay. Its bottled mineral waters long have been distributed throughout the country. A brewery also uses Minas' famous water. Neighbouring mines and quarries, administration, trade and some industry provide the city's principal occupations. Minas is on a national highway and railroad line. Its population (1962 est.) was 39,005. (M. I. V.)

**MINAS DE RÍOTINTO:** *see* RÍOTINTO.

**MINAS GERAIS** (*i.e.*, "general mines"), an inland state in Brazil. Area 225,192 sq mi. Pop. (1960) 9,798,850. Among the Brazilian states it is exceeded in population only by São Paulo. Minas Gerais, formerly spelled Geraes, is bordered by the state of Rio de Janeiro on the southeast, by the state of São Paulo on the south and west, by Goiás on the northwest, by Bahia on the north and by Espirito Santo on the east. An area of 3,614 sq mi. along its eastern border is claimed by both Minas Gerais and Espirito Santo. The state capital is Belo Horizonte (q.v.).

**Physical Geography.**—Minas Gerais lies almost wholly within the geologically ancient uplands known as the Brazilian highlands. Only small parts of the southern and eastern parts of the state are within the zone of the Great Escarpment. In the southwest, along the border of São Paulo, is the commanding range of mountains known as the Serra da Mantiqueira, whose highest summit, Itatiaia peak (Agulhas Negras), reaches 9,144 ft. This range ends near the easternmost border of São Paulo. The other principal mountain range in Minas Gerais is the Serra do Espinhaço, which begins a little south of Belo Horizonte and extends northward into Bahia. It forms the divide between the rivers draining to the São Francisco (q.v.) and those draining eastward directly to the Atlantic (Doce, Macuri, Jequitinhonha). The greater part of the state consists of a much dissected hilly upland, with hilltops reaching an elevation of about 3,600 ft. above sea level. In the west, on the border of Goiás, Minas Gerais includes a part of the ancient erosion surface still untouched by stream erosion over wide areas and standing about 4,000 ft. above sea level. The stream divides, often erroneously described as mountain ranges, are in fact the undissected remnants of an ancient erosion surface. Minas Gerais is drained to the east and south of the Serra do Espinhaço by the smaller streams named above and by tributaries of the Paraíba river. In the southwest it is drained by the Rio Grande, one of the major headwaters of the Paraná river which reaches the sea at Buenos Aires, Arg. The whole northwest part of the state is drained by the great São Francisco, which flows northward through a rift valley to the west of the Serra do Espinhaço. Along the western border of the state there is a triangular projection (Triângulo Mineiro) lying between the Rio Grande on the south (border of São Paulo) and the Paranaíba river (border of Goiás).

The climate is characteristic of an upland region in the low latitudes. Temperatures are not so high as they are along the coast. At Belo Horizonte (2,800 ft. above sea level) the average of the warmest month (February) is 72.1° F.; and the average of the coldest month (July) is 62.2°. The rainfall throughout most parts of the state averages between 40 and 60 in., but is concentrated in a rainy season between November and March. The period between May and September is very dry, and lack of moisture is a major factor in agriculture along the stream divides. Reflecting these climatic conditions, the southern and eastern part of the state was originally covered with a dense tropical forest.

consisting of many species of trees that retained their leaves throughout the year, but with a few that shed their leaves in the dry season. This semideciduous type of forest was called *mata da primeira classe* ("first-class forest") by Brazilians. On the upper slopes of the Serra da Mantiqueira and of the Serra do Espinhaço the forest gives way to upland meadows or to a scrubby growth of deciduous woodland. All of southwestern and western Minas Gerais is covered by a woodland savanna, consisting of stretches of grassland mingled in complex fashion with stands of woodland. The latter (*campo cerrado*, literally "closed grassland") is made up of low broadleaf trees with gnarled trunks. The woodland species lose their leaves in the dry season. Even in the midst of the woodland savanna, however, semideciduous forests extend along the deeply cut river valleys.

**Agriculture.**—The agricultural area of Minas Gerais is almost exclusively a region once occupied by the semideciduous forest. This forest has been largely cleared by centuries of land rotation. In this system of agriculture, a tenant farmer clears the forest by cutting and burning it at the end of the dry season. He then plants maize, rice, beans and cassava in the newly cleared land, and fair harvests are gained for a period of two or three years before the essential infertility of the soil becomes apparent. He then plants pasture grass, chiefly for cattle grazing, and moves to a new part of the forest. This area is the chief source of beef for Rio de Janeiro, São Paulo and other cities. Dairy farming is important in southern Minas Gerais. In only a few spots is the land used for sugar cane or coffee, which were formerly of greater importance. On the hillsides, which today are used only for poor pasture, the marks of former coffee trees can be seen.

**Minerals.**—Minas Gerais has long been known for its wealth of minerals and for its mining activities (as its name suggests). It supplies half the mineral production of Brazil. Gold was discovered by explorers from São Paulo in 1698. At first the many prospectors who rushed into Minas Gerais only looked for gold in the stream gravels, and today there are many marks of abandoned placer mines at the valley bottoms and on hillsides. The gold was found in the various streams draining away from the Serra do Espinhaço.

In 1729 diamonds were discovered, also in stream gravels, near Tijuco (now called Diamantina). These precious commodities created great wealth in the 18th century, and Ouro Preto (*q.v.*), the administrative centre of Minas Gerais, became a city of great splendour, with numerous beautifully decorated churches. But after 1800 the richest gold sources had been used up, and the miners turned their attention elsewhere. It is interesting, however, that at Nova Lima, a few miles south of Belo Horizonte, a British mining company has been mining gold continuously since 1834. This mine is now one of the world's deepest. In modern times Minas Gerais is also widely known for its semiprecious gems, such as aquamarine, amethyst, tourmaline and topaz. From the high country in the western part of the state come the large quartz crystals that are used in radios.

Of greater importance in the 1960s, however, are the vast deposits of high-grade iron ore and manganese. In the southern part of the Serra do Espinhaço is one of the world's largest stores of iron ore, in which impurities are few and which is so disposed that it can be mined by steam shovels without expensive shafts or tunnels. A huge ore deposit exists at Itabira, on the headwaters of the Doce river, and ore from this source is now exported in small quantities through the port of Vitória (*q.v.*). Another huge deposit near Lafaiete, at the southern end of the Espinhaço, is used to supply the new steel plant at Volta Redonda in the Paraíba valley. Also mined near Lafaiete are the manganese supplies needed for Volta Redonda; and limestone for the new steel plant is supplied from quarries in western Minas Gerais. There are also a number of small, charcoal-burning steel plants, notably at Sabará, Caeté, Barão de Cocais, Monlevade and Itabira. In addition to the iron and manganese, the industrial diamonds and the gem stones, Minas Gerais supplies bauxite, zirconium, iron pyrite, rutile, graphite, chromite, molybdenum, nickel, tungsten, titanium, beryl and mica.

**Tourism.**—Another aspect of the economy of Minas Gerais is tourism. In the Serra da Mantiqueira and in the southwestern uplands of the state to the north of these mountains are a number of resort towns, most of them possessing various hot and curative baths. The mineral waters are bottled and widely dispensed in Brazil. The more important centres are Araxá, Caxambú, Lambari, Poços de Caldas and São Lourenço. Health resorts have also been established at the higher elevations.

**Transportation.**—Minas Gerais is served by railroads, all-weather highways, airports, and by river steamers that descend the São Francisco from Pirapora to Juazeiro in Bahia. The main railroad, Central do Brasil, runs from Rio de Janeiro to Belo Horizonte, with a narrow-gauge extension to Pirapora. To the west of this line is the narrow-gauge Oeste de Minas; east of it is the Leopoldina, also narrow gauge. A railroad also ascends the valley of the Doce river from Vitória to Itabira. It connects with a branch of the Central do Brasil which crosses the Serra do Espinhaço to Belo Horizonte. In the period since World War II, all-weather motor highways have been built to connect Rio de Janeiro with Belo Horizonte, and also São Paulo city with Belo Horizonte. Another road runs through east Minas Gerais to Bahia. Most of these roads parallel the earlier railroads rather than providing feeder service. Away from the main highways and the railroads the roads are passable for motor traffic only in dry weather.

**History.**—Minas Gerais was established as a separate captaincy general in 1720, shortly after the discovery of gold. It has traditionally played an important role in Brazilian politics, in part because of its central position, but also because of the dense population in its southwest. In 1824 Minas Gerais became a province in the Brazilian empire, and in 1889 a state in the federal republic. In 1897 the old colonial capital of Ouro Preto was deprived of its administrative function. The new capital was placed at Belo Horizonte, where a new city, laid out on previously almost unoccupied land, was planned and built. Ouro Preto is a national monument, while Belo Horizonte has become a city with a population (1960) of 642,912.

The second city of the state is Juiz de Fora in the south, noted for its textiles. There is a dense rural population in the south and east, but the whole northern and western part of the state is still very thinly occupied. (P. E. J.)

**MINBU,** a district in Magwe division of the Union of Burma lying in the Dry Belt west of the Irrawaddy river, where there are considerable areas irrigated from the Mon, Maw, Salin and other streams flowing from the forested hills in the west where the district stretches to the crest of the Arakan Yoma. Area 3,602 sq.mi.; pop. (1962 est.) 361,071. Valleys in the foothills are cultivated but tend to be malarial and unhealthy. Dry zone crops (sesame, millet, gram, peanuts) are cultivated in the nonirrigated lowlands of the Irrawaddian tract, but much land is covered with semidesert scrub. Fishing in the Irrawaddy is important. Oil occurs near the mud volcanoes of Minbu, and three small oil fields have been developed in the line of hills (an anticline of Peguan rocks) which runs through Minbu town, and there are other small fields.

Minbu town (pop. [1962 est.] 85,273), the district headquarters, stands on the Irrawaddy. The river there is about 3 mi. wide but with many islands and sandbanks so that in the dry season steamers can come no nearer than four miles south of the town. Salin town is the centre of the northern part of the district. (L. D. S.)

**MIN-CHIA** (Pai), a non-Chinese people centred on Ta-li, Yünnan province, in southwest China. Min-chia is the Chinese name for these rice cultivators, who call themselves Po or Pai in their own language. Occupying a triangular area from Shihkü located on the high Yangtze river down to Hsia-kuan (Siakwan) at the foot of Lake Erh Hai, the Min-chia in the 1960s number nearly 1,000,000, of whom 480,000 live on the fertile plain between the Ts'ang Shan mountains (14,000 ft.) and the lake, which is about 20 mi. long. Until recently the Min-chia language was not written, although commonly spoken throughout the district. It contains many Chinese loan words based on a non-Chinese, tonal, polysyllabic language with a grammatical structure markedly different from Chinese. Since the establishment of the People's Republic of China, the Min-chia, in accordance with the general policy toward non-Chinese peoples, have been given status as a National

Minority and are now organized in an autonomous *chou* (district). Ta-li, the capital of the region, was in the 6th–9th centuries A.D. the capital of the kingdom of Nanchao, the rulers of which were Shans (*see* SHAN). It would seem probable that the Min-chia already then formed the bulk of the population of the district. *See* also TA-LI; CHINA: *The People*.

*See* C. P. Fitzgerald, *The Tower of Five Glories* (1941). (C. P. F.)

**MIND:** *see* PSYCHOLOGY; *see* also CONSCIOUSNESS. For epistemological aspects, *see* KNOWLEDGE, THEORY OF, and articles on the major philosophers there discussed; IDEALISM; INNATE IDEAS. *See* further BODY AND MIND.

**MINDANAO,** second largest island of the Philippines, located in the southern part of the archipelago and comprising Agusan, Bukidnon, Cotabato, Davao, Zamboanga del Norte, Zamboanga del Sur, Misamis Occidental, Misamis Oriental, Surigao, Lanao del Norte and Lanao del Sur provinces. Area, including several small neighbouring islands, 36,537 sq.mi. The rapidly growing population was 5,358,977 in 1960. The island measures 294 mi. north to south and 320 mi. from east to west; it is marked by the long, irregular Zamboanga peninsula on the west. Rugged faulted mountains and volcanoes occur in many areas, particularly paralleling the east coast, along the southwest coast, in the north central part of the island and at the backbone of Zamboanga peninsula. Mt. Apo, 9,691 ft., on the Davao-Cotabato border, is the highest peak in the Philippines. Rolling plateaus characterize central Bukidnon. Broad plains and extensive swamps are found in the valleys of the Mindanao river in Cotabato and of the Agusan river. Narrow coastal plains almost surround the island and broaden considerably near Davao and Pagadian. In the lowlands temperatures average 73° to 83° F. Rainfall varies from 38 to 208 in., averaging about 80 in. a year. Shortly after the advent of U.S. rule Mindanao became the Philippine pioneer frontier. Migration to the island was slow at first, expanded somewhat in the late 1920s and grew rapidly from 1939; following World War II migration from Cebu, the Ilocos provinces, Panay, Negros, Bohol and Manila was resumed. Major crops are corn, rice, abacá and coconuts, with cotton, ramie, coffee and cacao as secondary products. Timber production is high, especially in Agusan and the Zamboanga provinces. Lateritic iron ore reserves in Surigao are large. *See* also PHILIPPINES, REPUBLIC OF THE; and articles on various Mindanaoan provinces. (R. E. HE.)

**MINDANAO DEEP** is a submarine depression in the Philippine sea section of the North Pacific ocean and one of the deepest areas on the earth's surface. The sounding made by the Danish ship "Galathea" in 1951 recorded a depth of 34,583 ft. A subsequent sounding recorded 35,430 ft. It is also known as the Mindanao trench, Philippine trench or Philippine deep. *See* PHILIPPINE SEA. *See* also OCEAN AND OCEANOGRAPHY.

**MINDAUGAS** (d. 1263), the first known ruler of unified Lithuania, is regarded as the founder of the Lithuanian state, though a 13th-century document mentions his father, Rimgaudas, as a "powerful duke who had no equal." After a long struggle with his brother and nephews, Mindaugas *c.* 1236 succeeded in consolidating the whole Lithuanian state, including Lithuania proper, Samogitia and the adjoining Russian territories, under his single rule. He was constantly threatened, however, by his nephews and by other dukes whom he had displaced and sent to the newly won Russian territories; for instance, his nephew Tautvilas and Vykintas, duke of Samogitia, were in alliance with the archbishop of Riga and with Daniel of Halich and Volhynia. Seeking peace with his enemies, Mindaugas decided to accept the proposal of the knights of the Livonian branch of the Teutonic Order that he should be converted to Christianity. He was baptized, along with his family and "a great many of pagans," in 1250 or 1251, and was crowned king at Naugardukas (Nowogródek) in 1253. For a while he remained on good terms with Tautvilas, Daniel and the southern Baltic tribe of the Jotvingai. Between 1253 and 1259 he donated several provinces in what is now northwestern Lithuania to the Livonian knights. Having thus taken care of the west, Mindaugas could win new lands in the east. Between 1237 and 1263 he conducted 20 campaigns into the Russian territories, regained Polotsk and subdued the principalities of Bryansk and Chernigov. Fighting the Tatars many times between 1238 and 1243, he played an important part in stopping their expansion toward the Baltic sea. In the west, however, peace did not last long. Encroachments by the Livonian knights provoked the Samogitians to revolt against them in 1256, and it is presumable that Mindaugas unofficially supported the Samogitians, who won successive victories near Skuodas (1259), at Durbe (1260) and at Lielvarde (1261). In 1261, in any case, Mindaugas broke the peace with the Livonian knights; and it may have been then also that he reverted to paganism. Mindaugas and his sons, Ruklys and Rupeikis, were killed in 1263 in a plot organized by Treniota, a Samogitian leader.

*See* J. Totoraitis, *Die Litauer unter dem Könige Mindowe bis zum Jahre 1263* (1932). (MA. G.)

**MINDEN,** a town of Germany and a *Kreisstadt* (county headquarters) in the *Land* (state) of North Rhine-Westphalia which after partition of the nation following World War II became part of the Federal Republic of Germany. It is situated on the Weser river near the Porta Westfalica (Minden watergap) at the entrance to the North German plain, 71 km. (44 mi.) W.S.W. of Hanover. Pop. (1961) 48,705. The town was founded as a strategic strong point by Charlemagne, who in 800 organized a military bishopric. Subsequently Minden became a trading place of some importance and joined the Hanseatic league. In 1648 the bishopric was converted into a secular principality under the elector of Brandenburg. Frederick II the Great fortified the town, which was held for a time during the Seven Years' War by the French, but after the victory of the British and Hanoverians at the Battle of Minden (1759; *see* SEVEN YEARS' WAR) it reverted to Prussia (British regiments that fought in the battle still wear roses on Aug. 1 as they did on the day of the battle). In 1807 Minden was included in the kingdom of Westphalia, but became Prussian again in 1814.

Historic buildings, grouped together in the centre of the town, include the Early Gothic *Rathaus* (town hall) and cathedral (dating from 952, with an outstanding Gothic nave) which were rebuilt 1948–57 after war damage; also the churches of St. Martin (1029) and St. Mary (12th century) and a number of old houses in "Weser-Renaissance" style.

Minden is an important road and traffic centre on the Cologne-Hanover-Berlin and the Bentheim-Hanover-Bremen railways. It is the junction of waterways where the Mittelland canal-aqueduct (an exceptional engineering accomplishment) bridges the Weser. Industries include the manufacture of textiles, furniture, metal and wood products, glass, ceramics and machinery. Other economic activities are based on farming and cattle breeding in the surrounding area. (W. KR.)

**MINDORO,** seventh largest island in the Philippine archipelago. Area 3,759 sq.mi. Pop. (1960) 311,440. It lies across Verde Island passage from Batangas province, Luzon, and contains a mountainous core surrounded by a discontinuous plain widest along the eastern shore. Lake Naujan, on this eastern plain, is the third largest lake in the Philippines. The rugged interior is peopled in part by Negritos, in part by other primitive groups, *i.e.*, Hanuóo, that practise a shifting slash-and-burn agriculture (*kaingin*). The coastal areas are settled principally by Christian Tagalogs, but Visayans have migrated to the southern part of the island. The timaroo, a small native buffalo, is found only in interior Mindoro.

The island is divided into two provinces, Mindoro Oriental and Mindoro Occidental. The former is the more populous and, since it faces Luzon, is the more progressive and has more commercial activity. The capital and principal town is Calapan (pop. [1960] 33,060). A provincial highway extends from Calapan southward along the east coast to Bongabong and east along the north coast to Puerto Galera, where the University of the Philippines maintains a small marine biological station. The principal products are lumber, rice of both upland and paddy varieties, corn, coconuts, bananas and sweet potatoes.

Mindoro Occidental, fronting on the China sea, is mainly upland. Its principal towns are Mamburao (pop. [1960] 5,832), the provincial capital, in the northwest and San Jose (Panduracan), on

a small plain at the southern end of the island. Principal crops are rice, corn, coconuts and sugar cane. *See* also PHILIPPINES, REPUBLIC OF THE. (AN. C.)

**MIND READING:** *see* PARAPSYCHOLOGY.

**MINE, LAND.** The land mine, an important weapon of World War II, was an encased explosive charge, sometimes laid on the surface of the ground but usually buried just below the surface. According to the type of fuze, it was fired by the weight of vehicles or men, by the passage of time or by remote control. The case was generally circular or square, made of metal or, to combat the magnetic detector, of wood, cardboard, glass or plastics. There were two types of mines, the antitank, to immobilize tanks and other vehicles, and the antipersonnel, to maim or kill soldiers.

**History.**—The ancestor of the antitank mine was the artillery shell buried by the Germans late in World War I to stop British tanks. The true antitank mine and the first antipersonnel mine appeared early in World War II. An economical way of stopping an enemy or restricting his movements, the mine field, composed of both types, was soon widely used by all major belligerents. Land mines were sown by the millions in the tank battles which took place in the north African desert and on the Russian front, and by 1943 had come to be considered almost a new arm of warfare. A postwar study of 10,000 tank casualties showed that 20% had been caused by mines. In the Korean War both the North Korean and the United Nations armies employed land mines extensively. Nuclear mines were not used but it was assumed that they were under development.

**Antitank Mines.**—The antitank mines developed in Great Britain, the Soviet Union and the United States between 1919 and 1939 contained only five or six pounds of TNT. They could stop a light tank, but had to be used in twos or threes against anything heavier. The Germans in 1939 had a mine that was twice as powerful. Their Teller mine (so named because it was plate shaped) had a profound influence on antitank mine history, for it led the Allies to manufacture similar heavy mines. As the Teller type was more likely to immobilize a tank by damaging its track than to destroy it, the emphasis in postwar research was on explosives that would penetrate the hull of a heavy tank and on fuzes that did not depend on pressure.

A standard postwar U.S. army antitank mine contained 12 lb. of TNT and weighed about 20 lb. in all. It required a weight of about 300 lb. to set it off.

In World War II the British and Americans also developed a very light antitank mine consisting of a flat quart can filled with tetrytol. Infantrymen could carry them in their pockets and use them in stacks against tanks or singly against other vehicles. Later this so-called "hasty" mine was given a secondary fuze that would function under the weight of a man; it thus became a combination antitank and antipersonnel mine.

**Antipersonnel Mines.**—The antipersonnel mine, generally containing less than one pound of explosive, could blow off a man's hand or foot or kill him with flying fragments. There were two types, the bounding mine that threw a shell a few feet into the air before it exploded, and the fixed mine that exploded in place. The bounding mine was developed by the Germans before 1939. Called the "S" (spring mine or jumping mine), it was copied by most belligerents and employed with a fragmentation or high explosive shell. The fixed mine was a specialty of the Russians, who organized special battalion-size mine units. The Soviet army used more than 50 models of mines during World War II, but they consisted of three main types: (1) a seven-ounce block of explosive in an oblong wooden box with a hinged lid, which was adopted by Germany and Italy and became known to Allied troops as the dreaded "Schu" (Schutzenmine or "rifleman's mine"); (2) a grooved, cast-iron shell on a wooden stake, which was copied by the Germans in concrete and used in large numbers in Europe; and (3) a cardboard "scatter" mine about the size of a shoe polish can, resembling in size the very small U.S. plastic mine used by the United Nations in Korea. *See* also FORTIFICATION; *Field Fortification in World War II and the Korean War*; AMMUNITION, ARTILLERY.

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**MINE, NAVAL.** A naval mine is an underwater weapon used in naval warfare. It may be used defensively, to protect a harbour or naval anchorage against enemy attack; offensively, as in the case of the British mining of the Danube river in World War II; or strategically, as in the U.S. blockade of Japanese shipping lanes which effectively cut off that nation's imports of raw materials. Mines may be laid by surface ships, submarines or aircraft, but all fit a basic description: an explosive charge fitted with a device that will cause it to explode when a target presents itself.

Mines are the only weapons that are not directed against a specific target, in contrast with guided missiles or projectiles such as rockets, torpedoes, bombs, shells and depth charges. These highly mobile weapons have their effective life only during the short time it takes them to travel from point of discharge to point of impact, while the mine, handicapped by its immobility, can sink only those objects that come to it, but its design enables it to wait days or even years for that event. There is also another difference between mines and other weapons: the result of gunfire or bombing, whether hit or miss, is usually plainly and immediately evident, but because of the indirect nature of mine warfare there is no such immediate evidence on which to estimate the effectiveness of minelaying. In fact, mines used with proper strategy can cause great loss even though they are never exploded.

Mines are comparatively cheap weapons to construct, but on a weight basis are the most destructive of all naval weapons because they explode under a ship where the surrounding water, being an excellent conductor of shock, transmits the explosion pulses against the relatively unprotected bottom. This factor, combined with the long effective life, makes the mine a favourite weapon of attrition for use against a strong naval power by a weaker naval power; an effective weapon against the merchant marine of a nation dependent on extensive imports; and a logical weapon to be employed by a self-contained continental power which has little to lose and everything to gain by unrestricted mine warfare.

**Early History and Development.**—Sir William Monson, an admiral in Britain's Royal Navy during the reign of Queen Elizabeth I, first realized that the most vulnerable part of a ship was that beneath the waterline. Monson planned to fire cannons into the underwater bodies of enemy ships from the hold of an attacking ship alongside, but there is no record that he ever tried this plan, which undoubtedly would have resulted in more damage to attacker than to attacked. The first use of a self-contained explosive agent against a ship occurred during the siege of Antwerp in 1585, when the Dutch used small boats filled with gunpowder and exploded by a clockwork device to dispose of several hundred Spaniards. Charles I of England later ordered his master of the ordnance to construct "divers watermines, water-petards and boats to go under water," and such devices were used by the duke of Buckingham, then lord high admiral, during the expedition for the relief of La Rochelle, France, in 1628, although without much success. In neither of these cases was the presence of an enemy ship necessary to set off the explosion, which did not take place under water. A "ship destroying engine" was invented by the marquess of Worcester in 1658. He adopted the Dutch idea of clockwork to explode the mine, but depended on a diver to fasten it to the target, which may have accounted for the fact that it was not used.

Technically, these early devices were delayed-action floating bombs, which could damage the sides of a ship only at or above the waterline, in contrast to the true mine which is designed to hit a ship under water. It should be noted that a torpedo is designed for the same purpose, and for many years the two names were used interchangeably. Robert Fulton applied the term torpedo to one of his mines, possibly because it had the power to stun or make one torpid. Until about 1870 any device which could be exploded under water was called a torpedo. Later, a torpedo was defined as a missile with self-contained propulsion and steering devices. (*See* TORPEDOES.)

American inventiveness was turned to the problems of underwater attack during the Revolutionary War, and David Bushnell,

the "father of the submarine," also became the originator of mine warfare. Bushnell used his submarine, the "Turtle," to carry a mine containing 150 lb. of explosive which was attached to a ship by a screw; the act of releasing the mine from the submarine started a timing mechanism which caused the mine to explode after a predetermined interval. Such a system required both skill and bravery on the part of the crew, who in the person of a sergeant, Ezra Lee, made a one-man attack on the British fleet in the Hudson river. Lee selected the 64-gun ship "Eagle" as the target for the world's first combined submarine and mine attack, but that ship's copper sheathing foiled his efforts with the screw and he was forced to drop his mine and withdraw. Bushnell then devised a form of contact mine, which greatly improved the efficiency of the weapon by eliminating the human factor; this was a keg, filled with gunpowder and supported by floats, which was fired by a gunlock actuated when it struck the target ship. Here was the direct ancestor of all modern mines; it would not explode until the target set it off. One of these "trigger mines" was used with great effect in 1777, when Bushnell launched it against the British frigate "Cerberus" in the Connecticut river; the mine missed that ship but completely demolished a schooner anchored nearby. The next year, on Jan. 7, 1778, Bushnell made another attack on the British fleet in the Delaware river near Philadelphia, Pa., but his kegs were hampered by ice and blew up only one small boat, although they created no little panic among the British. This incident is sometimes referred to as the "battle of the kegs."

The next step in developing underwater warfare was made about 20 years later by another American, Robert Fulton, better known for his success with the steamship "Clermont." Fulton had invented a form of mine, which he termed an explosive carcass, and a submarine, the "Nautilus," to carry it. (It was this vessel on which Jules Verne later based *Twenty Thousand Leagues Under the Sea.*) The French Revolution gave Fulton a chance to test his ideas in 1797, when French ports were blockaded by the British. While Napoleon became interested in Fulton's devices, to the extent of providing a schooner which the inventor managed to blow to bits in a test, his interest waned when negotiations broke down on the issue of granting belligerent status to Fulton and his crew; besides, there was a general feeling among French naval officers that this new form of underwater attack was not in keeping with the traditions of chivalry. (There was some agreement, even after World Wars I and II, that the use of mines is like an unexpected stab in the back, but probably the principal objection to mine warfare, as to atomic, biological and radiological warfare, lies in the fear of retaliation in kind by the enemy. On the other hand, an able tactician will endeavour to surprise an enemy by striking the first blow, and the element of surprise contained in a well-placed mine is not to be overlooked.) Rejected by the French, Fulton went to the British, who, possibly considering the advantages of opportunity over chivalry, decided to use his inventions against the French. The British fleet made an attack on the French off Boulogne in 1804, using Fulton's catamarans, each carrying 40 bbl. of gunpowder, with exploding devices operated by clockwork. Although no damage was inflicted, the French thought even less of the British use of mine warfare than they had of their own.

All early developments in mines were of the noncontrolled or independent type. The first example of a controlled mine, representing the other major classification of mine types, was introduced in 1843 by Samuel Colt, who is better remembered for the revolver bearing his name. Colt experimented with mines fired by electric current supplied from the shore through underwater cables and was finally able to blow up a ship five miles at sea from the control station. Shortly after this, in 1848, a form of controlled mine resulting from German experiments at Kiel university was used during the Schleswig-Holstein war of emancipation to protect Kiel from the Danish fleet. This was the first use of mines as weapons of defense.

Mines were again used defensively during the Crimean War, when the Russians employed contact mines to protect Sevastopol, Sveaborg and Kronshtadt. The fuzes for these mines, designed probably by Alfred Bernhard Nobel, consisted of glass tubes of sulfuric acid which, when broken by a ship's hull, allowed the acid to mix with chlorate of potassium and sugar, generating sufficient heat and flame to set off the main charge of gunpowder.

Both sides employed mines (called torpedoes) in the American Civil War. The most dramatic incident of this mine warfare occurred when Adm. David Glasgow Farragut's squadron was steaming into Mobile bay, in column, under gunfire from Ft. Morgan and the Confederate vessels inside. A new monitor leading the Union line struck a mine and sank instantly. Other ships stopped and massed together blanketing each other's gunfire. Admiral Farragut ordered all to go ahead. Lookouts called out "Torpedoes!" Farragut replied, "Damn the torpedoes! Four bells! Captain Drayton, go ahead! Mr. Jouett, full speed!"

Between the end of the Civil War and the start of World War I the most important development was the perfection by the German mine defense committee of a highly improved method of firing independent mines, the Herz horn. This contained a glass phial of acid solution which on impact was released to become the electrolyte for a primary cell, thus producing sufficient current to fire an electrical detonator. Its technical beauty lies in the fact that it is inert until struck and therefore has an unlimited life.

The buoyant type of mine is held at the desired depth because moored by a heavy sinker laid with it. Until about 1890 all such mines were laid with a preselected fixed length of mooring rope; thus the depth of the mine beneath the surface depended upon placing the unit in a position where the depth of water was accurately known. The two systems of automatic depth-taking that still hold the field are the plummet method and the hydrostatic method. In the former a plummet is released from the sinker directly after laying. The length of plummet line is preselected to equal the depth setting desired. The sinker then sinks, the wire mooring rope connecting it with the floating mine being paid out from a rotating drum in the sinker. The drum can be locked by a spring-loaded pawl but the pawl is held out of engagement by the pull of the plummet. When the plummet strikes the bottom the pawl engages; thus the sinker draws the mine down to a submergence equal to the length of plummet line. In the hydrostatic system the mine is fitted with a hydrostat preset to operate at the depth at which the mine is intended to float; mine and sinker are launched together and sink to the bottom, where either a soluble plug or timing device releases the mine after a safety period that allows the mine layer to get clear. The mine then rises toward the surface on a cable unreeled from the sinker or anchor, carrying with it a hydrostat on a pilot wire attached to the cable reel. When the mine reaches the proper level, reduced water pressure causes the hydrostat to operate, thus setting up a pull on the pilot wire which applies to a brake on the cable drum and stops the mine's ascent.

Mines were used on both sides in the Spanish-American War with no casualties, but the war between Russia and Japan, commencing in 1904, resulted in liberal use of mines by both powers, with effective results. In particular, minefields laid in the open sea were used to influence the movements of an enemy fleet as the first step in a new concept of mine warfare to be greatly exploited in World War I. The Russian fleet, concentrated in Port Arthur, was protected by a series of controlled mines. Early in April 1904 the Japanese laid a minefield of their own off the harbour entrance, attempting to screen this operation by a diversionary torpedo attack which failed to prevent the Russians from observing and plotting the action. The following day a squadron of Japanese cruisers moved into the mouth of the harbour to tempt the Russians out across the minefield, while the main Japanese fleet remained at sea just over the horizon. Adm. Stepan Osipovich Makaroff accepted the challenge and gave chase, but when the full strength of the Japanese forces became apparent he declined action, in the meantime having been maneuvered by Japanese tactics into such a position that a return to harbour would probably involve crossing the minefield. Either the Russians forgot, or else discounted, the minelaying operations of the day before, because they did attempt to go through the minefield, with the result that the battleship "Petropavlovsk" was sunk with 600 casualties, while the "Pobieda" was badly damaged.

A month later the Russians turned the tables on the Japanese,

when the minelayer "Amur," after careful observations of the movements of the blockading Japanese warships, laid a minefield in the patrol area. The battleships "Hatsuse" and "Yashima" both hit mines in this field; the former sank and the latter was abandoned en route to Japan. The Japanese then tried to sweep the area clear of mines, but before the task was completed three of their cruisers were also mined—possibly because Japanese buoys marking safe areas had been moved by the Russians.

The value of accurate knowledge of the location of minefields, whether one's own or the enemy's, was again demonstrated when the Japanese minelayer "Yenisei" was blown up in one of her own fields. This was not the last incident to emphasize that independent mines, once laid, lose all sense of nationality: in World War II, Japan alone lost 21 merchant ships in its own minefields. Before the Russo-Japanese War terminated, Russia had lost a battleship, a cruiser, two destroyers and two smaller craft, while Japan lost two battleships, four cruisers, two destroyers, a torpedo boat and a minelayer, all to mines.

**World War I.**—Mines were used on a vast scale during World War I, with belligerents and neutrals together laying about 240,000, of various types, in all parts of the world. Germany was the first to lay mines outside its own territorial limits, planting a minefield at sea off Lowestoft, Eng., the night of Aug. 4, 1914; in fact, the minelayer "Königin Luise" responsible for this operation was en route when war was declared. By the end of 1914 Britain had established extensive minefields in the English channel to ensure free communications with the continent, and had declared the entire North sea a military area in which designated safety lanes were presumably protected by minefields. Russia mined the gulfs of Finland and Riga in the Baltic sea as protection against German U-boats in that area, while Turkey mined the southern approaches to the Suez canal and the Dardanelles, making effective use of drifting mines in the latter area where the current always moved out into the Aegean sea. As soon as Turkey entered the war Russia also mined the entrance to the Bosporus.

As early as Nov. 1914 the Germans began construction of 15 small submarine minelayers; 96, of varying sizes, were in service during the war. Their first results were achieved the following June, though the element of surprise was partly lost in July when the British salvaged the German UC-2 and proceeded to convert six of their own submarines into minelayers. During the war the Germans laid 43,000 mines, chiefly aimed at Allied shipping, of which they sank 1,000,000 tons. Between May and September 1918 four U-boats laid mines off the east coast of the United States but with little success except for the sinking of the U.S. cruiser "San Diego" off Fire Island. Against British warships German mines were more effective; 40 were sunk, including the battleships "Audacious," "King Edward VII" and "Russell," the cruiser "Hampshire" with Lord Kitchener aboard, and 225 British naval auxiliaries. The Turks scored significant successes in March 1915 when drifting mines in the Dardanelles halted an Allied offensive.

British mines were employed chiefly against the U-boats, though few successes were scored before 1917, when the Mark H-2 mine, based on German models, went into production. Five U-boats were sunk in the Bight before Feb. 1918; thereafter, though the U-boat routes were blocked for days at a time, the mines constantly laid there and in the Kattegat, east of Denmark, took no toll because submarines were escorted through swept channels. The most effective minefield of the war was laid (beginning Nov. 21, 1917) in the Straits of Dover between Folkestone and Gris Nez; by Aug. 1918 the straits, patrolled night and day and illuminated by night, had been sealed with nearly 10,000 mines, and U-boats abandoned the route, passing north of Scotland instead. Between June and October an attempt was made to close this northern exit by laying the Northern barrage from Norwegian waters to the Orkneys (230 mi.). The large central portion contained American Mark VI mines that were detonated electrically upon contact with a 35-foot antenna. The smaller fields at each end contained both British and American mines. In all, 70,000 mines were laid. The results were rather disappointing: three U-boats were certainly sunk, three more may have been sunk, and four were damaged. Submarines found several gaps in the fields—partly because the American mines sometimes exploded spontaneously or at some distance from U-boats—and continued to go through them until the end of the war. Even assuming 100% mine efficiency (which was certainly not afforded by the antenna device) a submerged U-boat had two chances in three of penetrating that barrage unscathed. By the end of Oct. 1918, however, commanders were often reluctant to enter the barrage.

No fewer than 27 U-boats, out of a total of 178 sunk during the war, were certainly sunk by Allied mines, and to this figure can be added almost the same number whose losses can be ascribed, with varying degrees of probability, to the same cause. In addition to these losses, chiefly due to British mines, German mines accounted for about nine U-boats. Most sinkings took place near the German bases or in the Straits of Dover, though a few U-boats were destroyed by mines in British and Russian waters. Great Britain laid about 128,000 mines in all, of which 40% were in enemy waters. British and U.S. minelaying accounted for about 150 enemy warships and naval auxiliaries.

Especially in 1917–18, the mine was the most effective anti-submarine weapon of World War I, largely because U-boat bases were so situated that mines could be laid in their vicinity and along transit routes, and because other weapons had not been fully developed. The mine itself, at first detonated only by contact, was developed in two directions: (1) the British employed magnetic mines of "ground" type (*i.e.*, laid on the seabed) and an acoustic attachment for buoyant moored mines; and (2) they laid shore-controlled fields at the ends of the Dover barrage and elsewhere, accounting for two U-boats sunk and two more severely damaged. (R. McQ. G.)

**World War II.**—Aerial minelaying, considered at the close of World War I, was not actively practised until 1939. By 1943 the British were using Lancaster bombers to drop mines with great accuracy from altitudes of 15,000 ft. In the seven weeks preceding the Allied landings in Normandy in 1944, the British bomber command laid 4,000 mines in enemy waters, accounting for the loss of approximately 100 ships. British bombers also laid mines in the Kiel and Königsberg canals, a feat which involved extremely low-level flying. Although this operation caused the Germans no shipping losses, it resulted in untold losses in delayed cargo movement before the mines could be cleared.

Wellington and Liberator bombers of the Mediterranean Allied air forces also systematically mined the Danube river for a six-month period commencing in May 1944; more than 1,200 mines were laid, resulting in 200 ships sunk. In all British minelaying operations involving aircraft, nearly 55,000 mines were dropped in 21,000 sorties, with the loss of 500 planes.

In the Pacific, aerial minelaying was carried out by U.S. army air forces, the Royal Air Force and the Royal Australian Air Force. The first minelaying mission by U.S. B-29 bombers, and also the longest combat mission of any kind during the war, took place on Aug. 10, 1944, when Superforts based in Ceylon flew 3,800 mi. round-trip to Palembang in Sumatra, where 16 mines dropped sank three Japanese ships and damaged four more.

The first mining of a harbour by planes flying from aircraft carriers was conducted in April 1944 when U.S. carrier forces raided Palau in the Caroline Islands. In order to prevent ships in the harbour from escaping it was necessary to mine the channels after the raid commenced. In broad daylight and under anti-aircraft fire, planes from the "Lexington," "Bunker Hill" and "Hornet" laid 78 mines, as a result of which, according to Japanese reports, "for 20 days all channels were closed to navigation."

Only a few mines had been laid in Japanese waters until the last few months of the war. In late 1944 and early 1945 the capture of air bases within practical bomber range of Japan gave every prospect of success for an aerial minelaying campaign designed to cut Japanese lifelines to the Asian mainland and the Indies. Submarine attacks on Japanese shipping had already forced most ocean-going traffic into a few crowded, mineable channels opening into the Inland sea.

On March 27, 1945, army B-29s dropped 900 mines in the approaches to Shimonoseki strait, which at that time handled 40% of all Japanese marine traffic. Before the war ended ten weeks

later more than 12,000 mines had been laid from the air, effecting a blockade that took a staggering toll of shipping and almost completely cut off raw materials desperately needed by Japan. Magnetic, acoustic and pressure-type mines were laid, some with ship-counting devices which allowed a specified number of ships to pass before they exploded, thus foiling too-eager minesweepers. In laying this blockade, army air forces flew a total of 1,529 sorties to drop 12,135 mines, with a loss of only 15 aircraft. The effectiveness of this operation is shown in figures for Japanese shipping losses credited to mines after March 27, 1945: April, 16 ships; May, 65 ships; June, 58 ships; July, 65 ships; August (9 days), 16 ships. Japanese losses from mines laid by U.S. planes for the entire war totaled 257 ships, with a combined tonnage of 580,360.

*Submarine Minelaying.*—To a large degree, aircraft replaced submarines as minelayers during World War II, but submarines were used by both Allied and Axis powers. Six British submarine minelayers (of which four were lost in operations) laid about 3,000 mines, accounting for 67 enemy vessels (59 sunk). During the early months of the war, U.S. submarines concentrated their efforts on the hunting down and torpedoing of Japanese naval and merchant vessels, and it was not until a shortage of torpedoes developed that the submarines had space to carry mines. It should be noted that as a U.S. submarine lays mines from its torpedo tubes, its load of torpedoes is reduced or eliminated completely by minelaying activities and its combat potential is restricted accordingly. The first U.S. submarines to mine enemy waters, in Oct. and Nov. 1942, laid mines from the Gulf of Siam to Kii Suido at the eastern entrance to Japan's Inland sea. These early mining expeditions, aside from actual destruction of Japanese shipping, provided valuable pointers for later mine planting, among them the conclusion that minefields laid in shallow coastal areas were valuable even though they sank no ships, because they forced shipping out into deeper water where the submarines could do the sinking.

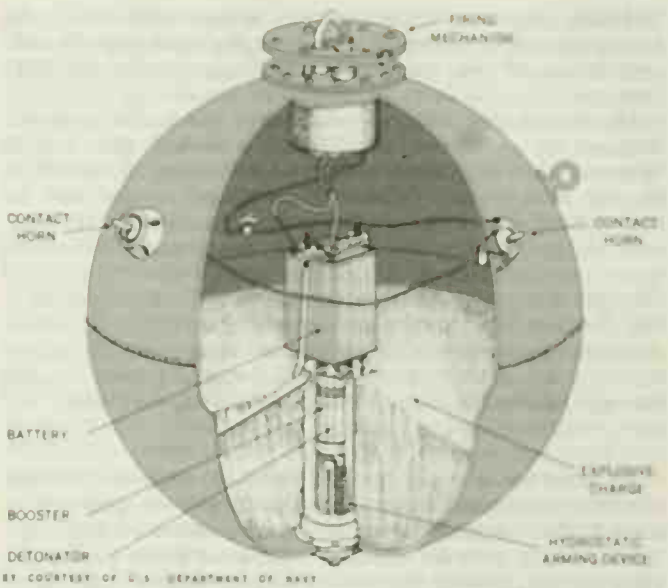
Many more minefields were laid in the Pacific by U.S. submarines operating out of Hawaii and Australia. The British submarines "Porpoise" and "Rorqual" and the Royal Netherlands submarine O-19 also laid mines in the Pacific.

*Japanese Mine Warfare.*—Japan made extensive use of mines. One vast minefield was laid from Formosa to Kyushu to keep U.S. submarines out of the East China sea, and another concentration of mines plugged the Strait of Formosa. The principal gates to the Sea of Japan, the straits of Tsushima, La Pérouse and Tsugaru, were mined, as were many other navigable channels in the Philippines, the Dutch East Indies and the Sulu archipelago.

The Japanese placed great faith in their type 93 mine, a moored contact mine fired by chemical horns, which could be used in water as deep as 550 fathoms. These mines conformed to requirements of international law in that they disarmed themselves if their mooring cables broke and they went adrift. The Japanese also used type 92, a moored controlled mine, in defensive fields for harbours. The type 92 carried 1,100 lb. of explosive and was fitted with hydrophones and magnetic detectors intended to warn the shore control station when a submarine approached. A third type of mine used was a moored contact mine laid in fields in the open sea. U.S. submarines managed to keep clear of the controlled minefields during the entire war, although three were lost to contact-type mines.

Japan lost 21 merchant ships in its own minefields. The small bag of submarines taken by Japanese mines is accounted for partly by the fact that sonar enabled U.S. submarines to keep clear of mines, and partly because Japanese notices of minefields, issued to warn their own ships of such dangers, sometimes were recovered by Allied personnel, with the result that these submarines often knew as much about Japanese minefields as the Japanese did.

*Mine Warfare in the U.S.*—German U-boats laid a total of 11 minefields off east coast ports in 1942 and 1943. These ventures cost Germany at least two submarines, sunk by aircraft almost as soon as they laid their mines, and resulted in several sunken or damaged ships. Not all the minefields laid were effective; four of them, including one off Boston, Mass., and one off Charleston, S.C., were either badly laid or consisted of defective mines and were not discovered until the war was over; their location was




BY COURTESY OF U.S. DEPARTMENT OF NAVY

FIG. 1.—CUTAWAY DIAGRAM OF CONTACT MINE

"Unarmed" mine is put into ready-to-fire condition when hydrostatic arming device reacts at a predetermined water depth. If a ship strikes a contact horn, an electrical current activates the firing mechanism. This switches on the battery, which sends a strong current through the detonator, firing the booster and exploding the charge

disclosed by German records. A field of 15 mines laid by the U-701 in the Chesapeake capes ship channel was the most effective, sinking the S.S. "Robert C. Tuttle," the British trawler "Kingston Ceylonite" and a coal barge. The steamer was later salvaged. The tug "J. R. Williams" was sunk by another field off Delaware. Mines forced the closing of the port of New York for two days, but no ships were lost in that area. Five German minefields were discovered and cleared before they caused any damage.

*Summary.*—It is estimated that British, dominion and Allied ships, including minelayers, destroyers, submarines, motor torpedo boats and motor launches, laid 206,969 mines in enemy waters during World War II, while aircraft laid another 53,552 mines. In addition, British surface minelayers laid about 185,000 mines in fields designed to discourage or to divert enemy shipping or U-boat movements. These included a barrage across the English channel, an extensive system off the east coast of Great Britain, a series of anti-U-boat minefields between Scotland and Iceland and between Iceland and Greenland, and fields in the approaches to the Irish sea and between Portsmouth and Cherbourg. Germany laid about 120,000 mines around northwest Europe and no small number in the Mediterranean, where Italy assisted in the operation. The U.S. laid about 25,000 mines in the Pacific, while Japan may possibly have laid three times that many.

Admiralty figures on Axis naval and merchant losses as the result of British minelaying indicated that a total of 1,050 such ships were sunk and another 540 damaged. Britain lost 281 naval vessels of all types to Axis mines, in addition to 296 merchant vessels. The total of merchant ships lost by the other Allies reached 521. The U.S. navy lost six destroyers and destroyer escorts, three submarines, nine large minesweepers and minelayers, two auxiliary craft and some small unnamed craft to mines. Japan lost 19 naval vessels and 247 merchant ships for a total of 266, out of which British mines claimed 10, Netherlands mines 2 and Australian mines 9.

At the close of 1947 it was estimated that a total of 251 ships of all nations had been mined in various parts of the world since the war ended, either by drifting or unswept contact mines.

**Korean War.**—The Korean War demonstrated the classic use of mines by a land power to hamper operations of a strong sea power. By extensive use of mines the North Korean forces achieved an initial surprise, sank or damaged several U.S. and South Korean ships, successfully interfered with U.S. fleet movements and tied up much Allied effort in minesweeping. Mines

laid from sampans took their toll first in Sept. 1950, sinking the U.S. minesweeper "Magpie" and damaging destroyers "Brush" and "Mansfield" and the Republic of Korea minesweeper YMS 504.

Mines used were Russian-made moored and ground magnetic-influence types. Extensive minefields off the east coast port of Wonsan, where U.S. minesweepers began clearing a channel on Oct. 10, 1950, actually delayed an amphibious landing there for one week; the 250-ship armada could not land its 50,000 troops, even though the city was in friendly hands, until about 2,500 mines were cleared out. The U.S. minesweepers "Pirate" and "Pledge" and the R.O.K. minesweeper YMS 516 were sunk in this operation; the "Partridge" was later mined in Korean waters. Attempts were made to "countermine" these mines by carrier aircraft dropping bombs in the water, but with no success. During this war helicopters proved valuable in locating minefields.

## TYPES OF MINES

All naval mines are of two general types, controlled or independent. Controlled mines can be made safe or dangerous as needed; their dependence on shore control and observation stations, plus the need for extensive underwater power and control cable systems, restrict their use to harbour defense areas where their laying or removal, while complicated, does not present the problems encountered in open seas or in enemy waters.

The greater percentage of mines used in modern warfare have been independent mines of two general classes: moored and ground mines, the latter resting on the sea bottom. Moored mines may be either contact (fired when hit by a ship) or influence mines; ground mines are, for obvious reasons, always influence mines.

**Magnetic Mines.**—These were used by the British as early as 1917, although it was not until the Germans commenced using aircraft to lay them in British harbour entrances during Sept. 1939 that they became a major threat. The operation of the magnetic mine depends on the fact that a steel ship acquires both permanent and induced magnetism; the firing mechanism of this mine is designed to be actuated by a ship's magnetic field. The unit for measuring magnetic induction is the gauss. Protection against magnetic mines is obtained by degaussing ships, or reducing their magnetic fields. This was achieved by passing an electrical current through a permanent coil, or degaussing girdle, which was built around the hull in a horizontal plane. Eventually, two simpler methods of degaussing were developed. "Flashing" involved placing a huge temporary coil around the ship and reversing the polarity of the permanent magnetic field. However, the process was expensive and each treatment lasted only a few months. "Wiping" consisted of simply moving a single cable, with about a 3,000-amp. load, up the ship's side, section by section, with the same results as from flashing. Another process, called deperming, referred to all steps taken to reduce the ship's permanent magnetic field, after which degaussing reduced the induced magnetic field almost to a zero condition.

Sweeping magnetic mines required that the minesweeper produce a magnetic field strong enough to detonate the mines, at a safe distance from itself. Eventually a type of buoyant cable was developed through which an electric current could be pulsed; each minesweeper towed two of these cables, one several times longer than the other, with an electrode at the end of each, and a current pulsed through the cables set up a field strong enough to detonate any mine in an area between the ends of the two cables and for some distance on either side. Two minesweepers steaming abreast of each other could thus clear a much wider path, and by timing the pulse intervals in accordance with their speed it was possible to make the fields overlap each other and produce a continuous sweep.

**Pressure Mines.**—This type of mine, simple in operation, involves a principle long known to canal engineers: beneath every ship in motion in shallow water there is an area of reduced pressure, and this reduction in pressure depends on the ship's draft and speed. The pressure mine contains a chamber divided into two parts by a diaphragm, with one side of the chamber open to the sea. The diaphragm is so constructed that any decrease in pressure on the sea side causes it to bend toward that side sufficiently to close a firing circuit and explode the mine. A small leak hole between the open and closed sides of the diaphragm serves to equalize pressure on both sides and to take care of slow changes such as those caused by tides, but a ship passing over the mine will reduce the pressure too fast for the leak hole to equalize and will thus fire the mine. The pressure mine's outstanding advantage is that it reacts only to a low-pressure change equal to that produced by a ship or an object the size of a ship, thus making it practically impossible to sweep. Pressure mines, first used by the Germans in 1944, were developed by both Britain and Germany, but as neither nation had found an effective countermeasure, they were reluctant to use them and invite retaliation in kind. Allied ships were informed of safe speed limits to use in sailing over pressure mines in order to avoid setting up the critical low-pressure effect, but this procedure could be used only by smaller ships.

*Sweeping Pressure Mines.*—Since pressure mines are fired by the reduced water pressure produced by a ship passing over them, the best method of sweeping them is to simulate the passage of a ship by towing a large, expendable target over them—a slow and sometimes costly procedure, as the exploding mine is likely to damage the target to the point where it must be laid up for repairs. Too, there is always the chance that heavy swells might temporarily inactivate the mine at the exact moment of sweeping. The Japanese had some success in sweeping these mines with bottom trawl nets and also used divers in some cases, but this was usually in the ratio of one diver to one mine. The U.S. used "guinea pig" ships in Japanese waters after World War II: they were damaged cargo ships, operated by volunteer crews at remote-control stations on the upper decks, which made high-speed runs through swept areas to see if all mines had been swept.

Because heavy seas sometimes actuate these mines—strong gales off the Normandy beaches in particular saved Allied minesweepers the work of sweeping some German pressure mines—it was U.S. practice to combine pressure mines with magnetic or acoustic mechanisms. In heavy swells, minesweepers had only to set up magnetic or acoustic influences to sweep the mines. In general, pressure mines retain a high nuisance value in comparison with other types.

**Acoustic Mines.**—These mines depend on a simple microphone which picks up and amplifies the sound of a ship's propellers or engine. As drifting mud or silt and accumulating marine growth foul the mine, it requires an increasingly higher sound level to fire it. In addition, the continuous drain on the battery will eventually sterilize the mine. Acoustic mines are swept by minesweepers using mechanical noisemakers, such as an air hammer heating on a steel plate. British sweepers used both built-in and towed-type "hammer boxes" in sweeping German acoustic mines. U.S. sweepers used the towed type of noisemaker exclusively. So far as is known, the Japanese laid no acoustic mines in the Pacific, but the U.S. used two different types, each responsive to different frequency bands of noise. Acoustic systems may be combined with magnetic systems by arranging for the firing mechanism to be cocked by an acoustic unit and triggered by a magnetic unit.

## MINESWEEPERS

Minesweeping is the term applied to the process of clearing an area of mines; the vessel which performs this task is a minesweeper by employment if not by design. The minesweeper's place in naval warfare is well described in "The End of an Empire," vol. iv of *Battle Report:* "It is always the minesweeps that spearhead an invasion; it is always the minesweeps that open up the vital gap through which the amphibious forces pour their massed weight. And it is almost always a minesweep that gets sunk first" (Capt. Walter Karig, Lieut. Comdr. Russell L. Harris and Lieut. Comdr. Frank A. Manson, Rinehart & Co., Inc., 1948).

Sweeping mines laid by an enemy is only part of the minesweeper's task; equally important and every bit as hazardous is the business of sweeping up one's own mines in order to render sealanes safe for maritime commerce. The earliest sweeping system, devised to clear anchored contact mines, consisted of two ships

BY COURTESY OF U.S. DEPARTMENT OF NAVY

FIG. 2.—U.S.S. "CONQUEST," AN OCEAN-GOING, NONMAGNETIC COASTAL MINESWEEPER, 172 FT. IN LENGTH, 630-TON DISPLACEMENT, SPEED OF 15 KNOTS

steaming across a minefield towing a wire rope between them. The wire was kept at the necessary depth by otters, a sort of underwater kite, and mooring lines of mines were cut by sawlike projections on the sweep wire or by cutting jaws. When the released mine floated to the surface it was destroyed by gunfire.

Fishing boats were first used by the British for minesweeping during World War I, but they were too slow for operations with the fleet. Special minesweeping vessels were designed, followed by high-speed minesweepers which could sweep at speeds up to 25 knots. At the same time the British developed the Oropesa sweep, named for the first ship to experiment with it, which provided a means of protection for all the minesweepers in a sweeping operation except the leader. The Oropesa sweep was a long cable, supported at the outboard end by a float, held at the proper spread by an otter and maintained at the proper depth by a kite at the inboard end, which swept a path to one side of the course followed by the minesweeper. Each following sweeper thus sailed in a swept channel. With the introduction of high-speed destroyer-type minesweepers using an Oropesa sweep on each side at once, a spread of about 450 yd. could be cleared at low speeds; the sweeps were modified so that increased speed reduced the spread to about 150 yd. at 25 knots.

For the protection of ships at sea in unswept areas, paravanes were devised and were used by both warships and merchant ships by 1917. The paravane is a torpedo-shaped float towed by a cable attached to a ship's forefoot and equipped with a rudder and planes which cause it to tow well submerged and to one side of the ship. With a paravane streamed to each side, the tow wires form a wedge which deflects anchored mines—unless hit bow on—away from the ship and along the towline to the paravanes, where heavy wire cutters shear the mooring cable and let the mines float to the surface.

At the close of World War I, both Great Britain and the U.S. engaged in a vast minesweeping campaign. By Nov. 1919 the British had swept more than 23,000 mines, with the loss of only six minesweepers, as compared with the loss of 214 sweepers during the war. The U.S. took on the task of clearing the North sea barrage; about 90 ships swept 56,033 U.S. and 15,093 British mines in an area of 5,000 sq.mi. between the Orkney Islands and the Norwegian coast. The impossibility of obtaining 100% success in clearing all such mines was demonstrated in July 1947 when a World War I-type mine was found off Cape May, N.J.

With the build-up of naval strength commencing in 1938, the U.S. added large numbers of minesweepers to the fleet, which at that time depended for such service on the "Bird" class minesweepers left over from World War I. Some high-speed minesweepers were converted from World War I-type destroyers; others were converted, during the war, from "Bristol" class destroyers. About 70 of the "Raven" class minesweepers, with speeds of 18 knots, were commissioned; another 130 "Admiral" class sweepers and about 70 "Accentor" class coastal minesweepers also joined the fleet. Other minesweepers were converted from trawlers, purse seiners and tuna clippers (all types of commercial fishing boats). Smallest sweepers were the 200-ton motor minesweepers, of which more than 450 were in service.

The extensive use of magnetic mines by Communist forces during the Korean War led to U.S. development of new types of wooden-hulled, nonmagnetic sweepers to replace most steel-hulled World War II types. Identified as MSO's, they displaced from 600 to 800 tons and were less than 200 ft. in length.

MSO's had plywood hulls, stainless steel alloy engines and metal fittings of aluminum, brass or magnesium. Approximately 100 steel-hulled sweepers of the World War II type remained in service. Another addition to the U.S. minesweeping force was the minesweeping boat (MSB) that was only 57 ft. long and displaced about 44 tons. These vessels were completely nonmagnetic, were equipped to sweep contact, magnetic or acoustic mines and were operated by a crew of six enlisted men. The U.S. navy also developed helicopter minesweepers; the powerful, slow-moving "whirly birds" can hover safely above the sea while towing minesweeping gear which explodes magnetic or acoustic mines.

During World War II U.S. minesweepers took part in every combined landing assault and many fleet operations. Before the Normandy landings, 255 minesweepers were assembled in England. On the opposite side of the world, when the U.S. fleet moved into Leyte gulf in Dec. 1944, 65 minesweepers were in the van. From the time sweeping started until the war ended U.S. minesweepers cleared about 10,000 mines; it was estimated that there remained in the Pacific alone 100,000 mines which had to be swept before safe navigation could be ensured. British, Australian and Dutch minesweepers took over the task of clearing the Asian coast off Formosa and the islands south of the Philippine Islands, while U.S. minesweepers cleared fields off the Philippine Islands, East Hainan strait, the Palaus, Marshall and Gilbert islands, Truk, the Bonins and Japan. At the peak of these operations, which were completed in March 1946, about 300 Japanese-manned minesweepers were assisting 374 U.S. minesweepers.

*Mine Watching*.—During World War II, Allied and Axis nations in Europe, and the Japanese, during the last months of the war, used mine watchers to detect night-flying minelaying aircraft and to mark exact locations of dropped mines, thus expediting their removal. Great Britain maintained mine watchers after the war and organized the Royal Navy mine-watching service in 1951. A uniformed civilian organization affiliated with and administered by the admiralty, it included shore-based watching posts with necessary plotting instruments and communications equipment and floating watching posts for all major ports and waterways consisting of a mother ship and several smaller watching craft. A port mine-watching service officer was stationed at each major port. Members of the service, frequently with prior military service, were recruited, furnished distinctive uniforms and trained in essential duties.

In the European theatre, from Sept. 3, 1939, to June 13, 1945, British and other Allied minesweepers cleared 20,429 mines, exclusive of U.S. operations. A total of 1,533 ships were used, of which 263 were lost. During the next three years, an international organization initiated by the British admiralty cleared 125,000 mi. of sea-lanes. About 1,900 minesweepers of many nations engaged in this project, destroying 12,000 mines.

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**MINEHEAD,** a market and seaside town and urban district in the Bridgwater parliamentary division of Somerset, Eng., on

the Bristol channel, 24 mi. N.W. of Taunton. Pop. (1961) 7,674. It owes its origin and growth to its good harbour, and there is still in existence a record of the port dues charged in 1350, although it was not until 1558 that the town was granted a charter of incorporation by Elizabeth I. This was revoked by James I, but until the Reform act of 1832 Minehead continued to send two members to parliament. A weekly market and annual fair were held from the 15th century, and since the reign of Edward IV the fair has been held on the Wednesday in Whitsun week. Buildings of interest include St. Michael's church (1450); Quirke's almshouses (1630), the Old Manor office; and the 17th-century cottages at the Quay and Church steps. The present harbour was built in 1616. During the 17th century Minehead was a thriving port conducting a considerable trade with the West Indies and other colonies, but now only coasting vessels use the harbour. Minehead's main industry is tourism, although light industry, notably shoemaking and the manufacture of electrical components, has been established in the town.

**MINEOLA,** a village on Long Island, New York, U.S., the seat of Nassau county, lies midway across the county at the junction of the main line and the Oyster Bay branch of the Long Island railroad. In the 17th century both the Dutch and English, who crossed Long Island sound from Connecticut, made settlements on Long Island (*q.v.*). Both started farming what was called Hempstead plains. Mineola, then called Hempstead Branch, was a part of the Hempstead plains. In 1858 the name was changed to Mineola. When Nassau county was created in 1898 by dividing Queens county, Mineola was made the county seat; in 1906 it became an incorporated village. Near Mineola are Roosevelt field (closed 1951; the site of a shopping centre), where many of the great names in flying made early aviation history, and Mitchel air force base (closed 1961). For comparative population figures *see* table in NEW YORK: *Population*. (D. L. D.)

**MINE PROSPECTING AND DEVELOPMENT.** The search for economically useful mineral deposits is called prospecting. Prior to the 20th century, mineral deposits were found by prospectors roving the surface of the earth looking for visible evidence of mineralization. Valuable minerals were recognized by their various distinctive physical properties. Gold occurs in nature as a heavy, malleable, yellow metal. The most important mineral of lead, galena, is dark gray, heavy and lustrous. The first ores of iron to be mined were deposits of magnetite, a black, heavy mineral capable of magnetically attracting a piece of iron. All three of these minerals are eye-catching. (*See* also METALLURGY: *History.*)

**Geologic Methods.**—As the deposits of minerals that cropped out at the surface of the earth were mined, the search for additional supplies of minerals took a more sophisticated turn. The science of geology was used to explain the occurrence of ore deposits. It was discovered that certain types of mineral deposits are associated with certain types of rock and geologic land forms and structures. (*See* GEOLOGY: *Physical Geology: Economic Geology.*)

Minerals of the common metals, copper, lead and zinc, generally form in igneous rock, which is formed by the cooling of masses of molten minerals at or near the surface of the earth. Wherever igneous rock came into contact with a bed of sedimentary rock a favourable location for the concentration of metallic minerals resulted (*see* ORE DEPOSITS). By mapping the rocks that crop out at the surface of the earth, geologists can sometimes infer such locations even though the contact between the sedimentary rock and the igneous rock does not appear at the surface. Drilling holes for samples of rock at depth will then confirm or disprove the existence of a mineral deposit at such a location. (*See* also MINERALOGY: *Geologic Occurrence and Origin.*)

**Geophysical Methods.**—As the science of physics progressed in the methods of measuring the properties of matter, these methods of measurement were adopted by prospectors to help find deposits of minerals that possess some detectable property not discernible to the naked eye. Probably the first use of a geophysical instrument to aid in the discovery of minerals was the use of a compass to locate bodies of magnetic iron ore. Prospectors found that a dip needle, a compass held in a vertical plane, could be used to find magnetic bodies that could not be seen at the surface. An instrument known as a magnetometer, which can detect very small forces of magnetism, was developed and is used extensively in the search for completely buried mineral deposits.

Often the mineral possessing the magnetic property, magnetite, is associated with more valuable minerals of copper, lead and zinc, and the magnetometer can be used to prospect for this type of deposit also. This instrument has been developed to the point where it can be used effectively from an airplane.

Another property that minerals possess is density. Some minerals are much heavier or much more dense than others and this difference in density can sometimes be detected with an instrument known as a gravimeter. Gravimetric methods were used to locate deposits of chromite, a heavy mineral of the metal chromium, in Cuba during World War II.

Some deposits of sulfide ores possess characteristic electrical properties. Acting like giant batteries, these deposits can cause the flow of electric currents in the ground surrounding completely buried deposits of these materials. These currents can be detected at the surface by sensitive voltmeters.

Metallic ores are generally much better conductors of electricity than the surrounding barren rock. A more sensitive and selective electrical method of prospecting involves the injection of an electric current into the ground by means of a generator and ground electrodes. The flow of this manufactured electricity will be concentrated in the best conductors. By means of an instrument known as a galvanometer, the path of flow of this electric current can be traced, and if a metallic ore is present beneath an overburden of soil and rock it can be detected.

The principle of electromagnetic induction can also be used to locate mineral deposits. These methods utilize the physical principle that an artificially created electromagnetic field will induce a flow of current in an electrical conductor. The flow of current in the conductor, a conducting ore body in the case of mineral exploration, will in turn induce a secondary electromagnetic field which can be detected at the surface of a buried deposit. As well as being used to find deposits, these electrical methods are often used to help determine the size and depth of known ore deposits.

Seismic methods of prospecting employ knowledge gained in the study of earthquakes. Different types of rocks will transmit earthquake waves with different velocities. An artificial earthquake can be created by exploding a charge of dynamite in a hole drilled into the surface of the earth. The exact time of the explosion is recorded and the time of arrival of seismic waves at a number of stations is also recorded. The seismic waves also travel down into the rocks of the earth and are reflected like sound waves from the boundaries between layers of different kinds of rock. The time it takes for these echoes to arrive at the recording station is determined and the velocity of the seismic wave can be computed. From the velocity of the wave, the type of rock through which the wave passed can be determined. Geologic structures can also be defined by this method, and favourable locations for the formation of oil reservoirs can be recognized. The seismic method is the most important geophysical prospecting method used in the search for new oil fields (*see* PETROLEUM).

Ores of uranium and thorium emit radiation that can be detected with an instrument known as the Geiger counter. A more sensitive instrument used in the detection of nuclear radiation is the scintillation detector. Uranium and thorium ores exposed at the surface can be easily found with this instrument. When uranium ores are covered by an overburden of loosely consolidated material they may still be detected. In the radioactive decay process a gas, radon, is formed which can migrate away from the ore deposit of uranium. This gas can work its way toward the surface, where it decays and forms elements which are also radioactive. This radioactivity can be detected by a scintillation detector or Geiger counter carried over the ore deposit.

For detailed discussion of geophysical methods and their application *see* GEOPHYSICAL PROSPECTING.

**Geochemical Methods.**—Geochemical prospecting methods involve chemical analysis for traces of metals in soils, vegetation and stream water or silt. The weathering of metal-bearing ores at the earth's surface results in a residual soil containing a higher than normal amount of the metal. Traces of this metal also find their way into the vegetation growing over the metal deposit and into water and sediment of streams flowing away from the deposit. Although to the unaided eye such metal-rich soils, vegetation and water are identical to normal materials, they can be distinguished by the chemical tests for the metals they contain. These simple tests, though extremely sensitive, are inexpensive and well-fitted to the pocketbook of the independent prospector.

**Prospecting Fields.**—Prospecting is carried on most intensively in areas where chances are best for the discovery of large-tonnage but relatively low-grade deposits that can be worked profitably by modern mining methods. An area is generally considered promising if some valuable deposits have been found there in the past and if there is reason to believe that other similar deposits remain to be found by the application of modern exploration techniques. To this should be added the requirement that political conditions be favourable for a heavily capitalized industrial operation. These conditions are met, for example, in the following areas:

1. The Pre-Cambrian shield of central Canada, where major deposits of nickel and uranium have been found.
2. Southern Arizona, where two very large copper deposits are being developed.
3. An area including southern Peru and northern Chile, where several major copper deposits are being developed.
4. Central Africa, where extensions of the rich Rhodesian copper belt are being sought.

Mention should also be made of the flurry of uranium prospecting in the Colorado plateau following World War II, that led eventually to the discovery of the major uranium deposits of the Ambrosia lake district in New Mexico. (*See* also NATURAL RESOURCES.)

**Exploration.**—After a mineral deposit is found by the prospector, its size and richness must be determined. Various geophysical methods can be used to some extent in this operation, known as exploration. Most commonly, either a percussive (churn) or rotary drill is used. The churn drill is simply a heavy steel chisel suspended on a steel cable or rod. The steel chisel is raised and dropped on the ground, crushing the rock and forming a hole. Water is placed in the hole to hold the crushed rock in suspension during the drilling process. Periodically, the crushed rock is bailed from the hole and this material is sampled and analyzed for its mineral content.

Rotary drills used to explore mineral deposits are capable of drilling 20,000 ft. into the earth. The diamond rotary drill has a hollow, cylindrical, diamond-studded bit which can cut a cylinder from the rock through which it passes. This rock cylinder is recovered and its mineral content is determined. While the percussive or churn drill can drill only vertical holes, the diamond drill can drill holes in any direction. Holes are drilled at measured distances across the ore deposit and the size and richness of the deposit can be estimated. (*See* also DRILLING MACHINERY.)

A profitable mine demands an economic balance between size and grade of the deposit, ease of transportation, availability of a market, availability of competent labour and political stability of the controlling government. Thus, a very low-grade but large copper deposit in the U.S. can be mined economically using skilled labour and mechanization while a much richer deposit in a remote area of the world may be uneconomic to mine.

**Development.**—If the main body of an ore deposit is near the surface, it can be mined as an open-pit mine and its development would entail the removal of the overburden. If the deposit is to be mined by underground methods, development entails the sinking of shafts, the installation of hoisting equipment and the driving of openings or tunnels through the ore body. Additional information on the shape and size of the ore body and the physical character of the ore and the surrounding rock is obtained during the development stage and many other factors, such as the type of artificial support required by the tunnels, the amount of water that has to be pumped from the underground workings and the ventilation that will be required, are determined.

*Mine Surveying.*—Once exploration is started, surveying assumes great importance in mining. The position and depth of all the exploration drill holes are accurately determined with surveying instruments. From these data, maps, which are blueprints for the mining engineer and geologist, are prepared which delineate the ore deposit in three dimensions. The locations of all tunnels, shafts and veins of ore are carefully recorded on these maps. Because the surveying is done in very close quarters and often in very wet or very dusty atmospheric conditions, special instruments are used for mine surveying.

For mining methods and production see MINING, METAL. *See* also COAL AND COAL MINING; COPPER; DIAMOND; LEAD; SALT DOME, etc. (H. E. H.; J. L. MO.)

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**MINERAL DEPOSITS:** see ORE DEPOSITS.

**MINERALOGY,** one of the geological sciences, is concerned with the study of minerals—the naturally formed and generally inorganic solid substances composing the crust of the earth, meteorites and other planetary bodies. The domain of mineralogy includes discovery, identification, description and classification of the different mineral species; study of their geological occurrences; explanation of their nature and properties; explanation of their origins; and consideration of their practical uses. In referring to minerals it should be borne in mind that popular usage of terms frequently differs from scientific usage. In everyday speech, the term mineral is likely to cover a great variety of inorganic matter, even that in foodstuffs. For scientific purposes, the term is reserved for substances having essentially the following characteristics: natural occurrence, homogeneity, definite chemical composition or ranges in composition, regular internal structure, and inorganic nature (with but few exceptions). However, as is the case for most natural substances, there exist many intermediate varieties between materials clearly covered by any simple definition and those that are not. The following examples illustrate some of the boundaries of the term. Coal is not a mineral because it is inhomogeneous, is composed chiefly of organic substances and is wholly to largely noncrystalline. On the other hand, two liquids, at ordinary temperatures and pressures (the usual reference conditions of man), are included as minerals—water and native mercury. A few natural crystalline organic compounds are also included as minerals (*e.g.*, whewellite, hydrous calcium oxalate, $CaC_2O_4 \cdot H_2O$).

This article presents a general survey of and introduction to the science of mineralogy and its more significant problems, directions, implications and applications, with special attention to developments in the second half of the 20th century. In addition to the cross references given in the various sections of this article further discussion of theories, concepts and techniques referred to will be found in the articles GEOCHEMISTRY; CRYSTALLOGRAPHY; GEOLOGY; PETROLOGY; METAMORPHISM; SEDIMENTARY ROCKS. *See* also separate articles on individual species and groups of minerals, as: FELDSPAR; HALITE; QUARTZ; etc.

Following are the main divisions:

I. History
II. Nature of Minerals
III. Classification and Nomenclature
IV. Descriptive and Determinative Properties
V. Geologic Occurrence and Origin
VI. Experimental Mineralogy

## I. HISTORY

The planet earth is a great ball of minerals. Not only do the minerals largely determine man's physical environment, but they

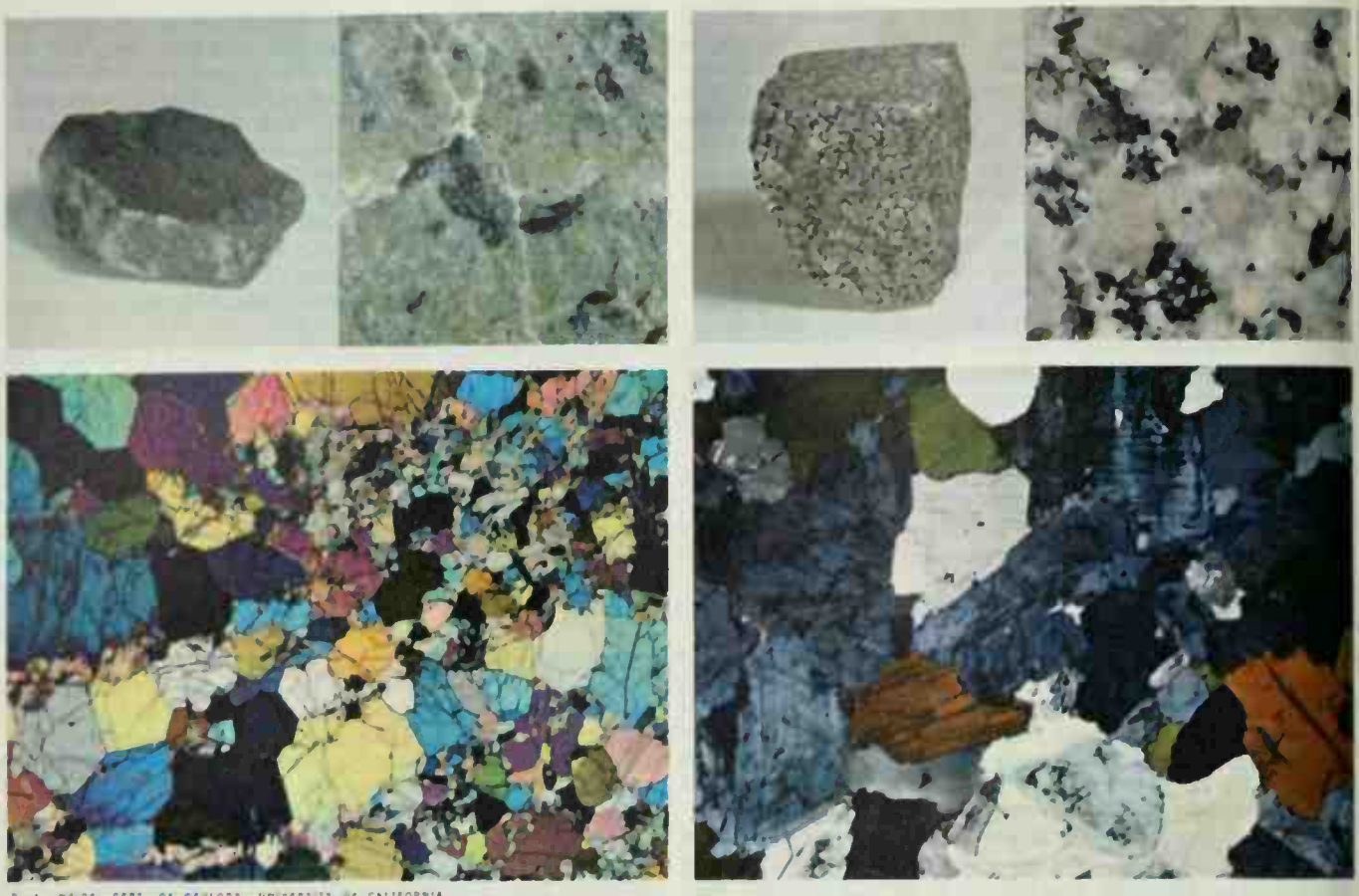

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FIG. 1.—MOST MINERAL CRYSTALS OCCUR WITHOUT FACES (ANHEDRAL CRYSTALS) AND AS CRYSTALLINE AGGREGATES IN THE FORM OF ROCKS. SHOWN ABOVE ARE TWO TYPES OF CRYSTALLINE AGGREGATES AT THREE LEVELS OF MAGNIFICATION

*Above left:* olivine crystals forming the rock dunite, an example of an essentially monomineralic aggregate. (Top left) specimen (from Jackson county, N.C.) in which the individual crystals can scarcely be distinguished. (Top right) cut and polished surface of the specimen magnified 2 ×. Light green grains are magnesic olivine, $(Mg,Fe)_2SiO_4$; dark spots are magnetite, $FeFe_2O_4$, and serpentine, $Mg_3Si_2O_5(OH)_4$. (Bottom) polarized light photomicrograph of a thin section of the specimen, magnified 12 ×, in which the individual crystals stand out clearly. Almost all the grains are olivine. The different colours are due to the optical effect of the different orientations of the olivine crystals on the polarized light. *Above right:* quartz, feldspar, biotite and hornblende crystals forming the rock granite, an example of a polymineralic aggregate. (Top left) specimen of St. Cloud granite (from Minnesota). (Top right) cut and polished surface of the rock magnified 1½ ×. Large pink crystals are microcline feldspar, $(K,Na)Si_3AlO_8$; white ones are sodic plagioclase feldspar, $(Na,Ca)Si_2Al(Si,Al)O_8$; small smoky ones are quartz, $SiO_2$; black spots are biotite, $K(Mg,Fe,Al)_3(Si,Al)_4O_{10}(OH,F)_2$, and hornblende, $(Ca,Na)_3(Mg,Fe,Al)_5(Si,Al)_8O_{22}(OH,F)_2$, not distinguishable from one another. (Bottom) polarized light photomicrograph of a thin section of the rock magnified 12 ×. White and gray crystals are quartz. Light to dark bluish-gray ones are feldspar: those with irregular crosshatching are microcline perthite; those with finely ruled parallel lines are sodic plagioclase. Most of the green and brown crystals are biotite; the brown one in the centre is hornblende

provide also the ultimate source of a vast number of raw materials and much of the energy essential to him. Minerals are, therefore, of great interest from many points of view and have been intimately associated with the material and intellectual development of mankind. Earliest man used stones, clay, colourful or shiny mineral pieces and crystals, and rarely occurring native metal for implements, building materials, pigments, charms and ornaments almost as furnished by nature. Later, metals were extracted from ore minerals, building blocks and bricks were worked from stone and clay; and pottery and glass were manufactured from clay minerals, feldspar and quartz. In modern times, an ever growing host of chemicals, metals, other useful products and energy are obtained directly and indirectly from mineralogic sources (*see* NATURAL RESOURCES: *Minerals*).

Although man has speculated on the "nature of things" since prehistoric times, scientific study of minerals scarcely began much before the 19th century. Moreover, the study was largely descriptive until well into the 20th century by virtue of the extremely complex nature, properties and occurrences of minerals. This complexity has required that mineralogy utilize an extensive application of other sciences such as geology, crystallography, mathematics, many branches of chemistry and physics, metallurgy and ceramics. The development of mineralogy has depended, therefore, upon a co-ordinate development of these other sciences.

The earliest surviving work on minerals is that of Theophrastus, *On Stones* (*c.* 315 B.C.). It appears to have been part of a much larger treatise that has been lost. The most important mineralogical writings of classical times are the last five "books" (chapters) of *Natural History* by Pliny the Elder (*c.* A.D. 77). The books summarize the knowledge (correct and incorrect) about the mineral kingdom held by the classical authorities up to that time. The modern aspect of mineralogy began with Georgius Agricola (*q.v.*), "father of mineralogy," and the publication of his *De natura fossilium* (1546) in which he classified minerals on the basis of physical properties and presented an extended description of the different varieties, many of them new. After Agricola, the attempts to develop the ideal classification polarized into: (1) the natural history method (*e.g.*, C. Linnaeus, 1735; F. Mohs, 1820), based on external characters; and (2) the chemical method (*e.g.*, A. F. Cronstedt, 1758; J. J. Berzelius, 1814). However, some mineralogists, notably A. G. Werner (1774), compromised with mixed systems.

Reliable quantitative chemical analysis of minerals was begun about 1800 by M. H. Klaproth and was widely and successfully applied by C. W. Scheele and Berzelius. During the same period, J. B. L. Romé de Lisle (1772) and especially R. J. Haüy (1801) laid the foundations of crystallography. W. H. Wollaston's invention (1809) of the reflecting goniometer (*q.v.*) made possible precise and rapid measurement of the angles of crystals. It then became apparent that chemical composition and crystallographic

characters are the fundamental properties of minerals. E. Mitscherlich's explanation (1819) of the puzzling phenomenon of isomorphism, that is, the similarity of crystalline form in substances that are chemically related, laid the beginnings of the modern crystallochemical approach to mineralogy. The improvement of the polarizing microscope by H. C. Sorby, his use of it (1849) to study extremely thin slices of rock (thin sections), and the determination and compilation of mineral optical data by A. des Cloizeaux (1867) and others inaugurated the third and final major approach of classical mineralogy.

The more recent direction of mineralogy was stimulated by Max von Laue's brilliant suggestion (1912) that crystals could diffract X-rays. Shortly thereafter, W. H. Bragg, W. L. Bragg and others began the development of X-ray diffraction techniques and employed them in the study of mineral construction. Soon after, V. M. Goldschmidt and his co-workers laid the foundations of crystal chemistry. In an equally important development, N. L. Bowen and his co-workers began a comprehensive program of investigating experimentally the complex conditions under which minerals form.

## II. NATURE OF MINERALS

The obvious properties of minerals, such as size, shape, colour and markings, are not essential or particularly informative ones. In fact, they tend to obscure those that are. Accordingly, minerals must be investigated by means of the less obvious properties, and special techniques must be devised to measure and interpret them. Crystal morphology, diffraction of X-rays, crystallophysical behaviour (e.g., optics) and chemical composition are the most informative. They are also of great value in determining the identity of mineral species and varieties. The nonessential properties are of interest chiefly as supplemental descriptive properties; they may aid in mineral identification in certain cases.

**Morphological Crystallography.**—The first information about the nature of minerals came from the study of the angular relationships and schemes of arrangement of crystal faces and cleavages (crystal morphology). (*See* figs. 1 and 2.) Such study, which began with and was long restricted to minerals, developed eventually into the independent science of crystallography. The most informative regularities in behaviour discovered were what are now known as the law of constancy of interfacial angle, the law of rational intercepts and the principle of symmetry. They indicate that minerals have characteristic internal structures made up of periodic arrays of submicroscopic "building blocks" (unit cells). Crystal morphology provides information about the shapes and relative dimensions (axial angles and ratios) of the building blocks but not their absolute dimensions or contents. An extended account of the subject is given in the article CRYSTALLOGRAPHY.

TOP LEFT, BOTTOM LEFT: FROM THE COLLECTION OF JOSEPH AND HELEN GOETTERMAN, BLUE HILL, ILL.; TOP RIGHT: FROM THE HARVARD COLLECTION; PHOTOGRAPHS; TOP LEFT, BOTTOM LEFT: JOHN W. GERARD © ENCYCLOPAEDIA BRITANNICA, INC.; TOP RIGHT: BENJAMIN W. EVANS; BOTTOM RIGHT: FLOYD B. GOTTSCHALL

FIG. 2.—ALTHOUGH MINERAL CRYSTALS BOUNDED BY FACES (EUHEDRAL) ARE IN THE MINORITY, THEY RECEIVE THE MOST ATTENTION BECAUSE OF THEIR BEAUTY AND THE STIMULUS THEY GAVE TO THE DEVELOPMENT OF CRYSTALLOGRAPHY AND MINERALOGY. ABOVE ARE FOUR EXAMPLES OF REPRESENTATIVE MINERALS SOMETIMES OCCURRING IN EUHEDRAL CRYSTALS

(Top left) wulfenite ($PbMoO_4$) from Chihuahua, Mexico; (top right) microcline feldspar ($KAlSi_3O_8$), var. "Amazon stone," with smoky quartz, from Colorado; (bottom left) pyrite ($FeS_2$) from Butte, Montana; (bottom right) calcite ($CaCO_3$) from Chihuahua, Mexico

**Structural Crystallography.**—The development of X-ray diffraction in 1912 opened up a completely new avenue of approach to crystallography and to the nature of minerals (*see* CRYSTALLOGRAPHY: *Crystal-Structure Analysis*; X-RAYS). It now became possible to determine the detailed internal symmetries (space groups), absolute dimensions and atomic contents of the building blocks (unit cells), and thus the crystal structures of minerals. The first substances investigated by the new technique were mostly minerals, and within a few years a large number of crystal structures had been worked out, especially by the Braggs (father and son) and their co-workers.

More recently, electron diffraction, infrared spectroscopy, neutron diffraction, and nuclear and electron spin resonance also have become valuable tools of structural crystallography. These newer methods confirm and add a large volume of significant detail to the results of X-ray diffraction.

Structural crystallography established as fact the deduction of classical morphological crystallography that each mineral species is characterized by its chemical constituents and their ordered arrangement. It further established that the solid state is essentially the crystalline state. Most of those minerals once thought to be amorphous (noncrystalline) are, in actuality, extremely fine crystalline (cryptocrystalline) aggregates. However, no clear cut discontinuity exists between the crystalline and the rarely occurring amorphous state.

**Chemical Composition.**—Accurate determination of mineral composition is more difficult than would appear. Not only are many compositions extremely complex but most minerals exhibit appreciable ranges (solid solution) and many exhibit great ranges in composition. Moreover, most minerals occur intimately intermixed with one or more others, and some minerals, notably the common rock-forming and ore minerals, may be intergrown on such a fine scale that the inhomogeneity can be observed only by methods such as optical and electron microscopy, or X-ray and electron diffraction (*see* fig. 3). Thus much difficulty has been experienced in understanding the true chemical nature of minerals. In a large part, progress in this direction has followed the coordinate development of crystallographic technique and theory.

Although almost all of the 90 or so natural elements play some part in mineral composition, by far the most important ones are oxygen (60.5%), silicon (20.4%), aluminum (6.2%), hydrogen (2.8%), sodium (2.5%), calcium (1.9%), iron (1.9%), magnesium (1.8%), potassium (1.4%) and titanium (0.2%), which compose 99.6 atomic per cent (relative numbers of atoms) of the earth's crust. Important subsidiary elements are carbon (0.08%), phosphorus (0.05%), manganese (0.04%), sulfur (0.03%) and fluorine (0.03%). The remaining elements are extremely rare and are contained in abundance only in minerals other than the rock-forming ones. These minerals compose an almost infinitesimal fraction of the crust. Many of the rare elements also are widely dispersed as traces in solid solution in the rock-forming minerals. In addition to the common metallic and nonmetallic elements, hydrogen is a significant constituent in many minerals and one that was commonly overlooked even as recently as the 1930s. It occurs in water molecules in crystal hydrates, in adsorbed water molecules, in hydroxyl (OH) ions, and less commonly as cations (giving rise to hydrogen bonds).

**Crystal Chemistry.**—Modern mineralogy makes extensive use of crystal or solid-state chemistry which combines crystallography and chemistry into a powerful unified approach. Much of the development of this field was based upon the study of minerals, and its early history is largely a part of the history of mineralogy.

LEFT, FROM THE COLLECTION OF THE DENVER PHOTOGRAPHS; LEFT, JOHN H. GERARD, © ENCYCLOPÆDIA BRITANNICA, INC.; RIGHT, TOP AND BOTTOM, ROBERT H. RICHARDS, DEPT. OF GEOLOGY, UNIVERSITY OF WISCONSIN

FIG. 3.—AGGREGATION AND INTERGROWTH OF ORE MINERALS AT MEGASCOPIC AND MICROSCOPIC SCALES

Most minerals, including ore minerals, are intimately and complexly intergrown. (Left) aggregate of copper ore minerals (from Arizona) composed mainly of bornite, $Cu_5FeS_4$, (reddish purple where freshest, iridescent blue to green where tarnished) with small amounts of covellite, CuS (dark blue and difficult to distinguish from tarnished bornite), chalcopyrite, $CuFeS_2$ (yellow), chalcocite, $Cu_2S$ (not visible) and quartz and altered rock (white and light gray). (Top right) photomicrograph of a polished surface of a specimen similar to some of the small dark blue patches in the specimen at left, magnified 125 ×. What appears megascopically to be wholly covellite is actually mainly bornite (faintly pinkish background in greenish-gray areas) that has been partly and pervasively replaced by extremely fine-grained covellite (greenish-gray). The covellitized bornite is itself intergrown with chalcocite (light gray), chalcopyrite (yellow), and a few anhedral crystals of enargite, $Cu_3AsS_4$ (gray). (Bottom right) photomicrograph of centre portion of polished surface above, magnified 250 ×, showing covellitized bornite (pink to red) more clearly; much more bornite is present than is apparent at lower magnifications. Also present are chalcocite (gray), chalcopyrite (yellow) and tiny crystals of pyrite, $FeS_2$ (pale yellow) in the chalcocite veins

Crystal chemistry considers the forces bonding atoms together, the gross and detailed features of crystal structures, the chemical-structural behaviour of the elements, and the explanation of the nature and properties of minerals and other crystalline matter. The great bulk of minerals, including the halides, most oxides and oxysalts (*e.g.*, carbonates, silicates) may be considered as ionic crystals (*see* SOLID STATE PHYSICS). They consist of positively charged cations (metallic elements) and negatively charged anions (nonmetallic elements) bonded together by electrostatic attraction. Native nonmetallic elements and many sulfides, on the other hand, are predominantly covalently bonded. Metallic bonding occurs in the native metals and some sulfides. Some minerals—*e.g.*, brucite, $Mg(OH)_2$, molybdenite, $MoS_2$, goethite, $HFeO_2$—are held together by weak van der Waals forces or by hydrogen bonding (*see* VALENCE; *The Hydrogen Bond*) as well as by ionic or by covalent bonding. (*See* fig. 4.)

Many properties such as crystal optics, habit, cleavage, the greasy feel of talc and graphite, conductivity and adsorption depend at least in part upon the bonding present.

The crystal structures of minerals range from the simple (halite) to the complex (feldspars, tourmaline). Consideration of many structural features is simplified by the use of the geometric conception of co-ordination. Co-ordination refers to the array of immediate neighbour atoms (or ions) around a given kind of atom (or ion). Crystal structures can be readily described and analyzed in terms of different combinations of linked co-ordination groups. The related concept of close-packing is also of extremely useful application because in a great many minerals the nonmetallic atoms (notably oxygen and sulfur) not only occupy most of the volume but are in (or close to) a close-packed arrangement. The structures of such minerals, therefore, are based upon a close-packed arrangement of nonmetals with the metal atoms occurring in the interstices.

There exist two crystallographic kinds of close-packing—hexagonal and cubic. Both have two sets of interstitial voids; each void of one set is surrounded by six nonmetal atoms (sixfold or octahedral co-ordination); and each of the other set by four (fourfold or tetrahedral co-ordination). Thus, the crystal structure of halite, NaCl, is described by stating that the chlorine anions are cubic close-packed and the sodium cations occupy the octahedrally (sixfold) co-ordinated sites. In sphalerite $\beta$ZnS, the sulfur atoms also are cubic close-packed, but the zinc atoms occupy the tetrahedral (fourfold) position. In wurtzite $\alpha$ZnS, on the other hand, the zinc atoms again occupy tetrahedral sites, but the sulfur atoms occur in hexagonal close-packing. In the more complex structure of olivine $Mg_2SiO_4$, the oxygens are approximately hexagonal close-packed and the metals occupy both types of sites, the silicons occurring in tetrahedral interstices and magnesiums in octahedral ones. (*See* also INTERMETALLIC COMPOUNDS.)

A notable early triumph of crystal chemistry was the explanation of the structure and properties of the complex silicate minerals. Their fundamental constructional unit is the silicate tetrahedron $[SiO_4]$, a co-ordination group of four oxygens around each silicon atom. These tetrahedral groups occur in different schemes of linkage so as to form different silicate anion radical types whose structures and formulas are illustrated in fig. 6. The structure of each silicate species is built with units of a particular kind of anion group bonded to one another by cations in the interstices between them. Many mineral properties such as crystal habit, cleavage, optics, viscosity in the molten state, adsorptivity, reactivity and geologic occurrence are controlled or influenced by the kind of silicate radical present. Because of this close connection of crystal structure with mineral properties it is common practice to write the chemical formulas as structural formulas. Thus, the formula $KAl_2[Si_3AlO_{10}](OH)_2$ for muscovite indicates that two structural species of aluminum atoms are present; one-third of the aluminum atoms are tetrahedrally co-ordinated ("tetrahedral aluminum") and two-thirds are octahedrally co-ordinated ("octahedral aluminum"). The tetrahedral aluminum is structurally similar to silicon and the two species together form alumino-silicate sheets (having the characteristic ratio of tetrahedral atoms to oxygen of 2:5).

Many different minerals (*e.g.*, halite, NaCl, periclase, MgO, and galena, PbS; barite, $BaSO_4$, celestite, $SrSO_4$, and crocoite, $PbCrO_4$) have the same kind of crystal structure, a property termed isostructuralism. On the other hand, some substances with the same chemical composition have different structures, the property of polymorphism. The structural differences can be of any degree. Some polymorphs (different forms having the same composition) have distinctly different atomic arrangements and are clearly different crystal or mineral species (*e.g.*, calcite and aragonite, $CaCO_3$; pyrite and marcasite, $FeS_2$; andalusite, sillimanite and kyanite, $Al_2SiO_5$). Others, such as the temperature modifications of certain minerals (*e.g.*, high- and low-temperature quartz, high- and low-temperature albite), differ so slightly that they are simply structural variants of a mineral species. Many of the minor polymorphic differences are caused by differences in kind and degree of structural order. Thus, microcline and sanidine, $(K,Na)Si_3AlO_8$, differ from one another in the positional order (sequence) of the aluminum and silicon atoms in the tetrahedral sites in the alumino-silicate framework (*see* FELDSPAR). Moreover, certain minerals (*e.g.*, wurtzite, clays and micas) have subtle variants (polytypes) due to different schemes of order in the stacking of their constituent layers (*see* MICA). The silica

minerals (quartz, tridymite, cristobalite and coesite, $SiO_2$) provide an especially notable illustration of variety in kind and number of different arrangements of the same atomic constituents (*see* SILICA). The particular polymorph present in a mineral system depends upon many factors, such as the temperature, pressure and composition of the environment during formation, the mechanism and rate of crystal growth, and the later thermal and mechanical history of the system.

Many mineral properties arise from the fact that real crystals are imperfect in terms of the ideal model of classical crystallography. The imperfections include various types of atomic thermal motion, vacant sites, interstitial atoms, impurity atoms, site disorder, dislocations and mosaic or domain structures. The colours, for example, of certain varieties of normally colourless minerals (*e.g.*, quartz, fluorite, halite) are attributed to colour centres, a type of imperfection in which electrons are trapped in vacant anion sites. Fluorescence and other varieties of luminescence result from the promotion of extra energy levels by certain impurity atoms.

**Solid Solution.**—The occurrence of ranges in chemical composition is an especially characteristic property of minerals. The phenomenon is termed solid solution and is caused by such mechanisms as simple proxy, cluster proxy, omission, interstitial "stuffing" and mixed crystals. In simple proxy, chemically different species of atoms are structurally equivalent (*e.g.*, magnesium and ferrous iron; aluminum and silicon; fluorine, hydroxyl and oxygen) and occur in different proportions to one another in the same kind of sites. For example, magnesium, ferrous iron and manganese occur in octahedrally coordinated sites between the independent silicate tetrahedrons in olivine $(Mg,Fe,Mn)_2SiO_4$. All ranges between occupancy entirely by magnesium or by iron can occur, whereas only a relatively small proportion of the sites can be occupied by manganese. That is, solid solution is complete with respect to magnesium and iron but limited for manganese. Where solid solution involves atoms of unlike valence (*e.g.*, Al and Si), electric neutrality is maintained by complementary proxy that compensates for the charge difference. Cluster proxy occurs in a few minerals whereby atomic clusters such as $Cl_2$, $CO_3$ or $SO_4$ substitute for one another. Such proxy is restricted mainly to minerals having large voids as in the framework types of silicates (*e.g.*, feldspathoids, scapolites).

Formulas for minerals are both compositional and structural; the symbols and their subscripts indicate the composition, and their location in the formula tells something about their structural function. Solid solution is symbolized by enclosing the structurally equivalent constituents in parentheses as follows: $(Mg,Fe)$. Two cases are: (1) complete solid solution, common in the so-called ferromagnesian minerals, *e.g.*, olivine, $(Mg,Fe)_2SiO_4$; and (2) limited solid solution with one or more dominant constituents (which may be indicated by underlining) and one or more less important but characteristic constituents, *e.g.*, microcline $(K,Na)(Si_3Al)O_8$ and biotite, $K(\underline{Mg},\underline{Fe},Al)_3(\underline{Si},Al)_4O_{10}(OH,F)_2$.

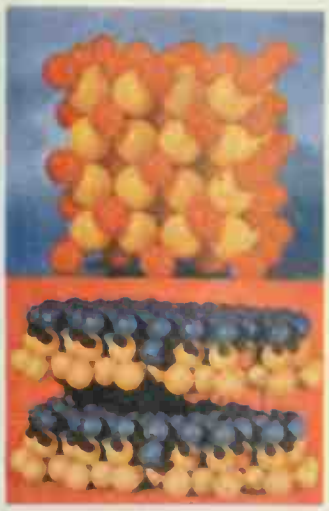


FIG. 4.—MODELS OF TWO TYPES OF CRYSTAL STRUCTURES OF MINERALS (TOP) FLUORITE, $CaF_2$, AND (BOTTOM) KAOLINITE, $Al_2Si_2O_5(OH)_4$, THE SIZES OF THE BALLS ARE SCALED IN PROPORTION TO THE IONIC RADII OF THE ATOMS THEY REPRESENT

(Top) crystal structure of fluorite, an example of strong ionic bonding. Red balls represent calcium and yellow balls fluorine ions. (Bottom) structure of kaolinite, bonded by covalent, ionic and van der Waals forces (*see* text). Yellow balls represent oxygen atoms arranged in sheets of tetrahedra (*see* Figs. 5 and 6); tiny silicon atoms occur within the tetrahedral pores and are not visible. Small brown balls are aluminum and blue are hydroxyl (OH) ions. The closely packed atoms in the composite slabs are held together by strong covalent and ionic forces; the slabs, however, are electrically neutral and only weakly held to one another (note large separation distance) by van der Waals bonding

Compositional variations involving departures from the low stoichiometric ratios (simple combining proportions) of classical chemistry are common among the sulfide and related minerals. Atomic omission (by metals, nonmetals or even both) is the most common cause. In pyrrhotite, for example, as many as one-fifth of the metal sites may be vacant (symbolically $Fe_{1-x}S$ with $x$ between 0 and 0.2), and in skutterudite as many as one-sixth of the nonmetal sites may be vacant—$(Co,Ni)As_{3-x}$ with $x$ between 0 and 0.5.

Much solid solution commonly attributed to simple proxy is due more probably to mixed crystals. They consist of extremely minute (at or near the atomic scale of magnitude) domains having similar or closely related structures but different pure or nearly pure end-member compositions. The domains are arranged to form single crystals, as far as ordinary methods of observation are concerned. All gradations probably can occur between a random sequence of solid solution constituents in simple proxy to the more ordered domains composing mixed crystals.

The extent of solid solution, whatever its mechanism, is controlled by the structural similarity and availability of the atoms involved, the nature of the host structure, and the temperature, pressure and composition of the environment of crystal growth. Structural similarity is related particularly to atomic size and bonding behaviour. High temperature promotes solid solution whereas low temperature inhibits it. Many minerals, notably feldspars and ore minerals, were formed originally at high temperatures with considerable solid solution and have exsolved or unmixed to separate phases of "purer" crystals upon later cooling. Much mineralogical research is devoted to the relationship of the solid solution compositions of co-existing minerals with temperature and to the application of this relationship to geologic thermometry.

## III. CLASSIFICATION AND NOMENCLATURE

In principle, a mineral species is defined by its chemical composition and crystal structure. (*See* fig. 5.) In practice, however, the principle often is difficult to apply and the differentiation of many species must be made somewhat arbitrarily. For example, complete solid solution can exist between gold and silver but the series is, by convention, split into the two species, native gold (Au,Ag) and native silver (Ag,Au). The boundary is set at the solid solution composition of equal numbers of gold and silver atoms. The complete solid solution series between magnesium and iron orthosilicate, on the other hand, is accepted as a single species, olivine $(Mg,Fe)_2SiO_4$.

Many structural differences also are gradational so that species distinctions based on them must in many cases be

FIG. 5.—ELECTRON MICROGRAPH OF KAOLINITE CRYSTALS, $Al_2Si_2O_5(OH)_4$, MAGNIFIED 24,000 ×, SHOWING THE MINUTE SIZE AND THE CRYSTAL NATURE OF THE CRYSTALS. KAOLINITE, A CLAY MINERAL, IS ONE OF THE SILICATES (*see* FIGS. 4 AND 6)

arbitrary. Generally, individual polytypes, that is, different forms of a single species (*e.g.*, those of wurtzite), are not recognized as different mineral species, although species status has been given (partly on historical grounds) to certain clay and micalike minerals whose chief differences are attributable to polytypism. The total number of recognized mineral species, therefore, depends upon the criteria applied and differs with the authority. Something on the order of 1,500 species are accepted by modern criteria, although more than 8,000 different names, most of them based on trivial differences, have been applied.

Modern classifications are based on chemical composition and crystal structure. The chief divisions are chemical classes based on the nonmetal or anion radical present. The most important classes are: elements, sulfides (and the related arsenides, tellurides, sulfosalts), oxides (and hydrous oxides), halides, carbonates, borates, phosphates, sulfates, tungstates and silicates. The classes are further divided into chemical types and these into isostructural groups of the individual species. The silicate class is a particularly important one. It contains one-quarter of all the mineral species, a score of which make up more than 90% of the earth's crust. The silicates are subclassified into structural divisions essentially along the lines shown in fig. 6 (*see* also figs. 4 and 5). (*See* also SILICON: *The Silicates.*)

Most mineral names, in modern practice, are characterized by a terminal "ite," a custom begun by the Greeks and Romans in naming stones. Mineral nomenclature is essentially the same throughout the English-speaking world since American and British mineralogists agreed on a uniform system around 1936. German and French nomenclature is essentially similar to it. Nonetheless, variation exists in the method of naming varieties of solid solution series. Although a scheme utilizing compositional modifiers (*e.g.*, magnesian olivine, manganoan calcite) along the lines proposed by W. T. Schaller, or one indicating symbolically a composition more quantitatively (*e.g.*, olivine $Fo_{75}$, plagioclase $An_{31}Ab_{66}Or_3$) would be desirable, a large number of individual varietal names are still widely used (oligoclase for plagioclase $An_{10-35}$, freibergite for argentian tetrahedrite, ankerite for ferroan dolomite).

## IV. DESCRIPTIVE AND DETERMINATIVE PROPERTIES

Crystal properties fall into two classes—scalar, which have magnitude only (density, chemical composition), and vectorial, which depend also upon direction (crystal faces, cleavage, refractive indices).

**Chemical Properties.**—In ordinary determinative work chemical properties are utilized mainly for confirmatory partial qualitative tests. Among the methods devised to deal with the extraordinary variety of chemical combinations occurring in the natural compounds, blowpipe methods, flame colorations, fused bead colorations and certain wet tests of ordinary qualitative analysis are much used. Such tests are described in the textbooks of mineralogy listed in the *Bibliography*. However, macrochemical tests commonly are inadequate, especially for the ores, because minerals are almost always intimately intergrown. Accurate identification of the opaque minerals commonly requires selection of minute samples under the reflecting microscope (*see* METALLOGRAPHY) and the use of microchemical tests.

Increasing use is made of partial quantitative analytical methods such as colorimetric tests, flame photometry, optical spectrography, and X-ray fluorescent spectrography for the determination of solid-solution composition (because of its significance in connection with the environmental conditions during mineral evolution).

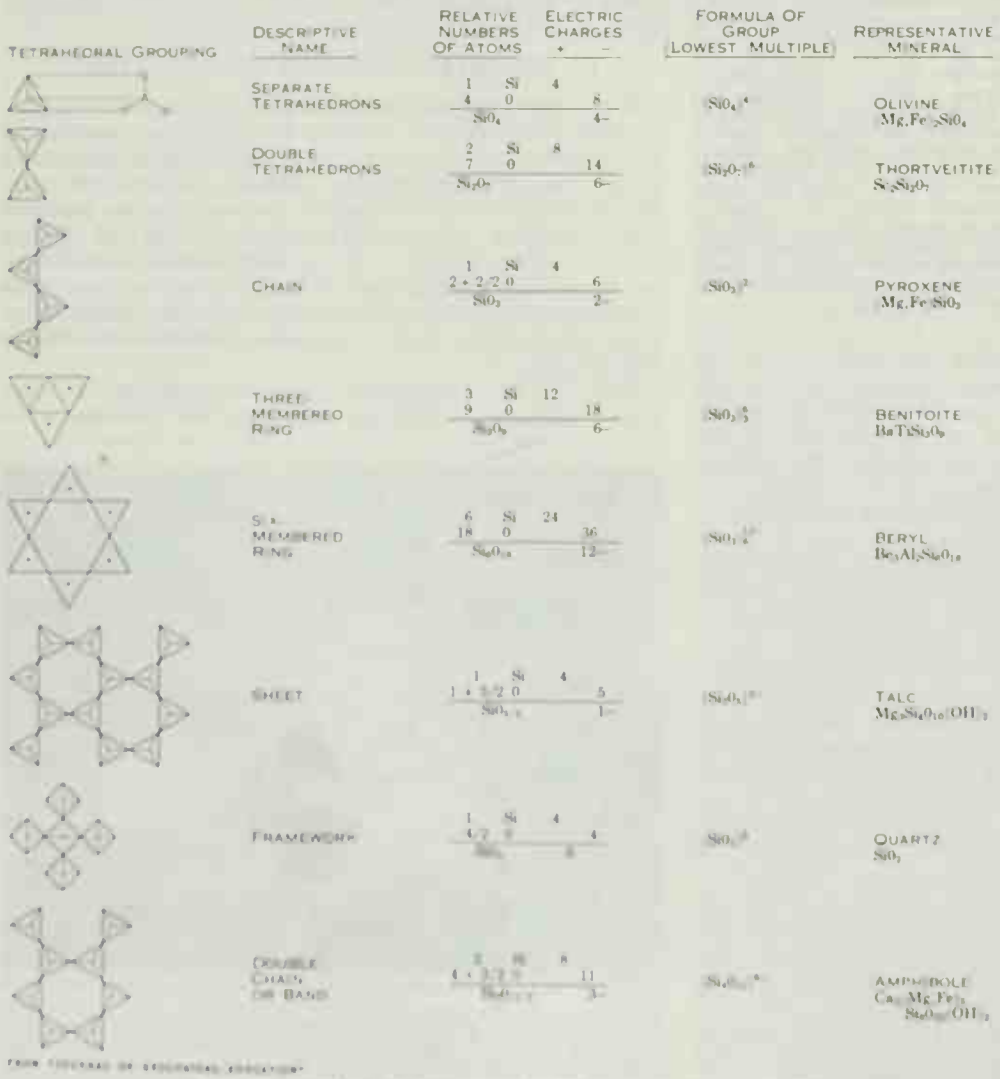
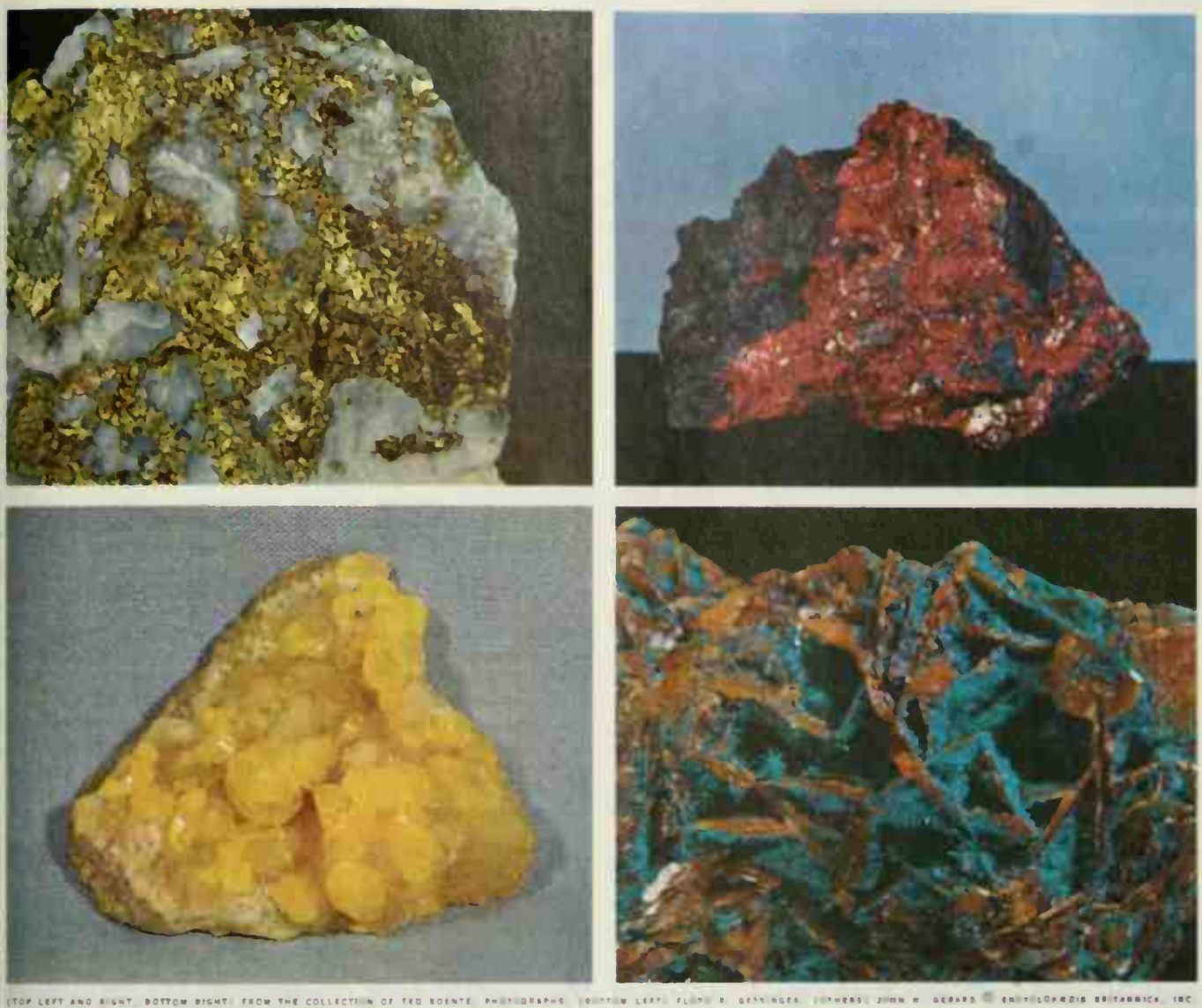



FIG. 6.—STRUCTURES AND COMPOSITIONS OF SILICATE RADICAL TYPES

**Density.**—Density (mass per unit volume of a substance) depends upon the number, atomic weights, and compactness of arrangement of the constituents and is a characteristic property of a mineral species. Solid-solution series exhibit ranges in density dependent upon the composition; in fact, the composition of certain minerals (*e.g.*, gold, sphalerite) can be determined with fair precision from density measurement. Densities generally are measured as specific gravity (ratio of the density of a substance to that of water at 4° C. and 1 atm.) by means of the Jolly balance (for samples of a few grams), Berman balance (for milligram samples), pycnometer (for granules and powder) and various heavy liquids.

Heavy liquids (*e.g.*, mixtures of acetone and acetylene tetrabromide ranging up to a specific gravity of 2.9) are much used in the "sink-float" separation of mineral powders for chemical analysis and other purposes. (*See* also PETROLOGY: *Methods of Investigation.*)

**Crystal Morphology.**—Minerals occurring in euhedral (completely bounded by faces) or subhedral (partly bounded by faces) crystals can be identified, in



(TOP LEFT AND RIGHT, BOTTOM RIGHT) FROM THE COLLECTION OF TED BOEHTE. PHOTOGRAPHS (BOTTOM LEFT) FLOYD P. GIBBONS (TOPMOST) JOHN H. GERARD © ENCYCLOPÆDIA BRITANNICA, INC.

FIG. 7.—EXAMPLES OF MINERALS IN WHICH THE COLOUR IS AN INTRINSIC PROPERTY OF THE SPECIES

(Top left) brass-coloured chalcopyrite, $CuFeS_2$, from Ontario, Canada; (top right) red cinnabar, HgS, from Arkansas; (bottom left) yellow sulfur, S, from Racalmuto, Italy; (bottom right) green dioptase, $Cu_6(Si_6O_{18})\cdot 6H_2O$, with orange-yellow wulfenite, $PbMoO_4$, from Arizona

principle, by their interfacial angles and symmetry, accurate determination of which requires use of the optical goniometer ("angle measurer"). Goniometry was formerly an important method of identification but has been largely supplanted by more powerful straightforward methods. Simple observation of crystal habit, nonetheless, is useful in the recognition of many minerals. It may be made megascopically or by optical and electron microscopy.

**X-ray Diffraction.**—X-ray diffraction effects in minerals are observed by several different techniques (*see* X-RAYS). Most extensively used is the powder (Hull-Debye-Scherrer) method in which the diffraction pattern produced by a minute sample of fine powder is recorded as a series of curved lines on a strip of film. Each crystalline species is characterized by a particular set of lines having certain spacings and intensities.

The method provides not only an extremely effective "finger print" for identification, but also yields information about homogeneity, composition, symmetry, unit cell, crystallinity and grain size. The powder and the related recording diffractometer methods are essential for the investigation of fine-grained minerals such as serpentines and clays.

The single crystal techniques (oscillation, rotation, Weissenberg and precession methods) are used chiefly for the determination of unit-cell dimensions and shape, space group, special twin laws, crystal structure determinations and various structural details.

**Optics.**—The interaction of light, that is, electromagnetic radiation in the visible region (4,000 to 7,500 Å), with crystalline matter provides another important class of properties. Minerals in which the bonds have significant metallic character absorb some and reflect the rest of the incident light; they are opaque and have a metallic lustre. Minerals whose bonds do not have appreciable metallic character can transmit light and are characterized by a nonmetallic lustre. A few minerals, however, have intermediate character and submetallic lustres. The optical properties of minerals with metallic lustre have to do mainly with the behaviour of reflected light. The colour of smooth fresh surfaces of such minerals depends largely on the principal constituents and is, therefore, a useful determinative property. (*See* fig. 7.) However, the true colour of many surfaces is camouflaged by tarnish (notably bornite), an extremely thin film of alteration product. The optical properties of opaque minerals are best observed on polished surfaces by means of the polarizing reflecting microscope.

The optical properties of the nonmetallic minerals depend mainly upon the behaviour of the transmitted light. However, the most obvious such property, colour, is much more variable than is the case for the metallic minerals. Although many nonmetallic minerals do have an intrinsic colour (sulfur, rhodonite, azurite), most do not (quartz, fluorite, beryl, celestite), and their colours, if any, depend on finely dispersed impurities, intergrown phases, state

FROM THE COLLECTION OF JOSEPH AND HELEN GOETTELMAN. PHOTOGRAPHS JOHN H. GERARD & ENCYCLOPAEDIA BRITANNICA, INC.

FIG. 8.—EXAMPLES OF MINERALS IN WHICH THE COLOUR IS NOT AN INTRINSIC PROPERTY OF THE SPECIES. COLOUR IN SUCH MINERALS VARIES BECAUSE IT IS CAUSED BY IMPURITIES. VARIATION IN SOLID-SOLUTION COMPOSITION AND STRUCTURAL IMPERFECTIONS THAT CAN DIFFER FROM SPECIMEN TO SPECIMEN AND EVEN WITHIN SMALL SINGLE CRYSTALS

(Top, from left) fluorite, $CaF_2$: green from England and yellow, colourless and purple from Rosiclare, Ill. The pieces are single crystals bounded mainly by cleavage surfaces. (Bottom, from left) beryl, $Be_3Al_2Si_6O_{18}$, from Brazil. Specimens on extreme right and left are gem varieties commonly referred to as aquamarine. Piece at centre left is common green beryl. Large pink crystal at centre right is a gem known as morganite or rose beryl. All are single euhedral crystals

of aggregation, imperfections such as colour centres, fracture and cleavage, and nature of the surface (*see* fig. 8). The colours, and even lustres, of many minerals having extensive solid solution (amphibole, olivine, wolframite) commonly show considerable range and can be of value in indicating approximate composition. The optical properties of crystals are vectorial, that is, depend upon direction. The repetitive arrays of atoms set up fields which polarize the transmitted visible electromagnetic radiation (*see* LIGHT).

The fields in minerals having isometric symmetry cause isotropic behaviour of light (same in every direction). For all others the fields cause anisotropic behaviour, the optical symmetry being controlled by the atomic structure. Optical behaviour is observed and measured by the polarizing or petrographic microscope. Even colour is vectorial and except for isotropic minerals, any colour absorption present varies with direction (pleochroism). The most fundamental optical properties are refractive indices (relative velocity of light in the substance to that in air—strictly speaking, to that in a vacuum), optic symmetry and orientation. For a given direction of light vibration the refractive index varies with the wave length (and slightly with temperature). The difference in refractive index for light of different specified wave lengths (e.g., that of the hydrogen C, 6563 Å, and hydrogen F, 4861 Å, lines) is termed the dispersion and is a fundamental property of the substance. In ordinary work refractive indices are measured with respect to white light, which gives values approximating those for the sodium D line (5893 Å).

Isotropic minerals are characterized by a single refractive index (with respect to a particular wave length or to white light) and a particular dispersion. Anisotropic minerals are of two kinds: uniaxial crystals (tetragonal and hexagonal) characterized by two, and biaxial crystals (orthorhombic, monoclinic and triclinic) characterized by three principal refractive indices, accompanying dispersions, and vibration directions whose orientations are limited by the crystal symmetry.

Derivative optical properties much used in mineral determination are birefringence (difference between the maximum and minimum indices), optic angle and sign, and extinction angle. Optical properties provide information about solid-solution composition as well as about the identification of species. Mineral optics are measured in thin sections and in crushed grains immersed in oils of known refractive indices.

Although the obvious gross optical properties (*e.g.*, varieties of nonmetallic lustre, transparency, colour, streak and iridescence) are sufficiently characteristic to aid in the identification of many species and varieties, they are likely to vary in unpredictable ways due to impurities, mineral intergrowths, nature of the surface, fractures and state of aggregation. Streak, the colour of the fine powder obtained by rubbing a mineral against unglazed porcelain, is the most useful colour-based property.

**Cohesion.**—Properties such as hardness, cleavage, parting, fracture, flexibility, elasticity, tenacity, glide, percussion figures, etch figures and corrosion forms depend upon the cohesion of the constituent atoms. Of these, hardness and cleavage are of the most use in identification. The others are distinctive only for certain species.

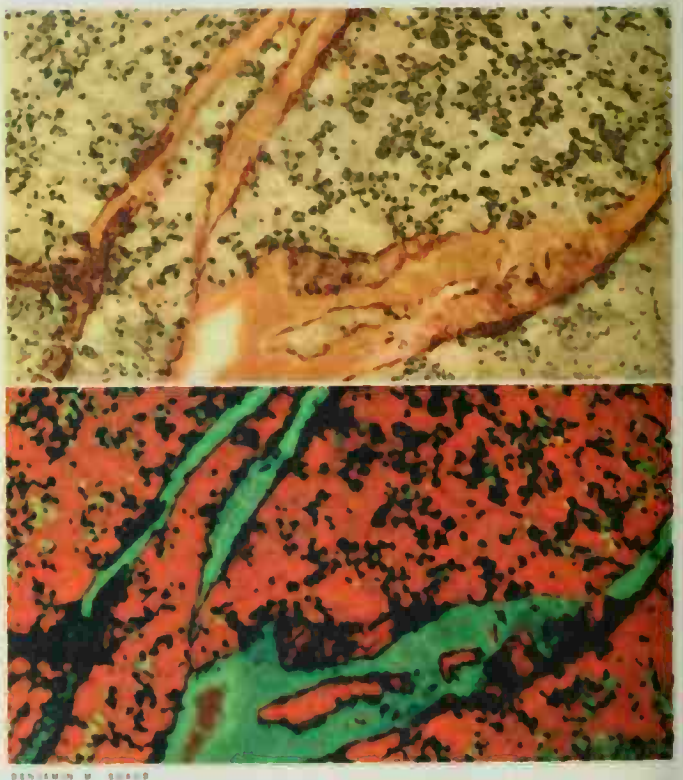
Mineral hardness is conventionally measured as the resistance to scratching (resistance to indentation is sometimes used in the microscopic study of ores) in comparison to an arbitrary reference scale, the Mohs' scale (*q.v.*) of hardness. Mohs' scale arranges a standard series of minerals in order of increasing relative hardness as follows:

| | |
|---|---|
| 1. Talc | 6. Microcline (or orthoclase) |
| 2. Gypsum | 7. Quartz |
| 3. Calcite | 8. Topaz |
| 4. Fluorite | 9. Corundum |
| 5. Apatite | 10. Diamond |

Hardness is vectorial although this is not usually apparent from the crude method of measurement used in determinative work. Hardness anisotropism is, however, very marked for kyanite; it is 4 to 5 parallel to the *c* axis and 6 to 7 perpendicular to it.

Cleavage, the property of breakage along planar surfaces in rational crystallographic directions, is controlled by the crystal structure and bonding. When present, it is characteristic of the mineral species and, consequently, is a useful diagnostic property.

**Magnetism and Electricity.**—A great many minerals are at-



BENJAMIN M. GERARD

FIG. 9.—SPECIMEN (FROM FRANKLIN, N.J.) OF CALCITE, $CaCO_3$, WITH GRAINS OF BLACK FRANKLINITE, $(Zn,Mn,Fe)(Fe,Mn)_2O_4$, AND VEINS AND GRAINS OF BROWNISH GOLD WILLEMITE, $Zn_2SiO_4$

(Top) specimen in ordinary light. (Bottom) fluorescent colours due to excitation by ultraviolet light (*see* text). Red is calcite, green is willemite, black is nonfluorescent franklinite

tracted by the poles of a strong electromagnet, that is, they are paramagnetic. Each such species is characterized by a particular magnetic susceptibility (or range of susceptibility), a property useful in the electromagnetic separation of fine-grained and intimately intergrown mixtures of rock and ore minerals for chemical analysis and other study. A very few minerals (magnetite, ilmenite, pyrrhotite) are ferromagnetic (having susceptibilities several orders of magnitude greater) and are attracted by an ordinary hand magnet. Still others (zircon, calcite) are diamagnetic and are repelled by a strong electromagnet.

Although electrical properties are rarely used in determinative work certain ones are important in the investigation of the nature of minerals and in technology. Minerals having metallic lustres are good conductors or semiconductors, while those having nonmetallic lustre are nonconductors (they are dielectric). Dielectric behaviour is receiving increasing attention in the investigation of the nature of minerals. Dielectric crystals not possessing a centre of symmetry exhibit piezoelectricity, whereby electrical charges develop upon the application of pressure. The property is used in the production of pressure gauges (tourmaline) and oscillators (notably quartz).

**Heat.**—Thermal properties include melting and inversion points, thermal conductivity, diathermancy (transparency to infrared radiation), thermal expansion, specific heat (or heat capacity) and the various heats of reaction, formation, solution, crystallization (latent heat of fusion), inversion and hydration. These properties are not used directly for determinative purposes, although the combined effects of several are involved in the property of fusibility and in the method of differential thermal analysis (DTA). Fusibility (a function of melting temperature and viscosity of the melt) ranges from that of stibnite (melting to a globule in a candle flame) to that of quartz (infusible in an ordinary blowpipe flame); it is diagnostic for a few minerals. Differential thermal analysis determines, for samples being heated up at a controlled rate, the intensities of and the temperatures at which thermal effects occur. The effects accompany compositional and structural changes (dehydration, oxidation, reaction, inversion, loss of crystallinity) during heating; they may be endothermic (absorb heat) or exothermic (give up heat to their surroundings). The thermal behaviour is recorded graphically (DTA curve) and is a characteristic property of many minerals. The shape of the curve depends on the various heats of hydration, reaction, inversion and crystallization of the mineral sample and also upon the instrumentation and procedure. The method is invaluable for the identification of many fine-grained minerals such as the clays; it is finding increasingly wide application to many others, including carbonates, hydroxides and hydrous oxides, and sulfides.

**Luminescence and Radioactivity.**—Luminescence (*q.v.*), the emission of visible light in response to excitation from an external source, is useful in the search for and identification of a number of minerals. Fluorescence is the variety of luminescence resulting from excitation by ultraviolet and shorter wave-length radiation. (*See* fig. 9.) The colour of fluorescence varies with impurity composition; a semiquantitative estimation of the molybdenum content of scheelite, $Ca(W,Mo)O_4$, for example, can be made by means of the fluorescent colour. Thermoluminescence (fluorite) results from thermal excitation. Triboluminescence (fluorite, sphalerite) arises from mechanical excitation by rubbing or scratching.

The radioactivity (*see* RADIOACTIVITY) associated with uranium and thorium containing minerals is an essential aid in the search for sources (*e.g.*, uraninite, carnotite, monazite) of nuclear energy. It is detected and measured mainly by Geiger and scintillation counters. Radioactivity is indicated in thin sections of rock by discoloured spots (pleochroic haloes) around tiny grains (zircon, allanite, thorite) enclosed in minerals such as biotite, muscovite and cordierite. The crystal structures of such tiny grains are commonly destroyed (metamict state) by the long-continued high-energy bombardment.

Several methods of measuring geologic time depend upon the radioactivity of minerals. The more reliable ones are based on the abundance ratios of isotopes (*e.g.*, lead-206/uranium-238, lead-204/lead-207, strontium-87/rubidium-87, argon-40/potassium-40) connected with the radioactive decay. The ratios are measured by mass spectroscopy (*q.v.*).

## V. GEOLOGIC OCCURRENCE AND ORIGIN

Minerals are the products of the geological processes and as such provide evidence leading to knowledge about these processes and about the evolution of the earth. Interpretation of the evidence, however, is a difficult and far from straightforward matter on account of the extreme complexity of the processes and because many of them operate under environmental conditions and durations of time far removed from our ordinary experience. Consequently, not only do a great many challenging problems remain to be satisfactorily explained but many of the genetic explanations already proposed are working hypotheses or trial models rather than proven fact. They are undergoing continual improvement or are being supplanted by alternative models. Consult the articles GEOCHEMISTRY; GEOLOGY; and ORE DEPOSITS for additional information about geological processes and occurrences of minerals. A further consideration to be kept in mind is that mineral evolution is a dynamic process—geologic environments undergo continual change in geologic time and mineral assemblages tend to change in response to the changing conditions.

**Igneous Rocks.**—The great bulk of the earth's crust is composed of generally massive aggregates of rock-forming minerals termed igneous rocks. The most abundant and characteristic minerals (essential ones) are feldspars, quartz, micas, amphiboles, pyroxenes, olivine, serpentines and feldspathoids. Igneous rock classifications are based largely upon the proportions of these minerals and upon the texture of the aggregate. Small amounts of accessory minerals are also present (*e.g.*, sphene, ilmenite, magnetite, zircon, allanite, apatite, fluorite and xenotime).

The problem of the origin of igneous rocks is still far from settled. Volcanic rocks can be observed to form by the crystallization of lava, a complex solution-melt (magma) of silicate, common metallic elements, small amounts of water and traces of many other constituents that have been erupted at the surface. The chemically and mineralogically analogous coarser-grained plutonic (deep-seated) rocks, however, form in regions inaccessible to observation and under extremely complex conditions. General agreement as to their origin has not been reached. Many geologists believe that all igneous rocks are magmatic (of molten origin) and that the plutonic ones are deeper-seated equivalents of volcanic rocks. Others believe that at least some plutonic rocks have formed by the transformation of pre-existing rocks without the agency of magma, by a process akin to extreme metamorphism. It is likely that both magmatic and transformational processes are operative in the crust, depending upon the conditions prevailing. *See also* PETROLOGY.

**Metamorphic Rocks.**—Metamorphic rocks are so varied that only a slight indication of the possible mineralogical combinations can be given. The gneisses and schists typical of regionally metamorphosed terrains are composed chiefly of quartz, micas, and feldspar. Many varieties contain minerals such as garnet, staurolite, chlorite, epidote, amphibole and ferroan dolomite (ankerite) with or in place of some of the first listed ones. Typical accessories are sphene, tourmaline, ilmenite, apatite, magnetite and rutile. Slates are composed of extremely fine-grained quartz and micalike and chloritic minerals intermediate to those in shales and in schists; marbles consist of calcite and dolomite; and quartzite almost entirely of quartz. Contact metamorphic rock (tactite or skarn) is composed of various combinations of characteristic and often beautifully crystallized garnet, epidote, idocrase, wollastonite, diopside-hedenbergite, tremolite-actinolite and calcite or dolomite.

Metamorphism is the transformation (without melting) of pre-existing rocks in response to changes in the temperature, pressure and composition. The transformations range from recrystallization of the original minerals (marble and quartzite) to complete changes in mineralogy, texture and structure. Some transformations also involve considerable change in bulk chemical composition, or metasomatism (*q.v.*). The intensity of the metamorphic

conditions appears to be reflected by the production, for a given bulk composition, of characteristic mineral assemblages (metamorphic facies). *See* also METAMORPHISM.

**Sedimentary Rocks.**—Sedimentary minerals include carbonates (calcite, siderite), sulfates (gypsum, anhydrite), phosphates (apatite), halides (halite), oxides (hematite, diaspore) and sulfides (pyrite), as well as the silicates. Many of them (notably the clays) are extremely fine-grained (*e.g.*, less than 2 microns, or 0.00008 in.) and commonly are poorly crystallized. Identification and knowledge about the nature of these has been possible only through the application of techniques such as X-ray diffraction, electron microscopy and differential thermal analysis.

Sedimentary rocks are formed at or near atmospheric conditions from the materials of pre-existing rocks (igneous, metamorphic or older sediments). Minerals such as quartz, and to a lesser extent ilmenite, garnet and zircon, are resistant to weathering and transport and thus survive in clastic (fragmental) sediments. Fragments of pre-existing rocks may also survive under certain conditions. Other minerals such as illite, montmorillonite and clay-chlorite, although inherited from the parent material, may be more or less reconstructed in the sedimentary environment. Still others (*e.g.*, calcite, halite, gypsum) form completely anew in the environment. Organic agents also participate in the formation of sedimentary minerals. Much of the calcite in limestones is produced originally by organisms such as algae, corals and brachiopods; quartz in many cherts commonly originates from opal (amorphous $SiO_2$) deposited by diatoms and radiolaria.

Ancient sediments generally are consolidated. Some of the more common types are: shale (illite, clay-chlorite, quartz, montmorillonite, organic matter), sandstone (largely quartz), graywacke (quartz, feldspar, micas and micalike clays, chlorite, rock fragments) and limestone (largely calcite). Evaporites are composed mainly of gypsum or anhydrite, commonly with interbedded halite, and less so with sylvite, carnallite and other highly soluble minerals. Recent sediments generally are unconsolidated. They are being intensely investigated in order to obtain mineralogical criteria for sedimentary environments and evolution. *See* also SEDIMENTARY ROCKS.

**Mineral Deposits.**—Mineral deposits include those mineralogic bodies that do not compose a significant part of the earth's crust (*i.e.*, those other than rocks). Their minerals include representatives from every class and they occur in a great variety of ways, such as veins and veinlets, irregular replacement masses, cavity linings, beds and disseminations in rock. Most have no economic value; those that do are ore deposits. Typical ore minerals are galena, chalcocite, hematite and pyrite containing gold. Those not having an economic value (as quartz, jarosite, siderite) are gangue minerals.

Mineral deposits probably form most commonly by deposition from solution. Deposits such as calcite veins in limestones, barite in sediments, bog iron (mainly goethite) and many bodies of quartz have been deposited by ground water at ordinary temperatures. Others, including most metalliferous ore deposits, have formed at elevated temperatures. They are generally surrounded by alteration zones, which may extend into the host rock for tens or hundreds of feet. Mineralogical study of these alteration zones is increasingly important in the search for ore deposits. Mineral deposits also form by sedimentary, metamorphic and igneous processes.

## VI. EXPERIMENTAL MINERALOGY

A notable feature of modern mineralogy is the extensive and fruitful use of experimental methods to supplement field and laboratory methods in the endeavor to understand the extraordinarily complex processes of mineral genesis. Common approaches include geochemistry, mineral synthesis, phase equilibria studies, experimental simulation of geological processes and investigation of mineral properties under different conditions.

Almost all the common minerals and a great many rarer ones have been synthesized by one means or another. Synthesis of individual minerals, however, generally is of limited direct application to mineral genesis. On the other hand, it is an important source of technologically useful substances (such as industrial diamonds, corundum and cubic boron nitride for abrasives; quartz for oscillators; soda niter for polarizing prisms); and for gem materials (such as ruby, star sapphire and iron-free rutile, or titania). The principal techniques are: precipitation from solution (yielding fine-grained products), crystal growth from solution (from seed crystals), crystallization from a melt, flame fusion (the Verneuil process), solid-state reactions and phase transformations, crystallization and reaction from vapour, and hydrothermal synthesis.

Phase equilibria studies of simplified analogues of geological systems are of particular importance in furnishing fundamental knowledge about mineral formation. They are also of great technological value (*e.g.*, in smelting, manufacture of ceramic and refractory bodies, cement production). Inasmuch as mineral stabilities are influenced by the presence of different components, studies of multicomponent systems are the most informative. One of the earliest major contributions was J. H. van't Hoff's investigation (1896) of saline solutions (at ordinary temperatures and pressures) and its application to the formation of evaporites such as those at Stassfurt. The most notable of all has been the meticulous and comprehensive program at the Geophysical laboratory of Washington, D.C. Following Bowen's classic study (1913) of the plagioclase binary system and its solid solution (*see* FELDSPAR), equilibrium relations of the mineral phases of a great many systems have been determined at high temperatures (and atmospheric pressures). Such work led Bowen to his fundamental reaction principle (*see* GEOCHEMISTRY: *Geochemistry of the Lithosphere: The Reaction Series*). R. W. Goranson's study (1931) of water-containing silicate systems at high temperatures and pressures showed that melts dissolve several per cent of water and that melting temperatures of minerals under these conditions are considerably lower than in the analogous anhydrous systems. With the availability of more practicable apparatus, Bowen and O. F. Tuttle (1949) stimulated systematic hydrothermal investigation analogous to the earlier work on anhydrous systems. More recently, the "simple squeezer" apparatus of D. T. Griggs and G. C. Kennedy has enabled the determination of mineral stabilities to at least 50,000 atmospheres and close to 1,000° C. These investigations reveal that, in the presence of water (and other volatiles) under high confining pressures, mineral reactions occur rapidly even at temperatures of only a few hundred degrees, temperatures at which a great many anhydrous systems show no appreciable reaction even during several months' time. This has made possible the observation of many hitherto unknown solid-state reactions. In addition to silicate studies, intensive investigation of carbonate and sulfide systems has been made. Besides the phase equilibria studies, methods for learning about geologic temperatures include use of the pressure-volume-temperature relations of liquid inclusions in minerals, isotopic ratios (*e.g.*, $oxygen^{16}/oxygen^{18}$ in quartz and in the calcite of shells) and the thermoelectric potential of pyrite (pyrite geothermometer). (*See* also SILICON; *The Silicates.*)

The investigation of the properties of minerals and aggregates under various conditions of temperature, pressure and stress is of considerable technological as well as some geological significance. Properties of interest are: refractoriness, shear strength, electrical conductivity, thermal expansion, viscosity of melts, resistance to abrasion, impact and seismic behaviour at high temperature and pressure. *See* CRYSTALLOGRAPHY; *see* also references under "Mineralogy" in the Index.

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**MINERAL PHOSPHATES.** The element phosphorus is known to be present in more than 150 minerals most of which belong to the apatite family of calcium phosphates. (For varieties and chemical composition *see* APATITE.) Phosphorus, an essential constituent for all living organisms, is one of the least abundant of the mineral nutrients. Its average content in soils and rocks of the earth's crust is 0.12%, whereas iron is 5%, calcium is 3.6%, potassium is 2.6% and magnesium is 2.1%. Thus when phosphorus is removed from the soil by crops, it must be replaced artificially by adding phosphate fertilizers to soils. Phosphorus also is used widely in manufacturing industries. Nearly all of the phosphate fertilizers and phosphorus for industrial uses are obtained from naturally occurring rocks containing high concentrations of phosphate-bearing minerals. Thus the availability of large quantities of phosphate rock is of primary importance to agricultural and industrial nations.

**Uses.**—Within the United States about 60% of all phosphate used, and in other countries a larger percentage, is for agricultural purposes, and most of this is made into fertilizers. The remaining production is used in making elemental phosphorus and phosphoric acid. These products are made into organic and inorganic chemicals to be used in preparing detergents, water softeners, leavening agents (cooking), plasticizers, insecticides and many other products. Elemental phosphorus also is used in military smoke screens and incendiary bombs, phosphorus alloys and pesticides. In addition phosphoric acid is made into fertilizers, animal-feed supplement, beverages, photographic supplies, dental and silicate cements, ceramics, and is used as a catalyst and oil-refining agent. A complete list of phosphate compounds would embrace almost every manufacturing process and nearly all chemical techniques.

**Principal Types of Phosphate Deposits.**—Primary, or original, phosphate deposits are: apatite-bearing igneous rocks, marine sedimentary rock phosphorites and phosphatic shales and limestones, and guano. These deposits may give rise by geological processes of erosion and deposition to secondarily enriched deposits known as: residual phosphorites, river-pebble phosphates and phosphatized rock.

Igneous apatite deposits are formed as a result of differentiation of the constituents of cooling magmas (molten rock material) which have been intruded into rocks of the earth's crust. These deposits are sheetlike or irregular masses associated with other types of igneous rocks and may contain as much as 35% phosphorus pentoxide, designated in the fertilizer industry as $P_2O_5$ or as phosphoric acid. Although these deposits are of less importance than marine phosphate deposits, they have been the ultimate source of the phosphatic compounds in solution in sea water from which marine phosphate deposits have been derived.

Inorganic and/or organic processes, operating upon phosphoric acid in solution in sea water, precipitated the carbonate-fluorapatite minerals as blanketlike deposits of marine phosphorite and phosphatic shales and limestones on ancient sea floors. Marine phosphorites consist of layers of phosphatic pellets and nodules ranging from less than 0.1 to more than 20 mm. in diameter. Individual layers may be more than six feet thick and contain as much as 35% $P_2O_5$. Phosphorites are associated with black, carbonaceous, and phosphatic shale, chert and minor limestone. Phosphatic layers generally are thin, but the total thickness of such deposits may be many tens of feet. These deposits consist of a small percentage of phosphate pellets mixed with other sedimentary material such as clay, silt, sand and calcium carbonate. The phosphate content may range from 0% to 30%. Marine phosphate deposits contain reserves calculated to be of the order of several billions of tons. The marine phosphorites and phosphatic rocks contain many minor metals. Of these, vanadium is recovered from western U.S. phosphorite, and uranium is recovered from some Florida phosphates.

Guano (*q.v.*) deposits form by the accumulation of seafowl or bat droppings. The largest deposits are formed on islands in low latitudes along western margins of continents where phosphate-rich sea waters permit a luxuriant growth of marine organisms upon which seafowl feed and where a semiarid climate permits preservation of their excreta. Guano deposits generally are small; the larger contain a few millions of tons at the most. Guano ranges widely in composition, and the phosphatic content generally is less than 25%. The phosphatic minerals in the deposits include hydroxylapatite, carbonate hydroxylapatite, brushite (a hydrous phosphate) or monetite (an anhydrous phosphate).

Residual phosphate deposits develop by decomposition of phosphatic limestones located within humid climatic regions. These deposits, consisting of phosphate pellets and nodules left behind when the calcium carbonate of the limestone is removed by solution, lie on the irregular weathered bedrock surface. In hilly country the residual phosphate deposits are narrow and conform to the outcrop pattern of the strata, but in valleys or flat country the deposits are blanketlike. These deposits range in thickness from one to several tens of feet. The phosphate content varies from a few to about 30%. The higher-grade deposits are utilized directly but lower-grade deposits must be beneficiated (to remove worthless material) by washing, screening or flotation, in order to yield a salable product. Phosphate reserves of residual deposits amount to many millions of tons.

River-pebble deposits consist of phosphate pellets and nodules weathered out of marine phosphatic limestone, located in humid climatic regions of low relief. The pellets and nodules are reconcentrated by stream action. Most river-pebble deposits do not contain sufficient phosphate to be mined profitably, but those in Florida are mined and beneficiated cheaply enough to produce a commercial product. Phosphate reserves in river-pebble deposits range from a few thousand to many millions of tons.

Phosphatized rocks develop in regions of tropical and subtropical climate when phosphate dissolved from phosphatic rocks or guano by percolating water is reprecipitated in openings or replaces the minerals of limestone, igneous rocks or clay that lie at a lower horizon. Phosphatized rocks are not abundant but some contain as much as 30% to 35% $P_2O_5$, and reserves are estimated in thousands to millions of tons.

**Phosphate Deposits in the United States.**—Examples of all the principal types of phosphate deposits are present in the U.S. Although phosphate concentrations are known in 28 states, current production is confined to four large fields. These fields, listed in order of their total production are: (1) the land-pebble deposits of Florida, (2) phosphatized (hard-rock) deposits of Florida, (3) the residual (brown-rock) deposits of Tennessee and (4) the marine phosphorites and phosphatic shales of the western field (principally Idaho, Montana, Utah and Wyoming). These fields contain practically all of the minable phosphate rock reserves in the U.S. recoverable under economic conditions prevailing in the second half of the 20th century.

The land-pebble phosphates of Florida are blanketlike deposits covering about 2,600 sq.mi. of west-central Florida. These are a combination of residual and fluviatile concentrations of phosphate pellets and nodules derived from phosphatic limestone of the Hawthorn formation of Miocene age. The phosphate was reconcentrated as the Bone Valley formation of Pliocene age. The phosphate deposits range from 1 to 50 ft. thick and average 12 ft. The deposits consist of nearly equal amounts of phosphate pellets and nodules, sand and clay. The phosphate zone is overlain by as much as 60 ft. of overburden which is removed by large draglines before the phosphate is mined by similar methods. Phosphorite particles are beneficiated by washing, screening and flotation methods. The recovered product is sold according to its B.P.L. (bone phosphate of lime) content which is 2.18 times the $P_2O_5$ content.

The hard-rock phosphate deposits of northwestern Florida are of Pliocene age and also were derived by weathering of the Hawthorn formation. These deposits are small but some contain as much as 35% $P_2O_5$. They are mined and beneficiated by the same methods as are used in the land-pebble fields.

The Tennessee brown-rock or residual deposits, located in the

Mt. Pleasant region of Tennessee, have been derived from Ordovician age phosphatic limestones of the Hermitage, Bigbey and Leipers formations. The deposits conform closely to the outcrop pattern of the parent limestones on the rolling, hilly topography. The thickest phosphate deposits fill solution-enlarged joints (locally called cutters) in the phosphatic limestones. These deposits also are mined by open-pit methods and beneficiated to produce a marketable product.

The marine phosphorites and phosphatic shales of the western field are in the Phosphoria formation of Permian age. Phosphate rock is mined in Idaho, Wyoming, Montana and Utah by open-pit and underground methods. Minable layers range from 3 to 20 ft. in thickness and contain from 20% to 32% $P_2O_5$. Most of the reserves in this field will have to be mined by underground methods.

The United States is self-sufficient in phosphate and has sufficient phosphate reserves to last for many centuries even under conditions of increased production.

**Phosphate Deposits in Other Countries.**—The principal resources of phosphate rock outside the United States are North Africa (the former French section of Morocco, Tunisia, Algeria and the U.A.R.-Egypt), U.S.S.R., the islands of the Pacific and Indian oceans and Brazil. In addition to these there are many others which are little developed and about which not much is known. These deposits are of the same types described above for the United States.

For information on occurrences, world reserves, production and processing, *see* FERTILIZERS AND MANURES: *Phosphorus-Supplying Fertilizers*. *See* also PHOSPHORIC ACIDS AND PHOSPHATES; PHOSPHORUS.

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(V. E. M.; W. R. Ll.)

**MINERAL WATERS** are waters that contain mineral salts (or sometimes gases) in solution in concentrations sufficient to provide special properties and taste. The waters usually contain the salts naturally but they may be added. Mineral waters have been used in the treatment of various illnesses since the dawn of time, especially at spas such as Baden-Baden, Ger., Bath, Eng., Hot Springs National park, Ark., and Spa, Belg. (*See* also SPRINGS: *Mineral Springs*.)

ETRUSCAN BRONZE STATUETTE OF MINERVA AS GODDESS OF WAR, 5TH CENTURY B.C. IN THE BRITISH MUSEUM, LONDON

**MINER'S PHTHISIS:** *see* PNEUMOCONIOSIS.

**MINERVA,** an Italian goddess of handicrafts who presided also over the professions and the arts. She is commonly identified with the Greek Athena (*q.v.*), and some scholars believe that she is not of native cult but is Athena introduced at Rome from Etruria. Indeed she is one of the Capitoline triad in association with Jupiter and Juno (*qq.v.*), traditionally introduced by the Etruscan kings, and it would be difficult to find traces of her cult at Rome before that time. Her name, on the other hand, is Italian, not Etruscan, and is connected with the roots in *mens*, "mind," and *memini*, "remember" (the archaic spelling is Menerva).

She had several temples at Rome. Besides her cult on the Capitoline she had an important shrine on the Aventine which was a meeting place for guilds of craftsmen, particularly dramatic poets and actors who made it their headquarters during the Second Punic War. A shrine on the Caelian was dedicated to Minerva Capta, probably in consequence of the destruction of Falerii in 241 B.C.

Her worship as a goddess of war encroached upon that of Mars (*q.v.*) and she is sometimes confused with Mars's cult partner Nerio (*see* BELLONA). The festival known as the Quinquatrus, falling on the fifth day after the Ides of March (*i.e.*, March 19), was originally a festival of Mars but was taken over entirely by Minerva, apparently from the coincidence that this was the founding day of her temple on the Aventine.

The festival eventually was extended over five days to include March 23, the Tubilustrium or purification of the trumpets. The fact that the tuba was used in military as well as religious ceremonies made this festival not inappropriate to a war deity, although it was probably not originally connected with Minerva. After the first day, which was devoted to a lustration of the arms announcing a new military season, the remaining four were given over largely to gladiatorial shows. The whole season was a school holiday. There was a festival called the lesser Quinquatrus celebrated on June 13, the feast day of the flute players, of whom Minerva was the patron deity.

The erection of a temple to her by Pompey out of the spoils of his eastern conquests shows that she was the bestower of victory like Athena Nike. Under Domitian, who claimed her special protection, the worship of Minerva attained its greatest vogue in Rome. His forum (dedicated as the Forum of Nerva) was dominated by a temple of Minerva, and he built a second shrine to her in the Roman Forum.

*See* Platner-Ashby, *Topographical Dictionary*, *s.v.* "Minerva," "Jupiter Optimus Maximus" and "Forum Nervae." (R. B. Lr.)

**MING,** a major dynasty that governed China, 1368 to 1644, providing an interval of native rule between eras of Mongol and Manchu dominance. The dynastic name means "bright." The dynastic capital was Nanking through 1420 and Peking thereafter.

The Ming emperors reigned over a unified China that included Manchuria and at times extended into Vietnam on the south and to Hami in Chinese Turkistan on the west. Their armies campaigned through Mongolia almost to Lake Baikal, through Manchuria to the Amur river in Korea, in Vietnam and in Burma; and their fleets roamed Indonesian waters and the Indian ocean almost to Zanzibar. The rulers of Korea, Mongolia, Chinese Turkistan, Burma, Siam and Vietnam regularly acknowledged Ming overlordship, and at times tribute was received from as far away as Japan, Java and Sumatra, Ceylon and south India, the east African coast, the Persian gulf region and Samarkand. Modern Chinese honour the Ming rulers especially for having restored China's international power and prestige, which had been in decline since the 8th century. They probably exercised more far-reaching influence in east Asia than any other native rulers of China, and their attitude toward the representatives of modern Portugal, Spain, Russia, Britain and the Netherlands, who appeared in China before the end of their dynasty, was a condescending one.

The Ming state included several notable new institutions: the grand secretariat (*Nei-ko*), provincial governors (*Hsun-fu*) and viceroys (*Tsung-tu*), and the *pao-chia* system of local organization and surveillance. The government was unusually stable but was gradually undermined by epidemic factionalism among civil officials, corrupting interference by palace eunuchs and a succession of weak and inattentive emperors.

The dynasty encompassed the reigns of 16 emperors:

1. Chu Yuan-chang (1328–98), reigned 1368–98; reign title Hung-wu; temple name T'ai-tsu.
2. Chu Yun-wen (1377–?), grandson of T'ai-tsu, reigned 1398–1402; reign title Chien-wen; temple name Hui-ti.
3. Chu Ti (1360–1424), son of T'ai-tsu, reigned 1402–24; reign title Yung-lo; temple name Ch'eng-tsu.
4. Chu Kao-chih (1378–1425), son of Ch'eng-tsu, reigned 1424–25; reign title Hung-hsi; temple name Jen-tsung.
5. Chu Chan-chi (1398–1435), son of Jen-tsung, reigned 1425–35; reign title Hsuan-te; temple name Hsuan-tsung.
6. Chu Ch'i-chen (1427–64), son of Hsuan-tsung, reigned 1435–

49, reign title Cheng-t'ung; restored 1457–64, reign title T'ien-shun; temple name Ying-tsung.

7. Chu Ch'i-yu (1428–57), brother of Ying-tsung, reigned 1449–57; reign title Ching-t'ai; temple name Ching-ti.

8. Chu Chien-shen (1447–87), son of Ying-tsung, reigned 1464–87; reign title Ch'eng-hua; temple name Hsien-tsung.

9. Chu Yu-t'ang (1470–1505), son of Hsien-tsung, reigned 1487–1505; reign title Hung-chih; temple name Hsiao-tsung.

10. Chu Hou-chao (1491–1521), son of Hsiao-tsung, reigned 1505–21; reign title Cheng-te; temple name Wu-tsung.

11. Chu Hou-tsung (1507–66), cousin of Wu-tsung, reigned 1521–66; reign title Chia-ching; temple name Shih-tsung.

12. Chu Tsai-kou (1537–72), son of Shih-tsung, reigned 1566–72; reign title Lung-ch'ing; temple name Mu-tsung.

13. Chu I-chun (1563–1620), son of Mu-tsung, reigned 1572–1620; reign title Wan-li; temple name Shen-tsung.

14. Chu Ch'ang-lo (1582–1620), son of Shen-tsung, reigned only one month in 1620; reign title T'ai-ch'ang; temple name Kuang-tsung.

15. Chu Yu-chiao (1605–27), son of Kuang-tsung, reigned 1620–27; reign title T'ien-ch'i; temple name Hsi-tsung.

16. Chu Yu-chien (1611–44), brother of Hsi-tsung, reigned 1627–44; reign title Ch'ung-chen; canonized by Manchus as Chuang-lieh-ti, by various Ming loyalists as Ssu-tsung, Huai-tsung and I-tsung.

The founder of the dynasty, T'ai-tsu, was one of the strongest and most colourful personalities of Chinese history. His 30-year reign established the governmental structure, policies and tone that characterized the whole dynasty.

T'ai-tsu left his throne in 1398 to a grandson, Hui-ti. In trying to assert central control over the government, Hui-ti provoked a rebellion on the part of his uncle the prince of Yen and was overwhelmed in 1402. The prince of Yen, posthumously titled Ch'eng-tsu, took the throne for himself and proved even more ambitious and aggressive than T'ai-tsu. He subjugated Annam (north Vietnam), personally campaigned against the reorganizing Mongols in the north and sent naval expeditions overseas, chiefly under the eunuch Cheng Ho, to demand tribute from rulers as far away as Africa.

For a century after Ch'eng-tsu the empire enjoyed peace, stability and prosperity. State administration began to suffer from corrupt domination by eunuchs—Wang Chen in the 1440s, Wang Chih in the 1470s and 1480s and Liu Chin from 1505 to 1510. But Jen-tsung, Hsuan-tsung and Hsiao-tsung were model Confucian rulers—unaggressive, benevolent, trustful of their civil ministers. The only serious disruption of the peace occurred in 1449 when Wang Chen led Ying-tsung into a disastrous military campaign against the Oirats (western Mongols). The Oirat leader Yesen ambushed the imperial army, captured the emperor and besieged Peking. The defense minister Yu Ch'ien forced him to withdraw unappeased and for eight years dominated the government with emergency powers. When the interim emperor, Ching-ti, fell ill in 1457, Ying-tsung was restored, having lived in retirement after being released by the Mongols in 1450. Yu Ch'ien was then executed as a traitor.

Wu-tsung and Shih-tsung were probably the least capable Ming emperors. Wu-tsung was an adventure-loving carouser, Shih-tsung a lavish patron of Taoist alchemists. For one period of 20 years, during the regime of the unpopular grand secretary Yen Sung, Shih-tsung withdrew almost entirely from governmental cares. Both emperors cruelly humiliated and punished hundreds of officials for their temerity in remonstrating.

China's long peace ended in Shih-tsung's reign. The Oirats, under the vigorous leadership of Anda (Altan), were a constant threat on the north from 1542 on; in 1550 Anda raided the suburbs of Peking itself. Concurrently, Japan-based pirates plundered China's southeastern coast. Japanese piracy, a problem in the early Ming years, had been suspended in Ch'eng-tsu's time, when the Ashikaga shogunate offered nominal submission to China in exchange for trading privileges. But now the Japanese grew dissatisfied with the trading arrangements, and during the 1550s pirate fleets looted the Ningpo-Shanghai region almost annually, sometimes sending raiding parties as far inland as Soochow.

The Ming government was still able to respond vigorously when challenged. Chinese fleets crushed Japanese pirates in 1559 and 1561, and the coastal raiding ceased. Anda was repeatedly defeated in the 1550s and made peace in 1571. For the next decade, during the last years of Mu-tsung and the early years of Shen-tsung, the Ming state was probably at its peak of stability. The government was dominated by Chang Chu-cheng, the outstanding grand secretary of Ming history; and two generals, Ch'i Chi-kuang and Li Ch'eng-liang, maintained effective military defenses.

In 1592, when Japanese troops under Hideyoshi invaded Korea, Ming China was still strong and responsive enough to campaign vigorously in support of its vassal. But the Korean war dragged on indecisively until 1598, when Hideyoshi died and the Japanese withdrew. It made heavy demands on Ming resources and apparently precipitated a military decline in China.

The reign of Shen-tsung was a turning point of Ming history in other regards as well. Partisan wrangling among civil officials had flared up in the 1450s in reaction to Yu Ch'ien's dominance and again in the 1520s during a prolonged "rites controversy" provoked by Shih-tsung. After Chang Chu-cheng's death in 1582 it became the normal condition of court life. Through the remainder of Shen-tsung's long reign a series of increasingly vicious partisan controversies absorbed the energies of the officialdom, while the harassed emperor abandoned more and more of his responsibilities to eunuchs. The decline of bureaucratic discipline and morale continued under Kuang-tsung, whose sudden death after a reign of only one month in 1620 provoked new controversies. Hsi-tsung was too young and indecisive to provide leadership. In 1624 he finally gave broad powers to Wei Chung-hsien, the most powerful eunuch of Chinese history. Wei brutally purged hundreds of officials, chiefly those associated with a reformist clique called the Tung-lin party, and staffed the government with sycophants.

A new threat had meantime appeared on the northern frontier. The Manchus, quiet occupants of far eastern Manchuria from the beginning of the dynasty, in 1583 were aroused by an ambitious young leader, Nurhachi, and during Shen-tsung's latter years steadily encroached on central Manchuria. In 1616 Nurhachi proclaimed a new dynasty, and overwhelming victories over Ming forces in 1619 and 1622 gave him control of the whole northeastern segment of the Ming empire, down to the Great Wall at Shan-hai-kuan.

Chuang-lieh-ti tried to revitalize the deteriorating Ming government. He banished Wei Chung-hsien but could not quell the partisan strife that was paralyzing the bureaucracy. The Manchus, bypassing Shan-hai-kuan, repeatedly raided within the Great Wall, even threatening Peking in 1629 and 1638. Taxes and conscriptions became more and more oppressive on the Chinese population, and banditry and rebellions spread in the interior. The Ming government became completely demoralized. Finally a domestic rebel, Li Tzu-ch'eng, captured the capital in April 1644. Chuang-lieh-ti committed suicide. The Ming commander at Shan-hai-kuan accepted Manchu help in an effort to punish Li Tzu-ch'eng and restore the dynasty, only to have the Manchus seize the throne for themselves.

Ming loyalists ineffectively resisted the Manchu Ch'ing dynasty from various refuges in the south for a generation. Their so-called Southern Ming dynasty principally included the prince of Fu (Chu Yu-sung, reign title Hung-kuang, d. 1646), the prince of Tang (Chu Yu-chien, reign title Lung-wu, d. 1646), the prince of Lu (Chu I-hai, no reign title, d. 1662) and the prince of Kuei (Chu Yu-lang, reign title Yung-li, d. 1662). The loyalist sea raider Cheng Ch'eng-kung (Koxinga) and his heirs held out on Formosa until 1683.

Direct contact between China and modern Europe was established in Wu-tsung's reign, when in 1517 a Portuguese squadron under Fernão Peres d'Andrade landed at Canton. Despite Chinese hostilities and some persecutions, the Portuguese got a permanent trading base at Macao by 1557. Other Europeans soon joined in the China trade. Christian mission work began on the mainland in 1582 under Matteo Ricci and by the end of the Ming dynasty had won influence and converts even at the Peking court.

Chinese culture under Ming rule was distinguished more by productive competence than by creative brilliance. The period is specially known for architectural construction (Peking, the Great Wall), blue and white porcelain manufactures, prodigious scholarly production, the melodious *k'un-ch'u* form of opera, vernacular fiction (novels and short stories) and the idealistic philosophy of Wang Yang-ming (*q.v.*).

*See* CHINA: *History*; HUNG WU; YUNG LO; *see* also references under "Ming" in the Index.

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**MINGHETTI, MARCO** (1818–1886), Italian statesman, twice prime minister of Italy, was born in Bologna, then one of the Legations of the Papal states, on Nov. 8, 1818. A member of the constituent council summoned to Rome in 1847, he was minister of public works in the cabinet formed in March 1848; but after Pope Pius IX's allocution dissociating the papacy from the revolutionary movement in Italy, he resigned on May 1 and joined the Sardinian-Piedmontese army (*see* ITALIAN INDEPENDENCE, WARS OF). Returning to Rome in Nov. 1848, he refused to form a cabinet after the assassination of Pellegrino Rossi, to whom Pius had just entrusted the government. He then spent eight years in study and travel. In April 1859 Cavour appointed him secretary-general of the Piedmontese foreign office; and when the Legations of the Romagna rejected papal rule Minghetti was elected president of their assembly before their annexation to Sardinia-Piedmont.

Appointed minister of the interior under Cavour in Dec. 1860, a few weeks before the transformation of the kingdom of Sardinia into the kingdom of Italy (Feb. 1861), Minghetti retained the same office in the new kingdom till Sept. 1861. Having been finance minister under Luigi Farini from Dec. 1862, he became prime minister on March 24, 1863. With the help of Emilio Visconti-Venosta he concluded the convention of Sept. 15, 1864, whereby, in return for the withdrawal of French troops from Rome, it was agreed that the Italian capital should be moved from Turin to Florence. Since this implied abandonment of designs on Rome, Minghetti was driven from office eight days later.

Minghetti took little further part in public life till 1869, when he was minister of agriculture under Luigi Federico Menabrea. Both in and out of office, however, he exerted his influence against an alliance with France and in favour of an immediate advance on Rome. In 1870 the ministry of Giovanni Lanza and Quintino Sella sent him to London and to Vienna to organize a "league of neutrals" for the duration of the Franco-German War. Thanks to France's defeat, Rome at last fell to the Italians.

On the overthrow of the Lanza-Sella cabinet (July 10, 1873), Minghetti again became prime minister and minister of finance. Representing the right in Italian politics, he inaugurated a *rapprochement* with Austria as well as with Germany and succeeded in producing budgets without deficits for the first time since 1860, but took arbitrary measures against political opponents at home. Forced to resign on March 18, 1876, he opposed Agostino Depretis and the successive governments of the left till the development of *trasformismo* (*see* ITALY: *History*) reconciled him to them in the 1880s. Minghetti died in Rome on Dec. 10, 1886. His published works include his memoirs, *I Miei ricordi*, 3 vol. (1888–90).

**MINHO,** the province of northwestern Portugal, is known also as Aquem-os-Montes, in contradistinction to Trás-os-Montes, in the northeast. It was formed in 1936 from the northern part of the old Entre Douro e Minho province and comprises the administrative districts of Viana do Castelo and Braga. Pop. (1960) 899,773; area 1,368 sq.mi. The coastal plain forms a narrow belt about 70 mi. long and 2–10 mi. wide, narrowing north of the Lima valley, where the mountains of Santa Luzia (1,790 ft.) rise steeply from the coast. Most of the region consists of undulating granitic plateaus at an altitude of 300–750 ft., traversed by deep river valleys. From the Spanish frontier southward these rivers are: the Minho, Lima, Cávado and Ave, all flowing west-southwest. In the interior, the mountain ranges between the Minho and the Lima (Serra de Suajo 4,642 ft.) are continued by the Serra do Gerez (4,944 ft.) and the Serra das Alturas (4,150 ft.).

The climate is the most favourable for intensive agriculture in Portugal. Mean annual rainfall rises from 50 in. on the coast to more than 70 in. in the mountains. Winters are mild, although snowfall can be heavy in the eastern mountains. Water resources are good, notably on the Cávado (Vila Nova dam has an installed capacity of 156,000 kva.) and on the Lima (Lindoso dam).

The high population densities ranging from 500 to 700 per square mile explain the intensive cropping. Maize (corn) and haricot beans are important. A rapid succession of winter and summer crops is possible with intercultural planting; even the field borders are used for fruit trees and vines. The use of irrigation, the flights of terraces scaling the slopes and the marked dissemination of rural dwellings are all traits of this wooded landscape. Stock rearing is important on the higher lands and the timber industry is significant. Many of the ethnographic features are traceable to the Roman occupation and the ruins of the Celtic castros or hill forts are numerous.

Fishing is of local importance at Esposende, Viana do Castelo (pop. 14,371), Âncora-Gontinhaes and Póvoa de Varzim (pop. 17,314), ports all situated on the north side of the river mouths to avoid the sandbanks built up by longshore drift. Braga (*q.v.*), regional capital and seat of an archbishop, and Guimarães (pop. 23,233) are textile centres. (J. M. Ho.)

**MINIATURE LANDSCAPE.** The original form of Japanese miniature landscape was *hako-niwa* ("box yard"), a small landscape in a wooden box. It has not retained the popularity it still had at the dawn of the 20th century, which was equal to that now enjoyed by *bon-kei*.

*Bon-kei* ("tray landscape"), also known as *ban kei*, an evolution of *hako-niwa*, took on new life around 1900 when Izumi Chisen introduced *keto-tsuchi*, a sort of peat which was easy to model, as a substitute for earth. As *bon-kei* gained popularity many devices were tried, such as coloured earths, sand (representing water) and even newspaper soaked in water, which permitted landscapes to be made and remade quickly according to fancy.

*Sai-kei* (*sai*, "to plant trees or grass"; *kei*, "scenery") is the name of a movement started by *bon-sai* artists (who work with dwarfed trees); to give permanency to *bon-kei* they introduced natural instead of artificial stones and planted trees by the method called *toriki*. *Bon-kei* deteriorates with time, while *sai-kei*, made with living roots, improves with time. It seems appropriate to call such miniature landscapes *suibanmochi-no ishitsuki* ("*bon-sai* with roots having rocks").

*Bon-seki* ("tray stone") is the Japanese art of creating miniature landscapes on black lacquered trays with stones and sand, but without vegetation. Its origin is traced to the reign of Empress Suiko (593–628), when stones of rare shapes were presented to the court from China. Stones were appreciated for their solid reality and their unchanging character; it was believed they had the power to soften the hardened hearts of men. Later, sand was used with stones to suggest water and mountains. In a further development, stones were used to represent the sentiments of poems, or to reproduce famous natural or literary scenes. Brushes are used effectively, but plumes of different birds are indispensable in shaping the *bon-seki*. Stones of different shades are used according to different seasons. Already in vogue at the time of Ashikaga Yoshimasa (1436–90), *bon-seki*, like other forms of Japanese art, passed through different styles; a prominent school is Hosokawa-ryu, which was revived by the rare talent of its chief master, Katsuno Hakuyen.

Another way of enjoying stones, popular for centuries among the

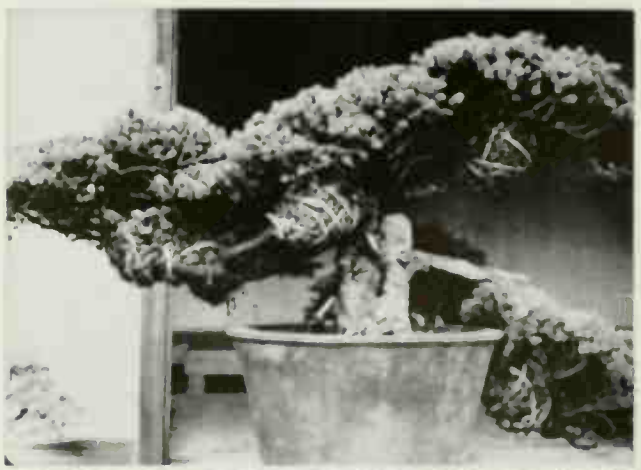
Grove of 15 spruce trees all joined by a single root. Designed and executed by the Kato brothers

Another Kato design, a forest scene with 70 sprucs from a single root of a 15-year old tree. Almost 20 years of work were required to produce this sai-kei

Ise province junipers, about 300 years old, growing on a rock. In the Manseiyen collection, Bonsai village

Rock and spruce scene suggested by an island in Matsushima bay. Manseiyen collection

Stunted growth of spruce and five-needle pine on a rock. Manseiyen collection



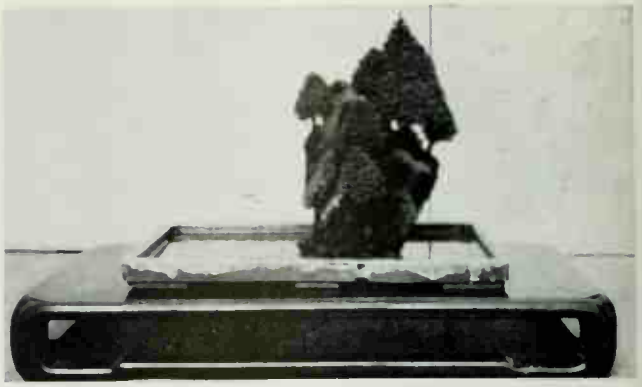
Air-layering a spruce. Moss and earth are bound around the branches with wire until the branches root. The rooted branches are then potted individually

## SAI-KEI OF JAPAN

Miniature trees growing from roots propagated by air-layering (toriki method)

# MINIATURE LANDSCAPE

Bon-seki, a landscape of sand and stone, without vegetation, on a black lacquered tray. This one depicts a boat on a stormy sea



Bon-sai of cedars and rock. Similar to sai-kei, but propagation is from cuttings (*sashime*) rather than by air-layering. By Sadasuke Uchida

Bon-kei of a coastal scene. This type of landscape is artificial, the mountains and other objects are modeled in peat or earth, and coloured earth is used to represent water and paths

Bon-seki showing a landscape with torii (Shinto gateway)

Complete miniature garden with running water in a Tokyo store, 9x12 ft.

Sui-seki, a landscape consisting of a natural stone and water in a porcelain or bronze tray

Sui-seki. After years of watering a coating of moss may appear on the rock

## OTHER TYPES OF JAPANESE MINIATURE GARDENS

BY COURTESY OF HOUSE BEAUTIFUL

"The Painter's Family" by Peter Adolph Hall (1739–93), Swedish born, painted in France. Wallace Collection, London

"Mrs. Pemberton" by Hans Holbein the Younger (1497?–1543), German. Victoria and Albert Museum

"Mme. Dugazon" by Jean Baptiste Isabey (1767–1855), French. Wallace Collection

"James II" by Samuel Cooper (1609–72), English. Victoria and Albert Museum

"A Young Man Leaning Against a Tree Among Roses" by Nicholas Hilliard (1547–1619), English. Victoria and Albert Museum

MINIATURES OF THE 16TH–19TH CENTURIES

# MINIATURE PAINTING

"The Duc de Berri" by Jean Baptiste Jacques Augustin (1759–1832), French. Bernard Falk collection

"Self-Portrait" by John Smart (c. 1742–1811), English. Victoria and Albert museum

"An Unknown Lady" by Jeremiah Meyer (1735–89), English. Victoria and Albert museum

"Countess Thun" by Heinrich Friedrich Füger (1751–1818), Austrian. Cleveland Museum of Art

"A Lady in Masque Costume" by Isaac Oliver (d. 1617), English. Victoria and Albert museum

"Mr. Bigland" by Richard Cosway (c. 1742–1821), English. Bernard Falk collection

"Self-Portrait" by Thomas Flatman (1637–88), English. Victoria and Albert museum

ENGLISH, FRENCH AND AUSTRIAN MINIATURES

Japanese, is known as *sui-seki* ("water stone"). A natural stone of admirable shape is placed in a porcelain or bronze tray with sand and water. Months and years of patient watering and care may, according to the kind of stone used, bring forth a coating of moss, enlivening the stone with verdure like a mountain or like an island with forest and meadow. (J. HAR.)

**MINIATURE PAINTING.** This article is concerned with the history of the small, portable and finely wrought portraits known as miniatures. The name is derived from the minium, or red lead, which was used by the medieval illuminators for rubrication. In the 16th and 17th centuries the usual name for portrait miniatures was limnings.

**Origins.**—The heyday of the portrait miniature extended from the beginning of the 16th century down to the middle of the 19th century. The art owed its origin to the interest felt by the men and women of the Renaissance in personality and in its outward revelation by faithful and searching portraiture. This interest had already been seen in a small, intimate compass in the revival of the classical medal by Antonio Pisanello and his contemporaries of the 15th century. At the same time, the first portrait miniaturists continued with the technique of the illuminators of manuscripts (*see* ILLUMINATED MANUSCRIPTS), painting with detailed precision upon vellum with water colour and body colour. The miniature may therefore be said to have arisen from a fusion of the separate traditions of the illuminated manuscript and the medal.

The emancipation of the portrait miniature from the pages of the book, as a separate portrait enclosed in either a locket or a covered "portrait box," is most plausibly traced to the illuminators of Ghent and Bruges, of whom the most prominent were the Master of Mary of Burgundy, Simon Bening and Gerard Horenbout. However, the earliest datable portrait miniatures are not Flemish but French, and consist of a group of seven portraits representing the warrior companions of Francis I known as *Les Preux de Marignan* and found in the pages of an illuminated manuscript of about 1519. One or two of these were repeated separately as portrait miniatures properly so called; all are probably by Jean Clouet (*q.v.*), whose recognized work consists mainly of portrait drawings of men and women connected with the French court. His son, François Clouet (*q.v.*), succeeded him as painter to the French kings.

French miniature painting in the 16th century is not plentiful; it is closely connected with court circles, and what survives is the work of Jean and François Clouet and their close followers. The attribution of the miniatures generally follows that of the drawings on which they are based, and art historians often disagree about these. It is probable, however, that the miniatures of Catherine de Médicis and Charles IX at Vienna, the Catherine de Médicis in the Victoria and Albert museum, London, and the portraits of Mary Stuart and Charles IX, as a boy, in the English royal collection are by François Clouet. They agree in a certain hard brilliance, the slightly mechanical quality of which may be due to the fact that they are derived not from life but from drawings.

**England, 16th and 17th Centuries.**—Soon after Francis I had installed Jean Clouet as his painter, Henry VIII, in a spirit of emulation, encouraged Gerard Horenbout to come to England with his daughter Susanna and with Lukas Horenbout, who was probably her brother. Lukas Horenbout (d. 1544) painted the first portrait miniatures recorded in England. The portrait of Henry VIII at 35 in the Fitzwilliam museum, Cambridge, is probably by him, and some half dozen other works can plausibly be ascribed to the same hand. These first English miniatures combine the naturalism of the Flemish illuminators with a certain gravity of interpretation which was to pervade the national art till the end of the 17th century. Hans Holbein the Younger (*q.v.*), who was instructed in miniature painting by Lukas Horenbout, soon outstripped his master. He put into this small-scale work all the intensity of vision and fineness of touch apparent in his easel paintings and drawings, so that at the very beginning of the new art form masterpieces were created which have never been surpassed. His portrait of Mrs. Pemberton in the Victoria and Albert museum is the finest miniature ever painted. Barely a dozen authentic miniatures by Holbein are known, but they include one of Anne of Cleves, also in the Victoria and Albert museum, which is of great historical interest. This, with the panel in the Louvre, Paris, was the product of an official mission to Düren so that Henry VIII might decide on the basis of the portrait whether to marry the lady.

Nicholas Hilliard (*q.v.*), the first native-born master of miniature painting in England, modeled his technique upon that of Holbein and was the first artist to devote almost the whole of his working life to the miniature. Unlike his French contemporaries, Hilliard, who has left a fascinating account of his methods and ideals in his *The Art of Limning*, worked from life, and his portraits in consequence have a greater vivacity and freshness. He adopted the oval form which had recently become fashionable on the continent of Europe in preference to the circular form and which remained the most popular shape until the beginning of the 19th century. Hilliard's miniatures give the Elizabethan age in a microcosm and are imbued with the imagination and exuberance which pervaded all facets of life in those times. He was limner to Queen Elizabeth I for over 30 years and painted her portrait many times; he also painted Mary Stuart and many of the chief courtiers and adventurers, such as the earls of Cumberland and Leicester, Sir Francis Drake, Sir Walter Raleigh and Sir Christopher Hatton. The most famous of his pieces, "A Young Man Leaning Against a Tree Among Roses," is justly celebrated as a romantic interpretation of those romantic times. Hilliard emphasized line rather than gradations of tone in his drawing and modeling, and a bias toward this linear approach has persisted throughout English miniature painting.

Isaac Oliver (*q.v.*) was the chief pupil of Hilliard, and during the reign of James I he rose to enjoy more popularity than his master. His parents were fugitives from religious persecution in Rouen, and though he was probably only a baby when he was brought to England, Isaac Oliver always retained French sympathies. He traveled in the Low Countries and Italy; his style is more cosmopolitan than Hilliard's and characterized by more dramatic lighting. Isaac Oliver became a member of the household of Henry Frederick, prince of Wales; he was ably succeeded in his practice by his son Peter, who finished some of his father's works and made a series of small limned copies of oil paintings in Charles I's collection. John Hoskins (*q.v.*) continued in his early work the reticent manner of Hilliard, which was more attuned to the national temper. The effect of Van Dyck's sojourn in England from 1632 is clearly marked in all forms of English portraiture, and especially in the miniatures which Hoskins painted after this date. Samuel Cooper (*q.v.*), who was Hoskins' nephew and pupil, followed directly in this tradition. He is first discerned as an artist with an independent style shortly before 1640, and from then onward his miniatures show a penetration of character and a force of handling which account for his preeminent reputation throughout Europe. Horace Walpole justly said of him that "if a glass could expand Cooper's pictures to the size of Vandyck's, they would appear to have been painted for that proportion. If his portrait of Cromwell could be so enlarged, I don't know but Vandyck would appear less great by the comparison." Cooper's portrayal of the serious and self-reliant characters of the Commonwealth culminates in the sketch portrait of Oliver Cromwell (duke of Buccleuch's collection) to which Walpole refers. After the Restoration he showed himself equally capable of mirroring the pleasure-loving court of Charles II. His full-scale sketches of the famous beauties, Barbara, duchess of Cleveland, and Frances Stuart, duchess of Richmond, which are among his supreme achievements in this field, are in the royal collection at Windsor castle.

During the second half of the 17th century the other leading miniaturists were Thomas Flatman (*q.v.*), a pupil of Samuel Cooper, Nicholas Dixon (worked 1667–1708), a follower of Hoskins, and Lawrence Crosse (d. 1724), who embodies certain continental traits in his style of stippling, and whose work stands at the end of the first great period of English miniature painting. Its strength had lain in the breadth of patronage available as well as in the talent of the artists. There were already in the 17th century collectors of miniatures for their artistic or antiquarian interest, and part of Charles I's cabinet is still in the royal collection at Windsor castle.

**Continental Miniatures, 17th and 18th Centuries.**—During the 17th century there was neither so plentiful an output of miniatures on the continent of Europe nor so continuous a tradition as in England. Patronage was confined more narrowly to the immediate circle of the court. In France the most striking feature was the introduction of the portrait miniature on enamel and its early perfection in the hands of Jean Petitot (*q.v.*). Petitot was born and died in Switzerland and worked for several years in England, but his fame rests on the many portraits of Louis XIV and his entourage which he produced in Paris with the help of his brother-in-law Jacques Bordier. In Denmark Jacob van der Doordt (d. 1629) painted some miniatures for Christian IV; Paul Prieur (d. 1682 or 1683) worked as an enamelist from 1663; and Louis Goullon (d. 1680) painted miniatures in the next decade. Alexander Cooper (*q.v.*), the scarcely less gifted elder brother of Samuel Cooper, worked in Holland and went subsequently to Stockholm, where he worked for Queen Christina. Pierre Signac was miniature painter to the Swedish court from 1646 till his death in 1684, and was succeeded by Elias Brenner (1647–1717).

Throughout the 17th century some miniatures were painted in oils on copper, particularly in the Netherlands and Italy. Though often of excellent quality, these oil miniatures do not rival in interest works carried out in the usual mediums of water colour and body colour; and since such works are rarely signed little is known about the artists who produced them.

About 1700 the whole future course of miniature painting was influenced by the introduction of ivory as the painting ground in place of the vellum or prepared card which had been universal before the development of enamels. The artist responsible for the new departure was Rosalba Carriera (*q.v.*), who is well known also as a pastelist in Venice; it was probably suggested to her by the ivory snuffboxes for which she made decorative paintings. The advantage of ivory is that it provides a luminous glowing surface for transparent colours and correspondingly heightens their effect. However, it was some time before the full possibilities of the new method were appreciated. Many of the earlier painters upon ivory, such as the English artist Bernard Lens (1682–1740), used opaque colour and so deprived themselves of one of ivory's chief advantages.

In the early 18th century the enamel miniature enjoyed the greatest popularity among English patrons. The Swedish-born Charles Boit (1662–1727) produced work in this medium in London for William III and Queen Anne, and the German-born Christian Friedrich Zincke (1684?–1767) painted most of the celebrities of the Augustan era in enamels of a remarkably even quality. Benjamin Arlaud, who worked in the first two decades of the 18th century, was one of the last miniaturists to paint on vellum in England; in France his brother Jacques Antoine Arlaud (1668–1746) pursued a similarly successful career. In that country Jean Baptiste Massé (1687–1767) was one of the first to paint miniatures on ivory and a leader of the French revival of the art.

The second half of the 18th century witnessed a great expansion of miniature painting and the complete absorption in the various national schools of the technique of painting on ivory. The English still favoured a linear approach to drawing and modeling, thus preserving a continuity with the methods used as far back as Holbein and Hilliard and giving full scope for the transparency of the water-colour pigment and the translucence of the ivory. The continental miniaturists, on the other hand, preferred broad washes of opaque water colour with delicate gradations of tone, a method more akin to rococo oil painting. The chief master of the latter style is Peter Adolf Hall (1739–93), who was born in Sweden, settled in Paris in 1766 and was unquestionably the leading miniaturist there until the Revolution. His style is remarkable for its texture and subtlety of colouring, as well as for the geniality it displays; it is seen at its most characteristic in "The Painter's Family" in the Wallace collection, London, and in his portrait of Augustin Pajou in the National museum, Stockholm. A fellow Swede, Niclas Lafrensen (1737–1807), is best known for his miniatures of *galant* scenes of a type made popular by Jacques Charlier (*c.* 1720–90). Jean Baptiste Weyler (1747–91), Jean Laurent Mosnier (1743 or 1744–1808), Marie Gabrielle Capet (1761–1818), Louis Marie Sicard (1746–1825), Antoine Vestier (1740–1824) and François Dumont (*q.v.*) are among the many gifted miniaturists who laid the foundations of their success in France before the collapse of the monarchy. The leading Danish miniaturist was Cornelius Hoyer (1741–1804), who worked also in France, Germany, Russia and Sweden. Augustin Ritt (1765–99) studied in Antwerp and Paris before achieving renown as court miniaturist in his birthplace, St. Petersburg. Heinrich Friedrich Füger (1751–1818), miniaturist to the imperial house in Vienna, is exceptional in that he reveals an English influence in his style, which is of extraordinary accomplishment; he has been called "the Austrian Cosway."

**England and America, 18th Century.**—In the mid-18th century English miniature painting began to recover from a rather dull period. Nathaniel Hone (1718–84), Luke Sullivan (1705–71) and Gervase Spencer (d. 1763) painted works of small compass—often intended for wearing in bracelets—and of a simple charm. The first of the remarkable miniaturists who were fashionable from about 1770 was Jeremiah Meyer (1735–89), a foundation member of the Royal Academy, London. He modeled the features of his sitters with a succession of fine-hatched hairlines scarcely distinguishable at the ordinary viewing distance, and rendered their colourful costume with rococo abandon. His skill was equaled by Richard Cosway (*q.v.*), who drew with a soft, curving gray line. Cosway was the miniaturist of the fashionable world and echoes the beauty and elegance of the entourage of the prince regent. The closely wrought enamellike finish of John Smart (*q.v.*) has many admirers among modern collectors; this same period also saw the masculine portraiture of Ozias Humphry (*q.v.*) and the prolific output of George Engleheart (*q.v.*) and Richard Crosse (1742–1810). The taste for the miniature spread through wide sections of society, and scores of able miniaturists were available to meet this greatly increased demand. Among the better known were Samuel Cotes (1734–1818), Andrew Plimer (*q.v.*), Samuel Shelley (*c.* 1750–1808), William Wood (1769–1809) and Edward Miles (1752–1828). Ireland supported a school of miniaturists at this time, leading members of which were Charles Robertson (1760–1821), George Place (d. *c.* 1809) and John Comerford (*c.* 1770–1832). All these and many others have their individual styles and sense of the sitter's character; the remarkable uniformity of merit in the work even of secondary artists is a testimony to the wide proliferation of good taste in the period.

American miniature painting began in the second half of the 18th century and was strongly under English influence. John Singleton Copley (*q.v.*) is said to have copied English miniatures in the 1760s; Charles Willson Peale and Rembrandt Peale (*see* PEALE) were trained in London. The miniatures of Edward Greene Malbone (*q.v.*) are outstanding for their refined handling; his work ranks with that of Benjamin Trott (*c.* 1770–1843) and Charles Fraser (1782–1860) as the most notable produced by American miniaturists. Among other able miniaturists who worked in America are John Ramage (*c.* 1748–1802), Walter Robertson (*c.* 1750–1802), Robert Field (*c.* 1769–1819), Joseph Wood (*c.* 1778–1830), Sarah Goodridge (1778–1853), Henry Inman (*q.v.*) and Thomas Seir Cummings (1804–94).

**The 19th Century.**—The sharper lighting and more incisive rendering of features introduced by J. L. David into easel portraiture is reflected after the French Revolution in the miniatures of Jean Baptiste Jacques Augustin (1759–1832), a complete master of naturalism in this genre. A similar approach is seen in the works of the Italian miniaturist Ferdinand Quaglia (1780–1853), who settled in Paris, and in that of his countryman Domenico Bossi (1765–1853), who worked in most European centres. Jean Baptiste Isabey (*q.v.*) followed the same principles of naturalism in his earlier works, but his later portraits, the mirror of the first empire, are light, atmospheric and fluid in treatment. Paris remained a prolific centre for miniatures of the highest quality; of the many followers of Augustin and Isabey, Jean Urbain Guérin (1760–1836), Daniel Saint (1775–1847), Jean Baptiste Singry (1782–1824), André Leon Larue, called Mansion (1785–after 1834), and Mme. L. A. Z. de Mirbel (1796–1849) were much in vogue. In Austria, however, Moritz Michael Daffinger (1790–

1849) pursued a style wholly English in its affiliations.

A pronounced break in style is seen in English miniature painting at the start of the 19th century, caused by the resolve of Andrew Robertson (1777–1845) to give his miniatures the force of oil paintings. The taste for larger miniatures of rectangular shape asserted itself from then on. Though there were more miniaturists practising than ever before, fewer stand out. John Cox Dillman Engleheart (1784–1862), John Linnell (1792–1882) and Frederick Cruickshank (1800–68) are among the more individual, while Alfred Edward Chalon (1781–1860) and the Frenchman Simon Jacques Rochard (1788–1872) painted with a liveliness attuned to the court of George IV. A final achievement was added to the history of the art in England by the immense talents of Sir William Charles Ross (1794–1860), who infused his portraits of the notabilities of Queen Victoria's early years with his own serenity of temperament. The invention of photography was the greatest single factor in bringing the annals of miniature painting to a close: the art lingered both on the continent of Europe and in England and the United States into the second half of the 19th century and even into the 20th, but had effectually lost all continuity with the traditions of its former excellence.

*See* also INDIAN ART; PERSIAN ART

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**MINIM:** *see* MUSICAL NOTATION.

**MINIMS:** *see* FRANCISCANS: *Minims;* ORDERS AND CONGREGATIONS, RELIGIOUS.

**MINING, METAL.** Mining, broadly, is the industrial process of removing a mineral-bearing substance from the place of its natural occurrence in the earth's crust. When the term is used with specific reference to producing a metallic material, it is called metalliferous mining or, more simply, metal mining.

**History.**—Through the discovery and identification of tools and weapons and similar artifacts found in various archaeological sites over the world, it became evident that mining has been practised since before the beginning of written history. (*See* METALLURGY.)

Perhaps the first great scholarly and practicable treatise of mining was *De Re Metallica*, compiled by Georgius Agricola (Georg Bauer) and published in 1556. This classic journal, the writing of which took over 25 years, was translated from the Latin in 1912 by Herbert C. Hoover and his wife. The descriptions in *De Re Metallica* are remarkable for their clarity and detail; the text is also profusely illustrated and serves as an excellent source of knowledge of early mining practices. Many of the procedures described are similar to those of the 20th century. In addition to their translation and treatment of Agricola's text, the Hoovers assembled notes about even earlier written works on mining. For example, as early as the 4th century B.C., Aristotle and some of his students, such as Theophrastus, had written of mining matters; Pliny likewise contributed noteworthy writings. Other authors, including Avicenna (an Arabian physician), Albertus Magnus and Roger Bacon, compiled treatises on mining. For the most part, however, few records of importance were developed prior to 1500. Preceding *De Re Metallica* there were three works of major consequence issued in the 16th century about mining technology: *Nutzlich Bergbuchlin*, probably by Calbus of Freiberg, according to the Hoovers; the *Probierbuchlein*, a collection of essays by several authors; and an Italian treatise, the *De La Pirotechnia* by Vannoccio Biringuccio.

After Agricola, the printing of dissertations on mining waned until the first part of the 19th century, the *Mining Journal* starting in London in 1835. Technical articles then began to be published in many journals and several formal treatises were issued. Mining associations and institutions came into being in Europe in the mid-19th century and the American Institute of Mining and Metallurgical Engineers (A.I.M.E.) was founded in 1871. (In 1956 it was renamed the American Institute of Mining, Metallurgical and Petroleum Engineers).

Some mines, such as the Almadén mercury mines of Spain, the tin mines of Cornwall, Eng., and the zinc deposits of Silesia (Poland), have been worked for many centuries in the old world, but not until colonization of the western hemisphere started about 1500 did mining of consequence begin in North America. It is true that the Inca and the Aztec peoples of South America and Mexico had accumulated wealth of gold and silver but industrialized mining does not appear to have been an outstanding feature of these agrarian cultures. Although the North American Indians used some metallic substances for weapons, paints and utensils, they crudely fabricated them from minerals which they exploited only by ill-directed surface scavenging. Neither the Indians nor the Eskimos had even small mines, and they give evidence of having had little, if any, use for gold, silver and other precious metals.

The first recorded copper mining in the western hemisphere was in Cuba in 1524 and it was followed early in the 17th century by activity in Massachusetts and elsewhere along the eastern seaboard of North America. A little later, copper mining was started in Vermont and, as early as 1718, De la Motte Cadillac, a French mineral expert, and Philip Renault located and began to work the famous Mine la Motte lead deposits of southeast Missouri. It was not until the discovery of the tremendous iron and copper deposits in Minnesota and Michigan and the finding of zinc deposits in Missouri, Kansas and Oklahoma, together with those of gold and silver in California, Nevada and elsewhere, that the development of modern metal mining in North America began.

The growing populace of the United States, contemporaneous development of transcontinental railroads and, of course, the discovery of great mineral deposits contributed to a pronounced expansion of mining in the mid-19th century. Mining enterprises were spurred especially by the discovery of gold at Sutter's mill in California and later by the famous developments of Grass valley and the Feather river; by those of the Comstock lode and Tonopah in Nevada; Cripple Creek, Leadville and Silverton, Colorado; Tombstone, Jerome, Bisbee and Morenci, Arizona; Virginia City, Helena and Butte, Montana; Bingham, Park City, Ophir and Eureka in Utah; Orofino, Bay Horse and the Coeur d'Alene of Idaho; the Homestake of the Black hills of South Dakota; the gold rush to the Yukon in Alaska; and many other fabulously productive mining camps.

The search for mines was particularly intense after the Civil War and much of the speed of the development of the western U.S. is attributable to it. The great wealth that accrued also served as an incentive to people of other lands, and great mines were discovered elsewhere in the world. Just as the Cornishmen of the tin-copper mines of England, for example, brought their skills to assist in the building of the great mines of the U.S., American craftsmanship and ingenuity joined in the building of flourishing mining enterprises throughout the world. From Canada, Mexico, Venezuela, Brazil, Peru, Chile, Bolivia, South Africa, Rhodesia, Australia, Burma, India and other countries, there has been a steadily growing production of an expanding range of metals. By the mid-20th century, the trend was to the increasing production of such comparatively uncommon metals as cobalt, titanium, nickel and niobium (columbium), and a great mining rush to search out and develop deposits of uranium and related radioactive minerals swept much of the world.

**The Broad Scope of Metal Mining.**—The tendency in mining has been toward the increased use and improvement of mining machinery so that modern mines are characterized by tremendous capacities. This has contributed to: (1) better working conditions; (2) the exploitation of lower-grade metal-bearing substances; and (3) the building of mines of great dimension and further promise.

The mining of any metalliferous deposit is basically an enterprise conducted for economic gain. The work may be done as a surface operation or it may be done by an underground method. The mode of occurrence of the sought-for metallic substance governs to a large degree the type of mining that is practised. Each mineral deposit has its unique characteristics and may require a special method of mining for maximum efficiency. Some mineral deposits are very rich in metal content while others are

lean (low grade). Some are large, irregularly shaped masses of hard rock; others have more or less flat-lying, tabular forms such as those of many rock beds or strata. Some ore bodies are tabular in shape but are inclined or tilted. These are called veins or lodes. Deposits in which the metal is associated with loose or semiconsolidated sand and gravel masses are known as placer gravels or, simply, as placers. The added problem of depth also affects the mining method. If the rock containing the metallic substance is at a shallow site and is massive and widespread, it may be economically excavated by a pit or quarrylike opening on the surface. If the metal-bearing mass is tabular, as a bed or vein, and goes to a great distance beneath the surface, then it will entail the adaptation of some method of underground mining.

The mining industry is not a stagnant one. New uses are constantly found for metals. More efficient operating practices, lower costs per ton and better working conditions for employees always are sought. There has been a prevailing trend to supplant handwork by machinery, thus lightening the worker's physical burden. Because of the achievements after 1900, and especially after about 1925, in the development of large mining machines, metalliferous underground mining by the mid-20th century was pursued at remarkable depths and through very wide reaches of the earth's crust. At Butte, Mont., the underground openings reach to depths of about a mile beneath the surface and a labyrinth of over 3,500 mi. of passageways has been made under an area of the city extending about 2 mi. in an east-west direction and approximately 1 mi. north and south.

Many underground mines go to more than 5,000 ft. in depth. Some noteworthy operations are conducted on the famous gold-bearing Witwatersrand of South Africa where some mine workings have reached depths exceeding 11,000 ft. Another example of the magnitude of some underground mines is at the St. Joseph Lead company in southeast Missouri. There, excavations are so extensive that they are served by two completely equipped underground machine shops that are 5.51 and 3.67 ac. in dimension. These shops are about 6 mi. apart and are connected by mine passageways so that very flexible service is available. All types of the mining equipment used in the mines are repaired in these underground shops and some new devices of major size actually are built in them. Many other illustrations of the scope of underground mining ventures might be given.

In several near-surface occurrences of iron- and copper-bearing substances, tremendous surface excavations have been made. These enterprises are outstandingly successful, particularly at the iron mines of Minnesota and at many copper deposits in the Cordilleran mountain systems of North and South America. As one illustration, the great opencut mine at Bingham, Utah, of the Utah Copper division of the Kennecott Copper corporation can be cited. It is reported that over 180,000 tons of barren rock and 90,000 tons of ore (rock which is rich enough in metal content to be profitably mined) are excavated each 24-hour period. The opencut which has been developed is about 2 mi. across from rim to rim and deep enough to accommodate two upright Empire State buildings, one on top of the other. It resembles a great stadium where all of the people of New York city could be seated. Approximately 4 tons of explosives are used to break each 80,000 tons of the rock material. The rock is loaded into 100-ton railroad cars by electric shovels that scoop up 12 to 15 tons at each "bite."

Because modern mining operations involve so many types of machines and because they are frequently carried on in a subsurface environment where the responsibilities of the individual worker often are of abnormal scope, safety becomes of prime importance.

## THE MINING CYCLE

Most mining ventures entail an operating cycle which, in its usual sequence, is comprised basically of: (1) rock breaking (drilling and blasting); (2) mucking (loading); and (3) transporting (hauling and hoisting). Because of the wide variation of earth materials encountered in mining and because some are surface operations and others underground, the mining cycle is very flexible in its application. Some soft, earthy materials will not require drilling and blasting but, if the work is underground, they will require the installation of roof and wall supports. Much underground mining is carried on in stronger rocks, and the placing of roof props or roof bolts often will not be necessary. Roof bolts are devices to stabilize ground by fixing heavy nuts to the free ends of steel rods which have been hammered into drill holes that have penetrated sound rock deep enough to reach undisturbed material in depth. A semblance of a form of truss support thus is provided.

In addition to the basic work cycle of mining, other activities usually must be performed. These generally include the disposing of spoil rock (unprofitable, barren rock sometimes called waste), shaft sinking, distribution of power supply, ventilating, lighting, draining, surveying, making of geologic investigations and the installing and maintaining of mine plants.

**Rock Breaking.**—As most mining operations are pursued in rock materials that must be forcibly broken from the solid medium, they entail the use of explosives confined in holes placed in the rock mass. Rock breaking consists basically of drilling of blast holes, emplacing of explosives in the holes, and blasting or detonating. Before the perfection of explosives for mining, rock was broken from the solid with picks, hammers and wedges and, even earlier, by a method which used heat. A fire was built against the rock and when it became sufficiently heated, water was dashed onto it. Because of the sudden contraction, spalling and fracturing would ensue.

General drilling methods are: fire setting as described above; drilling by hand tools; and drilling by machine tools, usually of a percussion type and operated by compressed air. Drilling by hand tools is done by driving a sharpened steel rod like a chisel or pointed wedge into the solid rock which is to be broken. The rod is caused to penetrate by being struck with a heavy, hand-held hammer. The hammer may be used either in one hand and is called single jacking, or it may be swung by both hands and is then called double jacking. In machine drilling, the unit is made up of three basic components, the machine, the rod and the bit. Most drilling machines employed for blast hole drilling are of the hammer-drill type. They are classified as hand-held hammers (jackhammers, sinkers, etc.), drifters (light or heavy) and stopers, and are of many sizes, varying in weight and rotative power (*see* DRILLING MACHINERY).

The drill holes generally are drilled in patterns or systems, the number and depth of holes being largely governed by the character and size of the rock mass to be broken and by the mining method followed. The explosives employed in metal mining of hard rocks may be of special design and composition, but, for many operations, gelatin dynamites fabricated into sticks or cartridges are used. Cartridges are amenable to good emplacement in drill holes and have relatively high density and resistance to breakdown under moist conditions. In addition, they produce a minimum of toxic fumes when detonated. Other explosives include black powder, liquid oxygen, carbon dioxide and ammonium nitrate-fuel oil (AN-FO). Compressed air is used in some operations. (*See* also BLASTING.)

**Mucking.**—Mucking (loading) and transporting, though of distinct character, are difficult to divorce in a discussion because of their close sequential relationship and interdependency. The method of mucking is reflected in the choice and design of the haulage system. In fact, if maximum speed and efficiency are to be realized, the capacity of the haulage system must be correlated to the rate of loading.

Loading in many underground operations is from chutes where the ore has been dropped into binlike excavations called raises (*see* later discussion of underground mining [stoping] methods). In other cases, the muck is loaded by shoveling or some similar means. Prior to the introduction of mechanical loaders for underground use, mucking often was the bottleneck of efficient progress in mining operations. Hand loading is slow, tedious and laborious whereas mechanical loading appreciably reduces both the time of loading and the number of men required. (*See* SHAFT SINKING.) The flexibility of mechanical loading in large scale surface min-

ing operations demonstrates how mechanization can reduce the unit cost of a mining venture.

Loading procedures can be classified as follows: (1) Loading from chutes or bins. (2) Hand loading (shoveling), almost obsolete, especially in larger mining operations. (3) Scraper loading (sometimes called slusher loading), either surface or underground mining, may be driven by compressed air or by electricity. (4) Overshot loaders in which the digging element crowds, lifts and discharges directly into a car or truck. The action is similar to the way a hand shoveler would throw a shovelful over his shoulder, the cycle being controlled by the operator and the machine moving by means of flanged wheels on rails or on caterpillar treads. (5) Conveyor-type shovel loaders, machines which dig on the forward motion and deliver the load on the backward motion to an integrated conveyor belt that discharges into the hauling device. (6) Continuous-type loaders, which have gathering arms or rakes that move the muck onto a shaker pan or conveyor belt that in turn moves it into a car or truck. (7) Stationary shovels or dippers, machines which crowd and load from a stationary position, are mounted on railroad wheels or continuous tread and are powered by steam, electricity or diesel engines. They are commonly used in surface mining and often are of very large capacity.

Before leaving the discussion of mucking, a special mining procedure known as dredging should be described. It is a method of surface mining formerly of appreciable economic consequence and, though somewhat restricted in its industrial application, is the means whereby major quantities of gold, tin, platinum and other heavy mineral materials often are obtained. Where the sought-for metals occur in loose or semiconsolidated sand and gravel deposits and where sufficient water is available, dredging frequently is economically feasible. A dredge may be either a chain-bucket or dragline type. The former is a boat-supported machine with an endless chain of scoop buckets which dig down and forward through a pond of water and load the metal-bearing gravel onto concentrating (separating) tables on the dredge deck. Such machines were commonly used on tin mining operations in Malaya. After the metal values have been recovered, the gravel is dumped out the rear of the dredge by means of a conveyor belt, called a stacker. Some of the larger dredges can reach gravels at depths of over 100 ft. and the buckets can be constructed to scoop 15 cu.ft. or more during each pass. (*See* also GOLD.) The common dragline dredge is a conventional dragline loading machine mounted on crawler tracks and is operated to pick up loads of gravel in a scraper bucket by an intermittent scooping process. Each scraper-load is dumped into a bin or hopper for subsequent treatment on concentrating tables. The dragline unit is used on land and thus it does not require a large supply of water as does the typical bucket dredge, described above.

**Transporting.**—Hauling of rock is not a critical problem if the loading is done by hand shoveling, since almost any type of conveyance will move the muck as rapidly as it is supplied; *e.g.*, wheelbarrows, sleds, carts, mine cars (sometimes pulled by animals), small locomotives (usually electric or compressed-air powered) or cable hoists. However, in larger underground mining operations and at most surface mines the haulage is primarily by electric locomotives pulling trains of cars, or by pneumatic-tired trucks. The trucks usually are diesel or gasoline powered. In some large operations, they can cost $60,000 and transport as much as 40 tons to the unit load.

In the operation of most underground mines, it is necessary to move ore, men and supplies through a shaft from the surface. This is accomplished by a process known as hoisting, which employs elevatorlike devices called cages and skips that move on signal or at the will of the hoistman. A well-designed hoisting plant must not only be capable of efficiently moving ore from the mine, but it also must accommodate the handling of all machinery, drills, drill carriages, rails and ties, ventilation equipment, timbers, explosives and all other items of supply. Hoisting arrangements must be safe for moving personnel, strong, of adequate capacity, smooth working and fast. (*See* ELEVATOR, *Mine Hoists.*)

**Ventilating.**—Successful mining requires a working environment that is as equitable as possible. As underground mining steadily grows deeper and of wider lateral extent, it requires more extensive and complex ventilation practices. Deeper mining and the increasing use of mechanized equipment steadily induce complicating conditions. The purpose of ventilation in subsurface mining is to provide an atmospheric environment that is safe and comfortable. To do this, it is necessary to remove or dilute undesirable gases, dusts and smoke, to introduce fresh air into the system and to condition the atmosphere for proper temperature and humidity.

One of the first problems in designing a ventilation system is to determine how much air is required to maintain a safe, healthful atmosphere in the mine. In general, 100 to 200 cu.ft. of fresh air is needed each minute for each man working underground. Peculiar local situations such as the extent of the mine, the type and amount of explosives used, the frequency of blasting, geologic phenomena, humidity and temperature affect the amount of ventilation required. Air movement occurs by a differential pressure sufficiently great to set a given mass of air in motion and to overcome friction and shock losses caused by protuberances and abrupt bends of the line of travel. Devices capable of producing air movements are: airscrews, such as propellers; centrifugal fans; rotary, positive blowers; injectors, such as Venturi blowers; compressed air blowers; ventilating furnaces, such as free, hot air systems; water sprays; deflectors and sails.

To suitably condition the atmosphere at great depths below the surface, it is commonly necessary to establish cooling systems as well as direct ventilating devices. The cooling units may be mechanical refrigerating machines or they may be designed to work as heat exchangers of the cooling-tower or spray-tower types.

## CLASSIFICATION OF METAL MINING METHODS

As has been discussed, the choice of a mining method to exploit any metal-bearing deposit depends on several related factors, of which the chief ones are: size and shape of ore-bearing mass; degree of richness of the ore; depth of occurrence; geographic location; and labour supply. A classification of the general methods of metal mining, as modified after the arrangement used by the American Institute of Mining, Metallurgical and Petroleum Engineers, follows:

- Opencut Mining (with or without stripping)
  - Benching
  - Glory-hole Mining
  - Placer Mining
    - Sluicing and hydraulicking
    - Dredging
- Underground Mining
  - Breast Stoping (tabular, flat-lying deposits or beds)
    - Continuous horizon
    - Drift mining
    - Casual pillars
    - Rooms and pillars
  - Underhand Stoping (veins and large masses)
    - Glory-holes with pillars
    - Open stoping
      - Stulls
      - Square sets
  - Overhand Stoping (steeply inclined veins or masses)
    - Open stopes
      - Pillars
      - Stulls
      - Square sets
    - Filled stopes
      - Horizontal cut and fill (flat back)
      - Inclined cut and fill (rill)
      - Square sets
      - Resuing or stripping
    - Shrinkage stopes
    - Sublevel stopes
  - Top Slicing (wide veins or masses)
    - Continuous horizon
    - Panel slicing
    - Block slicing
    - Inclined slicing
  - Caving (large masses)
    - Sublevel caving
    - Block caving
      - Undercut from main level
      - Undercut from sublevel
      - Block caving into chutes
      - Block caving with branch raises

**Opencut Mining.**—Opencut, open-pit or opencast, mining practices comprise the working of metalliferous deposits which either outcrop at the surface of the ground or are covered by a shallow overburden or capping. There is an economic limit to the maximum thickness of overburden that can be removed and, when such a limit is exceeded, some method of underground mining must be adopted. The depth of capping may vary from a few feet up to 300 ft.

*Benching.*—Power-driven shovels working on benches load the ore into railroad cars or diesel-powered trucks (*see* fig. 1). The muck is loosened by blasting, and care is taken that the pieces are small enough to be handled readily by the shovels. The height of bank is determined by the thickness of the deposit, the size of the shovels, the physical character of the ore and climatic conditions. The higher the bank, the more material the shovel can handle from one position, but the greater is the danger of a slide burying the shovel and of falling rock injuring the men. The material may stand at a high angle when dry, but slides may occur in wet weather. Thick deposits are worked in several benches; the slope of the banks which extend from bench to bench varies at different mines, but for preliminary investigations may be taken as 45° from the horizontal. This gives a general slope (including both benches and banks) of from 35° to 40° for the entire side of the cut.

The shape of the ore body has an important bearing on the feasibility of opencut mining. Because of the slope which the sides of the cut must take, a narrow ore deposit cannot be mined as economically by this method as can a large flat-lying one. If the deposit is irregular or veinlike in outline, it may be difficult to prevent diluting the ore with waste and even under favourable conditions it is seldom possible to mine the entire body without resorting to underground mining for the lower part of it.

The electrically operated shovel fitted with caterpillar tread has largely superseded the steam shovel, especially in large scale work. The electric shovel eliminates the problems of water and fuel supply, a fact which makes it particularly advantageous in cold weather. Power-shovel work, because of the high cost of equipment, must be on a large scale, and consequently can be economically applied only to big ore deposits.

*Glory-hole Mining.*—In this case a vertical connection, called a raise, is driven to the surface from an underground haulage way. The top of this raise is broken out to form a funnel-shaped opening, which is widened and deepened by blasting around the inside.

FIG. 1.—OPENCUT OR OPEN-PIT MINING. POWER SHOVEL IS LOADING COPPER ORE INTO A TRUCK

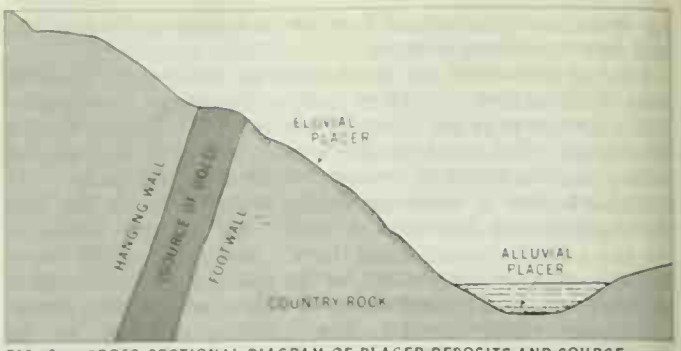


FIG. 2.—CROSS-SECTIONAL DIAGRAM OF PLACER DEPOSITS AND SOURCE

The broken ore slides down the funnel into the raise which serves as a chute, the ore being drawn off through gates into cars on the haulage level. This is a cheap method of mining, but it is dangerous especially if pieces of the wall tend to break off and the excavation is large.

A series of holes may be mined and widened until they intersect. The intervening ridges then are worked out.

*Placer Mining.*—This is a surface mining method applied to deposits of minerals accumulated into workable quantities of economic importance through the natural geologic processes of weathering, erosion and deposition. An alluvial placer occurrence is one formed by the mechanical action of moving water, whether of streams or lakes or along a seacoast. Eluvial is a term applied to placers formed mainly by weathering and thus it is found close to the parent rock (*see* fig. 2). Erosion of the parent rock has set free the heavy, metallic components and these have worked down the slope because of the combined action of gravity and washing by rains. Once a flowing stream is reached, the metal may be carried a long distance before it is deposited. A placer deposit may be formed by concentrations of gold or tin or by a number of other minerals, but mining for gold is generally the most common. A few workable placers have been formed also by the action of wind, which carried away the lighter minerals leaving a residual, heavier mineral deposit which is of economic importance.

The size of placer gold varies from nuggets of 2,000 oz. troy or more to very fine flakes. Small pockets of auriferous or gold-bearing gravel may be worked by hand by using a pan or a rocker to separate the gold from the gravel mass. A rocker is a small wooden trough or box mounted on two transverse rockers so the device can be given a shaking or rocking motion which tends to cause the heavy metals to sink out or go to the bottom of the mass.

By diligent work an experienced panner can handle about 1 cu.yd. of gravel in ten hours. Two men with a rocker can work from 3 to 5 cu.yd. of gravel in approximately ten hours under average conditions.

Sluicing and hydraulicking broadly are mining methods in which a slightly sloping wooden trough (box sluice) or a ditch cut in hard gravel or rock (ground sluice) is used as a channel along which gold-bearing gravel is carried by a stream of water. Riffles, in the form of cobblestones, wooden blocks, wooden poles or steel rails, are placed transversely along the bottom of the sluice to cause the water to eddy into small retarding basins so that the current is reduced and the gold may settle and thus be trapped. Sluices vary from 1 to 6 ft. in width and from 1 to 4 ft. in depth, their cross section being proportional to the volume of material passing through them. Their length should be sufficient to allow the gravel to disintegrate and the gold to settle. This usually takes place in the first 100 to 300 ft. The slope or grade of sluices is commonly specified as the number of inches that are dropped in a length of 12 ft.

Sluicing is the term applied to working placers where the gravel is carried to the head of the sluice by shoveling, in wheelbarrows, in small cars, by scrapers or by dragline excavators. Large placer deposits are worked by hydraulicking, gravel being loosened from place and washed into the sluice by powerful jets of water from nozzles called hydraulic giants or monitors. To be effective, the

head of water on the giant should not be less than 200 ft., which is equivalent to a pressure of 86.5 lb. per square inch. Water for the hydraulic giant is measured in terms of the miner's inch, or a flow of 1.5 cu.ft. per minute. As a rough guide, under average conditions a miner's inch will move from 3 to 6 cu.yd. of gravel per 24 hours.

Hydraulicking is employed in underground mining operations in Russia, China and Poland to burst off coal from the solid face. Gilsonite, a solid hydrocarbon, is mined by this method in Utah.

**Underground Mining.**—There are numerous types of underground mining or stoping (*see* classification outline above). Their general characteristics are presented below. Stoping is used as a general term to indicate the process whereby ore-bearing materials are produced commercially during an underground mining operation. The underground excavation in which the miners perform their work is called a stope.

*Breast Stoping.*—Breast stoping is a method of mining that may be applied to thin ore deposits that either are flat-lying or inclined (dipping) at a small angle to the horizontal. The thickness of deposits worked by this method usually is not over 12 ft., although in modified form this system may be applied to beds up to 70 ft. In thin deposits the entire thickness of ore is mined at one time, thus advancing the work in a vertical face or breast. In thicker deposits the ore is mined in a series of crude or rough benches. Continuous horizon implies a long working face which is attacked simultaneously at a number of points.

Drift mining, as it is used with reference to the exploitation of placer deposits, is a variety of breast stoping. The paystreak or zone of major concentration of sought-for values is reached through a horizontal, tunnellike opening called a drift or sometimes under special cases an adit (*q.v.*), or through a shallow, vertical shaft. Small cars commonly are used for transporting the gravel which is removed in some system of regular cuts or slices across the paystreak.

Timber posts and headboards usually serve to support the roof but, if the gravel is so loose as to "run," tight timbering or a method of forepoling (which is the lengthwise driving ahead of sharpened supporting timbers before the ground is excavated) must be used.

Gravel that is frozen, such as that which is quite often encountered in Alaska and other places of the northern latitudes, must be thawed before it can be mined. Steam, hot water or cold water have been used successfully for thawing, being forced into the frozen gravel through pointed pipes that are applied somewhat as hypodermic needles.

Breast stoping in the Missouri lead and zinc region is done by leaving casual pillars of ore deposit to support the roof. These pillars, left at irregular intervals as the name signifies, range from 10 to 40 ft. in diameter. From 10% to 15% of the ore generally is left in the pillars, depending upon the hard or soft nature of the floor, the strength of the roof and total weight supported. The recovery of ore from the pillars is low, it being usually more economical to leave some of the ore than to use artificial means of roof support.

Small power shovels or scrapers commonly are used in the stopes for gathering and loading the broken ore.

The room and pillar method of stoping is that of cutting the ore deposit into regular lines of square or rectangular pillars, which later are removed as much as possible. It is not uncommon to leave, temporarily at least, as much as 50% of the ore in the pillars.

*Underhand Stoping.*—As the name implies this is a method of working a vertical or steeply inclined ore body from the top down. Holes for blasting are drilled downward and the rock which is broken must be shoveled and hoisted as in digging a pit, or in more extensive operations it may be moved downward to a previously formed excavation lying below. In the mining process, it is customary to concentrate the handling of ore and waste and the distribution of supplies on certain horizons called levels, which are commonly spaced 100 ft. apart vertically, though this distance may be lessened or increased in some mines. On any level the passageways driven lengthwise of the vein are called drifts and those driven across the vein from wall to wall are called crosscuts. If the vein is inclined, the upper or overhanging ground is the hanging wall, and the lower, underfoot zone is the footwall (*see* fig. 2). Two levels may be interconnected by vertical or inclined openings, called raises if driven upward from a level, and known as winzes if excavated downward from a level. Thus, a connecting opening may be a raise or a winze depending upon which level it has been driven from. Raises and winzes are ordinarily timbered to afford at least two closed compartments, one to be used as a chute for ore or waste and the other fitted with a ladder to serve as a manway. The term back is applied to both the roof, arch or top surface of an underground mine working and to the entire body of ore lying between a level and the next one above.

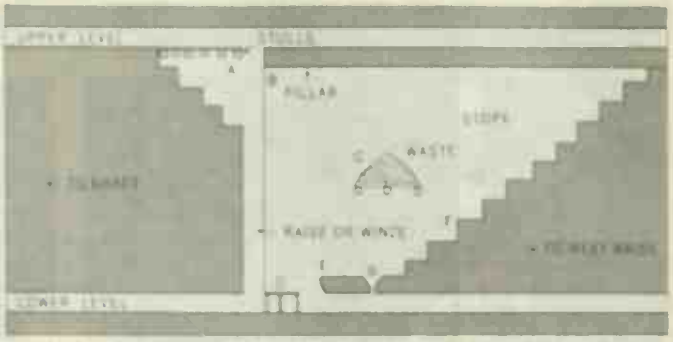


FIG. 3.—VERTICAL LONGITUDINAL SECTION OF UNDERHAND STOPE

An underhand stope (*see* fig. 3) is started by working outward from the top of a winze in a series of horizontal slices, which operation leaves the underlying unmined ore in a rough, steplike form. To protect a lower level during the stoping process and to provide a means of loading cars, the lower level is either timbered, as shown at D, or a pillar of ore, E, is left, through which chutes, G, are cut at intervals of 25 to 50 ft. The face of the ore forms a rough slope or series of steps as indicated at F. The angle of repose of broken ore in the stope is from 35° to 45°, the steeper angle being for hard ores. If possible, the slope should be maintained of such steepness that the ore which is mined will slide downward.

If the ore is rich, timbers called stulls or props are covered with planks, called lagging, to form the bottom of the upper drift, as at A, but if the ore is lean (low grade), it is usually more economical to leave a pillar of ore as at B. Should the level be the lowest level in the mine, the ore must be hoisted to the top of the winze, but as the cost is comparatively high, this procedure is used only for recovering small bodies of ore below a level. When underhand stoping is applied to large ore bodies it generally takes the form of underground glory holes, sometimes called mill holes, one series of holes being separated from another group by an intervening pillar of ore. In these cases, as in the working of a narrow vein, the men are in danger of rock falling from the back or walls of the stope, hence the desirability of having a firm back and strong walls.

*Overhand Stoping.*—In this system of mining where open stopes are used, they are advanced upward, the ore being removed in horizontal, vertical or inclined slices. The stopes are started from the bottom of a raise, either from the top of a protecting pillar of ore, as at P, fig. 4 (B), or directly off the level, as at S, in which case the level is protected by stulls or square or drift sets (framed-timber units) which are covered with lagging. As the stoping proceeds upward the miners must have some support on which to work. For veins having an inclination or dip of 40° or less, the men can work directly by standing on the footwall, but in steeper ore bodies, the stulls or other timbers are covered with lagging to afford temporary working platforms.

The practice of filled stopes is used if the ore is likely to fall very soon after it is undercut and if the walls are weak. This is done because a stronger support than can be given by timbering alone is required and thus the filling of the stope with rock material of uneconomic value is resorted to. This nonvaluable rock is secured

FIG. 4.—LONGITUDINAL SECTION VIEWS OF OVERHAND STOPES

by sorting the ore, by driving small drifts or inclined raises into the barren walls of the deposit or getting the rock from outside the mine. The horizontal-cut-and-fill or flat-back system of overhand mining is shown in fig. 4(C). At H the cut is being made horizontally to the right, the miners drilling holes from the top of the pile of broken ore at O. Chutes, C, are for drawing off the ore to the level below. These timbered chutes are built to keep the top just above the waste filling, W, which is brought in on the upper level and dropped down the waste chute in the raise to be distributed by cars or scrapers through the stope. As the mining progresses away from the main raise, additional waste raises, B, are driven at intervals to save hauling distance. Before a slice of ore is shot down, the waste filling is leveled and covered with planks. The planks are removed when waste is to be dumped. After the slice H has been carried beyond the first waste raise, another slice may be started from the main raise. In this way several sets of miners may be working simultaneously in a stope. The ore chutes may be built of large pieces of waste arranged in circular form and some support to the back, that is, the body of ore overhead, may be afforded by cribs built on the waste or on the ore as at A, fig. 4(C), but no heavy weight can be supported in this way.

The method of mining called inclined-cut-and-fill stoping, known also as rill stoping, is a type of overhand stoping in which inclined slices are taken, as is shown at R, fig. 4(A). The method works well where the ore is hard and the walls are firm and regular. The slices or cuts are made either from the top down or the bottom up, the miners standing on the broken ore. After a slice has been shot down and the ore has drawn off at the level below, waste is brought down the raise from the level above. The waste runs in under the influence of gravity and takes its own angle of repose. A layer of planks then is laid on the waste, another slice of ore is shot down and drawn off, and the planks are removed for the next layer of waste filling. Both ore and waste require a minimum of handling. At T, fig. 4(A), stulls and posts are used as support. Here, the broken ore is shown lying on the plank-covered waste, W. As the stope increases in height, the lower point, or toe, moves away from the raise. The danger of falls of rocks from the back limits the length of the stopes, which in some cases may be only 50 to 60 ft. An ore chute is started from the level at the toe of the slope and is carried up, keeping pace with the waste filling. Sometimes no planks are used in the stope inasmuch as water is used to wet and thus to compact the surface of the waste before the ore is shot down. After the ore is drawn off, the fine material remaining is carefully scraped off the waste before additional filling is run in.

A flexible method of stoping is one wherein filled square sets are used for mining of especially heavy (insecure) ground. The term square sets refers to a particular type or system of timber supports in which each of the several component units is known as a set. That is, a complete set is composed of 12 pieces of timber, as shown in fig. 5, four each of posts P, caps C and girts G. As additional sets are added each timber becomes common to four adjacent sets. Round timbers also may be used in sets, but they require a slightly different framing or end design. Sets are held in place by short blocks placed at the corners and wedged tightly against the walls of the stope. By extending sets vertically and horizontally this skeleton framework of timber may be shaped to fit a stope of very irregular outline. By varying the number of sets opened laterally on the bottom or so-called sill floor of a stope, and by limiting the vertical number of sets left unfilled, this system can be made to suit the nature (degree of instability) of the ground being mined. If no great pressure is brought on the timbers, a sill floor 12 to 15 sets wide, or even more, may be opened. However, in the mining of ground that has a tendency to slough, the sill floor may be only two or three sets in width. This area of horizontal or lateral cut is carried up to the level above, and then another similar cut is started next to the filled sets, and the operations are repeated. Thus a large block of heavy ground may be safely mined in a series of small vertical slices. Chutes and manways are made by lining square sets tightly on the inside with vertically placed planks or lagging.

Resuing or stripping is applied to the mining of narrow veins or of veins in which rich ore lies in a streak of less width than the vein as a whole. The object of resuing is to mine the ore clean and free from waste, and thus save diluting the ore with waste and sending a larger tonnage of lower grade ore to the mill or smelter. This is done generally by first mining the lean or worthless portion of the vein; the high grade streak then is drilled and blasted to yield a separate, comparatively rich material.

Shrinkage stoping is a type of overhand stoping in which only enough ore is drawn progressively from the stope to afford working space so that the miners can stand on broken ore while drilling holes in the back. Broken ore occupies about 60% more volume than ore in place; consequently, about one-third of the ore must be drawn off, as it is broken, through chutes closely spaced, from 25 to 50 ft., along the bottom of the stope. Two-thirds of the ore is left in the stope. This method is best suited to veins or tabular masses of hard, uniform character, in which the walls are firm and regular and which are dipping (tilted) at not less than 50° from the horizontal. A disadvantage of this method lies in the long time the ore is left in

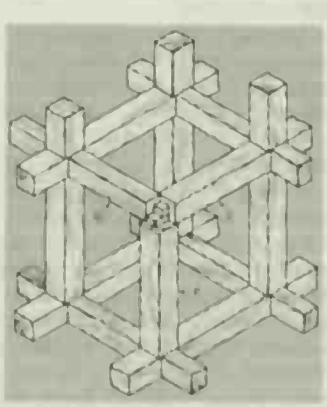

FIG. 5.—TIMBER SQUARE SET

stopes, two or three years in some cases, before it can be removed for milling or smelting.

Fig. 6 is a longitudinal diagram showing shrinkage stoping as applied to a large ore body. The lower level is protected by a pillar through which short raises, C, for chutes are put up at 25-ft. intervals. Raises are driven through the pillars at the end of the stope. Short cuts, driven through the pillars at small vertical intervals, connect with the working space in the stope, as shown at M. To prevent large pieces of ore from clogging the chutes, grizzlies (bar screens), G, are placed at the top of the chutes C. A pillar of ore, as indicated at P, may be left to protect the upper level. Later, the pillars are mined by another method.

The principles of sublevel stoping are illustrated in fig. 7. Main levels usually are from 100 to 150 ft. apart, and are connected by raises as needed. At vertical intervals of 20 to 25 ft., sublevels 7 to 8 ft. high are driven from the raise to the end of the stope. Each sublevel is commonly a single drift down the centre of the stope. By driving crosscuts at the end, sublevel No. 1 is for a short distance widened to the limits of the stope. Inclined holes are drilled around the chute raises C which are put up from the haulage level at intervals of 25 ft. or even less. These holes are blasted to give a funnel-shaped top to the chutes. The sublevels are taken back in benches by progressive stoping from each sublevel to the one above. For example, after stoping has begun in sublevel No. 1, sublevel No. 2 is taken back by first crosscutting to the full width of the stope, and then drilling down-holes in the floor to remove part of the lower pillar and "uppers" in the back to take out half of the upper pillar. Thus miners in No. 2 sublevel retreat toward the raise, drilling down-holes in slice B and up-holes

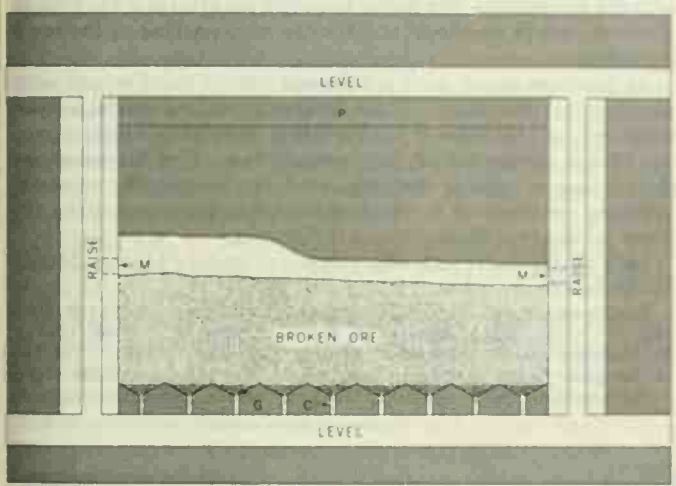


FIG. 6.—LONGITUDINAL SECTION, SHRINKAGE STOPING

in slice D. The same sequence is followed for sublevel No. 3, the broken ore falling toward and into the funnel-shaped chutes. In wide stopes, 40 to 100 ft. in width, two parallel haulage drifts may be driven. These are connected at intervals by crosscuts as at A. This method entails a high cost for development, but requires little timber and gives a large output from each stope because of the several working places.

*Top Slicing.*—Top slicing by the continuous horizon method is done in horizontal slices, 10 to 12 ft. thick, working downward from the top of the deposit. The first slice is taken just beneath the capping, which is supported by timbering. As the slice of ore is taken out, lagging is laid on the floor to cover tightly the ore below. The posts supporting the capping are then shot out and the capping caves onto the timber floor or mat. This mat is temporarily supported by the timbering that is installed as the second slice is taken. After the ore in the second slice has been removed, a timber floor again is laid and the posts are shot out. Thus, the timber mat, which serves to prevent the capping from mixing with the ore, receives additions as each slide is progressively stoped. From the haulage level a raise, containing a chute and manway, is put up to the top of the ore and a main drift is driven to the boundaries of the block. Cross drifts are turned off at right angles

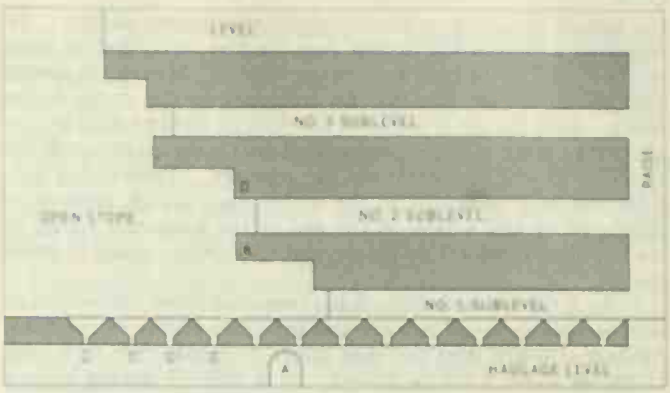


FIG. 7.—LONGITUDINAL SECTION, SUBLEVEL STOPING

to the main drift and are driven to the limits of the block. The ore is broken by breast stoping, and is shoveled into cars to be hauled to the chute. After a cross drift has been completed, the floor is covered with a layer of timber and the posts are shot out, using small charges of dynamite. The overlying capping or timber mat settles down onto the new floor. In variations of this mining practice a form of square-set timbering is used, and successive cuts may be two sets wide and two or three sets high.

By using a stoping method of either panel, block or inclined slicing, a large ore body is not worked in one continuous horizon, but rather in a series of blocks or panels. Inclined top slicing was devised to save shoveling the ore. The cuts (frequently called slices) are inclined upward from the chute at an angle of 33° with the horizontal, so the ore will roll or slide down to the chute. This method does not permit sorting of the ore in the stope and is more difficult to work than horizontal slicing. Top slicing is applicable to weak ore with poor walls. It is most suitable for deposits of large horizontal extent which have a capping that caves readily. It is a safe method and gives as much as 95% extraction of ore.

*Caving.*—Sublevel caving is suitable for the large-scale mining of ore that is moderately hard, and that has fairly regular limits and a capping which caves readily. Fig. 8 illustrates the principles of the practice although details vary at different mines. From the haulage level, raises (R) are put up at about 50 ft. intervals, and sublevels are driven from the raises at vertical intervals of from 15 to 18 ft., leaving a horizontal pillar of ore about 9 ft. thick between the sublevels. The development work on each sublevel consists of longitudinal drifts, marked No. 1 sublevel, No. 2 sublevel, etc., and cross drifts marked D. These are spaced about 50 ft. apart. Mining is started on the top sublevel, No. 4 in fig. 8, by driving a cross drift parallel to D across the block of ore at the end of the sublevel. The drift is timbered with three-piece sets of two slightly inclined posts and a cap and is lagged (slabbed over) overhead. A second drift is driven alongside the first one.

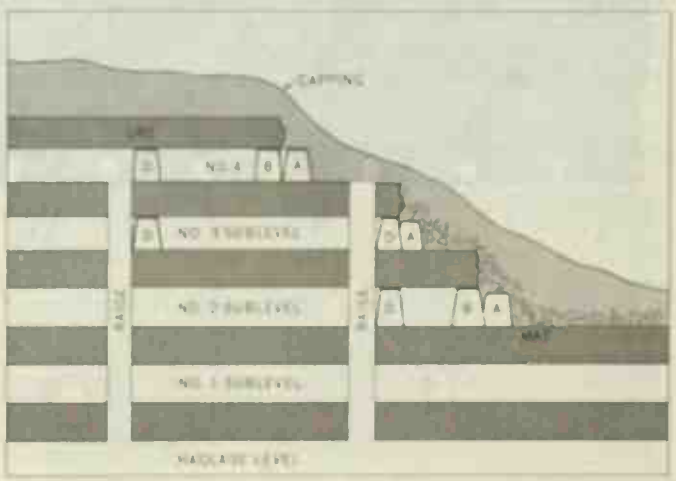


FIG. 8.—LONGITUDINAL SECTION, SUBLEVEL CAVING

the feet of the posts in the two drifts overlapping slightly. By removing a little of the lagging over the first drift, shallow holes can be drilled in the back and the ore blasted. Men in the second drift shovel the ore into cars for tramming to the chutes in the raises. After the ore is removed, the floor of the first drift is covered with a layer of timber, and a third drift is driven alongside the second drift and the operations are repeated. The capping subsides and, as it is caught on the timber mat, enough pressure is developed by this weight on the end of the horizontal pillars of ore to reduce considerably the amount of blasting needed to break the ore.

In fig. 8 the ore over drifts A has been shot down. Shovelers in drift B have removed this ore and have laid planks on the floor. As soon as a new drift has been driven alongside drift B, mining of the ore above B will be started. As in sublevel stoping, mining is done in a series of steps. From one-half to two-thirds of the ore is broken by the caving that ensues.

In the block caving method, a block of ore is undercut, and then subsides through the height of the undercut. This relatively minor movement of the ore is sufficient to break it into small pieces. Ore bodies should be large, and the ore must be firm enough to stand well during the work of undercutting and yet be brittle enough to break up well during the process of settling. The capping should cave readily. The broken ore is drawn off at the bottom of the block until capping appears. If undercut from the main level, the block is cut by intersecting drifts and cross drifts into a series of pillars, which are as small as safety permits. The pillars are drilled and blasted, and time is allowed for the ore to settle. The broken ore is mined by driving a series of closely timbered drifts into the shattered material. The ore runs in at the ends of the drifts and is shoveled into cars. When waste appears a few sets in the drift are blasted down and drawing is resumed at a new point, thus following a retreating system.

If a block is undercut from sublevel, the general features are similar to those just described. From the main haulage level, drifts are turned off at right angles at, say, 50 ft. intervals, and are driven to the limits of the block. A sublevel is driven above the main level, and the block is undercut by intersecting drifts and cross drifts on the sublevel. Chutes are put up to the sublevel from the haulage level. The pillars are blasted and the ore is worked into the chutes.

Block caving by using branch raises is a method followed at several large copper mines. It is illustrated in fig. 9a and 9b. From the haulage level, main inclined chutes (also called transfer raises), I, are driven to the grizzly level, where drifts, G, are used to connect a line of chutes. The tops of the chutes are covered with a grizzly made of rails to catch the large pieces of ore which would tend to choke the chutes. From the grizzly level, inclined chutes, K, are carried up and terminate in a square set, C, from which two or four inclined "finger" raises, F, are driven to the undercutting level at the bottom of the block. The tops of the finger raises are spaced 12.5 ft. apart each way, thus offering an ample number of points for drawing off the caved ore.

The ore is undercut by running a series of drifts, D, 25 ft. apart to the limits of the block. At one end of the block the ends of the drifts are widened. Holes then are drilled in the intervening ribs or pillars and in the back. Blasting these holes generally starts the caving. Shrinkage stopes, called boundary stopes, are made across the ends or sides of the block before the ore is undercut to separate it from the adjoining ground and thus to facilitate the caving. This method is suitable for ore that is soft or of medium hardness in which there is little or no waste. The capping should follow down freely and the ore should break into fragments small enough to run well into the chutes.

A thick body of ore may be worked in more than one lift. For a given amount of development work, the higher the lift taken the less is the cost per ton for the development work, as the cost is spread over all the ore in a block. However, other factors such as the horizontal extent of the ore and the economic life of the working also must be considered. Because the method is applied to low-grade copper ores bearing generally between 1% and 2% copper, special care must be taken to keep the diluting of the ore by waste to a minimum. The line of contact between the broken ore and the cappings (*see* fig. 9b) is usually between 40° and 70° with the horizontal. The flatter the angle the greater is the amount of broken ore in the stope, and trouble from packing of the ore is increased.

As has been noted, each ore deposit has its peculiar and often complex characteristics. These frequently induce special adaptations and combinations of the foregoing methods, or even a practice that is unique for efficient exploitation. For discussion and illustrations of mining methods used for nonmetallic minerals, including conventional mechanized mining, continuous mining and auger mining, *see* COAL AND COAL MINING.

*See* ORE DEPOSITS; *see* also references under "Mining, Metal" in the Index.

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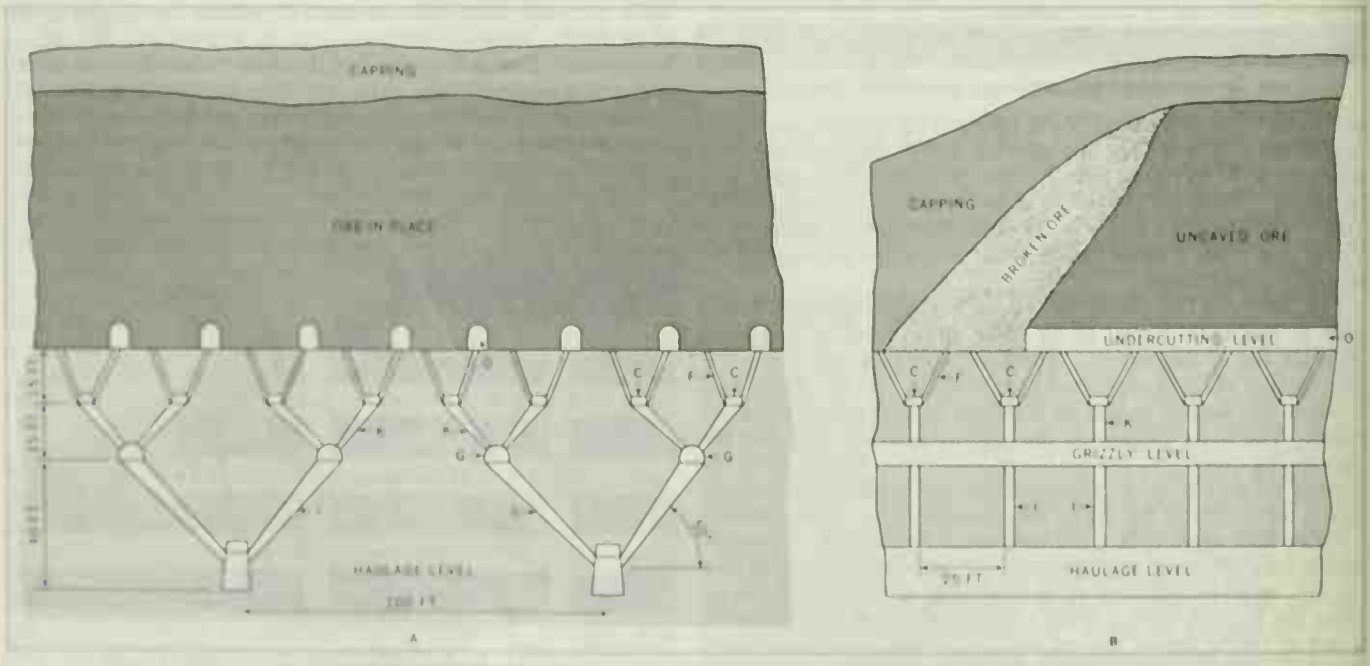


FIG. 9.—BLOCK CAVING (A) CROSS SECTION, (B) LONGITUDINAL SECTION

such as *Mining Engineering* (A.I.M.E.), *Engineering and Mining Journal*, *Bulletin of the Institution of Mining and Metallurgy*, U.S. Bureau of Mines *Information Circulars* and *Bulletins* and *Mining Journal* (London). (J. D. Fa.)

**MINING ENGINEERING** is an amalgam of many branches of engineering. Long before the majority of the world's major engineering schools had been founded, mining schools had been established throughout Europe. Typical of such schools was Bergakademie Clausthal at Clausthal-Zellerfeld in the Harz mountains, founded in 1775.

In the late 19th and early 20th centuries the phenomenal increase in the demand for metals and minerals and the opening up of new areas providing opportunities for the discovery and exploitation of rich mineral deposits created a need for large numbers of competent engineers and many mining schools were established.

In these early days the isolated location of most mines forced the mining engineer to assume many duties. He was responsible for prospecting; construction of buildings, roads and structures; provision of compressed air, water and electricity; analysis of ores; and possibly even supervision of crushing, grinding and concentration of the ore, all in addition to the main task of actually getting the ore excavated. The profession of mining engineering was generally assumed to include some knowledge of these many overlapping fields.

With the tendency toward specialization typical of all fields, mining engineering has become confined to the problems of breaking ore and excavating it from underground mines and surface pits. *See* BLASTING; DRILLING MACHINERY; COAL AND COAL MINING; MINE PROSPECTING AND DEVELOPMENT; MINING, METAL; QUARRYING; SHAFT SINKING.

The discovery of ore deposits relies heavily on the theories and techniques noted under GEOLOGY and GEOPHYSICAL PROSPECTING. Analysis of ores makes use of many procedures described under ASSAYING; CHEMISTRY: *Analytical Chemistry* and SPECTROCHEMICAL ANALYSIS. The milling of ores has become a separate field described under ORE DRESSING. *See* also METALLURGY: *History* and *Ores and Ore Treatment*. (A. W. S.)

**MINISTER,** an official title both civil and ecclesiastical. *See* AMBASSADOR; CABINET; DIPLOMACY; MINISTRY, GOVERNMENT; MINISTRY, CHRISTIAN.

**MINISTERIALES** (from Latin *minister*, "servant"), a class of officials whose rise from servile status to nobility was a peculiar feature of German history in the middle ages. The *ministeriales* were originally unfree personal servants holding the higher positions (butler, chamberlain, steward, etc.) at the courts of ecclesiastical and secular princes. At first maintained in their lord's households, they were later granted fiefs, the tenure of which was by special virtue of their office. This raised their social position, which was further improved when they were entrusted with political, military and administrative tasks and powers. The extension of public administration from the 11th century onward caused this class of "civil servants" to grow steadily. There developed on the one hand a certain uniformity in the legal status of the *ministeriales* and on the other an increasing differentiation among them according to the posts that they held and according to the rank of their lords. Above all, the so-called *Reichsministerialen*, in the service of the German kings, played an important political role under the Salian and Hohenstaufen rulers: in Germany they strengthened the kings against the princes, and in Italy they were the leading military commanders and administrative officials (the *ministerialis* Markward of Annweiler, for instance, became regent of the kingdom of Sicily after the death of the emperor Henry VI).

From the 12th century, moreover, while impoverished free men often joined the ranks of the *ministeriales*, the *ministeriales* themselves married ladies of noble birth. They began also to hold ordinary fiefs beside those held by virtue of their office; and, as the latter too became hereditary in course of time, the distinctions based on form of tenure disappeared, so that the feudal law of the *ministeriales* became assimilated to the general feudal law of Germany. From the 14th century onward the *ministeriales* no longer showed any traces of their unfree origins, being accepted as of equal birth by the old nobility. Recognized as members of the estate of knights, they formed the core of the lesser nobility; and some families of *ministeriales* even rose to the rank of immediate princes of the empire, with territorial sovereignty (for instance the house of Reuss).

The *Reichsministerialen* lost their major importance with the end of the Hohenstaufen dynasty; in many cases they and their fiefs fell under the dominion of the princes of the empire. Under these princes, however, they came likewise to occupy the highest posts in army and in the administration.

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**MINISTERS OF THE SICK** (CAMILLIANS; ORDO CLERICORUM REGULARIUM MINISTRANTIUM INFIRMIS; M.I.), a Roman Catholic order of clerks regular founded by St. Camillo (*q.v.*) de Lellis in 1582 (confirmed 1586) for hospital work. They numbered about 1,300 in the 1960s, fewer than half of whom were priests. *See* ORDERS AND CONGREGATIONS, RELIGIOUS.

**MINISTRY, CHRISTIAN,** those Christians believed to be called by God and set apart by ecclesiastical authority to minister in the church. This article deals first with the origins of the traditional ministry of bishop, priest and deacon, and second with the ministry in Protestant churches. For further information *see* HOLY ORDERS; ORDINATION; EPISCOPACY; CLERGY; BISHOP; PRIESTHOOD; DEACON; DEACONESS; ELDER; and the articles on the separate churches.

## THE TRADITIONAL MINISTRY

According to the belief of the majority of professed Christians, a belief that was largely unquestioned until the Reformation, the Christian ministry is threefold and consists of bishops, priests and deacons.

**Bishops.**—Evidence shows the existence of bishops in several centres of Christianity in the early 2nd century and in all centres by *c.* 200. The origins of this order are, however, obscure and any theory is unlikely to convince more than a minority of scholars. The facts that may be gleaned from the New Testament are difficult to interpret. Jesus appointed 12 men as his representatives (Mark iii. 14); their number, corresponding to that of the patriarchs, suggests that they were intended to be prince-rulers of the new Israel (*see* APOSTLE). The number was preserved, after the defection of Judas, by the appointment of Matthias (Acts i. 26). At some stage the title "apostles" applied to these men was extended to others, such as Paul (I Cor. ix. 1), Barnabas (Acts xiv. 14), Adronicus and Junias (Rom. xvi. 7). The apostles also ordained seven men to assist them (Acts vi. 1–6); these may possibly have been the first elders or presbyters who formed a kind of council with the apostles in Jerusalem (xv. 2), and elders were appointed in local churches (xiv. 23). These elders were on occasion called *episcopoi*; *i.e.*, overseers (guardians) or bishops (xx. 28). From the Pauline Epistles there emerges the picture of Paul himself as an apostle with plenary authority; under him there were subordinate missionaries such as Timothy (I Thess. i. 1), while in the local churches there were overseers (or bishops) and deacons (Phil. i. 1). In the Pastoral Epistles, which many scholars regard as late and non-Pauline, the threefold hierarchy of bishops, presbyters (or elders) and deacons seems to be established (I Tim. iii. 1–13, v. 1, 17–19; Tit. i.).

Difficulty in relating and interpreting these facts arises from the uncertainty as to whether or not it is function rather than order that is in mind, whether all presbyters were *episcopoi* or only some of them, and what the link between them and the apostles was considered to be. Various theories have accordingly been propounded. It has been argued (1) that authority passed from the apostles to the presbyters and that the institution of bishops was a usurpation of that authority; (2) that bishops came into existence as a distinct order by the uniting in particular localities of apostolic men such as Timothy and Titus; (3) that bishops were created by the elevation of one presbyter in each locality to the

position of president, possibly by apostolic ordering.

The emergence of the threefold order is attributed by many to apostolic initiative, and it is closely associated with the idea of apostolic succession; *i.e.*, the belief that the bishops are the successors of the apostles. Such a view would seem to be expressed in the last quarter of the 1st century by Clement of Rome in his Epistle to the church in Corinth. Of the various factors contributing to this outcome, three may be listed as especially important. First, there was the organization of the Jewish synagogues. This consisted of a collegiate body known as a Sanhedrin (*q.v.*; Gr. *gerousia*), composed of elders or presbyters under a president. The Palestinian Sanhedrins seem not to have had regular presidents, but the head Sanhedrin at Jerusalem had one *ex officio* in the high priest. This arrangement is closely parallel to that which obtained in the Christian church. Second, there was the constitution of the church in Jerusalem. After the martyrdom of James, the son of Zebedee (Acts xii, 2), the 12 were dispersed and James, the brother of Jesus, became president of a council which included presbyters (Acts xv, 6 and 13). Here there is a double parallel with the Jewish Sanhedrin under the high priest and with the bishop and his presbyteral council which is found later in all centres of Christianity. Third, the liturgical gatherings of the local community required a celebrant at the Eucharist, and it is reasonable to suppose that the one performing this task should be regarded as in some sense pre-eminent. A combination of these various influences provides a possible explanation of the emergence of the bishop as the chief liturgical minister of the early church.

A summary of the bishop's functions is to be found in the consecration prayer preserved in Hippolytus' *Apostolic Tradition* (*c.* 217):

> Grant unto this thy servant whom thou hast chosen for the episcopate to feed thy holy flock, and to exercise the High-priesthood before thee, without blame to serve thee day and night, unceasingly to propitiate thy countenance and to offer the gifts of thy holy Church; endued with the high priestly spirit to have power to forgive sins according to thy command, confer orders according to thy precept, and to loose every bond according to the authority thou didst give unto the apostles, and to be well-pleasing unto thee in meekness and cleanness of heart.

In the course of time, circumstances compelled him to delegate many of these functions, but he still remains ideally the chief shepherd, the guardian of orthodoxy and the centre of unity.

**Presbyters or Priests.**—As mentioned above, the account of the appointing of the seven (Acts vi, 1–6) may refer to the institution of the first presbyters. The reason for holding such a view is the apparent dependence of the passage in Acts upon that which records the appointing of the 70 elders by Moses (Num. xi). In both there is a "murmuring," the selection of a specific number of men and a reference to the Spirit vouchsafed to them. If this interpretation is not accepted, then there is no account in the New Testament of their first institution; on the other hand, if it is accepted, this does not preclude recognition of the influence of such existing bodies as the Jewish Sanhedrins.

Although the presbyterate eventually formed the backbone of the church, insofar as its members became the parish priests of the medieval and modern periods, in the first centuries it is not easy to differentiate it from the episcopate, because, with the exception of ordination and, in the west, confirmation, a presbyter could perform all the functions of a bishop. Nevertheless he did so as the bishop's deputy. "Let that Eucharist be considered valid," states Ignatius in his Epistle to Smyrna (*c.* 114), "which is under the bishop or him to whom he commits it." The presbyter therefore taught, baptized and celebrated only insofar as he had the bishop's express permission to do so.

The presbyter was subject to the bishop, who could call him to account, whereas he and his fellow presbyters could not censure their superior. At the same time, the presbyters did assist in the government of the church, forming a kind of senate or council under episcopal presidency. It was indeed seldom that a bishop acted without seeking their advice, and so in the ordination prayer of the *Apostolic Tradition* the petition is made that the presbyter might be filled "with the spirit of grace and counsel . . . and govern thy people with a pure heart."

**Deacons.**—According to the traditional view, the seven of Acts vi were the first deacons, and indeed in later years it was a widespread custom to limit their number to seven in any one city. The title however is not used in that passage which, as argued above, may rather refer to the first presbyters, in which case conjecture is the only method of approaching the origin of the diaconate. The Christian ministry is generally regarded as the organ of the continuing ministry of Christ in his church. According to Mark x, 45, "the Son of man came not to be ministered unto, but to minister" (literally "to be a deacon"). So Paul, as an apostle of Christ, says, "I magnify my ministry" (literally "my deaconing"; Rom. xi, 13). The wholeness of Christ's ministry, undifferentiated in Christ himself, was gradually divided between the three orders. Hence Paul addresses the Christians at Philippi "with the bishops [or overseers] and deacons" (Phil. i, 1). Whereas this statement may refer to functions rather than to distinct orders, by the time of the Pastoral Epistles the diaconate, embodying the principle of Christ's service, is a separate office and a list is given of the virtues required in any candidate (I Tim. iii, 8–13). The deacon thus appears as the bishop's right-hand man and a 4th-century document refers to him as the ears, eyes, heart and mouth of the bishop.

The deacon was the main channel of communication between the bishop and the laity. All offerings were made through his hands and he acted, under the bishop, as the steward of church property and almoner of charitable undertakings. It was his task to give a list of the sick to his superior. He examined the letters commendatory carried by visiting Christians and was frequently entrusted with embassies to foreign parts. He acted as a disciplinary officer under episcopal jurisdiction; he had to reprimand offenders and to deal with the less complex cases that came up for adjudication. His disciplinary duties overlapped with his liturgical, for at the Eucharist he was responsible for the maintenance of order. He stood by the door to prevent the entrance of unbelievers. At the actual celebration, the deacon read the gospel, summoned to prayer, dismissed the catechumens and penitents, presented the offerings of the people, gave the signal for the kiss of peace, administered the chalice and carried the reserved sacrament to the absent.

**Development.**—The threefold ministry was not initially a graded hierarchy; that is, a series of offices through which an individual might advance. A deacon might remain a deacon all his life. This was because the various orders were regarded as functions rather than as offices; for the harmonious progression of the church's life all were necessary. This understanding arose in part from the conception of the church as an organism that required for its life and witness both the continuing ministry of Christ and a structure visible to all. The threefold ministry has continued up to the present day in many churches, although both its authority and its necessity were called in question at the Reformation.

(J. G. Da.)

## THE MINISTRY IN PROTESTANTISM

Throughout the middle ages the threefold ministry of the church in the west was taken for granted, although the great development of the papacy during this period introduced an important new factor which sometimes created tension between various parts of the church. The situation was, however, radically changed with the emergence of the Protestant Reformation of the 16th century. The question of the nature of the ministry was not at first in the forefront of the attention of the Reformers, but once the authority of the papacy was challenged it was inevitable that the authority of the ministry which was bound up with the papacy should also be challenged and its nature redefined. The problem became inescapable when the question of the ordination of ministers who would not accept the papal obedience arose.

**Lutheranism.**—What moved Luther to challenge the authority of the papacy was not, in the first place, a lack of conviction about the validity of papal claims but his rebellion against the understanding of the nature of the gospel implied in Roman Catholic teaching and practice about indulgences, which was prompted by his experience of penitence, forgiveness and justifica-

tion by faith. It was this, in its turn, which led him to rethink the doctrine of the church and to state his characteristic teaching about the priesthood of all believers, with its implied denial of the hierarchical ministry described above.

The intention of Luther was to reassert the ministry of the whole church as a community with a mission to the world. Luther believed that the sphere of faith's works was worldly society and its order and this meant that the church moved out of the cloister into ordinary life. It also meant a new style of life for the ministry. Ministers were encouraged to marry and they were not thought of as a separate order in the church. All that mattered was that they should be duly called (*rite vocatus*). So little attention was paid to episcopal succession that some Lutheran churches did not trouble to retain it when they could have, while others did retain it but attached little significance to the fact (*see* EPISCOPACY).

In practice, however, two considerations prevented the ministry in Lutheran churches from developing fully according to the ideas of Luther. One was the great emphasis laid upon the authority of the secular power, "the goodly prince," and the other was the stress upon the preaching of the Word and the defining of theological truth. These led to an attitude of respect for the state and to a magnification of the office of the minister which hindered the expression of the common life of the church as the communion of saints.

**Calvinism.**—In the Calvinist Reformation the place of the ministry was more explicit. Indeed, some have argued that the Calvinist idea of the ministry has many affinities with that of the middle ages. Unlike Luther, Calvin claimed to be re-establishing the New Testament pattern of ministry, and he and his colleagues tried to assert a degree of ministerial control over discipline and common life, which the Lutherans, with their dependence on the secular authorities, would not have attempted. The authority of the preaching office was magnified at least as much as in Lutheranism. On the other hand, Calvinism taught the parity of ministers and recognized offices of teaching, ruling and diaconate as well as that of preaching. The facts also that congregations had part in the choice of officers and that many elders were not professional ministers helped to modify the clericalism of the Calvinist system and to place the Calvinist churches among the precursors of modern political democracy.

**Independents.**—These latter tendencies were more marked among the Independent, or (as they came to be called) the Congregational, churches and the Baptist churches which emerged in England, and later in New England, in the 17th century. They shared broadly the Calvinist theological viewpoint of the Reformed or Presbyterian churches but differed from them over church government. They emphasized the authority of the particular congregation rather than the presbytery and gave decisive power to the whole membership of the church rather than to the session of ministers and elders. Their conception of the role of the minister in the church was, however, substantially similar to that among the Reformed churches which were more directly under Calvinist inspiration. They emphasized the importance of spiritual gifts in the ministry but, in contrast to Anabaptists and the early Quakers, insisted that learning was no less important than gifts. While they have had little sense of historical continuity, Congregational churches often have achieved an intimacy of personal relation between minister and people for which there are few parallels in Christian history. Throughout the centuries, the role of the minister in the church has grown progressively similar in all churches in the Reformed tradition, just as the offices of eldership in Presbyterian churches and diaconate in Congregational and Baptist churches have grown more like each other.

**Anglicanism.**—The situation in the main church of the English Reformation, the Church of England, is more complicated. The English Reformation was very much a national movement, and, like Lutheranism, it laid great stress on the initiative and authority of the monarch. Anglicans believed that each national church had the right to reform itself in the light of scripture and Christian antiquity. They considered themselves fortunate that, in their situation, they were enabled to do this and to retain the episcopal succession in the traditional ministry. They recognized, however, that Reformed churches on the continent were often in situations where the retention of episcopal succession was impossible. They regretted this, but did not make it a reason for refusing to have intercommunion with them. The position of dissenters within the sphere of their own jurisdiction was different. It was only with the rise of the Oxford movement in the 19th century that many Anglicans began to lay great emphasis on episcopacy as the essential form of apostolic ministry. This emphasis has, perhaps, been increased by the growth of the Anglican communion throughout the world in the 20th century where the link between the bishops, meeting every decade in the Lambeth conferences, is of great importance.

**Methodism.**—The Protestant revivalist movements in the 18th century were led in several countries by individuals of great charismatic power, of whom the chief was John Wesley, and were notably successful in creating large new Christian communities. These communities needed ministry of the Word and sacraments and pastoral care which old-established churches were often unwilling or unable to provide. It was this need, especially as it presented itself in America, together with the convictions that the episcopate and presbyterate were the same office and that the Methodist movement had been vindicated by its fruits, that led Wesley, who was a priest in the Church of England, to take the step of ordaining his own ministers, a practice continued by the large Methodist communities throughout the world. The superintendent ministers of the Methodist Church in the United States are called bishops, but episcopal succession is not retained. In Britain especially, large numbers of trained laymen called lay preachers conduct nonsacramental services in Methodist churches every Sunday and, traditionally, Methodist churches encourage a great deal of spiritual initiative among laymen. In the highly centralized Methodist organization, however, the powers of the ministry remain strong and the centralization, together with the practice by which few ministers stay in any one district for more than a comparatively short time, gives the Methodist ministry something of the character of a religious order.

**Pentecostal and Similar Groups.**—In the 19th and early 20th centuries many new Protestant groups which laid little stress upon a separated ministry emerged in different parts of the world. Some Pentecostal groups in particular attach great importance to charismatic gifts and the ability to evoke experiences of conversion among their leaders, but none to ordination or to office as such. The tendency is, however, as these churches become more well established, for a separated and salaried ministry that receives some formal education to emerge in their midst. The Salvation Army is an important world-wide Protestant organization which does not have offices of ministry in the traditional sense but has large numbers of highly trained officers, who perform many of the functions of the ministry but who are organized on the analogy of a military body.

**Quakers.**—The small but influential Society of Friends does not, except in parts of the United States and in a few mission fields, have an ordained ministry. The duty of ministry of the Word is shared by all members and occasionally individual members are recorded as having a special gift for vocal ministry. Elders are chosen to supervise and guide the corporate spiritual life but do not hold any intermediary position between ordinary members of the society and God.

**20th-Century Developments.**—In the 20th century, most Protestant churches have sought to redefine some of the functions of the ministry, partly in order to meet the needs of the churches in a rapidly changing world and partly in order to draw nearer to each other and to Catholic churches under the inspiration of the ecumenical movement. In a few churches, women have been admitted to full ministerial status, although they still have to struggle for their ministries to win "parity of esteem" with men. In more churches, women have so far been admitted only to the eldership or the diaconate. Many specialized forms of ministry have been developed. The close connection between the ministry and the world of education has long been recognized and there has been vast extension of administrative offices in connection with

the churches and of chaplaincies within the general institutions of society. These are often on an interdenominational basis. The number of ministers who, while ordained in one particular church, are yet the servants of organizations supported by many is steadily increasing. Efforts are being made also to cultivate gifts of ministry among laymen who are not and are not expected to become professional ministers but who are active in the ordinary life of society.

In the Church of South India, a union of former Anglican, Presbyterian, Methodist and Congregational churches, an apparently successful effort has been made to unite ministries deriving from episcopal and nonepiscopal churches in one community. Active discussions with a view to union or intercommunion are proceeding between other episcopalian and nonepiscopalian churches. The principles which most modern Protestants would want to maintain in such discussions are that the one essential ministry in the church is that of Christ, God's Word to man, made known in the Spirit, and that whatever authority the various ministries might have within the churches derives from faithfulness to him rather than from any external source. (D. T. J.)

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**MINISTRY, GOVERNMENT.** This term denotes a department of government or group of departments under the control of a minister or the whole body of persons holding political office in the country.

## GREAT BRITAIN

In the United Kingdom the ministry, in the collective sense, consists of the following: (1) ministers in the cabinet; (2) ministers of cabinet rank who are not in the cabinet; (3) ministers of state, parliamentary undersecretaries of state, parliamentary secretaries, financial secretaries and others of equivalent rank; (4) lords commissioners of the treasury (other than the first lord or prime minister and the chancellor of the exchequer) and other government whips; and (5) certain officers of the royal household. They are appointed by the sovereign on the advice of the prime minister; they are, with rare exceptions, either peers or members of the house of commons, and they are considered to hold their offices at the prime minister's disposal; *i.e.*, if the prime minister wishes to change any of them he advises the sovereign accordingly. Also, they go out of office forthwith if the prime minister resigns because of a defeat in the house of commons or at a general election. For this reason the whole ministry, and not merely the cabinet, is said to be "collectively responsible to parliament." However, the ministry as such has no corporate existence, because the decisions are taken by the members of the cabinet, who are formally described as "her majesty's confidential servants" and who are sworn of the privy council.

Many of the modern conventions concerning the ministry were established during the reign of Queen Victoria. From 1783 the sovereign had progressively withdrawn from political controversy, and William IV was almost a constitutional monarch in the modern sense. After 1841 it was clear that the essential duty of the sovereign was to find a prime minister whose party (or, if a coalition was necessary, whose group of parties) could command the confidence of the house of commons. This implied that the whole ministry would be drawn from one party or a coalition of parties. The ministry so appointed was collectively responsible to the house of commons and resigned in a body if defeated there or at a general election. After 1841 the size of the ministry greatly increased. After 1945 the number reached 90. The decrease in the powers of the house of lords resulted in a tendency toward a concentration of ministers in the house of commons, though the Ministers of the Crown act, 1937, made it necessary that some senior ministers and some junior ministers be peers. Apart from the household officers there are usually at least five or six ministers and two or three junior ministers in the house of lords. Consequently, about 70 or 75 members on the government side of the house of commons normally hold paid office under the crown.

A new ministry is assumed to come into existence when a new prime minister kisses hands (of the sovereign at the time of appointment in traditional acknowledgment of the king's favour) or when the existing prime minister, having submitted his resignation, is asked to form a new government.

For the history of the development of the ministry in England and for further details, *see* ENGLISH HISTORY; HOUSEHOLD, ROYAL; PRIVY COUNCIL; CABINET; PRIME MINISTER. *See* also LORD HIGH CHANCELLOR; SECRETARY OF STATE; ADMIRALTY; FOREIGN SERVICE; WAR OFFICE, BRITISH. (W. I. J.)

### BRITISH PRIME MINISTERS

| | |
|---|---|
| 1721 | Robert Walpole (earl of Orford, 1742) |
| 1742 | Earl of Wilmington |
| 1743 | Henry Pelham |
| 1754 | Duke of Newcastle |
| 1756 | Duke of Devonshire |
| 1757 | Duke of Newcastle |
| 1762 | Earl of Bute |
| 1763 | George Grenville |
| 1765 | Marquess of Rockingham |
| 1766 | Earl of Chatham |
| 1768 | Duke of Grafton |
| 1770 | Lord North (earl of Guilford, 1790) |
| 1782 | Marquess of Rockingham |
| 1782 | Earl of Shelburne (marquess of Lansdowne, 1784) |
| 1783 | Duke of Portland |
| 1783 | William Pitt |
| 1801 | Henry Addington (Viscount Sidmouth, 1805) |
| 1804 | William Pitt |
| 1806 | Lord Grenville |
| 1807 | Duke of Portland |
| 1809 | Spencer Perceval |
| 1812 | Earl of Liverpool |
| 1827 | George Canning |
| 1827 | Viscount Goderich (earl of Ripon, 1833) |
| 1828 | Duke of Wellington |
| 1830 | Earl Grey |
| 1834 | Viscount Melbourne |
| 1834 | Sir Robert Peel |
| 1835 | Viscount Melbourne |
| 1841 | Sir Robert Peel |
| 1846 | Lord John Russell (Earl Russell, 1861) |
| 1852 | Earl of Derby |
| 1852 | Earl of Aberdeen |
| 1855 | Viscount Palmerston |
| 1858 | Earl of Derby |
| 1859 | Viscount Palmerston |
| 1865 | Earl Russell |
| 1866 | Earl of Derby |
| 1868 | Benjamin Disraeli |
| 1868 | W. E. Gladstone |
| 1874 | Benjamin Disraeli (earl of Beaconsfield, 1876) |
| 1880 | W. E. Gladstone |
| 1885 | Marquess of Salisbury |
| 1886 | W. E. Gladstone |
| 1886 | Marquess of Salisbury |
| 1892 | W. E. Gladstone |
| 1894 | Earl of Rosebery |
| 1895 | Marquess of Salisbury |
| 1902 | A. J. Balfour (earl of Balfour, 1922) |
| 1905 | Sir Henry Campbell-Bannerman |
| 1908 | H. H. Asquith (earl of Oxford and Asquith, 1925) |
| 1916 | David Lloyd George (Earl Lloyd George of Dwyfor, 1945) |
| 1922 | Andrew Bonar Law |
| 1923 | Stanley Baldwin |
| 1924 | J. Ramsay MacDonald |
| 1924 | Stanley Baldwin |
| 1929 | J. Ramsay MacDonald |
| 1935 | Stanley Baldwin (Earl Baldwin of Bewdley, 1937) |
| 1937 | Neville Chamberlain |
| 1940 | Winston Churchill |
| 1945 | C. R. Attlee (Earl Attlee, 1955) |
| 1951 | Winston Churchill (K.G., 1953) |
| 1955 | Sir Anthony Eden (earl of Avon, 1961) |
| 1957 | Harold Macmillan |
| 1963 | Sir Alexander Douglas-Home (formerly earl of Home) |
| 1964 | Harold Wilson |

### LORD CHANCELLORS FROM 1707

For the history of this office, *see* LORD HIGH CHANCELLOR. The following table lists lord chancellors after the Act of Union, 1707, which established one great seal for the United Kingdom. Between 1707 and 1757 vacancies in the chancellorship were twice filled initially by the appointment of a lord keeper (*see* LORD KEEPER OF THE GREAT SEAL). These appointments are indicated in the table by an asterisk. From 1766 all appointments were directly to the lord chancellorship.

| | |
|---|---|
| 1707 | Lord Cowper |
| 1708 | The seal in commission Sept. 1708–Oct. 1710 |
| 1710 | *Sir Simon Harcourt (Baron Harcourt, 1711; chancellor, 1713; Viscount Harcourt, 1721) |
| 1714 | Lord Cowper (Earl Cowper, 1718) |
| 1718 | Lord Macclesfield (earl of Macclesfield, 1721) |
| 1725 | The seal in commission Jan.–June 1725 |
| 1725 | Lord King |
| 1733 | Lord Talbot of Hensol |
| 1737 | Lord Hardwicke (earl of Hardwicke, 1754) |
| 1756 | The seal in commission Nov. 1756–June 1757 |
| 1757 | *Sir Robert Henley (Lord Henley, 1760; chancellor, 1761; earl of Northington, 1764) |
| 1766 | Lord Camden (Earl Camden, 1786) |
| 1770 | Charles Yorke |
| 1770 | The seal in commission Jan. 1770–Jan. 1771 |
| 1771 | Lord Apsley (Earl Bathurst, 1775) |
| 1778 | Lord Thurlow |
| 1783 | The seal in commission April–Dec. 1783 |
| 1783 | Lord Thurlow |

| | |
|---|---|
| 1792 | The seal in commission June 1792–Jan. 1793 |
| 1793 | Lord Loughborough (earl of Rosslyn, 1801) |
| 1801 | Lord Eldon (earl of Eldon, 1821) |
| 1806 | Lord Erskine |
| 1807 | Lord Eldon |
| 1827 | Lord Lyndhurst |
| 1830 | Lord Brougham and Vaux |
| 1834 | Lord Lyndhurst |
| 1835 | The seal in commission April 1835–Jan. 1836 |
| 1836 | Lord Cottenham |
| 1841 | Lord Lyndhurst |
| 1846 | Lord Cottenham (earl of Cottenham, 1850) |
| 1850 | Lord Truro |
| 1852 | Lord St. Leonards |
| 1852 | Lord Cranworth |
| 1858 | Lord Chelmsford |
| 1859 | Lord Campbell |
| 1861 | Lord Westbury |
| 1865 | Lord Cranworth |
| 1866 | Lord Chelmsford |
| 1868 | Lord Cairns |
| 1868 | Lord Hatherley |
| 1872 | Lord Selborne |
| 1874 | Lord Cairns (Earl Cairns, 1878) |
| 1880 | Lord Selborne (earl of Selborne, 1882) |
| 1885 | Lord Halsbury |
| 1886 | Lord Herschell |
| 1886 | Lord Halsbury |
| 1892 | Lord Herschell |
| 1895 | Lord Halsbury (earl of Halsbury, 1898) |
| 1905 | Sir Robert Reid (Lord Loreburn, 1906; earl of Loreburn, 1911) |
| 1912 | Viscount Haldane |
| 1915 | Lord Buckmaster (Viscount Buckmaster, 1933) |
| 1916 | Lord Finlay (Viscount Finlay, 1918) |
| 1919 | Lord Birkenhead (earl of Birkenhead, 1922) |
| 1922 | Viscount Cave |
| 1924 | Viscount Haldane |
| 1924 | Viscount Cave |
| 1928 | Lord Hailsham (Viscount Hailsham, 1929) |
| 1929 | Lord Sankey (Viscount Sankey, 1932) |
| 1935 | Viscount Hailsham |
| 1938 | Lord Maugham (Viscount Maugham, 1939) |
| 1939 | Viscount Caldecote |
| 1940 | Viscount Simon |
| 1945 | Lord Jowitt (Viscount Jowitt, 1947; Earl Jowitt, 1951) |
| 1951 | Lord Simonds (Viscount Simonds, 1954) |
| 1954 | Viscount Kilmuir (Earl Kilmuir, 1962) |
| 1962 | Lord Dilhorne |
| 1964 | Lord Gardiner |

### Chancellors of the Exchequer

The office of chancellor of the exchequer (*q.v.*) dates in name from the 13th century, but in its modern sense from 1714 when the office of lord high treasurer (*q.v.*) was put permanently into commission. The relationship in the 18th and early 19th centuries between the senior commissioner (the first lord of the treasury) and the chancellor of the exchequer is not clear. It seems evident, however, that the chancellorship did not attain its present importance (which arises from the fact that the first lord is normally also prime minister and consequently unable to attend to the day-to-day running of the treasury) until some time after the first quarter of the 19th century.

| | |
|---|---|
| 1714 | Sir Richard Onslow (Lord Onslow, 1716) |
| 1715 | Robert Walpole |
| 1717 | James Stanhope (Viscount Stanhope, 1717; Earl Stanhope, 1718) |
| 1718 | John Aislabie |
| 1721 | Robert Walpole (K.B., 1725; earl of Orford, 1742) |
| 1742 | Samuel Sandys (Lord Sandys of Ombersley, 1743) |
| 1743 | Henry Pelham |
| 1754 | Sir William Lee |
| 1754 | Henry Bilson-Legge |
| 1755 | Sir George Lyttelton (Lord Lyttelton, 1756) |
| 1756 | Henry Bilson Legge |
| 1757 | Lord Mansfield |
| 1757 | Henry Bilson-Legge |
| 1761 | Viscount Barrington |
| 1762 | Sir Francis Dashwood (Lord le Despenser, 1763) |
| 1763 | George Grenville |
| 1765 | William Dowdeswell |
| 1766 | Charles Townshend |
| 1767 | Lord Mansfield (earl of Mansfield, 1776) |
| 1767 | Lord North (earl of Guilford, 1790) |
| 1782 | Lord John Cavendish |
| 1782 | William Pitt |
| 1783 | Lord John Cavendish |
| 1783 | William Pitt |
| 1801 | Henry Addington (Viscount Sidmouth, 1805) |
| 1804 | William Pitt |
| 1806 | Lord Henry Petty (marquess of Lansdowne, 1809) |
| 1807 | Spencer Perceval |
| 1812 | Nicholas Vansittart (Lord Bexley, 1823) |
| 1823 | Frederick John Robinson (Viscount Goderich, 1827; earl of Ripon, 1833) |
| 1827 | George Canning |
| 1827 | J. C. Herries |
| 1828 | Henry Goulburn |
| 1830 | Viscount Althorp (Earl Spencer, 1834) |
| 1834 | Sir Robert Peel |
| 1835 | Sir Thomas Spring-Rice (Lord Monteagle of Brandon, 1839) |
| 1839 | Sir Francis Thornhill Baring (Lord Northbrook, 1866) |
| 1841 | Henry Goulburn |
| 1846 | Sir Charles Wood (Viscount Halifax, 1866) |
| 1852 | Benjamin Disraeli |
| 1852 | W. E. Gladstone |
| 1855 | Sir George Cornewall Lewis |
| 1858 | Benjamin Disraeli |
| 1859 | W. E. Gladstone |
| 1866 | Benjamin Disraeli (earl of Beaconsfield, 1876) |
| 1868 | G. W. Hunt |
| 1868 | Robert Lowe (Viscount Sherbrooke, 1880) |
| 1873 | W. E. Gladstone |
| 1874 | Sir Stafford Northcote (earl of Iddesleigh, 1885) |
| 1880 | W. E. Gladstone |
| 1882 | Hugh Childers |
| 1885 | Sir Michael Hicks Beach |
| 1886 | Sir William Harcourt |
| 1886 | Lord Randolph Churchill |
| 1887 | G. J. Goschen (Viscount Goschen, 1900) |
| 1892 | Sir William Harcourt |
| 1895 | Sir Michael Hicks Beach (Earl St. Aldwyn, 1915) |
| 1902 | C. T. Ritchie (Lord Ritchie, 1905) |
| 1903 | Austen Chamberlain |
| 1905 | H. H. Asquith (earl of Oxford and Asquith, 1925) |
| 1908 | David Lloyd George (Earl Lloyd-George of Dwyfor, 1945) |
| 1915 | Reginald McKenna |
| 1916 | Andrew Bonar Law |
| 1919 | Austen Chamberlain (K.G., 1925) |
| 1921 | Sir Robert Horne (Viscount Horne, 1937) |
| 1923 | Stanley Baldwin (Earl Baldwin of Bewdley, 1937) |
| 1923 | Neville Chamberlain |
| 1924 | Philip Snowden |
| 1924 | Winston Churchill (K.G., 1953) |
| 1929 | Philip Snowden (Viscount Snowden, 1931) |
| 1931 | Neville Chamberlain |
| 1937 | Sir John Simon (Viscount Simon, 1940) |
| 1940 | Sir Kingsley Wood |
| 1943 | Sir John Anderson (Viscount Waverley, 1952) |
| 1945 | Hugh Dalton (Lord Dalton, 1960) |
| 1947 | Sir Stafford Cripps |
| 1950 | Hugh Gaitskell |
| 1951 | R. A. Butler |
| 1955 | Harold Macmillan |
| 1957 | Peter Thorneycroft |
| 1958 | Derick Heathcoat Amory (Viscount Amory, 1960) |
| 1960 | Selwyn Lloyd |
| 1962 | Reginald Maudling |
| 1964 | James Callaghan |

### Principal Secretaries of State (1685–1782)

The division of the secretariat of state into northern and southern departments dates from 1662, but did not begin officially until 1689. In 1782 the secretariat was reorganized, the southern department becoming the home office, the northern the foreign office. Other departments were added later. Those who were sole secretary for any period are indicated by an asterisk in the list.

| | *Northern* | *Southern* |
|---|---|---|
| 1689 | Earl of Nottingham | Earl of Shrewsbury (duke of Shrewsbury, 1694) |
| 1690 | *Earl of Nottingham | |
| 1690 | Viscount Sydney (earl of Romney, 1694) | Earl of Nottingham |
| 1692 | *Earl of Nottingham | |
| 1693 | Sir John Trenchard | Earl of Nottingham |
| 1693 | *Sir John Trenchard | |
| 1694 | Duke of Shrewsbury | Sir John Trenchard |
| 1695 | Sir William Trumbull | Duke of Shrewsbury |
| 1697 | James Vernon | |
| 1698 | *James Vernon | |
| 1699 | James Vernon | Earl of Jersey |
| 1700 | *James Vernon | |
| 1700 | Sir Charles Hedges | James Vernon |
| 1702 | James Vernon | Earl of Manchester (duke of Manchester, 1719) |
| 1702 | Sir Charles Hedges | Earl of Nottingham (earl of Winchilsea, 1729) |
| 1704 | Robert Harley (earl of Oxford, 1711) | Sir Charles Hedges |
| 1706 | | Earl of Sunderland |
| 1708 | Henry Boyle (Lord Carleton, 1714) | |
| 1710 | Henry St. John (Viscount Bolingbroke, 1712) | Lord Dartmouth (earl of Dartmouth, 1711) |
| 1713 | William Bromley | Viscount Bolingbroke |
| 1714 | Viscount Townshend | James Stanhope |
| 1716 | James Stanhope (Viscount Stanhope, 1717; Earl Stanhope, 1718) | Paul Methuen |
| 1717 | Earl of Sunderland | Joseph Addison |
| 1718 | Viscount Stanhope | James Craggs |
| 1721 | Viscount Townshend | Lord Carteret |
| 1724 | | Duke of Newcastle |
| 1730 | Lord Harrington (earl of Harrington, 1742) | |
| 1742 | Lord Carteret (Earl Granville, 1744) | |
| 1744 | Earl of Harrington | |
| 1746 | *Earl Granville | |
| 1746 | Earl of Harrington | Duke of Newcastle |
| 1748 | Earl of Chesterfield | |
| 1748 | Duke of Newcastle | Duke of Bedford |
| 1751 | | Earl of Holdernesse |
| 1754 | Earl of Holdernesse | Sir Thomas Robinson (Lord Grantham, 1761) |
| 1755 | | Henry Fox (Lord Holland, 1763) |
| 1756 | | William Pitt |
| 1757 | *Earl of Holdernesse | |
| 1757 | Earl of Holdernesse | William Pitt (earl of Chatham, 1766) |
| 1761 | Earl of Bute | Earl of Egremont |
| 1762 | George Grenville | |
| 1762 | Earl of Halifax | |
| 1763 | Earl of Sandwich | Earl of Halifax |
| 1765 | Duke of Grafton | Henry Seymour Conway |
| 1766 | Henry Seymour Conway | Duke of Richmond |
| 1768 | | Earl of Shelburne |
| 1768 | Earl of Hillsborough | |
| 1779 | | Lord Weymouth |
| 1779 | Lord George Germain | |
| 1780 | | Lord Hillsborough |
| 1782 | Lord Grantham | Lord Shelburne |

| | | |
|---|---|---|
| 1766 | | Earl of Shelburne (marquess of Lansdowne, 1784) |
| 1768 | Viscount Weymouth | |
| 1768 | Earl of Rochford | Viscount Weymouth |
| 1770 | Earl of Sandwich | Earl of Rochford |
| 1771 | Earl of Halifax | |
| 1771 | Earl of Suffolk | |
| 1775 | | Viscount Weymouth |
| 1779 | *Viscount Weymouth | |
| 1779 | Viscount Stormont (Earl Mansfield, 1793) | Viscount Weymouth (marquess of Bath, 1789) |
| 1779 | | Earl of Hillsborough (marquess of Downshire, 1789) |

FOREIGN SECRETARIES

| | | | |
|---|---|---|---|
| 1782 | Charles James Fox | 1874 | Earl of Derby |
| 1782 | Lord Grantham | 1878 | Marquess of Salisbury |
| 1783 | Charles James Fox | 1880 | Earl Granville |
| 1783 | Earl Temple (marquess of Buckingham, 1784) | 1885 | Marquess of Salisbury |
| | | 1886 | Earl of Rosebery |
| 1783 | Marquess of Carmarthen (duke of Leeds, 1789) | 1886 | Earl of Iddesleigh |
| | | 1887 | Marquess of Salisbury |
| 1791 | Lord Grenville | 1892 | Earl of Rosebery |
| 1801 | Lord Hawkesbury (earl of Liverpool, 1808) | 1894 | Earl of Kimberley |
| | | 1895 | Marquess of Salisbury |
| 1804 | Lord Harrowby (earl of Harrowby, 1809) | 1900 | Marquess of Lansdowne |
| | | 1905 | Sir Edward Grey (Viscount Grey of Fallodon, 1916) |
| 1805 | Lord Mulgrave (earl of Mulgrave, 1812) | 1916 | A. J. Balfour (earl of Balfour, 1922) |
| 1806 | Charles James Fox | | |
| 1806 | Viscount Howick (Earl Grey, 1807) | 1919 | Earl Curzon of Kedleston (Marquess Curzon of Kedleston, 1921) |
| 1807 | George Canning | | |
| 1809 | Earl Bathurst | 1924 | J. Ramsay MacDonald |
| 1809 | Marquess Wellesley | 1924 | Austen Chamberlain (K.G., 1925) |
| 1812 | Viscount Castlereagh (marquess of Londonderry, 1821) | 1929 | Arthur Henderson |
| | | 1931 | Marquess of Reading |
| 1822 | George Canning | 1931 | Sir John Simon (Viscount Simon, 1940) |
| 1827 | Earl of Dudley | | |
| 1828 | Earl of Aberdeen | 1935 | Sir Samuel Hoare (Viscount Templewood, 1944) |
| 1830 | Viscount Palmerston | | |
| 1834 | Duke of Wellington | 1935 | Anthony Eden |
| 1835 | Viscount Palmerston | 1938 | Viscount Halifax (earl of Halifax, 1944) |
| 1841 | Earl of Aberdeen | | |
| 1846 | Viscount Palmerston | 1940 | Anthony Eden |
| 1851 | Earl Granville | 1945 | Ernest Bevin |
| 1852 | Earl of Malmesbury | 1951 | Herbert Morrison (Lord Morrison of Lambeth, 1959) |
| 1852 | Lord John Russell | | |
| 1853 | Earl of Clarendon | | |
| 1858 | Earl of Malmesbury | 1951 | Anthony Eden (K.G., 1954, earl of Avon, 1961) |
| 1859 | Lord John Russell (Earl Russell, 1861) | | |
| | | 1955 | Harold Macmillan |
| 1865 | Earl of Clarendon | 1955 | Selwyn Lloyd |
| 1866 | Lord Stanley (earl of Derby, 1869) | 1960 | Earl of Home |
| | | 1963 | R. A. Butler |
| 1868 | Earl of Clarendon | 1964 | Patrick Gordon Walker |
| 1870 | Earl Granville | | |

HOME SECRETARIES

| | | | |
|---|---|---|---|
| 1782 | Earl of Shelburne (marquess of Lansdowne, 1784) | | 1830) |
| | | 1830 | Viscount Melbourne |
| 1782 | Thomas Townshend (Lord Sydney, 1783) | 1834 | Lord Duncannon (earl of Bessborough, 1844) |
| 1783 | Lord North (earl of Guilford, 1790) | 1834 | Henry Goulburn |
| | | 1835 | Lord John Russell (Earl Russell, 1861) |
| 1783 | Earl Temple (marquess of Buckingham, 1784) | 1839 | Marquess of Normanby |
| | | 1841 | Sir James Graham |
| 1783 | Lord Sydney (Viscount Sydney, 1789) | 1846 | Sir George Grey |
| | | 1852 | Spencer Walpole |
| 1789 | William Grenville (Lord Grenville, 1790) | 1852 | Viscount Palmerston |
| | | 1855 | Sir George Grey |
| 1791 | Henry Dundas (Viscount Melville, 1802) | 1858 | Spencer Walpole |
| | | 1859 | T. H. S. Sotheron Estcourt |
| 1794 | Duke of Portland | 1859 | Sir George Cornewall Lewis |
| 1801 | Lord Pelham (earl of Chichester, 1805) | 1861 | Sir George Grey |
| | | 1866 | Spencer Walpole |
| 1801 | C. P. Yorke | 1867 | Gathorne Hardy (earl of Cranbrook, 1892) |
| 1804 | Lord Hawkesbury | | |
| 1806 | Earl Spencer | | |
| 1807 | Lord Hawkesbury (earl of Liverpool, 1808) | 1868 | H. A. Bruce (Lord Aberdare, 1873) |
| 1809 | Richard Ryder | 1873 | Robert Lowe (Viscount Sherbrooke, 1880) |
| 1812 | Viscount Sidmouth | | |
| 1822 | Robert Peel | 1874 | R. A. Cross |
| 1827 | W. Sturges-Bourne | 1880 | Sir William Harcourt |
| 1827 | Marquess of Lansdowne | 1885 | Sir Richard Assheton Cross (Viscount Cross, 1886) |
| 1828 | Robert Peel (2nd baronet, | | |

| | | | |
|---|---|---|---|
| 1886 | Hugh Childers | 1929 | J. R. Clynes |
| 1886 | Henry Matthews (Viscount Llandaff, 1895) | 1931 | Sir Herbert Samuel (Viscount Samuel, 1937) |
| 1892 | H. H. Asquith (earl of Oxford and Asquith, 1925) | 1932 | Sir John Gilmour |
| | | 1935 | Sir John Simon (Viscount Simon, 1940) |
| 1895 | Sir Matthew Ridley (Viscount Ridley, 1900) | 1937 | Sir Samuel Hoare (Viscount Templewood, 1944) |
| 1900 | C. T. Ritchie (Lord Ritchie, 1905) | 1939 | Sir John Anderson (Viscount Waverley, 1952) |
| 1902 | Aretas Akers-Douglas (Viscount Chilston, 1911) | 1940 | Herbert Morrison (Lord Morrison of Lambeth, 1959) |
| 1905 | H. J. Gladstone (Viscount Gladstone, 1910) | 1945 | Sir Donald Somervell (Lord Somervell of Harrow, 1954) |
| 1910 | Winston Churchill (K.G., 1953) | 1945 | J. Chuter Ede |
| 1911 | Reginald McKenna | 1951 | Sir David Maxwell Fyfe (Viscount Kilmuir, 1954; Earl Kilmuir, 1962) |
| 1915 | Sir John Simon | | |
| 1916 | Herbert Samuel | | |
| 1916 | Sir George Cave (Viscount Cave, 1918) | 1954 | Gwilym Lloyd George (Viscount Tenby, 1957) |
| 1919 | Edward Shortt | 1957 | R. A. Butler |
| 1922 | W. C. Bridgeman (Viscount Bridgeman, 1929) | 1962 | Henry Brooke |
| | | 1964 | Sir Frank Soskice |
| 1924 | Arthur Henderson | | |
| 1924 | Sir William Joynson-Hicks (Viscount Brentford, 1929) | | (X.) |

## OTHER COUNTRIES

Throughout the world ministries are the institutional devices that link together the political and administrative fields of government. In some countries they are essentially policy-making institutions; in others their technical work predominates. But in only a few cases are they exclusively political or wholly administrative institutions. Their number and their competence differ from one country to another, but they all have one feature in common: an appointed minister, responsible to the political power, assumes responsibility for the work of one more or less self-contained part of the apparatus of government. The various types fall under three headings—unitary, federal and Communist.

**Unitary States.**—The ministries of modern unitary states in the European tradition are distinguished from their 18th-century predecessors in that they no longer draw their powers from some great hereditary office of state, nor do they (with very rare exceptions) have simple territorial jurisdiction and competence. They have instead developed out of the five great departments of state that are to be found in every civilized community: foreign affairs, justice, finance, defense and war, and internal affairs.

Ministries of internal affairs possess the residual powers of government and in all unitary states it is normal constitutional practice to regard powers not explicitly assigned to or assumed by another central authority as falling under the jurisdiction of the ministry of the interior or internal affairs.

During the 19th century this ministry covered a very extensive field of government; e.g., transport, highways, education, trade, agriculture, church affairs, law and order and the police powers. The modern growth of public services resulted in some of these fields assuming such importance that they were first split off from the ministry of the interior to become special departments, and later separate ministries. By the 1960s virtually all modern unitary states had separate ministries of education, agriculture, transport, trade, etc.

A third category of ministries is to be found in some countries; these are the social ministries that have emerged as the result of pressures for government-organized welfare schemes. Among these are ministries of national insurance, pensions, social security, health and so on.

The status of ministries was influenced by the political movements of the 19th century. Whereas under the absolute monarchs and emperors the heads of ministries were directly responsible to the head of the state, the 19th century saw the emergence of the concept of the politically nominal head of state. He appointed ministers, but only in so far as they possessed the confidence of elected legislatures. The constitution of the Orléans government in France (1830–48) under Louis Philippe served as a model for many countries, and when the monarch was replaced by an elected president the tradition of the political responsibility

of ministers to the elected representatives was continued. Thus, the constitution of the French third republic laid down that "ministers are collectively responsible before the Chambers for the general policy of the Government, and individually responsible for their personal acts." This remained true under the fourth and fifth republics.

Nevertheless, the 20th century saw many exceptions to this rule. Fascist states reversed this doctrine, ministers becoming agents of one man, and in many newly independent states of the post-1945 era a cult of leadership replaced the more traditional western concepts of democratic government, even when the parliamentary institutions remained theoretically the same as those of western unitary states.

The organization of ministries in most modern unitary states in the European tradition differs markedly from Britain in two respects. First, the administrative pyramid does not have at its apex a single, full-time, permanent head comparable to the British permanent secretary. Instead, following the French and European tradition, the ministry is organized on a basis of bureaus and divisions, with a director as the head of each division. The directors are each responsible for a single self-contained branch of the administration with direct responsibility to the minister, the political head. This is a continuation of the old tradition of the collegial direction of administrative boards. Second, in the absence of a permanent secretary, the work of policy formation and advice is shared between the directors and the minister's private office, his cabinet. His cabinet has far more extensive powers than the British minister's private office and is also considerably larger. Members of the minister's cabinet are appointed by the minister and hold office during his tenure; they are mainly chosen from younger civil servants, a few political aspirants and technical advisers. This cabinet forms the minister's private brain trust, as well as acting as his political and parliamentary secretariat.

Sweden is an exception to these general rules governing the organization of ministries in modern unitary states. The ministry is very small, and is essentially comparable to the minister's private office or cabinet mentioned above. The great bulk of administration is hived off to special boards, each with its own director and each possessing statutory powers and duties prescribed in a royal letter of instruction. The ministry, as such, is therefore relieved of all detailed administrative work and acts as the policy- and decision-making institution for one of the main branches of government. The Swedish system is the oldest unchanged administrative structure in the world.

**Federal States.**—The most striking feature of the organization of federal states is the relatively restricted field of government covered by the central ministries. This is a direct consequence of the nature of the federal state in which a written constitution prescribes with varying degrees of detail the powers to be vested in the federal government and the powers to be exercised by the constituent states. In Switzerland there are only seven ministries: the political department (foreign affairs), the department of the interior, the department of justice and police, the military department, the department of finance and customs, the department of public economy and the department of postal service and railways.

Similarly, in the United States there are only ten central departments. But in this case administrative expediency has led to the growth of a large number of agencies, boards and commissions responsible for the detailed administration of various technical branches of government, created *ad hoc* by the federal legislature or by the president. Their responsibility to the executive varies a good deal, but it is not without significance that they have become widely known as the "headless fourth branch of government."

In some federal states the distinction between federal and state matters is blurred by the concept of concurrent powers; thus in the German Federal Republic the ministry of foreign affairs exists only at the federal level, there are some ministries, *e.g.*, for education, which only exist at the *Land* (state) level, and there are some ministries, such as those of justice and the interior, which exist at both levels.

Two other points of federal organization need to be noted. First, except for those federations of the Commonwealth of Nations which have adopted British parliamentary practice (*e.g.*, Canada, Australia, India), the ministers are normally in a position of relative weakness vis-à-vis the head of the executive. In the United States it is the president who appoints the heads of the departments and they retain office at his discretion. They cannot be members of the legislature and are not independent political figures in their own right. Similarly in the German Federal Republic "The Federal ministers are appointed and dismissed by the Federal President on the recommendation of the Federal Chancellor . . . The Federal Chancellor determines, and is responsible for, general policy. Within the limits of this general policy, each federal minister conducts the business of his department independently and on his own authority."

Secondly, although the head of the executive branch in many federations dominates and overshadows his cabinet colleagues, the federal legislature plays a more important role in approving who may be appointed to cabinet office than is the normal practice in unitary states with parliamentary systems of government. The president of the United States, for instance, can appoint to cabinet office only "with the advice and consent of the senate," and his proposed nominations are subjected to searching scrutiny by the appropriate senate bodies. In Switzerland each of the seven ministers (the federal councillors) is elected at a joint session of the two houses of the legislature for four years, the life of the legislature itself. Switzerland also offers a unique example of a rotating presidency. One federal councillor is elected president for one year by the assembly and another is elected vice-president. Neither may be reelected to the same position. The collegial responsibility of the federal councillors is further emphasized by the constitutional provision that "decisions shall be in the name of and authority of the Federal Council as a whole."

In all federations there is an informal convention that ministers or cabinet officers should to some extent be chosen to represent the major political and territorial interests of the various constituent states.

**Communist Countries.**—The nature of Communist doctrine concerning the organization and structure of the state involves three differences from those countries considered so far. In the first instance, although many Communist countries are officially styled federations, the constituent elements have little or none of the constitutional autonomy possessed by federal units in other countries. This means that there is a good deal more subordination of the republican (state) ministries to the federal ministries than elsewhere. In the U.S.S.R., for instance, there are three types of ministry: the all-union ministry, which exists only at the federal level; the union-republican which exists at both the federal and the republican level; and the republican ministries which exist only at the level of the republics. Furthermore, there are ministries also at the level of the autonomous republics, but these are essentially subordinate agencies of the republican or union-republican ministries at the level of the union republic.

In the second place, since the state effectively controls all economic activities, ministries in Communist countries are to be found with titles and fields of operation unknown elsewhere. For instance, in the U.S.S.R. at either the all-union or the republican level, in addition to the ordinary type of ministry such as the ministry of defense, justice or foreign affairs, there are to be found technical ministries for the automobile industry, machine building, heavy machine building, paper and wood products industry, building of enterprises for the metallurgical and chemical industries, instrument-making and automation devices, etc.

Finally, the ministers themselves are not strictly comparable to those to be found in other countries. They are very frequently technicians and seem for the most part to be career specialists. They have no independent political standing and in many cases they do not even appear to rank very high in the Communist party organization. Their tenure of office is uncertain, due to the freedom with which, in the U.S.S.R., ministries themselves are created, amalgamated or abolished. The result of this ministerial technocracy is that the council of ministers in the U.S.S.R. is of less

significance as a policy-making organ than it is in other countries. Its senior members tend not to hold ministerial portfolios at all, but simply serve as first vice-chairmen; and it is believed that the full council of ministers only rarely discusses issues of policy, which are instead determined by a restricted group of nondepartmental ministers in conjunction with the senior party members.

*See* also GOVERNMENT DEPARTMENTS and articles on individual countries. (B. CH.)

**MINK,** a small fur-bearing animal belonging, along with the ferret, stoat and ermine, to the genus *Mustela*, of the weasel family (Mustelidae; *see* CARNIVORE). Mink differ from typical weasels in slight ways associated with their semiaquatic mode of life. The best known species are *M. vison* of North America and *M. lutreola* of Eurasia.

The North American mink measures about 20 to 28 in. in length, 6 to 8 in. of this being tail. Like all weasels, the body is long and slender; the legs short; the neck long and flexible; the head broad; and the ears short and rounded. The deep, rich brown pelage consists of a dense, soft underfur overlaid with dark, glossy, almost stiff, guard hairs; one of the most highly prized of all furs, it has long been a luxury fur of commerce.

Mink are accomplished swimmers and able fishers. They forage for food commonly at night. Besides fish, their diet includes frogs, muskrats, crustaceans, eggs, birds, mice, rats and poultry. Few mammals are as voracious and bloodthirsty. Mink are evil-smelling creatures, the stench being produced by anal glands. But unlike its cousin the skunk, the mink cannot spray its vile-smelling substance; it deposits it in droplets. Mink live along streams, rivers, ponds, lakes and the sea coast. They are equally at home on dry land and, although they prefer forested areas, are less inclined to climb trees than most weasels. The hunting territory of a family of mink will include several square miles. Usually the den is the bank burrow of another animal—a hollow log, a crevice among rocks or commonly a muskrat house whose builders were devoured by the mink. The den is a temporary home, and a few days later the family moves to other quarters. The family unit disperses in late summer, each member establishing a new territory. The larger males may travel extensively at this time. Breeding takes place from midwinter to spring, one male mating with several females, and eventually remaining with one. The four to eight young are born after a gestation of 39 to 76 days, spring pregnancies being shortest. The young are born blind and covered with fine hair. They are breast fed at first, but even before their eyes open—at five weeks—they are eating meat.

In the U.S.—mostly in southern states—mink are raised commercially on mink farms or ranches. The female is of a savage disposition, and in captivity she often kills her young when she becomes excited. Controlled crossbreeding has led to the production of many mutant colours of fur. However, except for the rarer mutant colours, the fur of wild mink is more valued than that of "ranch mink." Few animals—large birds, foxes—prey on mink; trappers and disease account for most deaths. Mink formerly occurred over the United States excluding the southwest, and throughout Alaska and Canada excluding the barrens of the north. They are now rare in the southern parts of this range.

NORTH AMERICAN MINK (MUSTELA VISON)

The European mink resembles the North American species but is smaller, measuring 15 to 18 in. in length. Formerly it occurred over northern and central Europe but, as in North America, has become rare in the southern parts of this range.

A very large species, *M. macrodon*, once occurred along a limited area of the coast of New Brunswick and Maine. It became extinct about 1860, and only a few bones and faded skins remain. *See* also FUR: *Fur Farming*. (K. R. KN.)

**MINKOWSKI, OSKAR** (1858–1931), German clinician and physiopathologist who discovered that lack of endocrine pancreatic secretion produces diabetes, was born in Kovno, Russia, on Jan. 13, 1858, but became a naturalized Prussian in 1872. He studied at the *Gymnasium* in Kovno (1867) and at Königsberg (1875), then studied medicine in Königsberg and Freiburg, graduating from Königsberg in 1885. Minkowski was assistant to Bernhard Naunyn at Strasbourg and later professor of medicine at Breslau, presiding also over the German Insulin committee.

Minkowski discovered that acids are eliminated in the urine combined with ammonia, and found that β-hydroxybutyric acid is the cause of diabetic acidosis and the decrease in sodium bicarbonate in blood plasma. In 1886 he removed the liver from birds and demonstrated that this organ is the site of formation of uric acid (from ammonia and lactic acid or amino acids) and of bile pigments. In 1889 he discovered that extirpation of the pancreas causes diabetes. He had removed the pancreas from a dog so that Joseph von Mering (*q.v.*) could observe whether certain fats could be absorbed without the action of pancreatic juice. He noticed that the animal passed large quantities of urine, which on being analyzed was found to contain glucose. This discovery was published by Mering and Minkowski in 1889.

Later Minkowski made a profound study of pancreatic diabetes, which he correctly interpreted as resulting from suppression of the then-unknown pancreatic hormone. He also published work on acromegaly, familial hemolytic jaundice, the esophageal pulse, gout, etc.

Minkowski died on July 18, 1931, in Wiesbaden. (B. A. H.)

**MINNEAPOLIS,** the largest city in Minnesota, U.S., seat of Hennepin county and port of entry, is situated on the 45th parallel by the Falls of St. Anthony at the head of navigation on the Mississippi river, about 350 mi. N.W. of Chicago. Contiguous on the south and east to St. Paul (*q.v.*), which is often referred to as its twin city, its land area (56.5 sq.mi.) lies on both sides of the river but has developed mainly on the west over an undulating glacial plain contained in the angle of the Minnesota and Mississippi rivers. Within the city limits are 22 lakes and lagoons, and in the suburban area to the west lies Lake Minnetonka, 12 mi. long with 110 mi. of irregular shore line. Its outlet, Minnehaha creek, flows eastward along a residential boulevard and then drops 50 ft. over an escarpment at Minnehaha falls, immortalized by Henry Wadsworth Longfellow in his *Song of Hiawatha*. St. Anthony falls, now flowing smoothly over an apron or cut-off wall, lies in the heart of the milling district whose massive and irregular skyline seems a symbol of the proverbial plenty of the midwest. The handsome stone arch railroad bridge, built in 1881, and three general traffic bridges add interesting perspectives to the scene. Of the many bridges over the river, creeks and lakes, some have great architectural beauty.

**History and Industrial Development.**—The first recorded white visitor was the French Franciscan missionary, Father Louis Hennepin (*q.v.*), who named the falls in 1680. An adventurous traveler, Jonathan Carver (*q.v.*), came to the area in 1766. The falls provided power for a mill which in 1823 ground coarse flour for the soldiers at Ft. Snelling, built above the confluence of the Minnesota and Mississippi rivers, and in 1849 the same cataracts turned the first commercial sawmill. The village of St. Anthony on the east side of the falls was incorporated in 1855. Meanwhile, settlers, mainly from the eastern states, poured in and occupied U.S. military-reservation land mostly on the west side of the

river. In 1855 the government gave these illegal squatters patent rights and a new village was incorporated in 1856. It derived its name from *minne* (a Sioux word meaning "water") and the Greek *polis* (meaning "city"), with a euphonic *a* added in between. St. Anthony was chartered as a city in 1860 and Minneapolis in 1867; in 1870 the population of Minneapolis was 13,066 and St. Anthony, 5,013. The two cities were amalgamated under the name of the larger in 1872.

During these years sawmills buzzed on both sides of the river and by 1859 about 31,000,000 ft. of lumber were shipped from St. Anthony in addition to the timber which was marketed locally. The lumber business reached its height in 1899 when logs from the seemingly inexhaustible forests of the north jammed the river. As wheat-growing in the northwest increased, flour-milling superseded lumbering as the leading industry (the last lumber mill closed in 1919), and a new milling process involving the "middlings purifier," which improved the quality of flour made from spring wheat, made Minneapolis known by 1885 as "the flour city of the United States." Railroads radiating from the city were completed in the late 19th century, multiplying connections with Chicago and the south and with the east through Sault Ste. Marie. These lines brought favourable transportation rates, but after World War I lower freight rates via the Great Lakes shifted much of the export flour trade to Buffalo, N.Y., though Minneapolis remained the headquarters for five large milling companies. Along with the flour, but somewhat separately, developed the grain trade, stimulated in 1881 by the organization of the chamber of commerce, and between 1879 and 1885 Minneapolis advanced from ninth to first place among the primary wheat markets of the country, a position it had not lost in the second half of the 20th century. The Minneapolis Grain exchange is probably the world's largest cash grain market. Two other leading industries of Minneapolis were established in the 1850s: the manufacture of agricultural and railroad machinery and the manufacture of linseed oil from flax of the surrounding country.

The history of Minneapolis was marked by two spectacular events. In 1869 the falls, yielding to a geological fault and overuse by man, threatened collapse, jeopardizing the whole economy of the city. With federal aid, the vital water power was restored by an apron which is still intact. In 1878 an explosion of a major mill destroyed half the milling district and killed scores of workmen. This resulted in intensive research on dust control in mills.

The leading industries of the twin city industrial complex are food products, printing and publishing, machinery, paper and metal products, apparel and transportation equipment, which, with the addition of precision instruments, are also the leading industries of Minneapolis, where an industrial park was developed along the Minnesota river. The city is also the retail shopping centre of the area.

**Population and Urban Growth.**—After 1880, which began the decade of largest population growth, the dominant foreign-born group was Swedish, followed by Norwegians and Germans. Representative nationalities from southern and eastern Europe increased proportionately between 1900 and 1920 though remaining small in number. In 1940 less than 15% of the population was foreign born and in 1950 the percentage was 9.4.

The population of Minneapolis grew steadily from 46,887 in 1880 to 521,718 in 1950. By 1960, however, movement to the suburbs had caused a drop in population of the central city to 482,872. (For comparative population figures *see* table in MINNESOTA, *Population*.)

The city became the centre of a standard metropolitan area of 525 sq.mi. and a population of more than 800,000 in 1930, and in 1950 of a land area of 1,721 sq.mi. with a population of more than 1,000,000.

An area of five counties (Anoka, Dakota, Hennepin, Ramsey and Washington), with a population of 1,482,030, was designated in 1960 as the Minneapolis-St. Paul standard metropolitan statistical area. Among the small older towns of the area are Stillwater on the St. Croix, where lumber manufacture began in 1844, and Anoka, north of Minneapolis, also an early lumber town. The eight townships and villages of the Minnetonka lake district, an area famous during the 1880s and 1890s for fashionable summer resorts, have become year-round communities. South St. Paul is a typical industrial satellite with meat-packing the dominant industry. Middle-class suburban communities have grown rapidly, and St. Louis Park, Richfield (*qq.v.*), Edina and Bloomington, lying contiguous to Minneapolis, showed marked increases in population between 1930 and 1960.

**City Planning.**—Civic improvement and development, begun abortively in 1917, was renewed, and by mid-20th century the face of the downtown area was remarkably changed by the erection of impressive new buildings, both public and private, and by the razing of the blighted area in the heart of the city. Some architectural landmarks are the Ninth Federal Reserve District bank (established 1915), designed in 1924 by Cass Gilbert, with 12 stories since added; the Foshay tower, built by a utilities baron in 1929 in the form of a shaft 447 ft. tall; and the First National bank building, built in 1955.

In 1917 river improvements begun in 1894 were completed to bring navigation into the heart of the city, and in 1948 the federal government began the upper harbour project with the purpose of bringing barge traffic above the falls. Ten trunk-railroad lines serve Minneapolis, and Wold-Chamberlain international airport is about 10½ mi. S. of the city loop.

**Culture and Recreation.**—The Minneapolis campus of the University of Minnesota (established 1851), on the river, in the southeast part of the city, is the centre for many of the cultural activities of the community. The Minneapolis Symphony orchestra, founded in 1903, performs there in Northrop Memorial auditorium, where concerts, ballets and lectures are also held. The university radio station gives cultural broadcasts, and an educational television station was launched in 1957 with the support of community institutions. The Municipal auditorium, built in 1927, seats 10,000 and the Metropolitan Sports stadium in Bloomington, built in 1956, has a capacity of 35,000. The Minneapolis Institute of Arts has been housed since 1912 in a neoclassical building owned and operated by the Society of Fine Arts, incorporated in 1883; the Walker Art centre, built in 1927, specializes in contemporary art. The activities of the American Swedish institute, housed in a late-19th-century mansion, are devoted to the cultural relations of the two countries.

Numerous trade and professional schools include Dunwoody institute, a leading vocational school founded by private endowment in 1914. Augsburg College and Theological seminary (Lutheran, 1869) is a four-year liberal arts college. The public library, its modern building opened in 1961, was enriched in 1885 through an amalgamation contract with the Minneapolis Athenaeum, a private subscription library incorporated in 1859. The Hennepin county library extends the work of the city institution into the surrounding area. A science museum and planetarium are connected with the library. A historic site is the round tower at old Ft. Snelling, south of the city.

Though the largest number of church congregations is Lutheran, all denominations as well as several independent evangelistic sects are represented. The Basilica of St. Mary (Roman Catholic), completed in 1915, was built in Renaissance style. The city is famous for churches representing various styles of 20th-century architecture.

Early in its history influential citizens of Minneapolis realized the beauty and recreational possibilities of the lakes. A park board was created by the state legislature in 1889, and a system of tree-shaded boulevards and parks, including historic Minnehaha park, has been maintained, extending with the growth of the suburbs into the county. The gateway to a great sports and resort area to the north, Minneapolis is conscious of the out-of-doors, and day camps, skating rinks, ski jumps and swimming facilities are numerous.

An annual summer event is Aquatennial week, featuring aquatic sports and a parade of floats. (MA. C. R.)

**MINNESINGER,** the generic name by which the German lyric poets of the 12th and 13th centuries are known. Strictly speaking, and in the usage of Middle High German poets them-

selves, the term *Minnesang* denotes only songs of love (*Minne*) written in the service of the ideal of *amour courtois*, or courtly love (*q.v.*), but it has come to be applied to the whole body of lyric poetry of the period, *Spruchdichtung* (political, moral and religious poetry) as well as *Minnelyrik*.

The songs of *amour courtois*, like the concept itself and the court culture from which it sprang, came to Germany either direct from Provence or through northern France. The minnesinger, like their Romance counterparts, usually composed both words and music and performed their songs in open court, so that their art stood in an immediate relationship to their public. Some were of very humble birth; at the other end of the social scale were men such as the emperor Henry VI, son of Frederick I Barbarossa. The majority, however, were *ministeriales*, *i.e.*, members of the lower nobility, who depended for their livelihood on court patronage, and from the vicissitudes of such an existence come many of the motifs in their poetry. In form, the lyrics follow in the main the tripartite structure taken over from the Provençal *canzo:* two identical sections (known individually as *Stollen* and collectively as the *Aufgesang*) followed by a third section (*Abgesang* —the terms derive from the meistersinger, *q.v.*), the formal ratio between *Aufgesang* and *Abgesang* being variable. On a larger scale is the *Leich* or lyric lay, an aggregation of short strophic elements (versicles) often arranged in an antiphonal pattern derived from the liturgical sequence. These *Leiche* are often several hundred lines in length and many incorporate religious motifs (such as veneration of the Virgin Mary), which are also to be found in the shorter lyrics.

The poems of the earliest minnesinger known by name, the Kürenberger (*c.* 1160—probably a member of the family whose castle stood on the Danube west of Linz), together with a few early anonymous strophes, suggest that, before the force of the new, troubadour-stimulated art was felt, there existed a native tradition of poetry sustained by entirely different attitudes and conventions: instead of the pained worship of a romantic ideal of womanhood, the realistic verses of the Kürenberger show a proud, imperious knight with a woman pining for his love. In Dietmar von Aist (d. *c.* 1170), also an Austrian nobleman, Romance influence begins to make itself felt in the reversal of the roles of the lovers, and by the end of the century, in the work of Heinrich von Veldeke, the Palatinate poet Friedrich von Hausen and the Swiss Count Rudolf von Fenis the art of the troubadours and trouvères (*qq.v.*; as these poets were called in Provence and northern France respectively) has taken control. The climax of the Romance-inspired *Minnesang* is reached in the work of the Thuringian Heinrich von Morungen and the Alsatian Reinmar der Alte (von Hagenau), both of whom flourished at the turn of the 12th and in the early 13th century. Morungen reveals in his love poetry an intensity of feeling and a degree of personal moral involvement unmatched by any of his contemporaries; Reinmar, on the other hand, who spent most of his mature life at the Viennese court, where he instructed Walther von der Vogelweide in the refinements of *Minnesang*, brings to their consummation the formal and conceptual values of the courtly love lyric as an expression of defined social ideals, and appears to the modern reader, as he did already to his own and to immediately succeeding generations, as the most representative poet of "pure" *Minnesang*.

While absorbing much of Reinmar's formal craftsmanship, Walther von der Vogelweide, the greatest lyric poet of the German middle ages, went far beyond the artificial conventions by which the *Minnesang* had been governed, and introduced an element of poetical realism, both in his love poetry and in his political, moral and religious *Sprüche*, or maxims, which in the course of the 13th century was to lead ever further away from the world of courtly ideals. By the time of Neidhart von Reuenthal, a Bavarian squire (d. *c.* 1230), the knight had turned his attention from the ladies of the castle to the wenches of the village. Descriptions of village festivities play a prominent part in his songs, most of which are for dancing; he also frequently introduces himself by name into a poetic situation to which the *pastourelle* motif and the folk song both appear to have contributed. The popularity of this so-called *höfische Dorfpoesie* ("courtly rustic poetry") is shown by the large number of spurious Neidhart-style poems ascribed to him in the manuscripts, and also by the development of the genre by later minnesinger such as Gottfried von Neifen, Tannhauser and Johannes Hadlaub.

While poets like Ulrich von Lichtenstein in his *Frauendienst* (1255) strove by means as fanciful as they were futile to keep the conceits of chivalry alive, others cultivated didactic poetry, which Walther von der Vogelweide, building on the work of earlier *Spruchdichter* such as Spervogel, had already raised to a high level. Prominent among these latter are Reinmar von Zweter, the Marner and Konrad von Würzburg, who all flourished about the middle of the 13th century and who all came to be reckoned by the meistersinger among the "12 old masters." At the turn of the 13th century stands Frauenlob, a poet who by his versatility, his power of rhetoric and his technical refinement points the way to the stylized art of the meistersinger.

There are extant four large codices of minnesinger verse, one compiled in the 13th century, the others in the 14th century; the most famous is the so-called Manesse manuscript, written in the first half of the 14th century and preserved in the university library at Heidelberg. There are also many smaller collections and fragments.

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**MINNESOTA,** called the "North Star" or the "Gopher" state, a north-central state of the United States. It is bounded north by the Canadian provinces of Manitoba and Ontario, east by Lake Superior and Wisconsin, south by Iowa and west by South and North Dakota. It is the 12th state in size in the union, with a total area of 84,068 sq.mi., of which 4,059 sq.mi. are water surface. It is 406 mi. long and 358 mi. wide. Its name, of Sioux Indian origin, was first applied to the river of that name and probably means "cloudy water." Minnesota was admitted to the union in 1858 as the 32nd state. The state flower is the pink and white lady's-slipper; the state bird is the loon. The state motto is *L'Etoile du nord* ("The Star of the North"); there is no official song, but the university song, "Hail! Minnesota," is popularly regarded as such. The state flag consists of a blue background on which, as the chief element, is placed a white circle, in the centre of which is shown the great seal of the state. The capital is St. Paul.

## PHYSICAL GEOGRAPHY

**Physical Features.**—Minnesota is almost at the centre of the North American continent, lying within approximately 43° 30′ to 49° 23′ N. and 89° 29′ to 97° 13′ W. It extends farther north than any other state of the union except Alaska. Its landscape is distinguished by variety and beauty, the diversity of its terrain being the result of an unusual geological development that was conditioned markedly by the glaciers that four times covered most of the area. The results of repeated glaciation are seen in the thousands of lakes; in the wilderness areas, rolling prairies, fertile valleys, high bluffs, rocky shores and hills that give a richly varied aspect to the scenery; and in the deep, rich soil, ground fine by the passage of ice rivers.

The highest point in the state is at the summit of the Misquah

## VIEWS OF MINNESOTA

*Top left*: A fisherman mending his nets along the shore of Lake Superior
*Top right*: Contour planting on a Minnesota farm
*Centre left*: Milling district of Minneapolis on either side of the Mississippi river
*Centre right*: The Mayo clinic, medical centre at Rochester
*Bottom*: An elk herd at Red Lake game refuge, northern Minnesota

# MINNESOTA

[illegible] STANDARD OIL CO. (NEW JERSEY); PHOTOGRAPHS, [illegible] LEFT, [illegible] NEWS, (CENTRE RIGHT) [illegible]

## SCENES IN MINNESOTA

*Top left:* Cathedral of St. Paul's, St. Paul

*Top right:* Reconstructed stockade at Grand Portage, a fur trading centre of northern Minnesota at the end of the 18th century. Rebuilt in 1937–38, made a national monument in 1958

*Centre right:* Aerial view of the harbour at Duluth

*Bottom left:* The Hull-Rust-Mahoning open-pit iron ore mine at Hibbing. This mine, started in 1895, is one of the largest open-pit iron mines in the world

*Bottom right:* Statues of the legendary hero Paul Bunyan and Babe, his blue ox, at Bemidji

hills in Cook county in northeastern Minnesota, where the altitude is 2,230 ft.; another high point of 1,960 ft. occurs at the crest of the Coteau des Prairies in Murray county in the southwest; and the Mesabi range in St. Louis county rises to an elevation of 2,005 ft. These points were a part of an extension of the Laurentian hills which once extended diagonally across the state from the northeast corner to the vicinity of Pipestone in the southwest corner. The lowest point in the state is the level of Lake Superior, 602 ft.

**Climate.**—Minnesota has a comparatively low mean annual temperature, but its climate is marked by great variation, the average annual range for Minneapolis and St. Paul being 119° (F.). The lowest temperature on record is −59° F. (about −51° C.) recorded at Leech lake in 1903, and the record high is 114° F. (about 45° C.) recorded at Beardsley in 1917. It is seldom that extreme temperatures prevail for more than a few days at a time, and the state has been remarkably free from destructive storms. The cold increases not only from south to north but to some extent also from east to west. The amount of rain decreases from east to west, varying from nearly 31 in. to less than 25 in. at some points, but in all sections there is enough moisture for humid farming. Days of snow cover annually average 120 in the north and 60 in the south. The elevation of the state, its fine drainage system and the dryness of the atmosphere, especially in the winter, help to make it one of the most healthful regions in the world.

**Soil.**—Over the greater part of the state the soil consists of surface drift of glacial origin—a dark brown or black sandy loam of great fertility, adapted to cereal crops. In the east-central part of the state the soil is sandy, excellent for hay and root crops.

**Drainage.**—Glacial action determined the direction and character of rivers, made numerous swamps and created Minnesota's lakes, of which there are more than 11,000. The lakes in the south, which occupy glacial moraines for the most part, are generally broad and shallow, while those in the north, formed by glacial basins scoured in solid rock, are generally deep, with rugged, rocky, pine-covered shores. Most of the larger lakes lie in the forested northern region of the state. Among them are Lake of the Woods and Rainy lake (which are shared with Canada), Red, Mille Lacs, Leech, Winnibigoshish and Vermilion.

The most interesting feature of the glacial epoch is the extinct Lake Agassiz, which the receding ice of the later glacial period left in the Red river valley of Minnesota, North Dakota and Manitoba. As the glacier retreated the lake waters drained northward, leaving Red lake as the most extensive remains of the giant body of water. The resulting flats of the Red river valley provide still another variation to Minnesota's changing landscape.

Minnesota has within its borders more inland water than any other state in the union, 1 sq.mi. of water for every 20 sq.mi. of land. Three of the state boundaries are also at least partly marked by waterways—the northern boundary by the Rainy and Pigeon rivers and the chain of border lakes, the eastern boundary by the St. Louis, St. Croix and Mississippi rivers and the western boundary by the Red river.

The sources of three of North America's great water systems are to be found in the state. From one watershed in the northeast the waters flow southward by way of the Mississippi river into the Gulf of Mexico and northward by way of the Red river to streams that empty into Hudson bay. From another watershed, waters in the northeastern tip of the state flow eastward through the Great Lakes and the St. Lawrence river into the Atlantic ocean. The largest of these three great river systems is, of course, the Mississippi, which, with its tributaries, drains 57% of Minnesota. This largest river on the North American continent begins in Lake Itasca and flows southward through the state, taking in the waters of the Willow, Crow Wing, Prairie, Platte, Elk and Rum rivers before it reaches Ft. Snelling. The largest of the Mississippi's tributaries in the state is the winding Minnesota river, which begins in Big Stone lake on the western border and flows across Minnesota to join the Mississippi near Ft. Snelling. Between Ft. Snelling and the Iowa border the Mississippi gathers in the waters of the Cannon, the Whitewater and the Root rivers, as well as those of the Chippewa and St. Croix flowing in from Wisconsin. The largest of these is the St. Croix, which begins as a small stream in northern Wisconsin and flows southward along Minnesota's eastern border, joining the Mississippi at Prescott, Wis. The Des Moines river, in the southwestern corner of the state, is also part of the Mississippi drainage system, emptying into the Mississippi in Iowa. A few other streams in Rock, Pipestone, Murray and Nobles counties in southwestern Minnesota drain into the Missouri river system and through it finally reach the Mississippi.

The next largest of the three great drainage systems whose headwaters are in Minnesota is the one flowing into Hudson bay. Thirty-four per cent of the state is drained by the waters of the Rainy river and the Red river and their tributaries. The Rainy, forming part of Minnesota's northern boundary, empties northward into Lake of the Woods. The Red river, forming a large section of the state's western boundary, begins at the junction of the Bois de Sioux and Otter Tail rivers and flows northward into Canada. In its rambling course it covers more than 545 mi., draining a rich and fertile valley of more than 100,000 sq.mi. Its main Minnesota tributaries are the Otter Tail, Buffalo, Wild Rice, Marsh and Red Lake rivers. Across the border it is joined by the Roseau river as it travels to Winnipeg where it is joined by the Assiniboine river.

Less than 9% of the state is drained by waters that reach the Atlantic ocean through the Great Lakes–St. Lawrence waterway. The Pigeon river and its headwaters, the chain of lakes stretching westward to North lake, form a part of the northern boundary of Minnesota. The waters of the St. Louis river, emptying into Lake Superior near Duluth, also find their way to the Atlantic, as do the many rugged streams along the north shore of Lake Superior. These small, rapid rivers, full of tumbling falls and cascades, bear such colourful names as Gooseberry, Beaver, Baptism, Caribou, Temperance and Devils Track. Although the various geographical components of Minnesota have all had a great effect on the development of the state, perhaps no single feature did more to shape its early history than did the rivers.

**Vegetation.**—The southern part of the state, before colonists arrived, was open, rolling prairie interspersed with groves of oak and other deciduous timber. A region known as the Big Woods, composed of broad-leaved hardwood trees, extended up the Minnesota valley to the "big bend" (centre at Mankato). The northern part, aside from the Red river valley, was once dense coniferous forest, made up largely of white, Norway and jack pine, but containing also some birch, poplar, maple and oak.

Most of the plants and animals of the north temperate zone are found in Minnesota. Along the streams of the southern part thickets of oak, elm, ash, maple, poplar, basswood, plum and cherry trees are still found in great variety, festooned with grape vines and sheltering small fruits and other shrubs, especially the hazel bush. Scattered over the prairies are strawberries, and the northern woods produce blueberries for many markets. These woods, though subject to intensive lumbering since the beginning of the 20th century, still contain more white pine than is found elsewhere in the country, besides other varieties of pine, balsam, spruce and hemlock. The state flower, the dainty pink and white lady's-slipper, is found in marshes that also shelter the fringed gentian and glow with marigolds and goldenrod in more than 30 varieties.

**Animal Life.**—The French explorers of the late 1600s found beavers working along every stream. Two centuries of Indian fur trade almost exterminated this animal, but in the 20th century, under the protection of the state, the beaver is again multiplying rapidly. Marten, otter, mink, muskrat, bobcat, skunk, raccoon, weasel, wolf, red fox and other fur-bearers have always been numerous. In the sparsely settled parts of the state coyotes and timber wolves, black bears, foxes, lynx and various rodents are prevalent. The gopher (really the striped ground squirrel), which gave Minnesota the name of "Gopher state," is fruitful except where care has been taken to prevent its becoming a nuisance. Deer, moose, bear and elk are the only large game animals; they attract thousands of hunters to Minnesota each year. Game birds —including wild duck, quail, sharp-tailed grouse, upland plover,

prairie chicken and ring-necked pheasant—are abundant; more than 1,000,000 wild ducks and 50,000 deer are killed by hunters each year.

The state's streams and lakes are well stocked with pickerel, pike, bass, crappies and sunfish, and some trout are caught by sportsmen. Minnesota has a larger area in game refuges than any state—5,500,000 ac.

**Parks, Monuments and Recreation.**—Tourism is an important business in Minnesota. The state park system includes 69 natural, scenic, historical and recreational areas of varying size, comprising a total of 100,000 ac. The national park service administers two national monuments, and the Minnesota Historical society administers five state historical sites. Two contemporary movements led to the establishment of the state park system in the late 19th century. The first of these set aside as public parks the major battlefields of the Sioux uprising of 1862. Camp Release, near Montevideo, became the first state park in 1889. The second effort, led by J. V. Brower, preserved as a public area the extensive and unusual wilderness area about Lake Itasca, the source of the Mississippi river. Itasca park, established in 1891, is the state's largest and most famous park. Other major state parks are Gooseberry Falls, Jay Cooke, St. Croix, Scenic, Sibley, Whitewater, Lake Carlos, Interstate, Frontenac, Cascade, Fort Ridgely and Mille Lacs Kathio. Pipestone National monument in the southwestern corner of the state was established in 1937. It is the place where for centuries North American Indians quarried the precious red stone from which they carved their peace pipes. Grand Portage National monument, located on Lake Superior at the northeastern tip of the state, was established in 1958 (it had been designated a national historic site in 1951). It was the great inland depot of the British North West company and the centre of the North American fur trade from about 1770 to 1804. Old Fort Snelling was designated a national historic monument in 1960. (R. W. F.)

## HISTORY

The first European visitors to the territory now embraced in the state of Minnesota found it occupied mainly by two Indian tribes, the Ojibwa (also called Chippewa; Algonkian family), who lived in the heavily wooded northern portion, and the Sioux (more properly Dakota), who made their homes in the more open country of the south and west. Between the two tribes there was almost continual warfare. The first white men known to have entered the state were Frenchmen. Pierre Esprit Radisson and Médart Chouart, sieur de Groseilliers, may have reached Minnesota territory on an expedition overland from Lake Michigan in 1655. It is more probable that they visited Minnesota on a journey southwest from Lake Superior about 1659.

Daniel Greysolon, sieur du Lhut (Dulhut or Duluth), is known to have penetrated the territory southwest of Lake Superior in 1679 as far as Mille Lacs, where he set up the standard of Louis XIV. The following year Dulhut crossed via the Bois Brule–St. Croix route to the Mississippi, where he met a party of three Frenchmen led by Michael Accault. They had been sent up the river by La Salle to make the first exploration of the upper Mississippi. Accompanying this expedition was Father Louis Hennepin, who during his wanderings before meeting Dulhut discovered and named the Falls of St. Anthony, and who later wrote the first published description of the country. Nicolas Perrot, a trader, ascended the Mississippi in 1686 to Lake Pepin, on the east shore of which he built a fort. Again in 1688 he visited the region, and in 1689 he proclaimed the sovereignty of France over it. In 1695 Pierre le Sueur, who had traded on the upper Mississippi for some years, established a post on Isle Pelée (Prairie Island) in the Mississippi between Hastings and Red Wing. In 1700 he ascended the Minnesota river to the mouth of the Blue Earth river near Mankato, whereon he built Ft. L'Huillier.

A period of lethargy followed these early explorations because of the death in 1698 of the energetic governor comte de Frontenac, who had encouraged them, and the absorption of France in the War of the Spanish Succession (1701–14). All French garrisons in the northwest were withdrawn. Not until Sept. 1727 did another French expedition reach the region. Then the sieur de la Perrière landed on the west bank of Lake Pepin and built a fort; the Jesuit fathers who accompanied him established a mission, but both institutions were short-lived. In 1731 a party under P. G. de Varennes, sieur de la Vérendrye, explored the chain of lakes along the northern border of Minnesota, and a detachment under his nephew, La Jémeraye, built Ft. St. Pierre on the north bank of Rainy lake. In the next year the main expedition pushed on to the Lake of the Woods, where, within Minnesota borders, they built Ft. St. Charles, occupied for 20 years, or longer than any French establishment in the territory.

In the treaty of Paris (1763) at the close of the Seven Years' War in Europe, the French ceded to England all their possessions east of the Mississippi except the site on which New Orleans was located; those west of that river they had cautiously ceded to Spain in a secret treaty the previous year.

During the period of the British regime, Jonathan Carver (*q.v.*) was sent out to treat with the Indians, in 1766, by Maj. Robert Rogers, commandant at Michilimackinac (Mackinac). He spent the winter of 1766–67 among the Sioux of the Minnesota valley, and in the spring he traveled to Prairie du Chien, where he joined an expedition under Capt. James Tute sent out by Rogers to find a route to the "western sea." Carver later published a lively account of his travels, which was widely read in Europe.

Another trader of the British period was Peter Pond, a Connecticut Yankee who spent two winters, from 1773 to 1775, on the Minnesota river. David Thompson, who was employed both in trading for the North West company and in determining the location of the 49th parallel, passed through northern Minnesota in the winter of 1797–98. His diaries are the earliest known scientific record of Minnesota topography.

**United States Ownership.**—After the Revolutionary War, the English relinquished their portion of the region (treaty of Paris, 1783) to the newly formed United States. There was no force to expel the English from the northwest wilderness, however, and the British flag remained flying over the trading posts of the North West company in Minnesota until after the War of 1812. This company had been formed to organize systematically the fur trade of the northwest. Its headquarters for the region during the last two decades of the 18th century were at Grand Portage, at the east end of the famous portage between Lake Superior and the Pigeon river.

In 1803 the western part of Minnesota was acquired by the United States as part of the Louisiana Purchase. In 1805–06, at the instance of Pres. Thomas Jefferson, Lieut. Zebulon M. Pike led an exploring expedition up the Mississippi as far as Leech lake and Upper Red Cedar or Cass lake. He visited the main posts of the North West company and took formal possession for the United States. He also negotiated with the Indians for a tract of land at the confluence of the Minnesota and Mississippi rivers upon which, in 1819, the post later known as Ft. Snelling was established. For many years this remained the northwesternmost military post in the United States, and it was also the centre of the fur trade in the region.

In 1816 the North West company's traders were forced out of Minnesota and their posts were taken over by the American Fur company, which was soon doing business throughout the upper valley of the Mississippi.

In 1818 the jurisdiction of Michigan territory was extended to the Mississippi river. Its governor, Lewis Cass, attempted to find the source of the Mississippi in 1820. In 1823 extensive explorations of the Minnesota and Red river valleys were conducted by Maj. Stephen H. Long, and subsequently knowledge of the Minnesota country was extended by investigations of the region by Henry R. Schoolcraft, who discovered Lake Itasca, the source of the Mississippi, in 1832; by George Catlin, whose journey of 1836 took him to the famous pipestone quarry; by Joseph N. Nicollet, whose tours of the late 1830s resulted in the first accurate map of the region; and by Maj. Samuel Woods, who explored the Red river valley in 1849. A settlement grew up about the headquarters of the American Fur company at Mendota, on the Minnesota river opposite Ft. Snelling.

In 1837 two treaties, one with the Chippewa and the other with the Sioux, were negotiated, extinguishing the Indian title to the wedge of land between the Mississippi and St. Croix rivers, a part of the Northwest Territory (*q.v.*), and opening it to settlement. Following these treaties thriving settlements grew up at St. Paul and Stillwater.

**Minnesota Territory.**—In 1849 the bill organizing the territory of Minnesota was passed by congress, and Alexander Ramsey was appointed governor. The first territorial legislature met at St. Paul on Sept. 3 of the same year. By the federal census of 1850 the territory had 6,077 inhabitants, most of whom lived east of the Mississippi or along the Red river in the extreme northwest. Treaties negotiated in 1851 with the Sioux opened to settlement the greater part of the land in the territory west of the Mississippi; and treaties with the Chippewa in 1854 and 1855 extinguished the Indian title to nearly two-thirds of the northern half of the state. Such an unparalleled rush to the new lands took place that a census in 1857 showed a population of 150,037. The lumbering business was booming and building up the towns of Stillwater and St. Anthony (Minneapolis), and St. Paul at the head of navigation on the Mississippi, became the commercial centre of the territory. Other river towns proved prosperous ports of entry from which settlers trekked to the interior, sometimes individually, sometimes by whole colonies transplanted from eastern states.

In July 1857 a convention met and drew up a state constitution, which was adopted the following October by an almost unanimous popular vote. On May 11, 1858, the state was admitted to the union with its present boundaries.

**Statehood.**—Minnesota supplied more than 22,000 men for the Federal armies during the Civil War. Even more important to the state than the war in the south was the defense of its frontier against the uprising of the Indians within its borders. The Sioux felt that they had been deceived and outdone in the treaty of 1851. In 1858 their small reservation was halved and most of the payment went to the traders. Many of the natives resented the government's attempts to make them farmers.

When in the summer of 1862 there was delay in the payment of annuities, bands of the Sioux suddenly began to massacre the settlers in the Minnesota valley. These attacks continued with increasing fury (more than 350 whites losing their lives) until forces under Gen. Henry H. Sibley decisively defeated the Indians under Little Crow, their principal leader, at Wood lake. Three days later 269 white captives were released. Many of the Sioux fled into the Dakota country, but expeditions under Sibley in 1863 and Gen. Alfred Sully in 1863 and 1864 marched against them and drove them beyond the Missouri.

The coming of peace marked the beginning of a new period of rapid growth, the federal census of 1870 showing a population of 439,706 or a gain of 155.6% in ten years. During the same decade railway construction, which had begun with a line between St. Paul and St. Anthony in 1862, reached close to 1,000 mi. The period 1870–80 was one of great discontent among the farmers, and one expression of their feeling was their opposition to certain widespread abuses of the railroads.

A number of regulatory laws, usually called the "Granger acts," passed the legislature. Cases arising out of these acts, and carried to the U.S. supreme court, which decided against the railroads, had far-reaching results in establishing principles of public regulation of common carriers. The railways themselves suffered severely in the panic of 1873, and the farmers were troubled by severe and repeated grasshopper invasions that destroyed the crops over large areas. Despite these setbacks, Minnesota's population increased 77.6% in the decade from 1870 to 1880; settlements spread over the prairies of the west and southwest and down the Red river valley. Many of the newcomers were Scandinavian and German immigrants. Wheat became the great crop of the prairies.

In the north the forests were falling under the organized attack of great lumber companies. Agricultural conditions revived, railroads again were being built, and the basis was laid for steady growth in the following decades.

In 1884 the mining of iron ore was begun on the Vermilion range and in 1890 and 1891 the much larger deposits of the Mesabi range were discovered. With the opening of the Cuyuna range in 1911, Minnesota became the source of most of the United States' iron ore. (J.X.)

Lumbering, flour milling and iron mining were major forces affecting Minnesota's economy in the 19th century and contributed to its industrial and urban development. But other factors were also involved. The combination of agricultural products and fine transportation facilities led to the growth of South St. Paul and Austin as meat-packing centres. The quarries of the St. Cloud area contributed to the growth of the "Granite city." International Falls developed around a by-product of the lumber industry, the manufacture of paper.

During the century from 1850 to 1950 Minnesota's population increased from 6,077 to 2,982,483. By the latter year, more than half of the state's people lived in the three large metropolitan areas of Minneapolis, St. Paul and Duluth.

Minnesota's political experience has been coloured by the rise of a number of strong third parties within the state, and these movements left a heritage of independence that characterizes the voting habits of the people. While the first state officials were Democrats, the Republican party took office in 1860 and remained dominant for a generation thereafter. Challenges from the Democrats and Populists increased toward the end of the century, and in 1898 John Lind, a Democrat, won the governorship. Between 1900 and 1930 Republicans were again in the ascendancy, although their control was less absolute than before. The post-Civil War tradition of the agrarian crusade led by Oliver H. Kelley, founder of the National Grange (*q.v.*), and Ignatius Donnelly was continued in the 20th century by another Minnesotan, A. C. Townley. In 1915 he organized the Nonpartisan league, and for some years it was a strong influence in the politics of the middle west. Another of the league's leaders was Charles A. Lindbergh, Sr., who helped found the Farmer–Labor party after World War I. This party elected Floyd B. Olson governor in 1930 and the party held that office until 1938 when the Republicans returned to power under the leadership of Harold E. Stassen. The Republican party held the governorship for 16 years. A merger of the Democratic and Farmer–Labor parties, effected in 1944, was successful in electing Gov. Orville L. Freeman in 1954, 1956 and 1958. In 1960 Freeman was defeated by Republican Elmer L. Andersen, who lost to Democratic-Farmer-Labor Lieut. Gov. Karl F. Rolvaag in 1962.

In presidential elections Minnesota supported every Republican candidate between 1860 and 1928, except in 1912 when Woodrow Wilson received more votes than William Howard Taft. In the elections of 1932 through 1960 Minnesota was Democratic, except in 1952 and 1956 when Dwight D. Eisenhower carried the state for the Republicans.

## GOVERNMENT

The constitution adopted on Oct. 13, 1857, was frequently amended. A proposed amendment must be approved by a majority of the votes cast at a general election. The legislature is composed of two houses, the senate (67 members) and the house of representatives (131 members), members of the former being chosen for four years and of the latter for two years. The legislature passed a reapportionment bill in 1959, the first such action since 1913. The executive department is made up of a governor, lieutenant governor, secretary of state, treasurer and attorney general, all elected for two years, and an auditor elected for four years.

In 1939 state departments and agencies, with a few exceptions, were placed under the department of administration, constituted as a staff agency of the governor, in all matters pertaining to budgeting and finances, purchasing and contracting, and the care and custody of state properties.

The governor has the power of veto, but any bill he fails to return within three days, if the legislature is still in session, becomes law without his signature. A two-thirds vote of each house is necessary to override the veto. The lieutenant governor presides over the senate and succeeds the governor in case of the latter's death.

*Minnesota: Places of 5,000 or more Population (1960 census)**

| Place | Population | | | | |
|---|---|---|---|---|---|
| | 1960 | 1950 | 1940 | 1920 | 1900 |
| Total state | 3,413,864 | 2,982,483 | 2,792,300 | 2,387,125 | 1,751,394 |
| Albert Lea | 17,108 | 13,545 | 12,200 | 8,056 | 4,500 |
| Alexandria | 6,713 | 6,319 | 5,051 | 3,388 | 2,681 |
| Anoka | 10,562 | 7,396 | 6,426 | 4,287 | 3,769 |
| Austin | 27,908 | 23,100 | 18,307 | 10,118 | 5,474 |
| Bemidji | 9,958 | 10,001 | 9,427 | 7,086‡ | 2,183 |
| Blaine | 7,570 | [illegible] | 921‡ | 550‡ | 374‡ |
| Bloomington | 50,498 | 9,902‡ | 3,647‡ | 1,330 | 1,085‡ |
| Brainerd | 12,898 | 12,637 | 12,071 | 9,591 | 7,524 |
| Brooklyn Center | 24,356 | 4,284 | 1,870 | 788 | 1,232# |
| Brooklyn Park | 10,197 | 3,055§ | 1,344§ | 948§ | 1,232# |
| Chisholm | 7,144 | 6,861 | 7,487 | 9,039 | — |
| Cloquet | 9,013 | 7,685 | 7,304 | 5,127 | 3,072 |
| Columbia Heights | 17,533 | 8,175 | 6,035 | 2,968 | 123 |
| Coon Rapids | 14,931 | — | — | — | — |
| Crookston | 8,546 | 7,352 | 7,161 | 6,825 | 5,359 |
| Crystal | 24,283 | 5,713 | 2,373 | 814 | 750♦ |
| Detroit Lakes† | 5,633 | 5,787 | 5,015 | 3,426 | 2,060 |
| Duluth | 106,884 | 104,511 | 101,065 | 98,917 | 52,969 |
| East Grand Forks | 6,998 | 5,049 | 3,511 | 2,490 | 2,077 |
| Edina | 28,501 | 9,744 | 5,855 | 1,833 | 749 |
| Ely | 5,438 | 5,474 | 5,970 | 4,902 | 3,717 |
| Eveleth | 5,721 | 5,872 | 6,887 | 7,205 | 2,752 |
| Fairmont | 9,745 | 8,193 | 6,988 | 4,630 | 3,040 |
| Falcon Heights | 5,927 | 3,884 | 4,777¶ | 1,562¶ | 1,076¶ |
| Faribault | 16,926 | 16,028 | 14,527 | 11,089 | 7,868 |
| Fergus Falls | 13,733 | 12,917 | 10,848 | 7,581 | 6,072 |
| Fridley | 15,173 | 3,796 | 1,392‡ | 533‡ | 443‡ |
| Golden Valley | 14,559 | 5,551 | 2,048 | 840 | 680 |
| Grand Rapids | 7,265 | 6,019 | 4,875 | 2,914 | 1,428 |
| Hastings | 8,965 | 6,560 | 5,662 | 4,571 | 3,811 |
| Hibbing | 17,731 | 16,276 | 16,385 | 15,089 | 2,481 |
| Hopkins | 11,370 | 7,595 | 4,100 | 3,055 | — |
| Hutchinson | 6,207 | 4,690 | 3,887 | 3,379 | 2,495 |
| International Falls | 6,778 | 6,269 | 5,626 | 3,448 | — |
| Litchfield | 5,078 | 4,608 | 3,920 | 2,790 | 2,280 |
| Little Falls | 7,551 | 6,717 | 6,047 | 5,500 | 5,774 |
| Mankato | 23,797 | 18,809 | 15,654 | 12,469 | 10,599 |
| Maplewood | 18,519 | — | — | — | — |
| Marshall | 6,681 | 5,923 | 4,590 | 3,092 | 2,088 |
| Mendota Heights | 5,028 | 2,107‖ | 1,360‖ | 757‖ | 813‖ |
| Minneapolis | 482,872 | 521,718 | 492,370 | 380,582 | 202,718 |
| Minnetonka | 25,037 | 11,896‡ | 6,466‡ | 2,298‡ | 1,083‡ |
| Montevideo | 5,693 | 5,459 | 5,220 | 4,419 | 2,146 |
| Moorhead | 22,934 | 14,870 | 9,491 | 5,720 | 3,730 |
| Mound | 5,440 | 2,061 | 1,189 | 393 | — |
| Mounds View | 6,416 | — | — | — | — |
| New Brighton | 6,448 | 2,218 | 658 | 368 | 350 |
| New Ulm | 11,114 | 9,348 | 8,743 | 6,745 | 5,403 |
| Northfield | 8,707 | 7,487 | 4,533 | 4,023 | 3,210 |
| North Mankato | 5,927 | 4,788 | 3,517 | 1,840 | 939 |
| North Saint Paul | 8,520 | 4,248 | 3,135 | 1,979 | 1,110 |
| Orono | 5,643 | 4,861‡ | 2,780‡ | 1,159‡ | 1,086‡ |
| Owatonna | 11,409 | 10,191 | 8,694 | 7,252 | 5,561 |
| Pipestone | 5,324 | 5,269 | 4,682 | 3,325 | 2,536 |
| Plymouth | 9,576 | 5,813‡ | 2,989‡ | 1,275‡ | 1,164‡ |
| Red Wing | 10,528 | 10,645 | 9,962 | 8,637 | 7,525 |
| Richfield | 42,523 | 17,502 | 6,750 | 2,411 | 1,537‡ |
| Robbinsdale | 16,381 | 11,289 | 6,018 | 1,369 | 520 |
| Rochester | 40,663 | 29,885 | 26,312 | 13,722 | 6,843 |
| Roseville | 23,997 | 6,437 | 4,777¶ | 1,562¶ | 1,076¶ |
| St. Anthony | 5,084 | 1,106 | 607‡ | 134‡ | 93‡ |
| St. Cloud | 33,815 | 28,410 | 24,173 | 15,873 | 8,663 |
| St. Louis Park | 43,310 | 22,644 | 7,737 | 2,281 | 1,325 |
| St. Paul | 313,411 | 311,349 | 287,736 | 234,698 | 163,065 |
| St. Peter | 8,484 | 7,754 | 5,870 | 4,335 | 4,302 |
| Shakopee | 5,201 | 3,185 | 2,418 | 1,988 | 2,047 |
| Shoreview | 7,157 | — | — | — | — |
| South St. Paul | 22,032 | 15,909 | 11,844 | 6,860 | 2,322 |
| Stillwater | 8,310 | 7,674 | 7,013 | 7,735 | 12,318 |
| Thief River Falls | 7,151 | 6,926 | 6,019 | 4,685 | 1,819 |
| Virginia | 14,034 | 12,486 | 12,264 | 14,022 | 2,962 |
| Waseca | 5,898 | 4,927 | 4,270 | 3,908 | 3,103 |
| West St. Paul | 13,101 | 7,955 | 5,733 | 2,962 | 1,830 |
| White Bear Lake | 12,849 | 3,646 | 2,858 | 2,022 | 1,288 |
| Willmar | 10,417 | 9,410 | 7,623 | 5,892 | 3,409 |
| Winona | 24,895 | 25,031 | 22,490 | 19,143 | 19,714 |
| Worthington | 9,015 | 7,923 | 5,918 | 3,481 | 2,386 |

*Populations are reported as constituted at date of each census. †Known as Detroit prior to 1940. ‡Township. §Brooklyn township, which includes the population of Brooklyn Park. ‖Mendota township, which includes the population of Mendota Heights. ¶Rose township, which includes the populations of Falcon Heights and Roseville. #Brooklyn township, which includes the populations of Brooklyn Center and Brooklyn Park. ♦Crystal Lake township, which includes the population of Crystal.
Note: Dash indicates place did not exist during census, or data not available.

Two significant constitutional amendments won approval at the polls in 1958; a "home rule" amendment, which encouraged and strengthened home rule and self-government in local communities; and the "four-year term" amendment, which put four-year terms (in contrast with the existing two-year terms) into effect in 1963 for five chief state offices (governor, lieutenant governor, secretary of state, attorney general and treasurer).

The supreme court consists of a chief justice and six associate justices, each elected for a term of six years. There are also 10 judicial districts, each with a district court presided over by from 3 to 14 elective judges. Every county has a probate court, while for the general administration of local justice there are municipal courts and justices of the peace.

## POPULATION

Minnesota is thought of as a state of Scandinavians, and in fact it probably does owe more to Scandinavians than to any other one national group. During the 1880s, when the flood of immigration was at its height, Scandinavians made up half of the foreign-born in the state. Early Swedish immigration was attributed in part to the writings of Peter Cassell, whose series of American letters published in local Swedish newspapers after his settlement in Iowa in 1846 had enormous circulation. The original Swedish immigrants were farmers, and they settled immediately on the land, their main stronghold being in east-central Minnesota. Norwegians originally tended to work in the lumbering industry, then turned to farming in the Red river valley and in the southeastern counties. Danish settlers were chiefly responsible for Minnesota's success as a dairying state. Germans were among the earliest of the national groups to come to the state, and between 1890 and 1900 they led in numbers of immigrants. Finns, Poles and Czechs make up the other largest national groups. The 1850 census enumerated 39 Negroes; in 1930 the number was 9,445, and in 1950 it was 14,022.

The population of Minnesota in 1850 was 6,077; in 1880 it was 780,773; in 1910, 2,075,708; in 1940, 2,792,300; in 1950, 2,982,483; and in 1960 it was 3,413,864, an increase of 14.5% over the population in 1950. The population per square mile in 1960 was 40.6, as compared with 49.6 for the U.S.

Of the 1960 population, 62.2% lived in incorporated places of 2,500 or more, as compared with 54.5% in 1950 and 49.8% in 1940 when these places constituted the urban area. The state's three standard metropolitan statistical areas—Duluth-Superior (shared with Wisconsin), Fargo-Moorhead (shared with North Dakota) and Minneapolis-St. Paul—had a total 1960 population of 1,864,653 (including 45,008 in Wisconsin and 66,947 in North Dakota). Of Minnesota's white population (98.8% of the total), 95.8% were native born and 4.2% foreign-born. Nonwhites compose 1.2% of the total population. Of the foreign-born, more than half were born in Sweden, Norway and Germany.

There were 101.7 females per 100 males in the native white population and 96.0 in the foreign-born; 10.4% of the population was 65 years old or over; and 77.8% of the population 14 years old and over was in the labour force. Of the total number of employed males, 14.4% was engaged in agriculture, 5.5% in construction and 19.5% in manufacturing.

## EDUCATION

General supervision of the state public-school system is the responsibility of the state department of education, and control of the department is vested in a nonsalaried board of education, consisting of seven representative citizens appointed by the governor and approved by the senate. The board's powers are exercised through the state commissioner of education, whom it elects.

As soon as the required standards are met the department metes out state aid in a certain fixed proportion. In addition, there is supplemental aid designed mainly to help the less affluent school districts. There are about 3,000 elementary schools in Minnesota and 670 accredited secondary schools, with a total enrollment of about 650,000. Nearly 30,000 teachers are employed in the public schools, and total state and local expenditures for elementary and secondary education amount to more than $300,000,000 annually. There are a number of junior colleges. Teachers are trained at the college of education at the University of Minnesota and its branches at Duluth and Morris, and at the five state colleges in Mankato (founded 1867), St. Cloud (1869), Moorhead (1887), Bemidji (1913) and Winona (1858).

The largest of the institutions of higher learning is the University of Minnesota, which enrolls about 26,000 full-time students yearly. The university was established under the Territorial act in 1851 and began instruction in 1869. It grants degrees on its three campuses at Minneapolis, St. Paul and Duluth, and is governed under its state charter by a board of regents, 12 citizens of the state elected by the legislature. The university's colleges include: the college of science, literature and the arts, the general

college (for general education), the Institute of Technology (including a college of engineering, school of architecture, school of chemistry and school of mines and metallurgy), the college of agriculture, forestry and home economics, the college of education, the school of dentistry, the school of nursing, the medical school, the school of public health, the school of business administration, the law school, the college of pharmacy, the school of veterinary medicine, the university college and the graduate school. The university also conducts schools of agriculture of less than college grade, a teacher-training junior-senior high school, a six-year elementary school and a nursery school and kindergarten. It offers extension and correspondence courses in a wide variety of subjects. The Mayo foundation for graduate study and research in the medical sciences works in co-operation with the Mayo clinic at Rochester. The university library numbers about 2,000,000 volumes.

Privately supported colleges of liberal arts are Carleton (founded 1866) and St. Olaf (Evangelical Lutheran; 1874) in Northfield; Gustavus Adolphus (Augustana Evangelical Lutheran; 1862) in St. Peter; Hamline university (Methodist; 1854), Macalester (United Presbyterian; 1885), St. Thomas (Roman Catholic; 1885) and St. Catherine (Roman Catholic; 1905) in St. Paul; Augsburg (Lutheran Free; 1869) in Minneapolis; St. John's (Roman Catholic; 1857) in Collegeville; St. Benedict (Roman Catholic; 1913) in St. Joseph; St. Mary's (Roman Catholic; 1913) and Saint Teresa (Roman Catholic; 1907) in Winona; Concordia (Evangelical Lutheran; 1891) in Moorhead; and St. Scholastica (Roman Catholic; 1912) in Duluth.

## HEALTH AND WELFARE

The department of public welfare supervises the county welfare programs, which serve more than 100,000 persons. It also maintains numerous institutions, including hospitals for the treatment of the mentally ill, schools for the mentally deficient, sanatoriums for tubercular patients, a school for the blind, a school for the deaf and a hospital for inebriates. The department of corrections, created by the 1959 legislature, operates a division of adult corrections and a division of youth conservation. The former administers a program for the custody, treatment and training of offenders committed by the courts to the state prison at Stillwater, the state reformatory for men at St. Cloud and the state reformatory for women at Shakopee. The division of youth conservation maintains a program for the diagnosis, custody and rehabilitation of youths under the age of 21 who have been adjudged delinquents or criminal offenders. It administers a state training school for girls at Sauk Centre, a state training school for boys at Red Wing and three forestry camps for boys at different locations in the state. The department of employment security assists people to find employment and pays unemployment insurance.

A state board of health, created in 1872, functions through seven divisions: disease prevention and control, medical laboratories, local health administration, environmental sanitation, special services, hospital services and administration.

## ECONOMY

**Agriculture.**—Minnesota has been pre-eminently an agricultural state (though manufacturing is slowly replacing agriculture as the chief source of income). The annual income of nearly $1,500,000,000 in the early 1960s from sale of crops, livestock and livestock products placed Minnesota fifth or sixth among the states in this respect. In production of farm crops Minnesota ranks second among the states in oats, third in corn and fourth in hay; it ranks high also in soybeans, flaxseed, green peas, barley, rye, sugar beets and potatoes. Approximately 20,000,000 ac. are devoted to the cultivation of crops. Apples are the only fruit crop raised commercially to any extent.

The value of all livestock and poultry on farms approximates $675,000,000; horses number about 60,000, cattle about 4,000,000 (including approximately 1,500,000 milk cows), sheep about 1,000,000 and hogs about 3,200,000. Minnesota is one of the great dairy states, leading all the states in butter production (about 400,000,000 lb. annually) and producing also 10,000,000 lb. of milk and about 9,000,000 lb. of cheese. Farmers' co-operative creameries were largely responsible for the growth of dairy product marketing.

Total area in farms is about 33,000,000 ac., with an average farm size of nearly 200 ac.

**Mining.**—Minnesota leads the nation in the production of iron ore, although shipments declined in the second half of the 20th century. The ore comes from three districts, the Vermilion, Mesabi and Cuyuna ranges, named in the order of their discovery and development, all lying in the northern part of the state. About 90% of the ore comes from the Mesabi range, from the first shipment of ore from this range in 1892 to 1950, the Mesabi contributed about 1,500,000,000 tons of high-grade ore. An estimated 1,500,000,000 tons of merchantable ore remains deposited in the three ranges. A great deal of the mining is of the open-pit character. Steam shovels in the mines load the ore on trains that run directly to the docks at Two Harbors or Duluth, where steamers wait to carry it to the steel mills at Chicago, Gary or Erie.

After World War II the production of taconite (*q.v.*) developed rapidly in Minnesota, a commercially feasible concentration process making possible the utilization of low-grade ore. The taconite industry, involving both mining and manufacturing, gave new economic life to northeastern Minnesota, and the state's taconite reserves have been estimated at 24,000,000,000 tons.

The remainder of the state's mineral output is made up largely of quarry products. Minnesota has extensive deposits of granite, limestone, jasper, sandstone, travertine, mica, feldspar and clay. The state ranks third in the production of granite with St. Cloud as the centre of this industry.

**Lumbering.**—During the years following the Civil War, the pine forest resources of the state were intensively exploited. Minneapolis and Duluth owed their rapid growth in the 1870s and 1880s in part to the milling and shipping of lumber. In 1905 production of lumber reached its peak with the cutting of 2,000,000,000 board feet of timber. By then the area's magnificent stands of white pine were nearly depleted and the industry declined rapidly. The mid-20th century saw the state's forest industries rise again, with the production of pulpwood, Christmas trees and other wood products. Scientific forestry practices and new uses for the less valuable timber created by modern manufacturing processes resulted in a larger annual income than was ever obtained from the original forests.

There are two national forests in the state, Superior and Chippewa, with a combined area of more than 4,000,000 ac., and 34 state forests with a combined area of 5,500,000 ac.

**Manufactures.**—Throughout most of its existence, Minnesota has been predominantly an agricultural state. In the mid-20th century, however, its industrialization accelerated, and by 1950 the dollar value of manufactured products exceeded cash farm receipts for the first time in the state's history. First in order of importance is the food industry, including meat slaughtering and packing (concentrated largely in South St. Paul and Austin), grain and feed mills and manufactured dairy products. Minneapolis has long been a principal centre of the flour-milling industry for the United States, and accounts for much of the manufactured output of grain and feed in the state. Water power from the Falls of St. Anthony was the chief factor for Minneapolis taking the lead in milling. By 1870 twelve mills were operating at the falls, and the industry continued to expand until 1916. Thereafter it declined, though remaining very important. The great grain elevators are a feature of the Minneapolis skyline.

The second largest manufacturing industry is that of machinery (other than electrical) and following that in importance are printing, publishing and allied products; chemical products; pulp, paper and allied products; and fabricated metal products.

Growth in development of electric power was tremendous in the period following World War II. The two chief sources were steam power and water power, with a smaller amount derived from internal combustion. The state's first atomic power plant, constructed at Elk river by the Rural Cooperative Power association in co-operation with the Atomic Energy commission, began to

provide electricity for co-op members in 1960. Three types of suppliers of electricity—power companies, municipally owned utilities and rural electric co-operatives—operate in Minnesota. Almost all occupied dwellings in the state are serviced by electricity.

**Transportation and Communications.**—Minnesota is well provided with transportation facilities by water, air and land. Duluth stands at the head of the Great Lakes, and through its port pass most of the iron ore extracted from the Minnesota mines and a large share of the grain grown in the northwest. It is also a receiving port and distributing point for coal and other products for the area. In gross shipping tonnage Duluth ranks second only to New York city. Several railways connect with Chicago while others reach out into the wheat lands of the Dakotas, Montana and western Canada. At the head of navigation on the Mississippi stand St. Paul and Minneapolis.

River transportation was developed early in the state's history, the first steamer reaching Ft. Snelling in 1823, and it continues to be important in Minnesota's transportation system. In 1930 a nine-foot channel on the Mississippi river with attendant locks and dams was opened to traffic, and after that time barge traffic increased steadily. By the early 1960s about 7,000,000 tons of freight were shipped annually on the Mississippi and its tributaries in Minnesota, as compared with 2,500,000 tons in 1949.

Minnesota's first railroad was completed between St. Paul and St. Anthony in 1862 by the St. Paul and Pacific, the road that was reorganized under the leadership of James J. Hill in 1878 and eventually became the Great Northern. From the older centres in Minnesota, tracks reached out to the west, north and south. The Northern Pacific, the first road to connect the state with the Pacific coast, was completed under the guidance of Henry Villard in 1883. By the 1960s Class I railroads in Minnesota operated approximately 8,500 mi. of track.

Air travel is of significance in the state, numerous communities being served by airlines. An amendment to the state constitution passed in 1944 made available state funds to assist municipalities in improving airports; federal funds also are available. A unique feature of the state's aviation activity concerns the wilderness area of Superior National forest. Fear that the increasing number of flights into the area would destroy its wilderness character led the state legislature in 1949 to take steps to control air activity, and in Dec. 1949 an executive order issued by Pres. Harry S. Truman banned flights over Superior National forest wilderness area beginning Jan. 1, 1951.

The state trunk highway system includes 12,000 mi. of mostly paved roads. All highways and roads total almost 125,000 mi. Annual disbursements for the trunk highway system were increased more than 500% in the decade beginning 1950, from $43,000,000 to approximately $242,000,000. Building and maintenance of the trunk highways was financed by taxes on motor vehicles and gasoline, bond issues and federal aid. The trunk system is kept open for motor travel all winter.

There are about 30 daily and more than 300 weekly and semi-weekly newspapers in Minnesota. The Minnesota Newspaper association was founded in 1867, though its membership includes all of the state's newspapers, it is primarily the voice of the weekly press.

Commercial radio broadcasting began in Minnesota in 1922 with station WLAG (forerunner of WCCO); network broadcasting came to the state in 1925. KSTP began experimenting with television cameras in 1939 and brought telecasting to the state on April 27, 1948.

Private experimental telephone lines were run to the Twin Cities in 1877, and the following year the Northwestern Telephone company was operating in Minneapolis. Numerous independent companies sprang up, some of them using the rapidly improving Bell equipment. Eventually, the majority of the companies were consolidated into the Northwestern Bell Telephone company, a subsidiary of the American Telephone and Telegraph company. However, a few independent telephone companies still operate in the rural areas of the state.

*See* also references under "Minnesota" in the Index.

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Current statistics on production, employment, industry, etc., may be obtained from pertinent state departments; the principal figures are summarized annually in *Britannica Book of the Year*, American edition.

(R. W. F.)

**MINNESOTA, UNIVERSITY OF,** an institution of higher learning with campuses at Minneapolis, St. Paul and Duluth, Minn., was established under the Territorial act in 1851 and began instruction in 1869 (*see* MINNESOTA: *Education*).

**MINNOW,** in North America the name given to a variety of small fishes, especially cyprinids (shiners, for example), mud minnows (family Umbridae) and killifishes (Cyprinodontidae); also, in a general way, to the young of many kinds of large fishes.

*Phoxinus phoxinus*, of the carp family (Cyprinidae), is the minnow of Europe and northern Asia; it is distinguished from the dace and chub, allied cyprinids, by its small scales. A length of three or four inches is usual, but specimens seven inches long are known. In New Zealand and Tasmania fishes of the family Galaxiidae are called minnows.

Mud minnows are related to the pike, from which they differ in having uniformly small, weak teeth. They live in mud or among weeds of sluggish streams and ponds. Among the killifishes, the top minnow or mosquito fish (*Gambusia affinis*) is the best known. It occurs naturally in lowland marshes, pools and lagoons of the south Atlantic and Gulf regions of the United States. It bears live young and is exceedingly prolific. This fish is so effective as a destroyer of mosquito larvae that it has been widely introduced to control mosquitoes. Anglers use all kinds of minnowlike fishes as bait. *See* also FISH; FISHING. (L. A. WD.)

**MINOAN CIVILIZATION:** *see* AEGEAN CIVILIZATION; CRETE.

**MINOAN LINEAR SCRIPTS.** This term denotes the well-developed varieties of writing used by certain Aegean civilizations (*q.v.*) during the 2nd millennium B.C. Like other early writing systems in the near east (*see* CUNEIFORM), this Minoan-Mycenaean type of script had its beginnings in pictography, originating on the island of Crete (*see* CRETE: *Archaeology*). There is no conclusive evidence for more remote outside origin or inspiration, though the latter is an a priori assumption with those scholars who believe in the monogenesis (single origin) of all writing.

**Origins.**—The origins of this script are seen on stone seals dating from the Middle Minoan period (beginning *c.* 2000 B.C.), found on the surface in different parts of Crete, and in early archaeological strata of the palace sites, notably Cnossus and Phaistos. The latter contain seal impressions in clay and tags or tablets of the same material which served the practical purpose of identification. The pictographic origin is still clearly visible in the signs at this hieroglyphic stage (*e.g.*, a double axe, an eye, a cat's head). Yet compared with the complicated word-syllabic stage of Egyptian, Mesopotamian, "Hieroglyphic Hittite," and other early systems, with their mixtures of ideographic and phonetic values of signs, classifiers and complements, Minoan writing early developed an everyday practicality; already the hieroglyphs were so limited in number that they indicate the emergence of a rudimentary but purely syllabic method for the phonetic rendering of proper names. A system of ideograms was restricted to a standard shorthand for objects listed on the tablets, accompanied by numerals and fractions; such ideograms were apparently never confused with syllabic writing. An isolated exception to this ancient practice is found on the so-called Phaistos disk, covered with pictographic clay impressions made from movable types; but it is uncertain that this unique find is truly Cretan, and not an import from Asia Minor.

**Linear A.**—The finds are rather limited in scope and length; both writing and language remain undeciphered. About 1700 B.C. a more advanced cursive system of writing began to displace the hieroglyphs in Crete; in some archaeological strata the two systems are found side by side. The later system, called "Linear A," occurs at many Cretan sites, but the documents are not numerous; they come from Cnossus, Phaistos, Palaikastro, Mallia, Gurnia, Tylissos and elsewhere. The largest find was made at Hagia Triada (well over 150 page-shaped clay tablets and seals), dating from the Late Minoan period (*c.* 1450 B.C.). Despite the spare range of the texts, Linear A tablets appear to record one and the same language (conjectured to be Minoan or Eteo-Cretan), at least to judge from recurring combinations of the same signs in various localities. The comparatively large uniform corpus of Hagia Triada has about 75 syllabic signs, many of which evidently are partly cursive equivalents of related hieroglyphic forms. The narrow oblong tablets necessitated frequent word-division from line to line, and a raised dot was used as a separator between words. The direction of writing, which varied in the hieroglyphs, ran uniformly from left to right. The system of ideograms continued the hieroglyphic tradition, but it also admits the ideographic use of signs otherwise syllabic, probably by way of an acrophonic abbreviation using the initial syllable of corresponding words. Several phonetic signs might be joined into a complex monogram on the same principle, and phonetic ligatures were added to the ideograms proper. The ideograms were followed immediately by signs for numerals and fractions which differ from the corresponding hieroglyphic signs.

**Linear B.**—The Linear B script belonged entirely to the Late Minoan period. Sir Arthur John Evans found over 3,000 tablets or fragments in the latest (i.e., most recent) stratum at Cnossus at the date of its destruction (*c.* 1400 B.C.), but not a single trace of Linear B has been discovered elsewhere in Crete. The script was used primarily on the Greek mainland during the chronologically parallel Late Helladic era. The largest corpus came from the site of Pylos in Messenia, where between 1939 and 1958 Carl Blegen excavated well over 1,000 tablets, many of considerable length and in an excellent state of preservation. Mycenae yielded over 50 tablets during the 1950s. Linear B is found also in inscriptions on jars and pots from Tiryns, Mycenae, Eleusis, Boeotian Orchomenos and, especially, Thebes.

There is no trace of monumental writing anywhere in the Minoan-Mycenaean orbit. Linear B, like its exclusively Cretan predecessor, served mainly for perishable records and inventories of royal palaces and commercial establishments. These temporary clay tablets (some of them of palm leaf shape, with long lines of text) were preserved by being baked in the conflagrations which destroyed the storerooms. Linear B contains 87 different syllabic signs, of which more than half correspond closely in shape to those of Linear A, while one third have no recognizable equivalents. The ideograms and numerals are quite close to the Linear A pattern, but the system of weights and measures contains distinctive signs for fractional quantities, placed after the ideograms but before the numerals; although several signs are obviously related in form to signs for fractions in Linear A, the very system represents a striking departure from the earlier method of reckoning. It might be said that in Linear A the commodities are measured in whole numbers and successively smaller mathematical fractions of an unstated total unit, while the Linear B system measures in terms of smaller conventional units in their own right, which happen also to be fractions of a larger basic unit.

**Decipherment of Linear B.**—One of the great achievements of decipherment in modern times has revealed that Linear B gives the Greek language of the 14th and 13th centuries B.C. The solution advanced in 1953 by Michael Ventris (*q.v.*) was founded on the surmise that the language is early Greek, and that accordingly Cnossus must have been in the hands of Helladic mainlanders before its final destruction about 1400 B.C. In view of the earlier Minoan influence on the mainland, beginning about 1700 B.C., it is uncertain whether Linear B was adapted from the Cretan type by 15th-century Greeks at Cnossus, or was developed on the mainland after Cretan models. The latter is more probable, although the Cnossian corpus antedates all inscriptional evidence from the mainland. The signs generally represent open syllables like *ma*, *mi*, *mo*; such a system may have suited the Minoan language quite admirably, but for Greek it resulted in very awkward rules of orthography, characterized by superfluous vowels and an inability to note certain grouped or final single consonants, or to distinguish between voiceless, voiced and aspirated orders of phonemes. Thus *pa-te* may denote *pater* ("father") or *panter* ("all"); such ambiguity, like the monotonous conciseness of the ledger style and the proliferation of proper names, places limitations on the results to be derived from knowledge of Linear B. Yet the impact of the decipherment has made itself felt in many classical studies.

A distant offshoot of the early Cretan scripts is the undeciphered Cypriote Linear or Cypro-Minoan type, found on a small scale in a number of baked clay tablets from Enkomi in Cyprus and Ugarit in Syria, dated from 1500 to 1100 B.C. A late development of it crops up in the Cypriote syllabary used in Cyprus for writing Greek and Eteo-Cypriote in classical times.

*See* M. Ventris and J. Chadwick, *Documents in Mycenaean Greek* (1956), with bibliography, pp. 428–43; J. Chadwick, *The Decipherment of Linear B* (1958). (J. PI.)

**MINORCA** (Sp. MENORCA), the second in size of the Balearic Islands and a part of Baleares province, Spain, is located 27 mi. N.E. of Majorca. Area 271 sq.mi. Pop. (1960) 42,688. Most of the island is a dry monotonous tableland with an average height between 150 and 300 ft., some rugged hills rising in its north centre to Monte Toro (1,174 ft.). The northern coast is deeply indented with many capes and deep inlets, such as the bays of La Albufera, Addaya and Fornells. The fine natural harbour of Mahón (*q.v.*) is the best port of the Balearics and was much prized for its strategic value in the wars of the 18th century. The south coast is more regular and has long stretches of cliffs. The climate is less equable and rainier than that of Majorca, the island being exposed to cool northerly winds in autumn and winter.

Many of the plateau limestone soils are suitable only for light grazing, but some of the higher districts are terraced and yield rich harvests, as do the few alluvial valleys which run down to the south coast. The *huerta* of Mahón, irrigated by artesian wells, is especially productive, and its windmills are a characteristic feature of the Minorcan landscape. The principal crops are cereals, potatoes, melons, pomegranates, figs and almonds. Cattle, horses, sheep and goats are kept, and cheese is exported to the mainland. The farming system is that of peasant proprietorship, and the domestic economy is supplemented by fishing, lobsters being plentiful off the north coast. The manufacture of leather shoes employs about 10% of the population in a number of small factories throughout the island. Minorca has many beautiful beaches, and its tourist business, formerly much inferior to that of Majorca and Ibiza, is expanding. A road constructed in 1713–15 by Sir Richard Kane, the British governor, connects Mahón (pop. [1960] 16,618 [mun.]), the capital, with Ciudadela (pop. [1960] 12,228 [mun.]), which from Moorish times until the 18th-century British occupation was the capital of Minorca. Air and maritime services link the island with Barcelona and Majorca, and there are air services from London.

Noted for its strong democratic traditions, Minorca remained in loyalist possession for most of the Spanish civil war, 1936–38. For archaeology and history, *see* BALEARIC ISLANDS. (G. J. B.)

**MINORITIES** are groups held together by ties of common descent, language or religious faith and feeling themselves different in these respects from the majority of the inhabitants of a given political entity. On this consciousness of difference the minorities base certain political claims, either for equality with the majority or for special treatment based upon the recognition of these differences, or for autonomy or, in the most extreme cases, separation.

In most cases minorities feel grieved by occupying an underprivileged position. But there are cases when numerical minorities are politically and economically highly privileged like the white population in the Republic of South Africa and when the vast majority of the population feels aggrieved. Thus "majority" and "minority" become primarily political and not numerical concepts.

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## I. ORIGIN AND NATURE OF MINORITY PROBLEMS

Minorities have always existed, but only after the rise of democracy, in the late 18th century, did they become a serious political problem and play a great role in international relations. Modern humanitarianism and law have tried to dull the sharpness of minority conflicts by providing protection, based upon international treaties, for minorities of race, language or religion.

The origin of some of these minorities can be found not only in past conquests but also in the peaceful unions of different groups. Thus the Muslim minority in India was the result of the conquest of a large part of India by Muslim invaders. Yet this minority, differing in religion and civilization from the Hindu majority, formed itself a majority in vast areas where the Hindus were a minority intermingling with the Muslims. The Russian empire included many minorities as a result of three centuries of widespread conquests in east and west. On the other hand, the Habsburg empire was largely built up by dynastic marriages and succession rights.

Poland contained large and important minorities as a result of a peaceful union between Poland and Lithuania, when the latter included White Russian and Ukrainian populations. Other minorities originated in migratory movements. In former times rulers frequently called colonizers from abroad to settle on wasteland or to introduce new skills and trades. These settlers received special privileges and were allowed to live in closed settlements according to their own rules. Thus important German colonies were scattered in the later middle ages and during the period of the absolute monarchs throughout central and eastern Europe.

Empress Catherine II of Russia settled them in the distant regions on the middle Volga river. In a somewhat similar way European traders settled in oriental communities and were there granted the privileges of extraterritoriality or, as called in the near east, capitulations. Migrations during the Industrial Revolution created minority problems in many parts of Europe and America. Still other minorities (e.g., many religious minorities in the near and middle east) represent the remnants of an older civilization which has resisted the otherwise victorious progress of new religious movements.

Migration also created strongly entrenched Chinese minorities throughout southeast Asia and equally strong East Indian minorities in East Africa and Guiana.

The term minority is flexible in its application with ever fluid limits and perplexing in its political and social consequences. Oppressed minorities often and easily tend to become, at the first opportunity, oppressive majorities, yet as long as they feel themselves underprivileged, they generally appeal to the principles of liberty and humanity and tend to identify their interests with those of the freedom and peace of mankind. They insist upon respect for their own traditions and cultural pattern, irrespective of whether such an insistence forms a bar to greater progress by the preservation of obsolete ways of life.

**1. Religious Minorities.**—Before the beginning of the 19th century, the age of nationalism and democracy, minorities scarcely played any decisive role in national or international politics. Only religious minorities played a distinctive role during the later middle ages and especially in early modern times, when states were often inclined to emphasize their religious homogeneity and therefore tried to eliminate all "heretics." This situation was much aggravated by the Reformation and the ensuing great religious split.

Religious minorities were often treated with great severity and sometimes even forced to emigrate. The great international conflicts of the age were often interpreted as religious wars. Catholic or Protestant princes intervened on behalf of their co-religionists in alien lands. Thus Oliver Cromwell, supported by English public opinion, intervened in 1655 with France for the Vaudois Protestants, a step of which John Morley wrote that "never was the great conception of a powerful state having duties along with interests more magnanimously realized." The treaty of Westphalia, 1648, tried to stabilize the situation, at least in Germany, then the classical land of conflicting religions. It confirmed for the princes of German territories the right of deciding by fiat the religion of their subjects (*cuius regio, illius religio*),

reserving however in such cases the right of emigration for the dissident subjects.

The intervention in favour of religious minorities expressed itself repeatedly in international treaties. In the treaty of Utrecht (1713–14) between Great Britain and France the liberation of the French Protestants in prison for religious causes was stipulated. More frequent were guarantees for the religious liberty of the inhabitants of territories ceded in peace treaties to powers where the majority of the inhabitants, and especially the prince, professed a religion different from that in the ceded territory. In the treaty of Oliva (1660) between Sweden, Poland and Brandenburg, the religious rights of the inhabitants of Livonia, ceded by Poland to Sweden, and of Pomorze, ceded by Brandenburg, were recognized. In the treaties of Nijmegen (1678) Louis XIV of France restored to Holland the town of Maastricht, taken by the French in 1673, reserving religious liberty in favour of the Catholic inhabitants. The same measures of safeguard were inserted in the treaty of Rijswijk (1697). When Prussia acquired under King Frederick II large territories with Catholic population, Silesia from Austria in 1742, and part of western Poland in the first partition of Poland in 1772, the treaties contained provisions in the interest of the new Catholic minorities of Frederick's realm. All these provisions safeguarding religious minorities applied, however, only to limited territories as a result of territorial transfer; they did not include any principle applicable to the states as a whole.

In the 18th century growing religious toleration ushered in an era of equal rights for religious minorities in the British empire and in western Europe. The secularization of the modern state with its separation of state and church brought this process of complete equality in religious matters to its conclusion in the 19th century, except in eastern Europe and in the orient. In the Russian empire the religious minorities remained until 1917 under various restrictions and disabilities as compared with the Orthodox Church. In Iran and other Muslim states Islam remained the dominant and privileged religion. In the Ottoman empire the non-Islamic religions were accorded a large degree of autonomy under their religious heads, and in the 19th century they received gradually equality before the law and citizenship rights. European powers often acted in the 18th and 19th centuries as protectors of their coreligionists in the Ottoman empire, the Russians for the Orthodox minorities, the French and others for the Catholic minorities.

**2. The Age of Nationalism.**—While the victory of religious toleration and liberalism removed gradually the question of religious minorities from the political scene, the growth of nationalism in the 19th century and its penetration to central and eastern Europe and later to Asia created new and ever more disturbing minority problems. The German philosopher and critic of civilization Johann Gottfried von Herder (1744–1803) emphasized the importance of the mother tongue for the cultural life and growth of the individual and his education. Under his influence many of the smaller nationalities in central and eastern Europe found their interest in their own languages and folklore rekindled and began to feel conscious of their position as linguistic and ethnic minorities in the Austrian, Russian and Turkish empires. They began to demand the recognition of their languages in the public administration of their countries; their intellectuals began to elaborate a literature in the native vernacular; and the spread of education in the 19th century carried this insistence upon language and nationality to ever wider circles. This cultural nationalism was strengthened by the message of self-determination carried by the French Revolution and spread over Europe through Napoleon's armies. It undermined the feudal dynastic structure of European society on behalf of the rights of the middle classes and the people. The insistence upon popular sovereignty replaced the supranational prince with a rising class of patriots and the supranational language of court and administration, French or Latin, with the vernacular. Historians and poets recreated a half-legendary past in which the peoples had supposedly played a great part. The dormant national consciousness was thus awakened, and the closer contact created by the Industrial Revolution with its improved communications and the spread of literacy, made the people more conscious of their unity as well as of their difference from groups speaking other languages or living according to different traditional patterns. The 19th century, the age of nationalism, became thus more and more the century of national minority problems. Race, religion and language began to play their roles as characteristics of the national minorities.

In central and eastern Europe, where the political and social developments lagged far behind western Europe, nationalism produced the theory that each nationality should form its own state and that each state should consist of only one nationality. Nationality, recognizable by language, was thus made to coincide, at least ideally, with the state. While the French never put forward the claim of uniting all the French-speaking citizens of Belgium and Switzerland within France nor the Dutch ever demanded the incorporation of the Flemish-speaking Belgians into the Netherlands, the Germans and the Italians directed their political energies to the union of all German- and all Italian-speaking peoples within a united Germany and Italy. Italian-speaking provinces outside the Italian peninsula were regarded as "unredeemed" (*irredenta*) and their movements toward "redemption" by union within a political Italian nation were called "irredentist," a word then applied to other national minority aspirations for separation from the state in which they lived. As far as Italy was concerned, after the unification of the Italian peninsula in the 1860s, the most important centres of irredentism were in Trent in Austrian South Tirol, and in Trieste, the great Austrian port.

While the Italian language minorities lived mostly contiguous with the main territory inhabited by Italian-speaking people, German language minorities were widely dispersed throughout central and eastern Europe, mostly in the midst of Slav populations. These minorities (and later on similar ones in the U.S. and especially in South America) formed the backbone of Pan-German aspirations, which wished to support the expansion of German power and the establishment of German world supremacy by making use of these minorities. In the 20th century Germans and others fostered the national consciousness of their "racial brethren" living "abroad" and tried to forestall the process of their integration with the people in the midst of whom they were living.

On the other hand many Slav people represented minorities in the four great empires of the east, Germany, Austria, Turkey and Russia. The 19th century saw the growth of independence movements among these Slav minorities which often threatened the territorial integrity of the political states in which they lived. Russia, by far the largest Slav nation and in the first half of the 19th century the only independent one, used the Slav aspirations within Austria and Turkey as an instrument of its own power aspirations; Pan-Slavism thus became a vehicle of Russian policy and was especially used to justify Russian interference in Turkish affairs.

The original motive of religious concern for the Greek Orthodox minorities (which in addition to Slav peoples included Greeks and Rumanians) and for the Armenian Orthodox minority was not dropped but fortified through Russia's interest in its "racial brethren," the Serbs and the Bulgarians. Thus minority problems in central and eastern Europe formed in the 19th century one of the most important issues in international relations. They were the cause of the Russo-Turkish wars and of the Balkan wars; they kept alive the tension between Russia and Austria and between Austria and Italy. The fates of the Serbian minority in Austria and of the German minority in Poland were the immediate causes of World Wars I and II.

While the minorities thus played a most important role in international relations, their role in the domestic policies of central and eastern European states was scarcely less important. The revolutions of 1848, often called "the spring of the peoples," awakened the dormant nationalities of central and southeastern Europe to cultural and political consciousness. The revolution of 1905 did the same for the many more backward nationalities

of the vast Russian empire. From 1821, the year of the beginning of the Greek war for independence, until the end of World War I the Turkish empire passed, as a result of minorities' pressure, through a period of progressive territorial disintegration. But it was above all the Habsburg empire which became in the later half of the 19th century the classical land of minority problems and the laboratory for attempts at their solution.

**3. Central Europe.**—The Compromise of 1867 divided the Habsburg empire into a western or Austrian part, and an eastern or Hungarian part. They followed different policies as regards their minorities, though the term "minorities" cannot be applied in either case in the strict sense of the word. Neither in the western nor in the eastern part was there a numerical majority, but in Hungary the Magyars, though numerically a minority, were politically in the position of a dominant majority. The Magyar language was made the only official language, except for the territory of Croatia-Slavonia which enjoyed a measure of autonomy. Government pressure was exercised to assimilate the minorities to the ruling Magyar group whose concern it was to create a purely Magyar state. The Magyars themselves lived in the centre of the country, in the fertile plains of the Danube and Tisza rivers, while around them the minorities—in the north and northwest Slovaks, in the northeast Ukrainians, in the east (Transylvania) Rumanians and in the south Croatians and Serbs—lived in compact groups. Yet even within these compact minority settlements, there were other minorities interspersed. Thus in Transylvania, among a large Rumanian majority, a Magyar minority, the so-called Szeklers, lived in the eastern part of the land, separated from the majority settlement of the Magyars, while in the south there was a German minority, the so-called Saxons. An even greater mixture of minorities was presented by the Banat in southeastern Hungary, where Magyars, Serbs, Rumanians, Germans and others intermingled, while German minorities, mostly called Swabians, were numerous in many parts of Hungary, especially in the south and the centre.

The non-Magyar minorities resented being treated as subject races to an ever growing degree, especially because some of them like the Rumanians, the Serbs, the Slovaks and the Ukrainians were living in direct contact with kindred peoples beyond the frontiers of Hungary, a fact which increased the centrifugal tendencies and prepared for the disintegration of Hungary in 1918.

Similar centrifugal tendencies threatened the existence of Austria, though in its case one cannot speak of any real oppression of the minorities. Article 19 of the constitutional law of Dec. 21, 1867, provided for the equality of the different nationalities ("all nationalities in the state have equal rights") and proclaimed that every nationality had an inviolable right to preserve and promote its national character and language. Austria recognized in its fundamental laws the equality of all usually spoken languages in education, in the administration and in public life. These provisions were by far the most liberal and progressive of the period, but they were vague, and the following half century was largely filled with a conflict for the interpretation of this fundamental act, the Magna Carta of the Austrian nationalities. Fierce national struggles centred around the rights and usages of the different languages and around changes in the economic position of the different nationalities. These struggles often impeded the functioning of the Austrian parliament. Many interesting and promising attempts to solve the minority problem were made, especially in the provinces of Moravia and Bukovina, but on the whole the problem remained unsolved in Austria until under the stress of World War I the state disintegrated and its minority problems were inherited by the so-called succession states.

Of the different provinces of Austria few were inhabited by only one nationality; most of them had their minority problems. In Bohemia, Moravia and Silesia there were Czechs and Germans, in the latter also Poles. In Styria and Carinthia Germans and Slovenes lived side by side; in the territories along the Adriatic coast Italians and Slovenes mingled in the north, Croats and Italians in the south. Southern Tirol had an Italian minority. In the Bukovina Ukrainians, Rumanians and Germans lived interspersed, while in Galicia the western part was predominantly Polish and the eastern part, except for the upper classes in the cities, largely Ukrainian. Many of these minorities were supported by kindred people speaking the same language on the other side of the frontiers. Thus the Austrian-Italian minority looked to Italy for guidance, some of the Croats and Serbs, especially after Austria's annexation of Bosnia-Hercegovina (1908) with its large Serbo-Croat population, saw in the independent Serbian kingdom in the Balkans the centre for the unification of all the southern Slavs, many of the Austrian Germans longed for inclusion in the German *Reich* created by Bismarck. This Pan-German movement was especially strong in the German-speaking parts of Bohemia, later called the Sudetenland, where Georg von Schönerer started a violently anti-Habsburg, anti-Catholic and anti-Semitic movement, a tradition in which Adolf Hitler later grew up. The Poles in Galicia had no independent nation outside the Austrian borders with which to be unified, but throughout the 19th century they hoped for the restitution of a united Poland, made up of the Russian, Prussian and Austrian parts of the former Polish state.

Of the three groups into which Poland had been divided, the Poles in Austria were by far the best treated; they were the only ones to enjoy full political and cultural liberties, and even occupied in Austria a privileged position and developed a class of high civil servants and well-trained administrators. Some Czechs and the Slovaks, living entirely on Austro-Hungarian territory, looked expectantly to Russia, the big Slav brother, for help in their national liberation. With all these mingled populations and conflicting aspirations, the dissolution of the Habsburg empire at the end of World War I presented a difficult problem for the new ordering of Europe, especially as the victors of World War I emphasized the principle of national self-determination and the liberation of minorities.

Infinitely simpler than in Austria were the minority problems within the German empire. There the minorities lived along the borders of the empire in compact groups contiguous with kindred populations beyond the frontiers, and had been incorporated into the German political system only in relatively recent times as a result of territorial aggrandizement and victorious wars. The Poles, mainly in the provinces of Poznania and western Prussia, had come under Prussian domination as a result of the partitions of Poland in the 18th century; the Danes in northern Schleswig were included in Prussia as a result of the Seven Weeks' War of 1866, and finally Alsatians and Lorrainers had been forced against their will into the new German empire after the German victory over France in 1871. All these minorities felt bitterly oppressed within the German empire; its defeat in 1918 offered the opportunity for the liberation of these minorities and their reunion with their Polish, Danish and French conationals. Especially the Polish minority had been subjected to a process of forced denationalization, and drastic methods had been adopted in the "eastern marches" to dispossess the Poles and to settle Germans in their stead.

As a result of this German settlement policy and of the germanization of some of the cities within Polish territory, the drawing of the frontier between Germany and Poland presented some difficulty in 1918. In addition to these three more recent minorities, who were backed by their conationals outside Germany, the German empire included some submerged Slav minorities like the Sorbs or Wends in Upper Lusatia and the Masurians of eastern Prussia.

**4. The Russian Empire.**—In the Russian empire, which had grown rapidly through the conquest of vast territories from the 16th to the 19th centuries, the Russians themselves formed barely a majority of the population. The country was inhabited by almost 100 different nationalities, some of them numerically insignificant, others very sizable, some of a higher cultural level than the Russians themselves, many others in different stages of backwardness, in their totality representing an infinite variety of races, European and Asiatic, and of religions, Catholic and Protestant, Muslim and Buddhist. The highly cultured minorities living on the western fringes of the empire, like the Germans in

the Baltic provinces, the Poles and the Finns, enjoyed in the first half of the 19th century varying but on the whole far-reaching degrees of autonomy. In the later part of the century, however, the empire followed increasingly a determined policy of russianization of all the minorities, reserving for the Russian nationality and for the Greek Orthodox Church a position of privilege while oppressing the minority nationalities and religions. This oppression took different forms, but the denial of equality and of political rights was common to all of them. The Jews formed the most oppressed minority. The revolution of 1905 marked the first step in easing the situation of the minorities; the democratic March revolution of 1917 brought the proclamation of their complete equality.

The highly developed border nationalities in the west, the Poles, Lithuanians, Latvians, Estonians and Finns, proclaimed their independence which the new Soviet government was then too weak to deny; the rest of the empire was reconstituted as the Union of Soviet Socialist Republics, which granted equality to all its minorities and, at least theoretically, abolished the privileged position of the Russian element. The unexpected simultaneous disintegration of Austria, Germany and Russia made possible the reconstitution of a unified Poland.

Similarly complex as in the Habsburg and Russian empires was the minority situation in the Ottoman empire in the 19th century. In its European part many minorities, the Greeks, the Rumanians, the Serbs, the Bulgarians and finally the Albanians, achieved their independence, but the intermingling of minorities left many problems unsolved, especially in Macedonia, which was claimed by Greece, Serbia and Bulgaria, and in Albania where in the north Serbs and in the south Greeks lived on territory claimed as Albanian. Asiatic Turkey with its Greek and Armenian minorities among the Christians, Arab and Kurdish minorities among the Muslims, presented a complex problem at the end of World War I which under the then existing circumstances was solved in different ways, by separation (Arabs), by suppression (Armenians and Kurds) and finally by exchange of populations (Greeks).

**5. Western Europe.**—Fundamentally different from the situation in central and eastern Europe was the problem in western Europe. If we regard as a minority in the technical sense here discussed "a group that does not feel at home" in the state where it lives (Edgar J. Fisher), neither the Scots nor Welsh in Great Britain nor the Bretons nor Basques in France nor the Italians in Switzerland can be regarded as minorities. Before World War I there were only two true minorities in western Europe: the Catalans and to a lesser degree the Basques in Spain, and the Irish in Great Britain since the union. The Catalans, culturally and economically more advanced than the Spaniards, demanded cultural and political autonomy and opposed the centralizing tendencies of the Madrid government which went so far as to suppress the use of the Catalan language. The Irish minority problem was on the way to solution before World War I by Great Britain's readiness to grant Ireland home rule. Efforts in that direction, started when William E. Gladstone's third ministry in 1886 introduced the first Home Rule bill, were crowned by the passage of the (third) Home Rule bill in Sept. 1914, but the Irish situation was complicated by a typical minority problem, the Scottish Protestant minority in northeastern Ireland (Ulster), which appealed to its own right for self-determination against its subjection to Irish Catholic majority rule. A further complication was presented by a large Irish Catholic minority within Ulster, the territory of the Irish Protestants. As in many other cases (Catholic Poles and Protestant Prussians, Catholic Poles and Orthodox Ukrainians, etc.), the national minority problem was aggravated by religious differences, though many of the leaders of the Irish Catholics in their struggle against England were Protestants of English descent.

## II. WORLD WAR I AND ITS AFTERMATH

That was the complex minority situation found at the beginning of World War I, a war which from its start involved the rights of small nationalities (Serbia and Belgium). As early as Aug. 5, 1914, the British prime minister, Herbert Asquith, declared that "We are fighting . . . that small nationalities are not to be crushed, in defiance of international good faith, by the arbitrary will of a strong and overmastering power." From the beginning of the war Germany appealed to the minorities within the Allied nations (the Irish in Great Britain, the Poles and others in Russia) and tried to enlist them in the service of the German cause. Similarly the Muslim Turks tried to enlist the Muslim subjects of Great Britain, Russia and France in a "holy war" on the side of Germany and Turkey. Later on the Allies appealed to the minorities in Austria-Hungary, in Turkey and in Germany and tried to win them for collaboration with the Allies for the realization of what soon became one of their declared war aims, the recognition of the principle of nationality and self-determination. The British entered into negotiations with the Arabs and succeeded in enlisting Sherif Husain ibn Ali of Mecca, to raise the banner of Arab independence and unity in 1916. The Russians, followed by other Allied nations and the United States, held out the prospect of autonomy or independence for the Armenians in Turkey. Leaders of the various non-Germanic and non-Magyar peoples of the Habsburg monarchy entered into negotiations with Allied and U.S. statesmen.

The principles of nationality and self-determination were accepted as an official war aim by President Wilson in his address to congress, Jan. 5, 1918, when he demanded in point 9 "a readjustment of the frontiers of Italy along clearly recognized lines of nationality"; in point 10 that "the peoples of Austria-Hungary should be accorded the freest opportunity of autonomous development", in point 11 the adjustment of Balkan relations along historically established lines of nationality; in point 12 "an absolutely unmolested opportunity of autonomous development" for the minorities in Turkey; and in point 13 the erection of an independent Polish state to include the territories inhabited by indisputably Polish populations and assured a free and secure access to the sea. In his address to congress Feb. 11, 1918, the president repeated that "All well-defined national aspirations shall be accorded the utmost satisfaction," but he introduced also the warning and restricting qualification "that can be accorded them without introducing new or perpetuating old elements of discord and antagonism that would be likely in time to break the peace in Europe and consequently of the world." Wilson's 14 and supplementary points were unfortunately as vague as regards national self-determination as in most other respects, proclaiming general principles rather than the clear bases of a policy to be followed.

**1. Peace Treaties of 1919.**—The peace treaties of 1919 created east of the Rhine and the Alps a new Europe. The intention was to bring central and eastern Europe into line with the progressive development of western Europe and to introduce there the principles of constitutional liberty and of the nation-state based upon self-determination. In reality, the new Europe was not shaped exclusively or even predominantly by the good intentions of the peace treaties but by events which preceded the deliberations and decisions of the peace conference—such as the revolution and disintegration in Russia and the dissolution of the Habsburg empire—and by events following the peace treaties and settling international disputes without reference to the peace treaties (the Russo-Polish campaign of 1920, the seizure of Vilnius and Memel, the events in Turkey, etc.). The intention of creating the new Europe of individual and national liberty could not be fully realized, too many conflicts of the past, some of them reaching back for centuries, continued to influence the political life of Europe and to arouse the emotions of the masses. But even within the narrow limits in which the new Europe was ordered by the peace treaties themselves, the complete realization of the principle of national self-determination was found impossible. Minorities continued to exist and to present serious problems for international relations and domestic policies alike.

Had the principle of self-determination been carried out with complete disregard of all considerations of strategy and welfare, there would have remained important minorities in central and eastern Europe as a result of the intermingling of populations.

Many minorities lived separated from their conationals, so that it would have been entirely impossible to include them in states with a predominant population of their own nationality. The partition of Austria-Hungary and the realization of the principle of national self-determination along the western borders of the Russian empire created a situation which had to a certain degree to continue the many centuries old cohabitation of minorities of race, language and religion. One of these minorities, the Jews, who in eastern Europe had not undergone the process of assimilation which integrated them into the western nations, but had preserved in their mass settlements their own language and civilization, lived dispersed over several of the eastern European states and thus represented—at least until the time when progressive assimilation would possibly change the situation—a permanent minority. The newly created or enlarged states, Czechoslovakia, Poland, Rumania and Yugoslavia, resembled the Habsburg monarchy by the composite character of their populations. But on the whole the peace settlements of 1919 created a map of Europe much more in accordance with the principle of national self-determination than the map of 1914 had been. While in 1914 about 100,000,000 persons did not "feel at home" in the states in which they lived, their number was reduced as the result of World War I to about 25,000,000.

But in their effort to promote the growth of liberty and equality the peacemakers of 1919 did not stop at redrawing the map of Europe. They developed a system of protection by international treaties for minorities of race, language or religion. Such protection by international treaty had already been applied on a very limited scale in the 19th century, without however any supervision by an international body. In the case of the new Balkan states the protection of religious minorities and their rights was made a condition for the recognition of the new states. The treaty of Berlin (1878) stipulated in article 44 that differences of religion should not cause any differences in civic and political rights. The treaty of Berlin sought to guarantee, above all, the civic and political rights for the Jewish inhabitants of Rumania, which had refused to recognize them as citizens. But even after 1878 Rumania deliberately refused for 40 years to naturalize its Jewish inhabitants and to treat them as citizens. In view of this experience and of the violent anti-Semitism prevailing in Rumania and in the western part of the Russian empire (Poland and Ukraine), the Committee of Jewish Delegations at the Peace conference in Paris petitioned the peace conference on May 10, 1919, to secure to the people of the newly created or enlarged states of Europe, with adequate constitutional guarantees under the sanction of the League of Nations, admission to citizenship, civil, religious and political liberties as individuals and the right of organization and development as national minorities.

**2. Europe After 1919.**—No provisions for the protection of national, religious and racial minorities were incorporated into the text of the covenant of the League of Nations, though the Japanese delegation pressed for such a provision. But at the eighth plenary session of the peace conference on May 31, 1919, the French prime minister Georges Clemenceau and President Wilson emphasized the need for special protection for minorities in certain states. As a result of all the preceding deliberations and negotiations a treaty was signed between the principal Allied and associated powers on the one hand, and Poland on the other, at Versailles on June 28, 1919, the same day when the treaty with Germany was signed. The treaty with Poland served as a model for similar minority treaties concluded with other nations. In the treaty, Poland, "desiring to conform her institutions to the principles of liberty and justice, and to give a sure guarantee to the inhabitants of the territory over which she has assumed sovereignty," undertook to assure full and complete protection of life and liberty to all inhabitants of Poland without distinction of birth, nationality, language, race or religion. All inhabitants of Poland were to enjoy religious freedom, persons residing in Polish territory at the time of the treaty were to become, if they so desired, Polish citizens, and all Polish citizens should enjoy the same civil and political rights. In addition to these general provisions characteristic of any progressive or democratic country, there were special provisions about the right of the free use of non-Polish languages in private intercourse and in publications and about adequate facilities for the use of these languages before the courts. Minorities received the right to establish at their own expense social and educational institutions, and Poland promised to provide adequate facilities to the minorities for education in elementary schools through the medium of their own language. Finally Poland agreed that these obligations should be placed under the guarantee of the League of Nations, and that any member of the council of the League should have the right to draw the attention of the council to any infraction, or any danger of infraction, of any of these obligations, whereupon the council might take proper and effective action. Poland also agreed that the minority protection could not be modified without the assent of the majority of the council of the League of Nations. Any difference of opinion as to the minority treaty should be held to be a dispute of an international character under article 14 of the League covenant and should, if the other party so demanded, be referred to the Permanent Court of International Justice.

Minority treaties were concluded only with a number of newly formed and enlarged states; similar provisions were inserted in the peace treaties with certain defeated states; and finally some new states, at the time of their admission to the League of Nations, accepted in solemn declarations the principles of the minority treaties. The states thus entering into international obligations for the protection of minorities formed finally a belt from the Finnish gulf in the north to the Persian gulf in the south. Minority treaties were signed, in addition to Poland, by Yugoslavia (Sept. 10, 1919), Czechoslovakia (Sept. 10, 1919), Rumania (Dec. 9, 1919) and Greece (Aug. 10, 1920). In the peace treaties with Austria, Bulgaria, Hungary and Turkey special chapters for the protection of minorities were inserted. In addition the following states when admitted to the League of Nations made declarations regarding minorities before the council of the League: Finland (in respect of the Åland Islands), June 27, 1921; Albania, Oct. 2, 1921; Lithuania, May 12, 1922; Latvia, July 7, 1923; Estonia, Sept. 17, 1923; Iraq, July 13, 1932.

In addition to these treaties and declarations, minority questions were also dealt with in a number of bilateral international agreements. The most important among these agreements were the German-Polish convention regarding the protection of minorities in Upper Silesia of May 15, 1922, and the Greco-Turkish agreement on the compulsory exchange of minority populations of Jan. 30, 1923. The convention regarding the Memel territory of Lithuania on May 8, 1924, also dealt with minority problems.

The international protection of minorities was not extended to old established states, not even to defeated Germany. As a result of World War I Italy incorporated into its national territory certain parts of the former Austro-Hungarian empire which were inhabited by Italians, South Tirol, Trieste and the Austrian maritime provinces, the main centres of the Italian irredentism of the 19th century. But while point 9 of Woodrow Wilson's 14 points had demanded the readjustment of the Italian frontiers along clearly recognizable lines of nationality, the new frontiers granted Italy by the peace treaty included large minorities, German in the case of South Tirol, Slovene and Croat in the case of Trieste and the maritime provinces. These minorities were not only not protected by any minority treaty, but were soon subjected by the fascist regime in Italy to an especially ferocious process of denationalization and persecution.

World War I did not create any new minority problems in western or northern Europe. One of the thorniest existing minority problems, the Irish problem, was solved by the treaty which the British government signed on Dec. 6, 1921, with the Irish representatives and which was accepted by *dail eireann* the following month. The Protestant minority in Northern Ireland received home rule under the Government of Ireland act of Dec. 23, 1920, and retained this position in agreement with the right of self-determination even after the rest of Ireland had been granted one year later dominion status as the Irish Free State. The large Catholic minority in Northern Ireland continued however to pre-

sent a minority problem, especially in view of the strong support which it found in the Free State.

In Spain the Catalans demanded with ever-growing insistence the autonomy of Catalonia. On July 5, 1917, the Catalan deputies and senators in the Spanish parliament asked the convocation of a Catalonian constituent assembly to draw up a constitution for Catalonia, and on Jan. 24, 1919, a Catalonian union met in the Catalonian capital, Barcelona, to draft a program for home rule. The Spanish dictatorship of Gen. Miguel Primo de Rivera (1923–30) rejected all these demands, but the Spanish republic granted limited local autonomy to Catalonia in its constitution of Dec. 9, 1931. Catalonian agitation resulted in a far more liberal and comprehensive measure in the Catalan charter of autonomy of Sept. 25, 1932, in which Catalonia was granted the right to its own flag and official language and its own president, parliament and cabinet. The Basques received a more limited autonomy on Oct. 5, 1936. But the victory of Gen. Francisco Franco's forces in the Spanish civil war and the establishment of a fascist nationalist dictatorship in 1939 led to the abolition of autonomy in Catalonia and in the Basque provinces and to a regime of persecution of the minorities, of their languages and cultural aspirations.

**3. Soviet Russia.**—The minority problem in the vast Russian empire remained of importance even after World War I. Movements for national independence on the part of the larger and more developed national minorities, the Ukrainians, the Caucasians and the Muslims in central Asia, were ruthlessly suppressed, the potential leaders of such national independence movements were executed or imprisoned, and the totalitarian direction of all life and all administration by the one strictly centralized Communist party throughout the empire provided an iron framework of uniformity. But within this framework the minorities of race and language at first received a formerly unknown legal equality, and the minority religions—Muslim, Jewish, Buddhist, Catholic, Protestant—were held to be on a footing of equality with the Orthodox Church. The Russian empire, though maintaining in its main body its unity and even strengthening the hold of Moscow over the vast extent of the empire, was transformed in 1922 into the Union of Soviet Socialist Republics, in which the European and Asian peoples were organized in federal republics, originally 7, 11 in 1939 and 16 in the early 1950s.

According to the census of 1926 the Union of Soviet Socialist Republics was inhabited by 185 peoples, speaking 147 different languages. Of these nationalities the Russians formed a bare majority of 52.9% (in 1939 the figure was 58.2%). Many of these nationalities were small groups, numbering less than 100,000; only 13 comprised more than 1,000,000 each. While some of these nationalities formed the republics of the Soviet Union, many more of them formed autonomous districts within one or the other of the republics. The largest of these republics, the Russian Soviet Federated Socialist Republic or R.S.F.S.R., which in the census of Jan. 1960 accounted for 117,494,000 out of a total population of 208,826,650 for the Soviet Union, dwarfed, however, all the other national republics in space and importance. Thus the U.S.S.R. remained predominantly Russian.

The practical policy of the Soviet government promoted actively and consistently the fullest development of the languages spoken by the minorities. The fight against illiteracy, the introduction of compulsory education, the spread of socialistic and popular scientific literature among the masses, the new equality of women, all this was accomplished through the medium of the mother tongue of each nationality or minority. While thus linguistic autonomy was granted, and no legal distinction was made between the Russian majority and the minorities in their rights and status, neither cultural autonomy nor political liberty in the accepted sense of the word existed, because the cultural and political life of all inhabitants, irrespective of race, nationality or language, was uniformly molded in the pattern of the totalitarian dictatorship.

The success of the Soviet minorities policy was tested in World War II. It became clear that many non-Russian nationalities were not loyal to the Soviet government, which in their eyes represented Russian domination. With the German attack in 1941 the Soviet government found itself obliged to dissolve the autonomous soviet socialist republic of the Volga Germans which it had established in 1924. Its German inhabitants were moved to Siberia and their autonomy liquidated. The capital of the republic regained its former Russian name, Pokrovsk (renamed Engels [q.v.] after 1931). At the end of World War II it became known, without any previous announcement by the Soviet government and without any explanation, that four other former autonomous republics and regions had been liquidated, the Crimean (Tatar) A.S.S.R., the Kalmyk A.S.S.R. west of the lower Volga, the Chechen-Ingush A.S.S.R. and the Karachai-Cherkess Autonomous Region in the Caucasus. Their cities were deprived of their native names and received Russian names. What happened to the populations was not revealed. The reason for these measures was believed to be the disloyalty of these minorities during World War II.

In a special report to the 20th congress of the Communist party of the Soviet Union, Nikita S. Khrushchev, the first secretary of the party, on Feb. 24, 1956, included the treatment of these minorities among the crimes of the Stalin era. He called the mass deportations from their native places of whole nations, together with all their Communists and Komsomols without any exception, a monstrous act. He revealed a fact unknown until then when he said that "the Ukrainians avoided meeting this fate only because there were too many of them and there was no place to which to deport them. Otherwise, Stalin would have deported them also." Khrushchev continued that "no man of common sense can grasp how it is possible to make whole nations responsible for inimical activities, including women, children, old people, Communists and Komsomols, to use mass repression against them, and to export them to misery and suffering for the hostile acts of individual persons or groups of persons."

After 1956 steps were taken by the Soviet government to restore some of the autonomous republics and regions abolished during World War II and to bring the populations back to their native places. Two of the autonomous republics liquidated during the war on Stalin's orders were not mentioned by Khrushchev and were not re-established, the Volga German and the Crimean Tatar republics. Apparently their populations remained in Siberia and Kazakh, distant regions to which they had been deported.

During the last 15 years of Stalin's rule the position of the minorities throughout the U.S.S.R. had rapidly deteriorated compared with the relative equality granted them under Lenin. Under Stalin's successors greater emphasis was placed again upon the theoretical recognition of equality and the cultural development of the non-Russian nationalities in the U.S.S.R. The only exception were the Jews who, under Khrushchev too, were denied freedom of cultural activity in their own language (Yiddish).

**4. Central and Eastern Europe.**—Different from these developments in western and eastern Europe was the evolution of minority rights in the 14 states in central-eastern and southeastern Europe which had accepted, by treaty or solemn declaration, the protection of minorities within their territories. It was with these states and their minority problems that the League of Nations dealt in the period between World Wars I and II. These states were the following:

Albania, with a population of 1,003,000 (1930), of whom 50,000 belonged to the Greek and 7,000 to the Yugoslav minority.

Austria, pop. 6,760,000 (1934), of whom 52,000 were Czechoslovaks, 25,000 Hungarians, 191,000 Jews and 85,000 Yugoslavs.

Bulgaria, pop. 5,478,000 (1926), of whom 27,000 were Armenians, 11,000 Greeks, 47,000 Jews, 61,000 Rumanians and 578,000 Turks.

Czechoslovakia, pop. 14,729,000 (1930), of whom 3,318,000 were Germans, 715,000 Hungarians, 357,000 Jews, 81,000 Poles and 560,000 Ukrainians.

Estonia, pop. 1,126,000 (1931), of whom 16,000 were Germans, 4,000 Jews, 7,000 Letts and 92,000 Russians.

Greece, pop. 6,205,000 (1928), of whom 20,000 were Albanians, 35,000 Armenians, 82,000 Bulgarians, 70,000 Jews and 103,000 Turks.

Hungary, pop. 8,684,000 (1931), of whom 103,000 were Czechoslovaks, 476,000 Germans, 444,000 Jews, 16,000 Rumanians and 34,000 Yugoslavs.

Iraq, pop. 3,185,000 (est. 1935), of whom 45,000 were Assyrians, 89,000 Jews, 485,000 Kurds and 80,000 Turks.

Latvia, pop. 1,900,000 (1930), of whom 8,000 were Estonians, 62,000 Germans, 93,000 Jews, 20,000 Lithuanians, 50,000 Poles, 233,000 Russians and 36,000 White Russians.

Lithuania, pop. 2,220,000 (1931), of whom 71,000 were Germans, 166,000 Jews, 14,000 Letts, 73,000 Poles and 44,000 Russians.

Poland, pop. 32,694,000 (1931), of whom 30,000 were Czechoslovaks, 1,700,000 Germans, 2,700,000 Jews, 300,000 Lithuanians, 56,000 Russians, 4,200,000 Ukrainians and 1,500,000 White Russians.

Rumania, pop. 17,793,000 (1930), of whom 361,000 were Bulgarians, 740,000 Germans, 1,426,000 Hungarians, 725,000 Jews, 415,000 Russians, 578,000 Ukrainians and 289,000 Turks.

Turkey, pop. 13,629,000 (1927), of whom 134,000 were Arabs, 64,000 Armenians, 96,000 Circassians, 120,000 Greeks, 82,000 Jews and 1,184,000 Kurds.

Yugoslavia, pop. 13,934,000 (1931), of whom 342,000 were Albanians, 176,000 Czechoslovaks, 499,000 Germans, 468,000 Hungarians, 77,000 Jews, 229,000 Rumanians and 132,000 Turks.

Thus the most important minorities in the 14 minority states were 6,885,000 Germans (mostly in Czechoslovakia, Poland, Rumania, Yugoslavia and Hungary), 2,638,000 Hungarians or Magyars (in Rumania, Czechoslovakia and Yugoslavia), 5,045,000 Jews (mostly in Poland, Rumania, Hungary and Czechoslovakia), 1,669,000 Kurds (in Turkey and Iraq), 5,347,000 Ukrainians (in Poland, Rumania and Czechoslovakia) and 1,536,000 White Russians (in Poland and Latvia).

Of these minorities the Germans and Hungarians (Magyars) presented internationally the greatest problem. They had formerly belonged to the ruling majorities in Germany and in Austria-Hungary, and their new position was a result of the defeat of the Central Powers in 1918. Both in Germany and in Hungary tendencies were dominant, from 1918 on, to undo the defeat of 1918 and to re-establish the former German and Hungarian hegemony in central Europe. German and Hungarian policy was dominated by the goal of revising the peace treaties, and with them the new minority situation in central Europe.

Different was the problem presented by the Ukrainian, Jewish and Kurdish minorities. The Ukrainians, a nation of about 40,000,000 people, found after 1918 their claim to national independence denied and the territory settled by them divided among the Soviet Union, Poland, Czechoslovakia and Rumania, the Ukrainians forming everywhere a minority. In the Soviet Union the Ukrainians, forming the second largest national group, were organized into one of the federated republics according to the Soviet pattern. Czechoslovakia promised in the minority treaty to grant to the Ukrainians, living on the eastern fringe of Czechoslovakia south of the Carpathian mountains, the fullest degree of self-government compatible with the unity of the state. This autonomy was very gradually realized and finally established only in 1938, shortly before the complete dismemberment of Czechoslovakia. A similar autonomy was promised by the Polish government to the Ukrainians in eastern Galicia, a province consisting of the three districts of Lvov, Stanislawow and Tarnopol. The Polish law of Sept. 26, 1922, provided for diets in these districts to deal with all questions relating to religion, education, welfare, local communications and local economic conditions. The law also prohibited the Polish colonizing of these districts, made the Ukrainian language one of the two official languages, and promised the establishment of a Ukrainian university. On the strength of this law the Conference of Ambassadors recognized on March 14, 1923, the Polish claims to eastern Galicia, not without pointing out that Poland had recognized for eastern Galicia "that the ethnographical conditions made a regime of autonomy necessary." After 25 years a plebiscite should decide, according to the Conference of Ambassadors, the status of eastern Galicia. But the Polish government refused to carry out the law of Sept. 26, 1922, and the 3,500,000 Ukrainians in eastern Galicia remained without the promised autonomy. After 1940 the Soviet Union, by the annexation of Bessarabia and northern Bukovina from Rumania and of eastern Galicia, Volhynia and Polesie from Poland, united all the Ukrainians, with the exception of those in Czechoslovakia, within the Soviet Union and its Ukrainian republic. In 1945 the Carpatho-Ukraine was ceded by Czechoslovakia to Russia, thus completing the process of the inclusion of all Ukrainians, for the first time in history, into the Soviet empire.

The Jews formed a minority in all the states involved. Special provisions were made in the treaties with Poland, Lithuania and Greece in the interests of the observance of the Jewish Sabbath. No elections should be held on Saturday. This provision did not, however, exempt Jews from such obligations as were imposed on all other nationals for the necessary purposes of military service, national defense or the preservation of public order. Similar regard for religious minorities was expressed in the treaties with Albania, Greece and Yugoslavia as far as Muslims were concerned. Greece also promised to maintain the traditional rights and liberties enjoyed by the monks of Mt. Athos, of whatever country they might be natives.

Like the Ukrainians, the Kurds formed no national state of their own but lived as minorities in Turkey, Iran and Iraq. There was no question of protection for minorities in Iran. Turkey assumed certain obligations, but it did not grant any minority rights to the Kurds nor did it make any provisions for the use of the Kurdish language in education or public life, though the Kurds formed a considerable minority living in compact settlements in the eastern parts of the country. The treaty of Sèvres (1920) had foreseen autonomy for the Kurds, but it was never ratified. The Turkish government suppressed movements for independence or autonomy on the part of the Kurds and subjected them to a process of turkification. Only in Iraq the Kurdish minority in the northern districts enjoyed full minority rights and a limited cultural and administrative autonomy.

More extended and better defined than in any other of the minority treaties were the rights of the German and Polish minorities in Upper Silesia as set forth in part iii of the German-Polish convention of May 15, 1922. The contracting parties agreed to observe, for a period of 15 years, certain detailed provisions concerning civil and political rights, religion, private education, public elementary education, vocational training and extension classes, secondary and higher education, the official language of education and the language to be employed in all legal proceedings of whatever nature. In both parts of Upper Silesia, German and Polish, a minorities office was set up to which persons belonging to a minority could, after having filed a complaint with the highest administrative authority of their territory, submit a petition for consideration. If the minorities office did not succeed in obtaining satisfaction for the petitioners, it transmitted the petition, with any comments of its own, to the president of a mixed commission. This commission was composed of two Germans and two Poles with a president of a third nationality. This commission communicated its views to the proper administrative authorities. If the petitioners were not satisfied with the findings of the administrative authority, they could appeal to the council of the League of Nations. This convention remained in force for the full duration contemplated in it and ended on May 15, 1937.

**5. Protection by League of Nations.**—Thus in the new system established by the peace treaties after World War I minorities of race, religion or language were to receive for the first time protection under an effective system of international law. Though, as in all the other provisions of the peace treaties, much remained vague and undefined and lacked sanction, nevertheless the arrangement marked important progress in a most delicate question, namely, how far effective protection of minorities could be achieved internationally without seriously impairing the national sovereignty of the states themselves. A principle, experienced by the assembly of the League of Nations in 1922, interrelated the duties of the state toward its minorities with the duties of the minorities toward the state. While the assembly recognized the primary right of minorities to be protected by the League from oppression, it also emphasized the duty incumbent upon persons belonging to racial, religious or linguistic minorities to co-operate as loyal fellow citizens with the nations to which they belonged.

In that connection nothing could be more disastrous than an appeal of the minority to some protecting outside government, especially a great power. Such appeals had been used successfully in the 19th century by minorities in the Ottoman empire, and this kind of protection of minorities by the intervention of some great powers had produced disastrous results by complicating international relations and provoking wars. The new procedure of protecting minority rights under the League of Nations should render, so the framers of the peace treaties had intended, such

appeals of minorities to single powers superfluous. The necessity of striking a delicate balance between the sovereign rights of states and the protection of minorities within those states was always taken into consideration by the League of Nations which tried to achieve its aims by conciliation and pacification rather than by judgment and sanctions. The resolution of the assembly in 1922 stated in this spirit that:

While in cases of grave infraction of the minorities treaties it is necessary that the Council should retain its full power of direct action, the Assembly recognizes that in ordinary circumstances the League can best promote good relations between the various signatory governments and persons belonging to racial, religious or linguistic minorities placed under their sovereignty by benevolent and informal communications with those governments.

In the course of the years the League of Nations worked out a procedure to be followed by the council in the settlement of minority questions. The minority treaties were extremely general in their wordings and vague about the procedure and the powers of the council. Only members of the council had the right to bring officially to the attention of the council any infraction or danger of infraction of any of the provisions relating to minorities. Other states not represented on the council, or minorities themselves, could petition the council or report to it, but only an action by a council member brought the question officially before the council. When the council dealt with such a question, the state involved, if it was not a member of the council, was invited to sit as a member during the consideration of the matter specially affecting its interests. The council could also ask the Permanent Court of International Justice for an advisory opinion or refer the question to it.

The procedure laid down by the council concerned petitions and communications for the examination of minority questions not sponsored by any of the members of the council. The council, anxious to give minorities a guarantee that their petitions would receive serious consideration, instituted out of its midst a minorities committee. A petition regarding minority protection was first submitted by the League secretariat to a preliminary examination as regarded its acceptability; if found acceptable, it was submitted to the government in question for its own observations, before being brought to the notice of the council. The observations of the government, if any, were communicated together with the petition. The council became competent to deal with the question, however, only if one of its members notified it that the subject of the petition constituted an infraction or danger of infraction of the treaties. To enable its members to decide whether the petition constituted such an infraction, the council instituted the minorities committee, consisting of the president of the council and two members appointed by him. According to a resolution of the council of June 10, 1925, the members of the minorities committee could not include either the representative of the state to which the persons belonging to the minority in question were subject, nor the representative of a neighbouring state or of a state a majority of whose population belonged from the ethnical point of view to the same people as the persons who were members of the minority in question. In such a way the impartiality of the minorities committee was to be assured. As a result, nationals of Latin-American or Asian states played a great role in these minorities committees.

This procedure was further improved by the resolution of the council of June 13, 1929. The secretary-general of the League was required to inform the petitioner when and why his petition was unacceptable. In exceptional cases the minorities committee could be expanded from three to five persons. It was declared desirable that these minorities committees hold their meetings not only during the sessions of the council but also in the intervals between them. The committees had to inform all the members of the council of the result of their findings regarding minority petitions, so that members who were not in agreement with the findings could raise the question before the council. The secretary-general of the League had to keep the relevant documents available for the members of the council and to transmit to them an annual compilation of all the findings of the minorities committees.

The League of Nations tried to proceed in all minority questions with due regard for the susceptibilities and sovereign rights of the states pledged to the protection of minorities by international treaties. Nevertheless, some of these states resented and opposed the minority treaties or at least repeatedly made the attempt to generalize a system of protection of minorities and to apply it to all states. As a result of Latvian proposals, the assembly of the League of Nations adopted on Sept. 21, 1922, a resolution expressing the hope

That the states which are not bound by any legal obligations to the League with respect to minorities will nevertheless observe in the treatment of their own racial, religious or linguistic minorities at least as high a standard of justice and toleration as is required by any of the treaties and by the regular action of the Council.

When the assembly met for its sixth session in Sept. 1925, the Lithuanian delegation proposed to set up a special committee to prepare a draft convention to include all the states members of the League of Nations, setting forth their common rights and duties in regards to minorities. Only the Rumanian and Polish representatives favoured the proposal, which was finally withdrawn.

At the meeting of the council on Dec. 9, 1925, M. de Mello Franco, the Brazilian delegate and *rapporteur* on minorities questions, expressed himself definitely against generalizing the system for the protection of minorities. He said

The mere co-existence of groups of persons forming collective entities, racially different, in the territory and under the jurisdiction of a state is not sufficient to create the obligation to recognize the existence in that state, side by side with the majority of its population, of a minority requiring a protection entrusted to the League of Nations. In order that a minority, according to the meaning of the present treaties, should exist, it must be the product of struggles, going back for centuries, or perhaps for shorter periods, between certain nationalities, and of the transference of certain territories from one sovereignty to another through successive historic phases.

This definition would exclude all minorities in the two Americas from protection as envisaged by the League of Nations, perhaps with the exception of the Mexican minority in New Mexico and other territories ceded by Mexico to the United States as a result of 19th-century wars.

Though some states which had accepted the minority treaties, such as Poland, owed their existence to the peace treaties of 1919, and though the minority provisions formed an integral part of the peace settlement, these states, especially Rumania and Poland, protested from the beginning against the minority provisions and thereby helped to undermine the whole peace settlement. With the progressive weakening of the peace settlement of 1919 the system of minority protection and the whole League of Nations was weakened. On Sept. 13, 1934, Col. Jozef Beck, Polish minister of foreign affairs, declared that Poland henceforth would refuse to collaborate with the League of Nations in the field of minority protection, and on Nov. 5, 1937, Poland concluded with Germany a bilateral minorities agreement outside the League of Nations.

In Sept. 1934, when Poland refused further co-operation with the League of Nations "in the matter of the supervision of application by Poland of the system of minority protection," a resolution was offered and discussed for extension of the contractual provision of minority protection to all nations, or at least to the whole of Europe. This was the last time that any important debate on the minorities problem was held before the League of Nations. Between July 1, 1938, and June 30, 1939, only four minorities petitions were sent to the League of Nations. Finally in 1939 the minorities section of the secretariat of the League of Nations was liquidated.

**6. Activities of Minorities.**—The minorities themselves tried to protect their rights by forming international organizations. Congresses of "oppressed nationalities" were held in 1912 and 1915 in Paris and in 1916 in Lausanne. After World War I the German minorities took the initiative in forming an international organization of national minorities of Europe, including the minorities not protected by treaties, such as the minorities in Spain, Italy and Germany. The Baltic German Ewald Ammende founded in 1925 the congresses of the organized national minority groups in Europe (outside the Soviet Union). The annual meetings, presided over by the Slovenian Josip Wilfan, were held until 1931 in Geneva, and afterward in Vienna. The last or 14th congress

met in July 1938. These congresses, however, were torn by violent dissensions among the minorities themselves, especially among those who before 1918 had belonged to ruling majorities and those who had then been oppressed by them. As a result of these conflicts, the minorities within Germany, which were not protected by treaty, left the congress as early as Aug. 1927. The German minorities dominated the congresses more and more and turned them into spokesmen for the German cause. In Aug. 1933 the representatives of the Jewish minority left the congress, which threatened to become an organ for irredentist propaganda.

With the growth of German influence throughout Europe, the concept of minority and of its duty of loyalty to the state of which it was a member changed fundamentally, at least as far as the German minorities were concerned. They regarded themselves now openly as members of a *Volksgemeinschaft* which transcended state frontiers. The spokesman of the Union of German *Volksgruppen* declared that:

*Volksgemeinschaft* is not only an identity of language but represents also in the cultural aspect the identity of experience. It would be a denial and an offense against the divinely intended division of mankind into individual folk entities to demand of the *Volksgruppen* that they cut themselves off from the regenerative experience of the main body of their people. Wherever sections of the German people consciously exclude themselves from this experience, the *Volksgemeinschaft* is imperiled (*Nation und Staat*, vol. xi, p. 352).

The blood was regarded as stronger than the citizen's loyalty to the state to which he belonged. The Germans denied that members of different ethnic groups could live peacefully side by side in one and the same state, a supposition accepted as valid in the United States and in western Europe. Prince Bernhard von Bülow, the former German chancellor, wrote in his *Imperial Germany* (New York, 1914, p. 291): "It is a law of life and development in history that where two national civilizations meet they fight for ascendency. . . . In the struggle between nationalities one nation is the hammer, the other the anvil, one is the victor and the other the vanquished." The peace settlement of 1919 and the minorities treaties under the supervision of the League of Nations were animated by the very opposite feeling of the possibility of the peaceful and orderly cohabitation of different nationalities in one state. This was possible only if the 19th-century principles of liberal democracy, constitutional guarantees and mutual tolerance prevailed. Unfortunately these ideas had not yet taken firm root in the soil of central and eastern Europe at the end of World War I.

As a result of this lack of a genuine atmosphere of tolerance in central and eastern Europe, the minorities had frequent cause for complaints which produced numerous petitions to the League of Nations. This body received the largest number of petitions in any single year, namely 204, in the period between July 1, 1930, and June 30, 1931. The most frequent complaints concerned economic discrimination, limitation in the use of minority languages and restriction of educational opportunities. Some of the economic complaints had their origin in economic and social measures which in spite of legal equality worked to the factual disadvantage of the minorities, as in the case of agrarian reforms, when estates owned by members of the minority were divided up among peasant members of the majority, or when new middle and professional classes were helped into existence at the expense of the minorities. In such an atmosphere even a very minor difference of interpretation or any minor shift in the existing balance of power became a source of deep irritation. The vague and much too broad phrasing of the treaties aggravated the situation. But it was not the imperfect letter of the treaties which formed the chief obstacle to a smooth cohabitation of the different minorities and majorities, it was the lack of the right spirit, an obstacle which even a more precise wording of the treaties could not have overcome.

To eliminate the threat which the existence and aspirations of powerful minorities present to the peaceful relations of neighbouring states, the compulsory exchange of minority populations has been suggested. Such an exchange was accomplished successfully between Turkey and Greece. But it was done under unique circumstances which do not easily allow favourable conclusions for general acceptance of the principle involved. The victorious Turks who had driven out the Greek army from Asia Minor, where lived a large and prosperous Greek minority, established since time immemorial, forced the Greeks in the agreement of Jan. 30, 1923, to accept the definite removal of the Greek minority in Turkey, comprising more than 1,000,000 persons, to Greece in exchange for the much smaller number of Turks living in Greece. Religion was to determine the question of who was to be regarded as Greek or Turk. The Greek Orthodox inhabitants of Istanbul and the Muslim inhabitants of western Thrace were allowed to remain in their countries. Mutual property settlements for the benefit of dispossessed persons were supervised by a commission including a majority of neutral members appointed by the League of Nations. The task was made much easier by the fact that far more than 1,000,000 Greek Orthodox citizens of Turkey had fled from Turkey to Greece with the retreating army even before the agreement was concluded. Thus only about 200,000 Christians had to be removed from Turkey and about 350,000 Muslims moved to Turkey under the supervision of the commission, which concluded its work on Jan. 15, 1935.

The League of Nations never ceased to stress the importance of the protection of minorities. When Iraq, after a relatively brief political education under British mandate, was to be admitted in 1932 to the League of Nations as a sovereign state, the Permanent Mandates commission wished to make the independence of mandated territories dependent upon guarantees ensuring the effective protection of racial, linguistic and religious minorities. Iraq, upon entering the League of Nations, declared its acceptance of the protection of minorities. At the council meeting of May 19, 1932, the committee reporting upon the situation of minorities in Iraq declared:

As regards the substantive provisions, the Committee desires first, to emphasize the satisfaction with which it has noted that many of the constitutional and legislative provisions of Iraq are based on a very liberal conception of the rights to be accorded to racial, linguistic and religious minorities. It is happy to recall the fact that during the course of the proceedings, the [Iraqi] Prime Minister made it clear that that conception has as its starting point the idea that all Iraqian nationals, irrespective of race, language or religion, form part, on a footing of equality, of the body of the state.

**7. The Near East.**—With the rise of nationalism and the demand for constitutional rights, under western influence, minority problems began to play a great role in the near and middle east and throughout Asia. At the same time the new nationalism acted as an integrating factor in overcoming the religious cleavages which until the beginning of the 20th century were as dominant in oriental countries as they had been down to the 17th century in Europe. Egypt, a predominantly Muslim country, has a native Christian minority, the Copts. Immediately before World War I much bitter antagonism between majority and minority had flared up. When Great Britain, in accordance with its liberal tendencies, set the example of emancipating colonial countries by granting independence to Egypt on Feb. 28, 1922, it reserved for further discussion the protection of minorities in Egypt. But the fast-growing feeling of national unity fused the Copts with the Muslim majority, so that when the Anglo-Egyptian treaty of alliance was signed on Aug. 22, 1936, no mention was made of the protection of minorities, and Egypt was admitted to the League of Nations on May 26, 1937, without the requirement of a declaration regarding the protection of minorities.

Minorities continued to play a great role in Syria and Lebanon, the part of the Arab world put under French mandate after World War I. The minorities in Syria and Lebanon were religious rather than linguistic minorities, but the difference of religion involved a deep difference in the whole way of life and in the social structure of the various communities which for many centuries had lived in strict segregation. But there too the national Arab movement brought the different Muslim and Christian communities ever more closely together. The Syrian and the Lebanese constitutions included elaborate provisions for the safeguard of the rights of the minorities, and in Lebanon the minorities received a proportionate share in the legislative body, in the administration and in the public service.

Palestine offered a special minority problem of its own. The Arab majority of the country felt itself threatened by the growth

of the Jewish minority, which interpreted the Balfour declaration of Nov. 1917 and the mandate charter of 1922 as a promise for the establishment of a Jewish majority and a Jewish commonwealth in Palestine. The Zionist movement wished to "redeem" the Jews from their permanent and ubiquitous minority status by the creation of a Jewish majority and state in Palestine, the ancient homeland of the Jewish people. The British government had from the beginning rejected the interpretation that the promised "Jewish national home" meant that Palestine would become a Jewish commonwealth. Even the Zionist demand for the promise of the "reconstitution of Palestine as the national home" was rejected in 1917 in drafting the Balfour declaration for the broader and much less definite phrase "the establishment in Palestine of a national home." The British government insisted that the national home must be interpreted in such a limited sense that the interests of the indigenous population should not suffer.

The actual developments, however, did not bear out British expectations. The rise of Hitlerism, which led to a wholesale extermination of Jews not only in Germany but throughout all the lands of central and eastern Europe which fell under German influence or occupation, produced the demand for large-scale Jewish immigration into Palestine. In a resolution adopted at a meeting in New York city the Zionists demanded in 1941 the creation of a Jewish state in the whole of Palestine. The United Nations recommended in 1947 partition of Palestine into an Arab and a Jewish state. The Arab states, however, refused to accept this recommendation and when in 1948 at the termination of the British mandate, the Zionist settlers in Palestine proclaimed the creation of the state of Israel, the Arab states intervened; they were defeated in the ensuing war. About 800,000 Arabs fled from the territory conquered by Israel, and in the 1950s they represented one of the thorniest of refugee problems.

## III. DEVELOPMENTS AFTER WORLD WAR II

Minority questions had received a great deal of attention in the League of Nations after World War I. They were given far less attention by the United Nations after World War II. There was nothing comparable to the minority legislation and minority treaties of the earlier postwar period. On the other hand, the draft covenant on human rights contained articles on the rights of minorities and on the prohibition of advocacy of national, racial or religious hostility. The Commission on Human Rights in the United Nations recommended also that member states uphold the principle of self-determination of all peoples and nations, facilitate the right of self-determination in territories under their administration—preferably through plebiscites under the auspices of the United Nations—and that the general assembly establish a commission to conduct a full survey of the status of the right of peoples to permanent sovereignty over their natural wealth and resources.

The situation of minorities in various countries after World War II constituted a problem of refugees on an infinitely larger scale than before the war. Accordingly, the general assembly of the United Nations established in 1950 an office of the United Nations high commissioner for refugees with his office in Geneva, Switz. His mandate extended to all persons who had fled from their native lands for political, racial or religious reasons and who were unwilling or unable to claim the protection of their own governments. The three main functions of the office were international protection, promoting permanent solutions to the problems of refugees, and administering emergency aid. Separate from this office was the United Nations Relief and Works Agency for the Palestine Refugees in the Near East, with its headquarters in Beirut, Lebanon. Other groups of refugees who did not come under the United Nations office were those in India, Pakistan and in the Federal Republic of Germany. Though they were refugees from their native lands, they were given the full right of citizenship by their countries of residence and were fully integrated in them.

To a degree unknown before modern times, expulsion of minorities from their native lands was used after World War II as a "solution" of minority problems. German minorities in Poland and Czechoslovakia for example, were expelled and most of them settled in western Germany. To a lesser extent the German minorities in Yugoslavia, Hungary and Romania and the Magyar minorities in Czechoslovakia faced a similar fate. Because of these expulsions the problem of minorities in Europe lost much of the great importance it had both before and after World War I. In Europe there were only two minority problems in the 1950s which created domestic and international tensions. The one was the position of the German-speaking South Tirolese in Italy who demanded autonomy and the protection of their economic and administrative position against increasing Italian pressure. The Austrian government made itself the spokesman of the complaints of the South Tirolese who until 1918 had formed part of Austria, and brought their case up in the United Nations at its fall session of 1959.

The other problem was presented by the Turkish minority in Cyprus. This problem became acute when the Greek majority in Cyprus attempted to end the status of the island as a British colony and to become united with Greece. The Turkish minority feared that such a development would undermine its own position. In Feb. 1959 the parties reached an agreement in which the British, Greek and Turkish governments concurred. The Greek Cypriot majority would in effect govern the island, but this agreement gave to the Turks a secure minority position under international guarantee. In 1963 friction between Greek and Turkish Cypriots concerning the government of the five chief towns on the island resulted in an outbreak of fighting and led to the dispatch of a United Nations peace-keeping force to the scene in March 1964.

In Palestine the establishment of the state of Israel over territory largely inhabited by Arabs brought with it a thorny minority problem that contributed to international tension throughout the whole middle eastern area. About 800,000 Arabs who fled from their homeland during the war of 1948 were not allowed to return to their homes, which were now in the state of Israel; over 200,000 Arabs who remained in Israel found themselves in an underprivileged position.

Less acute were the minority problems in Lebanon, which were not based on nationality but on religion, and in Iraq where in the northern part of the country a strong Kurdish minority lived. The various religious groups living in Lebanon enjoyed full equality, and the Kurds in Iraq enjoyed not only equality but also the recognition of autonomy, which was not the case with the Kurdish population in neighbouring Turkey and Iran.

The new nations in Asia had their minority problems, too. The independence of India and the partition of that subcontinent into Pakistan and the Republic of India led to Hindu-Muslim riots, as a result of which many Hindus migrated from Pakistan to India and many Muslims migrated from India to Pakistan. In the Republic of India, divisions by descent and religion as well as language and caste created a number of problems which the Indian government tried to overcome by the principles of democracy and federalism. One of the most vexing minority problems was that of the untouchables in India. The inferior status of this minority had been regarded as sanctioned by the Hindu religion. Although the almost unique, depressed situation of this very large minority, which comprises about 60,000,000 persons, was legally alleviated under British rule and then in the constitution of the Republic of India, by 1960 the force of social tradition was still much too strong to allow a status of equality or full integration of this minority into Indian life.

Other minority problems leading to disputes and even to internal strife were created by the Pathans who lived on both sides of the border of Pakistan and Afghanistan. In the 1950s, Afghanistan made itself the spokesman for the independence of the Pakistani Pathans. In Burma the Karen people demanded independence; their army of national liberation kept up an armed struggle against the Burmese government after the declaration of Burmese independence in 1948. In the Republic of Indonesia various movements for independence or autonomy in the southern Moluccas, Sumatra and Celebes led to much fighting and violent suppression throughout the 1950s. An outstanding example of bitter minority conflicts was supplied by the attempt of the Sinhalese majority in Ceylon to curtail the equality of the Tamil minority. In the Com-

munist Chinese empire the wish for independence or autonomy of the Muslim population in Sinkiang and of the Tibetans was suppressed after bitter fighting.

With the growing desire of the African peoples for independence and with the establishment of a number of African nations in accordance with this desire, various minority problems were created, partly by the fact that tribal and linguistic differences continued in most African countries, and partly by the fact that minorities of white settlers attempted to hinder the wish of the majority of the population for independence or equality. Such obstructionism was apparently successful in South Africa but failed in Algeria.

## IV. MINORITIES IN THE AMERICAS

In the two Americas only the French Canadians in Canada present a minority problem in the European sense of the word. Canada presents the same struggle for the right of language and for economic positions, mitigated by the British traditions of democracy, federalism and tolerance. French was recognized as an official language in 1848 and confirmed in the British North America act of 1867. The French Canadians wished to maintain their own traditional way of life and not fuse with the majority of the Canadian nation.

Such a tendency of segregation and cultivation of differences runs counter to the fundamental policy of the United States, where from the beginning of its nationhood a policy of amalgamation of the different ethnic and linguistic strains forming the new nation was pursued. English was the official language; without any strong pressure in that direction, it quickly supplanted, by the sheer weight of the American tradition, the many languages of the immigrant peoples. From the end of the 18th century on, the United States was regarded as a melting pot where people of the most different origins, religions and languages formed a new nation, based upon a common loyalty and common ideals. This process of assimilation was relatively simple at the beginning. But in the later 19th century, with the rapid growth of immigration, the new immigrants, settled in the large cities in the east and in the agrarian spaciousness of the middle west in compact groups, preserved their own languages, their own national traditions and ideas and partly even their former loyalties. The theory of the melting pot apparently did not work sufficiently well or fast. This new situation created a twofold reaction. Some suggested that the melting pot theory be replaced by the theory of cultural pluralism, which would maintain, within the common political nationhood, the cultural traditions and potential contributions of the various minority groups. Others saw in the rapid growth of the minority groups and in their adherence to their own cultural pattern a danger to the unity of the nation. To preserve the American character, the quota laws of 1921 and 1924 severely restricted immigration to the United States and established quotas in such a way as to strengthen those elements believed most easily assimilable to the American cultural pattern.

But the principle of the melting pot was from the beginning a fundamental factor in the building of the nation, fusing in a spirit of tolerance and liberty various religious and ethnic groups as never had been done in Europe, so that minorities, at least theoretically, became one with the majority in a common cultural tradition and a common political loyalty. As far back as 1782 M. G. J. de Crèvecœur, a French settler in Pennsylvania, stressed in his *Letters From an American Farmer* the variety of groups mingling in the American melting pot:

> What then is the American, this new man? He is either a European, or the descendant of a European; hence that strange mixture of blood, which you will find in no other country. I could point out to you a man, whose grandfather was an Englishman, whose wife was Dutch, whose son married a French woman, and whose present four sons have now four wives of different nations. He is an American, who, leaving behind him all his ancient prejudices, and manners, receives new ones from the new mode of life he has embraced, the new government he obeys, and the new rank he holds. He becomes an American by being received in the broad lap of our great Alma Mater. Here individuals of all nations are melted into a new race of men, whose labors and posterity will one day cause great changes in the world.

And more than a century later Israel Zangwill in his play *The Melting Pot* made one of his characters say:

> Now understand that America is God's crucible, the great melting pot where all the races of Europe are melting and reforming! . . . Yes, east and west, and north and south, the palm and the pine, the pole and the equator, the crescent and the cross-bow, the great Alchemist melts and fuses them with his purging flame! Here shall they all unite to build the Republic of Man and the Kingdom of God.

The minority problems in the United States differ fundamentally from those in central and eastern Europe. Minorities came to the U.S. (with the exception of the Negroes) voluntarily and as individual immigrants, abandoning gladly their homeland and seeking assimilation to higher standards of political liberty and economic equality; their assimilation, always in theory and very often in practice, has been welcomed and facilitated. But there is no doubt that ethnocentricity and strong group solidarity within some of the immigrant groups, and prejudice on the part of the majority, have often strained the relations between majority and minorities. Evidence of incomplete assimilation among minority groups was widespread in World War I, though much less in World War II, and has sometimes presented a real danger. Conscious and well-organized propaganda on the part of the German and Italian governments preceding World War II threatened to undermine the loyalty of the German and Italian minorities. The events of World War II, however, proved that in the overwhelming number of cases even those minorities whose conationals in Europe or Asia fought against the United States remained loyal to the United States and that the process of assimilation had taken much deeper root than many had supposed. With the act of 1924 the period of large-scale immigration to the United States came to an end. The attitude of the first-generation minority groups, fusing themselves completely with the majority, was well expressed in 1937 by one of the prominent foreign-born citizens of the country, Aleš Hrdlička, when he declared of America:

> It received them without any sentiment, without any care, often, perhaps, with outright neglect and selfishness. But it gave them freely of the precious new air of spiritual liberty. It dealt with them perhaps at times rudely, but frankly. It gave them a chance, a chance to educate themselves and their children, a chance to progress in every direction if they were willing and capable. What wonder that with all the initial difficulties and even sufferings, so many of the immigrants became deeply grateful to the country of their adoption, became fused with it like so many wholesome grafts on a healthy virile tree, and became within less than a generation true, loyal Americans.

The most difficult minority problems of the United States are presented by the factual and sometimes even legal position of the nonwhite minorities—Negroes, Asians and American Indians. In Latin-American countries minority problems are of a twofold character: in some of them large European immigrant groups have yet to be fully integrated into the cultural pattern and the political loyalty of their new country; in others the numerical majority of native Indians live, as regards actual political rights, educational facilities and economic opportunities, in the status of an underprivileged minority.

## V. CONCLUSION

With all the diversity of the positions and problems of minorities all over the world, it can be said that in the 20th century the awareness of the rights of minorities to equal opportunities grew, in spite of the fact that German national socialism and other totalitarian movements, on behalf of the absolute authority and uniformity of the state, rejected the liberty and equality of minority groups. These tendencies represented the most extreme form of racial or ideological (or religious) exclusivism. Only the growth of the liberal tradition of individual liberty and tolerance can solve the minority problems in a form acceptable to the conscience of civilized humanity.

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**MINOR PLANET:** *see* ASTEROIDS.

**MINOS,** a legendary ruler of Crete. Difficulties with genealogies led some ancient myth writers to distinguish between Minos the Elder and a grandson, Minos the Younger, a discrimination never observed in the myths themselves. He was the son of Zeus and Europa and, after expelling his brother Sarpedon (*q.v.*), obtained the Cretan throne by the aid of Poseidon. From Knossos (or Gortyna in some Latin authors) he gained control over the islands of the Aegean, colonized many (Thucydides i. 4), and cleared the sea of pirates. He established wise laws, was venerated as a friend of Zeus and, apparently, ruled in eight- or nine-year terms (*Odyssey*, xix. 178–179). He married Pasiphaë, the daughter of the Sun, who bore him, among others, Androgeos, Ariadne and Phaedra. Minos was punished by the gods for refusing to sacrifice a certain bull. Especially in the Athenian tradition, Pasiphaë became enamoured of the creature and bore the Minotaur (*q.v.*). In other legends the bull ravaged the land of Crete. Minos later went to war against Athens, according to many sources to obtain redress after his son Androgeos was killed. After capturing Megara by the treachery of Scylla, who cut off the lock of purple hair by virtue of which her father, Nisus (*q.v.*), the king, had been unconquerable, Minos forced the Athenians to surrender. In Athenian drama and legend Minos becomes the tyrannical and heartless exactor of the tribute of children to feed the Minotaur until Theseus slew it in the Labyrinth. Minos died in Sicily, where he had gone in pursuit of Daedalus, who had built the Labyrinth. The daughters of King Cocalus poured boiling water over him as he was taking a bath. After his death he became a judge in Hades, along with Aeacus and Rhadamanthus.

Although Athens preserved a hostile tradition (Plutarch, *Theseus*, 16), the general account shows Minos as a powerful, just ruler (Diodorus, v. 78) very closely associated with religion and ritual. In light of the excavations in Crete, many scholars consider that Minos was a royal or dynastic title for the priestly rulers of Bronze Age or "Minoan" Knossos. Probably various traditions were ascribed to one name, and thus memories were preserved of an early Cretan power which seems to have been important at sea and was regarded with mixed feelings of respect, awe and hatred. *See* also references under "Minos" in the Index.

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**MINOT, GEORGE RICHARDS** (1885–1950), U.S. physician and co-winner of a Nobel prize for his work on liver therapy in pernicious anemia, was born at Boston, Mass., on Dec. 2, 1885. He received his medical degree from Harvard university in 1912. After serving as intern at Massachusetts General hospital in Boston, he became resident at Johns Hopkins hospital, Baltimore, Md., and next year research fellow in physiology at Johns Hopkins, under William H. Howell. In 1915 he returned to Boston and continued work on transfusion and disorders of the blood while serving on the medical staff of the Massachusetts General hospital until 1923. In 1921 he developed severe diabetes and was among the first patients in Boston to receive insulin. After appointments at the Huntington Memorial (cancer) and Peter Bent Brigham hospitals, he became in 1928 professor of medicine at Harvard and director of the Thorndike Memorial laboratory at Boston City hospital.

Minot and another Boston physician, William Parry Murphy (*q.v.*), by systematically employing a liver diet, achieved in 1926 the first successful treatment of pernicious anemia. This followed earlier nutritional experiments of the pathologist George Hoyt Whipple (*q.v.*) on dogs kept anemic by bleeding, and in 1934 all three shared the Nobel prize in medicine. Meanwhile, with the physical chemist Edwin J. Cohn, Minot had prepared efficient liver extracts. His research on anemia and nutritional disturbances continued at the Thorndike Memorial laboratory, where many subsequent leaders in U.S. medicine came under his influence. Minot died in Brookline, Mass., on Feb. 25, 1950.

*See* Francis Minot Rackemann, *The Inquisitive Physician: the Life and Times of George Richards Minot* (1956). (W. B. C.)

**MINOT, LAURENCE** (fl. 1333–1352), English poet, was the author of 11 battle songs, first published by Joseph Ritson in 1795 as *Poems on Interesting Events in the Reign of King Edward III.* These had been discovered by Thomas Tyrwhitt in an early 15th-century manuscript (Cotton. Galba E. IX., British museum) which contains many other poems. Minot's poems were evidently written contemporaneously with the events they describe. The first celebrates the English triumph at Halidon hill (1333) and the last the capture of Guines (1352). Nothing whatever is known of Minot's life, but the minuteness of his information suggests that he accompanied Edward on some of his campaigns. The poems are vigorously, if somewhat crudely, written in heavily alliterated rhyming verse. The language of the manuscript is northern, with some midland features.

*See* the ed. of Minot's poems by J. Hall (1887; 3rd ed., 1914). (X.; N. D.)

**MINOT,** a city of North Dakota, U.S., 55 mi. S. of the Canadian border on the Souris river, is the seat of Ward county. Settled in 1886 when the Great Northern railroad reached the Souris, Minot had 5,000 inhabitants within a year and was incorporated as a city in 1887. Because of its location in the short-grass ranching country, cowboys and horse and cattle thieves gave it a "wild west" atmosphere. After 1892, when its hinterland, about the size of Indiana, was opened to homesteaders, it became the largest city and the leading retail and wholesale centre between the Red River valley and Great Falls, Mont. A steady population increase was brought about by the growth of small industries, lignite shipment and the location of a U.S. air force base nearby. (For comparative population figures *see* table in NORTH DAKOTA: *Population*.)

Minot's business centre is built on the flood plain of the Souris, which winds eight miles through the city. The rugged hills up which it has spread give Minot a striking appearance uncommon on the plains. The North Dakota State Teachers college opened there in 1913. There are 300 ac. of parks, one of which, Roosevelt, contains a large zoo. Minot has a council-manager form of government in effect since 1933. Its name is in honour of Henry D. Minot, eastern capitalist and friend of Theodore Roosevelt. (R. P. Wi.)

**MINOTAUR** (Gr. *Mino Tauros*, "Minos' bull"), in Greek mythology, a fabulous monster in Crete having the body of a man and the head of a bull. This creature was supposed to be the offspring of Pasiphaë, the wife of Minos (*q.v.*), king of Crete, and a snow-white bull sent to Minos by Poseidon for sacrifice. Minos, instead of sacrificing it, kept it alive; Poseidon as a punishment made Pasiphaë fall in love with it, and with the help of Daedalus she disguised herself as a cow. Her child by the bull was shut up in the Labyrinth (*q.v.*).

BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

MINOTAUR. DETAIL FROM PAINTING ON A GREEK AMPHORA. IN THE BRITISH MUSEUM

It happened that Androgeos, son of Minos, had been killed by the Athenians, who were jealous of the victories he had won at the Panathenaic festival. To avenge the death of Androgeos, Minos demanded that seven Athenian youths and seven maidens should be sent every ninth year (alternatively, every year) to be devoured by the Minotaur. When the third sacrifice came round Theseus (*q.v.*) volunteered to go, and with the help of Ariadne (*q.v.*) killed the Minotaur.

It seems probable that the legend is in some way connected with the ceremonial bull leaping represented on Cretan frescoes, sealstones, etc., which was perhaps a sacred rite. Representations of half-human monsters are also common in late Minoan art.

*See* Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. xv, 2, 1927–34 (1932).

**MINSK,** an *oblast* (established 1938) of the Belorussian Soviet Socialist Republic, U.S.S.R., covers an area of 15,830 sq mi. in central Belorussia. Along its northwest are the rolling hills of terminal moraine which form the Belorussian ridge (Belorusskaya Gryada) and rise to 1,135 ft. in Mt. Dzerzhinskaya on the Minsk upland (Minskaya Vozvyshennost). From the ridge the central Berezina plain slopes gently to the southeast, drained by the Berezina, its tributary the Svisloch and tributaries of the Pripyat (Pripet).

The mixed forest cover of the upland has been almost wholly cleared for agriculture and gully erosion has developed, but the plain is still thickly forested in many areas with pine, spruce, oak, birch and, in wetter areas, with alder. Swamps, both grass marsh and peat bogs, are widespread, especially in the south and east. Soils are usually podsols.

The population numbered 1,982,519 in 1959, of whom 782,072 (39.5) were urban, mostly concentrated in Minsk (509,489). The other 12 towns and 25 urban districts are all small. The largest is Borisov (59,250). Industry is chiefly concentrated in Minsk, although Borisov is an important timber-working centre. Other towns are mostly concerned with processing farm and forest products. Timber cutting is well developed. Arable land is found mainly on the uplands and around Slutsk in the south. Rye, wheat, buckwheat, barley and flax are the chief crops. Animal husbandry, especially dairying, is important. (R. A. F.)

**MINSK,** the capital and largest city of the Belorussian Soviet Socialist Republic, U.S.S.R. and administrative centre of an *oblast*, stands on the Svisloch river. Pop. (1959) 509,489. The first documentary evidence refers to Mensk or Menesk in 1067. In 1101 it became the seat of a principality. The town was often sacked and in the 14th century passed to the grand duchy of Lithuania and later to Poland. In 1505 it was laid waste by the Crimean Tatars, and destroyed by fire in 1546 and several times in the 17th century. Russia acquired Minsk by the second partition of Poland (1793) and made it the seat of a *guberniya* (province). In 1812 it was occupied by Napoleon's troops and again suffered damage. The building of the Moscow-Warsaw and Vilnius-Gomel railways through Minsk in 1871 accelerated its growth from 6,656 inhabitants in 1800 to 90,912 in 1897. Minsk underwent three further occupations: by the Germans in 1918, the Poles in 1919–20 and the Germans again in World War II. In the Soviet advance of 1944 heavy fighting took place in the city and it was almost entirely destroyed. Modern Minsk consists almost wholly of new buildings in the postwar Soviet architectural style, and few relics of the past survive. Still in existence are the Mariinski cathedral and the church of the Bernadine monastery, and the small house, now preserved as a museum, where the first congress of the Russian Social Democratic (Revolutionary) party met in 1898.

A major industrial centre, Minsk's wide range of products includes heavy and tipper trucks, timber wagons, tractors, motorcycles, machine tools, radio and television equipment, bearings, footwear and leather goods, clothing, chinaware, pharmaceutical goods, furniture, spirits, tobacco and foodstuffs. It is an important printing centre. Among many cultural institutions are the Belorussian Academy of Sciences, an academy of agricultural sciences, the V. I. Lenin State university (1921) and 11 other higher educational institutes. There are a ballet and opera theatre, a musical conservatoire and Russian and Belorussian theatres. (R. A. F.)

**MINSTREL** (from Old French *ménestrier*), in popular usage a general name for secular musicians of earlier times. More precisely, it was the normal term for a professional secular musician of any kind in the 13th and 14th centuries. During the 15th century, which brought the rapid development of formal part music and specialized ensembles, its use tended to be restricted to those musicians who did not fulfill a specialized function. In the 16th century it came to mean a somewhat disreputable itinerant musician, and by the 17th it ceased to be a meaningful term.

In western Europe until about the 11th century music was not a separate entity but an adjunct to the church liturgy and, in secular life, to dancing and to the chanting of long heroic or satirical tales. The indigenous instruments were simple lyres (robust survivals from classical antiquity), whistle flutes of Neolithic ancestry, panpipes and animal horns with or without fingerholes. During the 11th century, when the feudal structure of France and England was consolidated, there emerged a class of general entertainers called *jongleurs* (Old French), who sang and had some skill on instruments but who were also acrobats, jugglers and trainers of performing animals. The nature of secular music changed considerably after the 12th century, following the sophisticated flowering in the songs and dances of the troubadours and trouvères, and the infiltration of instruments of Arab origin, such as lutes, psalteries, fiddles and rebecs, shawms, trumpets and drums. The word minstrel began to be used, apparently for an executant of more specifically musical skill than the jongleur.

A court minstrel was expected to play many instruments; the troubadour Giraut de Calanson (fl. *c.* 1210) lists citole, monochord, fiddle, mandore, pipe and tabor, and bagpipe among them. It is likely that less exalted minstrels were less well equipped. There were certain regional preferences in instruments, the harp in the British Isles, for example, and the vièle, or troubadour fiddle, in France and Germany. In the music of that time, although unspecified as to instrumentation, there are characteristic pieces for every type of instrument. The minstrel's *expertise* was learned as a craft. No exact records survive of the instrumental practice of those days, though much may be deduced from current techniques on folk survivals of medieval instruments. Besides the minstrels attached to royal and noble households, there were, in

the 14th century, large numbers of free-lance minstrels employed when necessary by city and town authorities for their lavish entertainments, by ecclesiastical authorities and by wealthy private citizens. In 1321 the minstrels of Paris formed a corporation and were affluent enough to open a hospice for poor minstrels in 1330 and to build a church, St. Julien-des-Ménestriers, begun in 1331. London minstrels formed a guild in 1350.

The nature of the minstrel's art, of individual and largely extemporized virtuosity on several instruments of strong and unblending tone quality, was not in keeping with the organized concerted part music which developed in the 15th century, and although the word continued to be used in a general sense, players of a specialized kind, such as those in shawm and sackbut ensembles used for some dance and ceremonial music, string players, royal trumpeters and virtuoso harpers, were often identified as such and not as minstrels. In 1469 Edward IV of England granted letters patent incorporating the Musicians' Company of the City of London, but during the next 60 years the London minstrels, declining in prosperity and prestige, twice made enactments against the activities of foreign minstrels within the city, demanding a fine of 3*s.* 4*d.* In England the word minstrel acquired its final disreputable meaning during the latter half of the 16th century. In France the minstrels' guild maintained an archaic and nebulous existence until its authority was challenged and overthrown by the professionally organized harpsichordists, organists and violinists of the mid-17th century. The harpsichord suite by François Couperin, "Les Fastes de la Grande et Ancienne Mxnxstrxndxsx," is a musical satire on the French minstrels' guild.

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**MINSTREL SHOW.** Negro minstrelsy, the only indigenous American theatrical form, was based upon the singing and dancing of Negro slaves. While in its early forms the minstrel show often presented accurate delineations of southern Negro types, later forms showed diminishing relationship to Negro life and feeling.

Individual Negro impersonators appeared early in the 19th century, the most famous being Thomas Dartmouth Rice, whose "Jim Crow" song and dance was first performed in 1828. The pioneer company, the Virginia minstrels, a quartet headed by Daniel Decatur Emmett, first performed in Jan. 1843. Emmett, who wrote "Dixie" as a "hooray song" or "walk-around" in 1859, became one of the more prominent minstrel performers. The most important of the early companies was the Christy minstrels. Organized in Buffalo, N.Y., they were in New York city by 1846, and, in 1847, leased Mechanics hall on Broadway, where they played for nearly ten years. Stephen Foster wrote his greatest songs for this company. Other noted companies were Bryant's, Campbell's and Haverly's. Negro minstrelsy, popular in England as well as the U.S., reached its zenith between 1850 and 1870, then gradually declined until it became purely a vehicle for amateurs. Its influence, however, was sometimes evident in vaudeville, radio, television and motion pictures of the mid-20th century.

The form of the minstrel show was established by the Christy company and changed little thereafter. The performance usually was in two parts. In part one, the performers were arranged in a semicircle, with the "interlocutor" in the centre, and the endmen, "Mr. Tambo," who played the tambourine, and "Mr. Bones," who rattled the bones, at the ends. The interlocutor, played whiteface, usually wore full dress, the others, their faces blackened with burnt cork, wore gaudy swallow-tailed coats and striped trousers. The program opened with a chorus, often with a grand entrance, and at the conclusion of the song, the interlocutor gave the stereotyped command, "Gentlemen, be seated." Then followed a series of jokes between the interlocutor and endmen, interspersed with ballads and comic songs and instrumental numbers, chiefly on the banjo and violin. The second part, or olio, consisted of a series of individual acts which concluded with a "hoe-down" or "walk-around" in which every member of the company did a specialty number while the others sang and clapped. Occasionally there was a third part, consisting of a farce, burlesque or comic opera. Sometimes this feature was made the last item of part two.

The minstrel show disappeared from the professional theatre. Its chief significance lay in its "folk" music, which made a permanent contribution to American culture. (C. I. S.)

**MINT,** a place where coins are manufactured, usually with the authority of the state.

**History of Development.**—The first state mint was probably established by Candaules (Sadyattes) king of Lydia in Asia Minor, or by his successor Gyges, early in the 7th century B.C. The example of the Lydians was soon followed by the Greeks of the Aegean Islands, and from there the art of coining quickly spread into Italy and other Mediterranean countries, as well as to Persia and India. The Romans, who began coining in the 4th century B.C., laid the foundations of modern minting. Coining also originated independently in China in the 7th century B.C. and soon spread into Japan and Korea.

Gold, silver and base metal coins were in use by various tribes in Britain before the Roman occupation. The Romans attempted unsuccessfully to suppress the tribal mints, but in the 3rd century A.D. the Emperor Marcus Aurelius Carausius himself opened three English mints, one of which was in London. They were soon closed, however, and not until the 6th century was there further definite record of a mint in England. By the reign of Alfred the Great there were at least eight mints in operation, and at the time of the Norman conquest there were more than 70 mints. The number was so large because most of the principal towns throughout the land were authorized to appoint their own "moneyers," *i.e.*, men who struck official coins by hand for local use. This policy was dictated by the fact that the transport of money from one city to another was risky, for road communications were very poor at this period of history and the countryside was infested by roaming robber bands. The number of mints later declined and since the 16th century all gold and silver coins, with one or two important exceptions, *e.g.*, the Great Recoinage of 1696 to 1698, have been struck in the London mint. Early in the 19th century the London mint moved out of the Tower of London, where it had been housed for five centuries, to its own premises on Tower Hill, not far away.

With the colonization of South America and Mexico by the Spaniards in the 16th century, mints were set up in these lands to utilize the gold and silver available there, particularly in Peru and Mexico. The early English colonists in Massachusetts started striking their own silver coins in the form of shillings in the 17th century. There have been seven coinage mints at various times in the United States since the establishment under the constitution of the first mint in Philadelphia in 1792, but only two mints were in operation in the mid-1960s, one in Philadelphia and the other in Denver, Colo. The latter had been established in 1906. A third mint in San Francisco, Calif., discontinued coinage in 1955.

Canada and many other countries throughout the world also operate mints of their own, but some, usually those where the demand for coins is not sufficient to make a national mint economically feasible, have their coins made in foreign mints. The London mint first struck coins for other countries in the 16th century. U.S. mints were authorized by congress in 1874 to contract for foreign coinage orders.

Functions other than minting, notably refining precious metals and manufacturing medals and seals, are performed by many mints. The U.S. mints provide storage for government stocks of gold and silver and the London mint assists in the maintenance of hallmarking standards by examining samples submitted by the provincial assay offices in England and Scotland. The London mint maintains a continuous program of research on coinage materials and processes.

**History of Technique.**—The method of preparing dies and striking coins continued more or less unchanged until the 15th century. Early coins were produced by being struck with a hammer. The lower die, or pile, was given a spiked end so that it

could be firmly driven into a large block of wood; a blank piece of metal of the required size would then be placed on the pile, with the hand-held upper die, or trussel, on top. When the trussel was struck one or more blows with a hammer the whole design was impressed on the blank. It was not until the 15th century, in Italy, that some degree of mechanization was evolved. Rolls for reducing the thickness of cast bars, machines for punching out blanks from sheets of metal and screw presses for striking coins were introduced into the Paris mint in the early 1550s, but it was only in the reign of Charles II (1660–85) that the use of the hammer was abandoned in the London mint. The screw presses were fed and often powered by hand but toward the end of the 18th century a method was devised by Matthew Boulton whereby basically similar presses were driven by steam and were automatically fed with blanks. Screw presses were displaced following the invention of the lever press in 1839. Minting by hand, however, persisted in the native states of India until the end of the 19th century.

In the 15th century the process of manufacture of dies was changed. Whereas in the past a series of punches had been used to build up the design on each individual die, the engraver now prepared a relief punch of the complete design, from which many standardized dies could be made. During the 19th century the practice of engraving punches was abandoned and designs were engraved in intaglio to produce master dies or matrices, and machinery was introduced by which it became possible to engrave master tools mechanically from models several times coin size.

**Modern Processes.**—Mints use furnaces heated by gas, oil, coke or electricity to melt raw materials and process scrap. The metal is cast into molds to obtain bars or slabs ranging in weight from a few pounds—for precious metals requiring very accurate control of composition—up to several hundred pounds—for base metal alloys that do not require such close control of composition.

Small bars are reduced to coin thickness by cold rolling, but a combination of hot and cold rolling, employing highly mechanized equipment, is needed to process large bars. Progressive hardening of the metal occurs during rolling, and it is nearly always necessary to soften it by annealing (heating and cooling) before rolling can be completed. The annealing temperature and time depend on the alloy, but are generally in the range 600°–900° C. for 20 minutes to 3 hours. Partly rolled bars are sometimes surface-machined to remove blemishes and to achieve uniform thickness across the width.

When the bars have been reduced to strip of coin thickness they are passed through blanking presses to produce coin size disks. Cutting or blanking entails the shearing of circular or shaped blanks from the strip by the penetration of cylindrical or shaped punches through the metal into matching holes cut in a bedplate. Multiple blanking is employed, the number of blanks produced at a stroke depending upon the machine capacity, strip width and thickness, and blank size. Normally, from four to ten blanks are cut at one stroke. The blanks are annealed and cleaned by acid pickling, washing, burnishing and drying to produce a bright finish.

Blank annealing is carried out in muffle furnaces of the rotary drum or conveyor belt type. The blanks move through hot zones which may have a controlled reducing or neutral atmosphere to minimize oxidation. Annealing temperatures vary from 500° to 900° C., according to the alloy.

Pickling to remove the oxide film formed during annealing is a chemical process in which the blanks are placed in a rotating drum containing diluted sulfuric acid to which is added bichromate of soda. The blanks are then passed to a rotating air dryer, or are dried with sawdust.

The impressing of the designs on the blanks takes place in coining presses capable of applying a load of 250 tons. The blanks are fed automatically onto the face of a die bearing one of the designs, and the other die is then brought under load into contact with the upper side of the blank, thus causing both designs to be stamped simultaneously. The blow is sufficient to cause the metal to spread outward into the shape of a collar which surrounds the blank at the moment of impact. The hole in the collar is slightly larger than the blank and may be plain on its inside surface or bear the milled pattern familiar on many white coins. Provided that the deformation required is not too great, polygonal (*e.g.*, 12-sided) coins can in this way be struck from circular blanks; shaped blanks are necessary, however, when it is desired to produce coins whose shape is markedly different from a circle.

Coining presses vary in design, but they rely basically on a toggle lever system to transfer the power from the drive to the striking mechanism. Automatic feed mechanisms vary in design also, from a mechanical version of the "finger-and-thumb" location, to rotary disk location of blanks. These mechanisms are in turn fed manually or automatically.

To protect the designs and facilitate stacking, coins generally have a raised rim. This is imparted in the striking process, but in order to reduce the amount of metal that has to be moved in striking, the blanks are often edge-thickened by a separate and earlier process called marking. In this, the blanks are rotated between a static segment and a rotating crown wheel mounted to give an annulus narrower than the diameter of the blank. Segments are usually plain but may bear letters or patterns which in the process are raised or more commonly imprinted on the edges of the blanks. Blanks bearing a raised pattern cannot be struck in a collar, and a more common process of producing coins with raised patterned edges is to have the patterns engraved on the inside of the collars used in striking. To allow the coins to be ejected, such collars are made in segments and open after striking.

Designs for coins are usually fashioned in the first instance by an artist working in clay or plasticine several times coin size. A plaster cast is taken from the artist's model and from it a replica is made, usually in bronze if it is cast or made by electrodeposition. Nickel is deposited first to give hardness and is followed by copper to give thickness for strength.

The metal copy is mounted on a machine on which its details are scanned in a fine spiral by a tracer fixed to the free end of a pivoted bar. A rotating cutter is also mounted on the bar nearer to the pivot. The cutter repeats the tracer's movements in proportion to the distance of each from the pivot, cutting a reduced-size copy in a softened steel block. All identical patterns, such as portraits on a series of coins, may thus be reproduced in different sizes by changing the relative positions on the bar of the cutter and tracer. The spiral path of the tracer and cutter is achieved by synchronized rotation of the model and tool-steel, combined with a gradual movement of the bar across their face.

The tool produced on the reducing machine, known as a reduction punch, is touched up by hand engraving, hardened and used to make a matrix which is itself used to make a working punch, and this in turn is used to make working dies. All these processes are carried out with the aid of a screw or hydraulic press, with hand engraving as necessary to maintain or modify the detail of the original model. Hand engraving may also be employed to introduce features not on the original model (*e.g.*, beads), to effect a change of date, and occasionally to cut a complete design into a matrix without resort to a model.

**Alloys.**—Until the 19th century, coins were usually made of gold, silver or copper, and normally their intrinsic value was equal to their face value. The earliest gold and silver coins made by the Greeks consisted of the pure metals or of electrum, a natural alloy of gold and silver; under the Roman emperors copper was intentionally added. The amount of alloy added to gold has varied considerably; some Roman coins contained only 2% of gold. The gold standard of 916.6 parts per 1,000 was adopted in England in 1526, though not exclusively until the next century. United States gold coins were struck in 900 standard gold, an alloy introduced in France soon after the French Revolution and later adopted in most other countries. A wide variety of standards of silver have also been used for coinage. The silver alloy of a fineness of 925 parts per 1,000 was probably introduced first in England by the Saxons and continued to be used until the 20th century, though on occasion the fineness of silver was deliberately reduced. In 1920 the standard of 500 was introduced, and after 1946 silver was abandoned altogether except for certain small special issues.

United States silver coins are of a fineness of 900 parts per 1,000. Other countries have used silver alloys ranging from almost pure silver to 250 parts per 1,000 or less.

With the acceptance of the idea of token coins—the bullion value of which is less than the face value—the field was opened to cheaper metals, though not to the total exclusion of the traditional alloys. Cupro-nickel, which replaced silver in England, was adopted by Belgium in 1860 and thereafter came into use throughout the world. Copper was generally used in the past for subsidiary coins, but in the 19th century it was largely replaced by bronze, an alloy of copper, tin and zinc. Of increasing importance in recent years have been aluminum alloys, brasses, pure nickel, stainless steel and clad steel (steel coated in sheet form with nonferrous metal). Zinc has been used mainly in times of emergency, as during World Wars I and II. (*See* also ALLOYS.)

**Inspection and Quality Control.**—To counter the threat of counterfeiting, as well as for other reasons, rigid dimensional and composition controls are imposed on the manufacture of coins; exact compositions, weights and tolerances are usually specified by law. Assay samples are taken from each cast of metal, at any process where the composition may be changed (*e.g.*, pickling), and, of course, from the finished coin. Dimensional control is usually exercised only on diameter, thickness being indeterminable because of design variations. Checks on weight are carried out at the cutting, blanching and postcoining stages. Depending on the intrinsic value of the coin, weight tolerances may be specified as applying to bulk samples or to individual pieces.

Superficial inspection of blanks and coins may be performed visually. This is facilitated by a system of belt conveyors upon which the blanks are spread in a narrow band, and which automatically turn them over to permit inspection of both sides in succession. Because of inherent difficulties in the casting process, gas inclusions may occur and give rise to pieces that are superficially perfect but are in fact split in the plane of the metal and therefore "dumb." Checks on this defect are maintained by inducing samples of the coins to resonate by bouncing them on a metal block.

The use of precious metals, and the direct relationship between face value and intrinsic value made desirable independent checks on the weight and composition of coins. Such checks were made from very early times in England by persons appointed by the crown, and the finding of any deficiency in weight or fineness often meant severe punishment for the moneyers, or minters. The check, known as the Trial of the Pyx, is still performed annually by the Company of Goldsmiths on samples of all United Kingdom gold, silver and cupro-nickel coins minted in the preceding year.

In the United States the Assay commission, appointed by the president, meets in February each year to examine and test the weight and fineness of the silver coins reserved at the Philadelphia and Denver mints during the preceding calendar year. The coins, one from each 2,000 pieces or fraction thereof made at each mint, are deposited in sealed packages in a so-called pyx or box for delivery to the commission. *See* also NUMISMATICS.

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**MINT,** the common name for strong-scented herbs of the genus *Mentha*, comprising about 25 species of perennial herbs, and certain related genera belonging to the mint family (Labiatae; *q.v.*). Mints are widely distributed throughout the temperate and subtropical portions of the globe, but chiefly in the temperate regions of the old world.

**True Mints.**—*Mentha* species have square stems, opposite, aromatic leaves, and a stoloniferous creeping rootstock. The flowers are arranged in axillary clusters, which either form separate whorls or are crowded together into a terminal spike. The corolla is usually small and of a pale purple or pinkish colour; it has four nearly equal lobes and encloses two long and two short stamens. All the genus *Mentha* abound in a volatile oil, contained in resinous dots in the leaves and stems. Most mints blossom in summer.

Although native to northern Eurasia and Australia, *Mentha* has a number of species naturalized in North America. The forms easily hybridize so that there is great confusion in the genus. *Mentha spicata* is the common garden mint or spearmint (*q.v.*), which is commonly used for culinary purposes; it is distinguished by its smooth, sessile leaves and lax tapering flower spikes. *Mentha longifolia* chiefly differs from the above in its coarser habit and hairy leaves, which are silky beneath, and in its denser flower spikes. This plant is supposed to be the mint of Scripture, since it is extensively cultivated in the east; it was one of the bitter herbs with which the paschal lamb was eaten. The water mint (*M. aquatica*) grows in ditches and is easily recognized by its rounded flower spikes and stalked hairy leaves. Peppermint (*q.v.*; *M. piperita*) has stalked smooth leaves and an oblong obtuse terminal spike of flowers; it is cultivated for its volatile oil. *M. crispa* belongs to a group in which the flowers are arranged in axillary whorls and never in terminal spikes; it otherwise bears some resemblance to *M. spicata*.

*M. pulegium*, commonly known as pennyroyal (*q.v.*), has small oval obtuse leaves and flowers in axillary whorls and is remarkable for its creeping habit and peculiar odour. It was formerly popular for medicinal purposes.

**Other Mints.**—The name mint is also applied to plants of other members of the family: *Monarda*, the bergamots, are called horsemint; *Pycnanthemum* mountain mint; *Nepeta cataria*, the catnip, is sometimes called catmint; *Cunila origanoides* is the stone mint or Maryland dittany of garden borders; *Prostanthera* species are tender Australian shrubs called mint bushes.

**MINTO, GILBERT ELLIOT-MURRAY-KYNYNMOUND,** 1ST EARL OF (1751–1814), governor general of India from 1806 to 1813, was born on April 23, 1751, the eldest son of Sir George Elliot. About 1763 Gilbert and his brother Hugh were sent to Paris where their studies were supervised by the noted philosopher, David Hume, then secretary to the British embassy in Paris. The brothers also became friendly with the comte de Mirabeau at this time. Returning to England, Gilbert entered Christ Church, Oxford, and then Lincoln's Inn, and was called to the bar in 1774. He entered parliament two years later as an independent Whig; became friendly with Edmund Burke, whom he helped in the attack on Warren Hastings and Sir Elijah Impey, and on two occasions was an unsuccessful candidate for the office of speaker. Elliot was appointed to govern Corsica in 1794; he assumed the additional names of Murray Kynynmound (from his mother's family) and was created Baron Minto in 1798. From 1799 to 1801 he was envoy-extraordinary to Vienna, and having been for a few months president of the board of control he was appointed governor general of India at the end of 1806. During his rule he had to provide against the danger from Napoleon, and deal with the nearer menace of the Sikh power at Lahore. Before he gave up office in 1813 Java and the Moluccas had been added temporarily to the empire. He was then created Viscount Melgund and earl of Minto. He died at Stevenage on June 21, 1814, and was buried in Westminster abbey.

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**MINTO, GILBERT JOHN ELLIOT-MURRAY-KYNYNMOUND,** 4TH EARL OF (1845–1914), governor general of Canada and viceroy of India, where he introduced the Morley-Minto reforms in 1909. He was born in London on July 9, 1845, the eldest son of the 3rd earl, and was educated at Eton and Trinity college, Cambridge. He joined the Scots guards in 1867 but obtained his discharge in 1870 in order to devote himself to riding; after breaking his neck in his fourth Grand National in 1876, however, he gave up serious riding. As a newspaper correspondent he was in Spain with the Carlist army in 1874, and then in Turkey in 1877 during the war with Russia. He was present in an unofficial capacity during part of the second Afghan War in 1879 and fought in the Egyptian campaign in 1882. He went to Canada in 1883 as military secretary to Lord Lansdowne, and served in the campaign against the rebellion of Louis Riel. He returned to England in

1886 and succeeded his father in 1891. He was appointed governor general of Canada in 1898, where his tact and knowledge of affairs enabled him to moderate the conflicts that arose between the imperialism of Joseph Chamberlain, the colonial secretary, and the nationalism of Sir Wilfred Laurier, the prime minister of Canada. He deprecated an excessive concentration on party politics and he never hesitated to proffer his advice to the prime minister on public questions, but Laurier himself paid tribute to his invariably constitutional behaviour.

Minto returned to England in 1904 and was appointed viceroy of India in 1905. Again he had to work with a forceful and opinionated secretary of state, John Morley (*see* MORLEY, JOHN MORLEY, Viscount), who was at the India office. But as the effective head of the government of India his own powers and responsibilities were much greater than they had been in Canada. His political ideas were much less radical than Morley's but the necessities of the time generally brought the two of them into some sort of agreement. In spite of occasional differences and in spite of Morley's autocratic temperament, their partnership was remarkably successful, largely because of Minto's tact and restraint. Many of the policies initiated by Minto's predecessor, Lord Curzon, had aroused hostility among the Indian nationalists. Minto and Morley were agreed that some political reforms were essential, both to satisfy the demands of educated Indians and also to strengthen the hands of the moderate leaders of the Congress party and prevent the rising tide of nationalism from being diverted into extremist or even terrorist channels. Two Indian members were appointed to the secretary of state's council and one to the viceroy's executive council. Minto also wanted to secure better representation both of the landed and commercial interests and of Muslims in the legislative councils. Separate electorates were therefore set up. He has since been strongly criticized for this move on the ground that it alienated the Muslims from the Hindus and was part of a policy of divide and rule that led to the eventual partition of India. But leading Muslims had already expressed their fears of the consequences for the Muslim minority of the extension of representative institutions, and it can be argued that Minto was concerned to reassure them. Moreover, the policy followed his general aim of securing a fair representation of the various interests in the community. On this basis the elective system was extended and the powers of the legislative councils were increased. Besides the concession of political reforms, Minto believed in decisive action against sedition and terrorism; he revived the government's power of deportation without trial to deal with Lajpat Rai and Ajit Singh, and took fresh powers to deal with incitement to murder and the making of explosives. Such measures strained his relations with Morley. The princes formed another interest that Minto wanted to associate more closely with British rule and his general attitude toward them was more conciliatory than Curzon's.

Minto returned to England in 1910, and died at his home at Minto in Scotland on March 1, 1914.

*See* INDIA-PAKISTAN, SUBCONTINENT OF: *History*.

*See* J. Buchan, *Lord Minto: a Memoir* (1924); Mary, Countess Minto, *India: Minto and Morley: 1905–1910* (1934). (KE. A. B.)

**MINUCIUS FELIX, MARCUS** (fl. 2nd or 3rd century A.D.), one of the earliest Christian apologists (*see* APOLOGISTS, EARLY CHRISTIAN) to write in Latin, is the author of the *Octavius*, a dialogue on providence and Christianity in general (without mention of Christ's name), between the skeptic and nationalistic pagan Caecilius Natalis and the Christian Octavius Januarius, a friend of the author. The arguments are borrowed chiefly from Cicero (especially the *De natura deorum*) and the Christian material mainly from the Greek apologists. The beauty of the treatise lies in its classical refinement, not in its originality. The *Octavius* was written before Cyprian's *Quod idola dii non sunt* (*c.* 250), which borrows from it, but it is a matter of controversy whether Minucius influenced or was influenced by Tertullian's *Apologeticum* and *Ad nationes* (197). If Minucius was the earlier author, the *Octavius* was written before 197; otherwise it dates from 197–250.

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(G. Q.)

**MINUFIYAH, AL,** a *muhafaza* (governorate) of lower Egypt situated in the western part of the apex of the Nile Delta. It is bounded east by the Damietta branch of the Nile, north by Al Gharbiyah *muhafaza*, west by the Rosetta branch of the Nile and the Western desert, and south by Giza *muhafaza*. Area 585 sq.mi. Pop. (1960) 1,347,953. The province includes some of the most productive land of the delta and supports some of the densest populations, exceeding 2,300 per square mile in the centre. Agriculture is the principal occupation, employing 67% of the occupied population. Nearly one-third of the land is under maize, the other principal crops being cotton, wheat, and clover. Dates and bananas are the principal tree fruits. The major source of irrigation water is the Raiyah al Minufiyah, a canal that flows from the Mohammed Ali barrage and supplies the centre of the province via the Bahr Shibin and the Baquriyah Canal. There are no mineral resources. Over 90% of the population lives in villages and small towns, the principal of which are Shibin al Kawm (the capital), Minuf, and Ashmun. These are market towns, the few industries being those associated with agriculture: cotton ginning and milling.

(A. B. M.)

**MINUIT (MINNEWIT), PETER** (*c.* 1580–1638), Dutch governor of New Netherland, founder of New Amsterdam, and colonizer of New Sweden, was born of Dutch ancestry in Wesel, Rhenish Prussia, about 1580. In Holland he was appointed director-general of the Dutch West Indies company's settlements in North America in 1625. He landed on Manhattan Island on May 4, 1626. Calling the native Indian chiefs into council, he purchased from them for merchandise valued at 60 guilders (about $24) the entire island of Manhattan, which he intended to make the centre of Dutch settlement. On its southern point he built a blockhouse, warehouse, and mill, around which the early settlers of New Amsterdam made their homes (*see* NEW YORK [CITY]: *History*).

Minuit was recalled by the company in 1631. A few years later he entered Swedish service and was given command of the two vessels of Swedish and Finn colonists who in March 1638 established the first settlement upon the Delaware River, near Wilmington. There Minuit built Ft. Christina. In June 1638 he set out on a trading expedition to the West Indies, and perished in the storm in which the ship was lost. (E. E. R.)

**MINYA, AL,** a town of upper Egypt, about 140 mi. SSW of Cairo by rail, capital of the *muhafaza* (governorate) of the same name. Pop. (1962 est.) 100,000. The town, an important trading centre, stands between the Ibrahimiyah Canal and the west bank of the Nile, which there runs well to the east of its valley. West of the town the valley is eight miles wide and intensively cultivated. There are a cotton ginnery and mills for carpet and rug weaving.

AL MINYA MUHAFAZA consists of the flood plain of the Nile for about 75 mi. between Asyut governorate in the south and Bani Suwayf governorate in the north, the Eastern and Western deserts being the other boundaries. Area 878 sq.mi. Pop. (1960) 1,560,311. The *muhafaza* is heavily agricultural and has a most efficient system of perennial irrigation based upon the great Ibrahimiyah Canal, which draws its waters from above the Asyut barrage to the south. About 70% of the working population is engaged in agriculture. Principal crops (in order of importance) are cotton, corn (each occupying about one-fifth of the farmland), wheat, sugar, millet, onions, and dates. Industrial activities are limited to the processing of agricultural commodities, principally cotton ginning and flour milling. There are sugar mills at Abu Qurqas and Shaykh Fadl. Principal towns are Al Minya, Abu Qurqas, and Bani Mazar.

(A. B. M.)

**MIOCENE,** in geology, the fourth series of strata in the Tertiary system, is thus the fourth epoch in the Tertiary period of the Cenozoic era, as is shown on the accompanying geologic time chart. The name is derived from the Greek for "less recent," in contrast to the "more recent" epoch, the Pliocene (*q.v.*), which followed

During Miocene time the tropic parallels of latitude were several degrees nearer the poles than at present. Yet nipa palms no longer grew on the site of modern London as they had during the earlier Eocene epoch; the extensive Eocene tropics had already shrunken equatorward.

These climatically intermediate aspects of the Miocene were reflected also, though more indirectly so, in the animal life of the epoch. By earliest Miocene time the more grotesquely archaic browsing mammals of the older Tertiary were gone. Most modern mammal families were already represented, yet in the land faunas of the Miocene these newcomers lived side by side with still other older mammalian stocks. Among the shellfish that flourished in the Miocene seas extinct species far outnumbered species that are still found living along the seashore today.

## MIOCENE GEOGRAPHY

The Oligocene had been an epoch of increased topographic relief, crustal uplift and land emergence. In the Miocene which followed, two widespread re-expansions of the sea, early and late, were interrupted during a middle Miocene interim by localized mountain-making movements and shiftings of the shelf seas. Late Miocene time was followed by another interval (Mio-Pliocene) of crustal uplift and regression of the seas, prior to the marine transgressions of the Pliocene.

In Europe the Oligocene North sea persisted into Miocene times in Denmark (Jutland) only. Nor was the Miocene North sea as extensive as that of the Eocene or Oligocene; it covered only the fringes of eastern England (?), northern Belgium, the Netherlands and northern Germany. A probable late-Miocene connection with southeastern Europe remains undemonstrated; nor were the Eocene and Oligocene marine connections with the arctic via western Siberia re-established. Much of Britain, Fennoscandia (the Baltic shield), central Europe, Iberia and Sardinia-Corsica remained land. The Alps, Pyrenees and Carpathians were already rising. Atlantic gulfs penetrated Brittany, Touraine, Aquitaine and Portugal, and though a barrier appears to have cut it off from the North sea, the Miocene Atlantic was connected with the Mediterranean by way of Andalusian and Riffian (northwest African) straits. Italy was under deep water. A narrow foredeep extended up the Rhône and, during the disturbed middle Miocene (Styrian orogenies, deep-water Schlier deposits) stretched across northern Switzerland to the Vienna basin. Thence a late Miocene sea extended eastward over Hungary, southern Russia and Turkistan where it subsequently changed into an extensive brackish-water, then fresh-water and finally a saline inland sea, of which the Aral, Caspian and Black seas are shrunken relics. Contemporaneously, Mio-Pliocene marine bays remained in parts of Europe (north Germany, Belgium, Brittany, Italy) which by then, from Greece (Pikermi) westward, was largely above the sea. Narrow landlocked marine troughs (Sahelian, after Sahel d'Oran, Alg.) with abyssal waters existed farther southwest.

From southern Asia Minor the Miocene eastern Mediterranean extended southward to Egypt (Globigerina marls), eastward to Persia (Fars, Iran) and western India (lower Miocene Gaj formation), and to the fringes of Zanzibar, Madagascar and Ceylon. But somewhere in this Afro-Asian region—perhaps in the Mascarene Islands (Indian ocean) area—low-lying land-bridges existed intermittently. The previous marine waterway (Tethys) connecting southern Europe and southeastern Asia, beginning to break up during the Oligocene, was finally sealed off by middle Miocene times. Thenceforth (through Pliocene time), along the foot of the rising Himalayas continental sediments (Siwalik) were deposited, preserving fossil remains of primates displaying manlike characteristics.

Eastward, beyond a nonmarine upper Burma and beginning with the "Beboeloe transgression" (Upper *e* and Lower *f*) of the sea over the land (*see* Miocene Correlation chart, Indo-Pacific, Upper *e* and Lower *f*), spread an Indo-Pacific ocean. Its tropical Miocene faunas reached the Philippines, Japan, New Zealand (Hutchinsonian, Altonian), the Pacific islands and Australia (Batesfordian, Balcombian).

In western North America a provincial marine fauna evolved out of earlier Caribbean, trans-Pacific and local sources. Miocene volcanism was marked (Columbia river, south-central California); early Miocene block-faulting and breccia accumulation (San Onofre) were extensive in southern California. The Sierra Nevada, rising along its eastern fault scarp, interrupted former westward-flowing drainage from the interior, permitting the accumulation of a biogenetic formation (Monterey) in the Coast Range marine trough immediately to the west, while landlaid beds (Rosamond) were deposited east of the range. While the Gulf Coast and Atlantic seaboard were beneath a Miocene shelf-sea, the West Coast Ranges, the Caribbean, Central America and northern and western South America were often under deeper waters. But largely, the Americas remained above the sea (archipelagic California, the western interior across to Florida, parts of Venezuela, Colombia, Bolivia, "Santacruzian" Patagonia).

*Geologic Time Chart*

| System and Period | Series and Epoch | Distinctive Records of Life | Years |
|---|---|---|---|
| **CENOZOIC ERA** | | | |
| Quaternary | Recent | Modern man | 01 |
| | Pleistocene | Early man | 1,000 |
| | Pliocene | Large carnivores | |
| | Miocene | Widely open, grazing forests | |
| Tertiary | Oligocene | Large browsing mammals | |
| | Eocene | Rise of flowering plants | |
| | Paleocene | First placental mammals | 70,000 |
| **MESOZOIC ERA** | | | |
| Cretaceous | | Extinction of dinosaurs | 135,000 |
| Jurassic | | Dinosaurs, insects, primitive birds, first small mammals | 180,000 |
| Triassic | | Appearance of dinosaurs | 225,000 |
| **PALEOZOIC ERA** | | | |
| Permian | | Reptiles developed, conifers abundant | 275,000 |
| Carboniferous | | | |
| Upper (Pennsylvanian) | | First reptiles, coal forests | 350,000 |
| Lower (Mississippian) | | Sharks abundant | 415,000 |
| Devonian | | Amphibians appeared, fishes abundant | 440,000 |
| Silurian | | Earliest land plants and animals | 500,000 |
| Ordovician | | First primitive fishes | 600,000 |
| Cambrian | | Marine invertebrates | 800,000 |
| **PRECAMBRIAN TIME** | | | |
| | | Few fossils | 3,000,000–4,000,000 |

## MIOCENE LIFE

**Marine Life.**—Physically, Miocene geography approached that of the earlier Eocene, but crustal disturbances during the intervening Oligocene time had erected new barriers to marine life dispersal (isthmic links, marine deeps, shifted isotherms). At high latitudes thermal barriers adversely affected current-borne tropical life; no cosmopolitan marine fauna reappeared. Endemic evolution and provincialism became established in the sea. Although elements of Eocene and Oligocene origin are still discernible in modern faunas, the major outlines of the Recent marine invertebrate faunal provinces were determined during the Miocene.

Many invertebrate lineages previously conspicuous declined or disappeared. *Turritella*, persisting, gave ground to other suddenly expanding gastropods (Cancellariidae, Columbellidae, Nassidae, Thaididae). The cocklelike "giant venericards" (*V. planicarta*), formerly widespread, had been replaced during the Oligocene by large scallops (*Pecten*) and certain clams (*Dosinia*); the older nummulite and discocycline foraminifers by orbitoids (*Lepidocyclina, Miogypsina*) and cycloclypeids; these still abounded in the Miocene though, except for a few living relics, tropical shallow-water large foraminifers such as those mentioned suddenly disappeared after the Miocene. Oysters attained great size; offshore, small foraminifers flourished; echinoid cake urchins and sand dollars (*Clypeaster, "Scutella," Astrodapsis*) multiplied, diversified and expanded. Other stocks (diatoms, corals, cephalopods, crustacea, insects, large-toothed sharks) were locally important. Mammalian marine adaptations appeared (seals, sea lions, *Dermatylus*), or became modernized (sea cows, whales).

**Land Life.**—Land mammals were more like modern ones than before. Among carnivores the huge bear dogs, *Amphicyon* (*see* CARNIVORE, *Extinct Carnivores*) were conspicuous. Eurasian faunas included deer, hyenas and eventually the earliest giraffes and

| Series | Europe and Mediterranean: North Sea-Atlantic | Europe and Mediterranean: Central and Eastern | | Southeast Asia and Pacific: Indo-Pacific | Southeast Asia and Pacific: N. Zealand-(*) Australia | North America: Pacific Coast | North America: Nonmarine | North America: Atlantic-Gulf |
|---|---|---|---|---|---|---|---|---|
| Pliocene | Diestian<br>Lenham | Plaisancian<br>Blue Clay | Rumanian, u. Dacian, m. Levantine<br>Cimmerian, l. Dacian, l. Levantine | Lower h<br>Middle Palembang, Lower "*Rotalia* zone" | Opoitian<br>Kalimnan* | Venturian<br>Etchegoin; Upper Purisima, Middle Pico | Hemphillian<br>Ash Hollow, Burge Channel | Lower Caloosahatchee |
| Miocene | Anversian, Redonian<br>Gimmerton | Sahelian, Zanclean, Messinian<br>Gessoso-solfifero | Pontian<br>*Paludina* beds<br>Meotian<br>*Congeria* beds<br>Sarmatian<br>Volhynian<br>Buglowian | Genseng<br>Tertiary g<br>Lower Canguinsa, Odeng, Lower Palembang | Kapitean<br>Mitchellian*<br>Tongaporotuan | Repettian<br>Jacalitos; Upper Santa Margarita<br>Delmontian<br>San Pablo; Upper Monterey | Monte-Diablan<br>Clarendonian<br>Cerro-Tejonian | ? |
| | Bolderian | Faluns of Touraine<br>Tortonian<br>"Second Mediterranean Stage" | Vindobonian | Tjilanang<br>Upper f<br>Upper Balikpapan | Waiauan<br>Upper Balcombian* | Briones<br>Mohnian<br>Lower Santa Margarita | Mint Canyon | Yorktown-Duplin, Choctawhatchee |
| | | Faluns of Salles<br>Helvetian<br>Marine Middle Molasse | Schlier | Njalindung<br>Middle f<br>Lower Balikpapan | Lillburnian<br>Batesfordian* | Uppermost Temblor<br>Luisian<br>Lower Monterey | Barstovian<br>Deep River, North Coalinga | Chesapeake |
| | Burdigalian<br>Langhian<br>"First Mediterranean Stage" | | | Rembang<br>Lower f<br>Poeloebalang | Clifdenian<br>Lower Balcombian* | Gould, Upper Sandholdt<br>Relizian<br>Upper Temblor | Heming-fordian | Alum Bluff |
| | Aquitanian<br>Calcaire de Beauce | Chattian | Cassel Sands | Beboeloe<br>Upper e<br>West Progo, Lower Vigo<br>Lower e | Altonian<br>Awamoan<br>Hutchinsonian<br>Otaian | Lower Astoria, Middle Temblor<br>Saucesian<br>"Vaqueros-Temblor transition" | Arikareean<br>Harrison, Rosebud | Tampa<br>Vicksburg |
| Oligocene | U. Hamstead, Sables de Fontainebleau<br>Stampian | Argile de Boom<br>Rupelian | Septarienton | | Waitakian | Zemorrian<br>Lower Temblor, Lower Rincon, Vaqueros, Blakeley | Upper Sespe, Upper John Day<br>Whitney-an | |
| | Calcaire de Brie<br>Sannoisian<br>Supragypsiferous Marls | Tongrian | Samland Amber-Bearing Beds<br>Lattorfian | | Duntroonian | | | |

CORRELATION CHART FOR MIOCENE AND DIRECTLY PRECEDING AND SUCCEEDING GEOLOGIC EPOCHS

bovines. Mastodonts spread into North America for the first time. There, as grasslands spread more widely, browsers were soon surpassed by grazing mammals; camels and horses evolved rapidly, horses especially spreading widely during the emergent Mio-Pliocene (*see* also Equidae). The distinctive South American mammals were still isolated on their insular continent, as were the marsupials and monotremes in Australia.

Vegetation, responding to climatic change through the Cenozoic, shifted equatorward along the north-south trending mountain ranges bordering the Pacific, except where east-west trending strandlines, or beaches, interfered (Malaysia, Caribbean). But where mountains run east-west through the old world a Miocene Mediterranean flora, trapped there, is ancestral to the modern flora upon which human agricultural civilizations first grew. *See* also Paleobotany; Paleontology.

## STRATIGRAPHY

The term Miocene was introduced by Sir Charles Lyell (*q.v.*). Derived from the Greek meaning less and recent (*see* above), it indicates that the series carries a smaller percentage of living species than found in the overlying Pliocene. The term first appeared, and apparently was first conceived, with reference to the Superga hills sequence, near Turin, Italy, as type, although other strata (Touraine, Bordeaux, Vienna) were also involved in the original studies. Lyellian correlation (by percentage of living species), supplemented locally by stratigraphically restricted (index) species, has permitted worldwide identification of the Miocene. Yet neither principle mentioned permits the refined age determinations required for correlating series boundaries or subdivisions.

Historically, in the sense of "original meaning," neither precise limits nor true subdivisions of the Miocene were involved in Lyell's definitions. Nonmarine beds, delimiting uppermost "type Oligocene" and separating "typical Miocene" from "typical Pliocene," further complicate both boundary problems; ambiguous usages have followed: Oligo-Miocene (for Aquitanian) below, Mio-Pliocene (for Sarmatio-Pontian) above. Based on degrees of biogenetic affinity (not per se indicative of time, since geological changes in environment do not affect all organismal lineages

equally), in general, invertebrate paleontology has included both transitional intervals within the Miocene; vertebrate paleontology has not.

Laterally, in correlating subdivisions (stages, zones) of the series, zoogeographic facies prevents a ready worldwide application of Albert Oppel's (*see* JURASSIC SYSTEM) zonation principle. Not in use everywhere (middle east and middle and South America) provincial stage-subdivisions of the Miocene have nevertheless come into local use in most other Miocene faunal provinces. See also PALEONTOLOGY: *Geological Paleontology*, and physical geography and geology sections of articles on continents and countries.

*See* also references under "Miocene" in the Index.

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**MIR**, the traditional Russian rural community. As an institution of local self-government the *mir* is very old, but no documentary evidence about its activities is available before the 15th and 16th centuries. At this time the peasants in each rural district (*volost*) elected an elder (*starosta*) and other communal officials. They had jurisdiction over local forests, fisheries, hunting grounds and vacant lands; the arable lands and meadows were held by the peasant households in hereditary tenure. In the middle of the 18th century the sphere of competence of the communal officials was enlarged, and in many provinces all local judicial and administrative functions were entrusted to them. During the 17th and 18th centuries the scope of peasant self-government was restricted by appointed government officials on state domains and by the landowners on private estates. The growth of serfdom gradually deprived the peasants on private estates of their personal and property rights, and the elected officials of the *mir* became auxiliary organs of the manorial administration.

About 1720, the government imposed a heavy poll tax upon all males of the lower classes, regardless of age and economic status. To make this tax more equitable, the manorial administration and the peasants themselves felt it necessary to establish a direct relation between the size of a household and the amount of land that it possessed. This was achieved through the periodic redistribution of arable land. On state domains this system became consolidated only at the beginning of the 19th century; the competence of the *mir* in land distribution and other local affairs was recognized by law in 1838. Most Russian peasants considered redistribution a just practice and often introduced the system on their own initiative. By the end of the 19th century it prevailed in more than three-quarters of all peasant households. Only in the western (formerly Polish) provinces did private landed property predominate among the peasants.

When serfdom was abolished in 1861, the liberated peasants received considerable self-government. The members of the community formed a village assembly (*selski skhod*), which elected an elder and freely managed all internal affairs. Only in 1889 was the activity of the assembly placed under the control of an agent of the government (*zemski nachalnik*). The land was granted to the former serfs and state peasants in communal tenure, and the members of the commune were collectively responsible for the payment of state taxes and the fulfillment of local obligations.

Communal landholding promoted the sense of equality and mutual aid within the community, and the decisions of the *mir* possessed indisputable authority. But from the economic viewpoint the system was inefficient. The communal land first had to be divided into sectors, according to quality and distance from the village; each sector was then subdivided into three fields; and within each field every household received, in temporary possession, a strip of land in proportion to its size. All field work had to be completed simultaneously since after the harvest the fields were used as communal pasturage. This system hindered agricultural progress and was largely to blame for the low standard of living of the Russian peasantry.

Nevertheless, the agrarian community was highly regarded by various currents of Russian public opinion. The Slavophils and the political conservatives praised it as a guardian of the old national values. A. I. Herzen and the revolutionary Narodniki saw in the *mir* the germ of a future socialist society. The government, until the end of the 19th century, considered the rural community the pillar of a patriarchal way of life, and in fiscal affairs it preferred to deal with the *mir* rather than with a great number of individual taxpayers.

After the revolution of 1905, the prime minister P. A. Stolypin issued the law of Nov. 22 (new style; 9, old style), 1906, which gave the head of every household the right to demand the transfer of his plots into private ownership. By the end of 1914, out of a total of 9,000,000 households possessing land in communal tenure, 2,500,000 had converted their allotments into private property, and about 600,000 applications for conversion were still pending.

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**MIRABEAU, HONORÉ GABRIEL RIQUETI,** COMTE DE (1749–1791), the greatest orator and probably the ablest political mind in the Constituent Assembly at the beginning of the French Revolution, was born at Bignon, near Nemours, on March 9, 1749. He was the elder son of Victor Riqueti, marquis de Mirabeau (*q.v.*), by his unhappy marriage to Marie Geneviève de Vassan.

**Early Life.**—Ugly from birth and further disfigured by smallpox at the age of three, the precocious Honoré Gabriel was soon on bad terms with his formidable father. At the age of 15 he was sent as a pupil to the strict abbé Choquard in Paris, and at 18 he went as a volunteer to serve in a cavalry regiment at Saintes, where his father hoped that military discipline would curb him. His misbehaviour, however, led to his imprisonment on the Ile de Ré, under a *lettre de cachet*. Released to serve in Corsica with the rank of sublieutenant in the army, he distinguished himself there in 1769. Returning with his father, he married a rich Provençal heiress, Émilie de Marignane, in 1772, but his heavy spending and further misconduct led his father to have him imprisoned under another *lettre de cachet* and put out of reach of his creditors. He was detained first at the Château d'If (1774), then at the Fort de Joux, near Pontarlier. Having obtained permission to visit the town of Pontarlier, he there met his "Sophie"—in fact the marquise de Monnier (Marie Thérèse de Ruffey), the young wife of a very old man. Eventually he decided to escape to Switzerland, where Sophie joined him; they then made their way to Holland, where Mirabeau was arrested in 1777. The tribunal at Pontarlier had meanwhile sentenced him to death for seduction

and abduction, but he escaped execution of the sentence by submitting to further imprisonment under a *lettre de cachet*. In the château of Vincennes, he composed the *Lettres de Vincennes* (addressed to Sophie), some erotic works and his essay *Des lettres de cachet et des prisons d'état*. Released in Dec. 1780, he finally had to surrender himself to arrest at Pontarlier in order to have the death sentence revoked; but by Aug. 1782 he was entirely free. He now became involved in a lawsuit against his wife, who wanted a judicial separation. Pleading on his own behalf, he gained the sympathy of the public but lost his case (1783). Rejected by his wife and by his father, he had to renounce the society into which he had been born.

For the next five years Mirabeau lived the life of an adventurer. He was employed sometimes as a hired pamphleteer, sometimes as a secret agent. He came into contact with the ministers Calonne, Vergennes and Montmorin (A. M. de Montmorin de Saint Hérem), made an enemy of Necker, at that time director of the finances, and engaged Beaumarchais in controversy. His activities necessitated much traveling. In London he was introduced into the best Whig society by Gilbert Elliot, who had been his fellow pupil under the abbé Choquard; he had to take refuge in Liège when his *Dénonciation de l'agiotage* (against stockjobbery) annoyed Calonne; and he undertook a secret mission to Berlin in 1786. With the active assistance of a Brunswick friend, Jacob Mauvillon, he wrote *La Monarchie prussienne sous Frédéric le Grand* (1788), which he dedicated to his father; but *L'Histoire secrète de la cour de Berlin*, in which he made unscrupulous use of material derived from his mission in Germany, created a scandal in 1789.

**The Revolution.**—When the estates-general were summoned (*see* FRANCE: *History;* FRENCH REVOLUTION), Mirabeau hoped to be elected as a deputy for the nobility of Provence. For this he needed his father's support. Pleased by the book dedicated to him, the marquis had summoned Mirabeau to Argenteuil in the autumn of 1788 but had not given him any real help. Mirabeau presented himself in the chamber of the nobility in the estates of Provence in Jan. 1789 and uttered violent diatribes against the privileged classes but was not elected deputy, as he held no fief. Turning reluctantly to the third estate, he secured election, in April, both at Marseilles and at Aix-en-Provence. He chose to represent Aix.

Unlike Sieyès, Mirabeau came to the estates-general without any precise constitutional doctrine. An avowed enemy of despotism (he had written an *Essai sur le despotisme* before he was 25), he was nevertheless a firm supporter of the monarchy and of the executive power. Without expressly adhering to the English system, he wanted representative government. A nobleman rejected by his class, he opposed the idea of an aristocratic second chamber. Like most of his contemporaries, he had no political experience, but his intelligence and his knowledge of men made him supremely capable of acquiring such experience rapidly. Lack of money, however, exposed him to pressure and to temptation.

From May to Oct. 1789, Mirabeau played a decisive part in the battle between the third estate and the privileged orders. His aim was to become the spokesman of the nation to the king and at the same time to moderate the expression of the nation's wishes. Thus on June 15 and 16 he was careful not to suggest the name "National Assembly," which was the rallying cry of the third estate in its revolutionary debate of June 17, when it set itself up as representative of the whole nation. Yet at the ending of the "royal session" of June 23, when the marquis Henri Évrard de Dreux-Brézé, in the king's name, ordered the assembled estates to return each to its separate chamber, Mirabeau's answer did much to confirm the deputies in their resolution to disobey; and in the feverish atmosphere of the early days of July he inspired the assembly's address on the dispersal of the troops concentrated round Paris. After the fall of the Bastille (July 14) he urged the assembly to demand the dismissal of the ministers who were to blame for the disorders. His popularity in Paris was then considerable. On the other hand, he disapproved of the assembly's precipitate action in abolishing feudalism (on the night of Aug. 4) and of the abstract Declaration of Rights, and while he was openly against a second chamber, he yet wanted the king to have an absolute veto. In October, when the Parisians marched on Versailles and took the king back to Paris, Mirabeau's attitude was ambiguous and gave rise to the suspicion that he might be plotting against the king—perhaps in favour of the duc d'Orléans (the future Philippe Égalité). To clear himself and to keep open the door to the court's favour, he addressed a memorandum to the king, advising him to leave Paris for Rouen, to secure the support of a small army and to appeal to the provinces.

Mirabeau's prime concern, however, was to win "the battle of the ministry." Ostensibly a supporter of Necker, he in fact did his utmost to destroy him: his brilliant speech on the bankruptcy of the nation was a masterstroke against the minister. Furthermore, he tried skilfully to induce the assembly to grant to the king the option of choosing members of it to be his ministers; but the assembly's decree of Nov. 7, 1789, precluding all deputies from the ministry for the duration of the session, frustrated his hopes of ministerial office for himself.

From Nov. 1789, notwithstanding his oratorical triumphs of Jan.–April 1790 in the cause of the Revolution (in particular his attack on the *parlement* of Rennes), Mirabeau was a prey to despondency and aimlessness until his friend Auguste de La Marck, with the approval of Florimund von Mercy d'Argenteau, Austrian ambassador to Paris and the queen's confidant, approached him with the proposal from Louis XVI and Marie Antoinette that he should become their secret counselor. Mirabeau accepted with delight: "I shall make it my chief business to see that the executive power has its place in the constitution" (letter of May 10). Part of the promised remuneration was to be the paying-off of his debts. In May 1790, when the assembly was debating the king's right to make war and peace, Mirabeau successfully opposed Antoine Barnave, whom he challenged with the words: "Tell us that there should be no king, do not tell us that there should only be a powerless, superfluous king." He impeded the progress of the Jacobins but risked his own popularity, and a pamphlet against him was circulated (*Trahison découverte du comte de Mirabeau*). From June to October he had to work to recapture his prestige. This was the more necessary because the king and the queen, despite their secret interview of July 3 with Mirabeau at St. Cloud, took little notice of his advice and continued to be influenced by Lafayette, who had scorned Mirabeau's offer of alliance. In Oct. 1790 the assembly further disappointed Mirabeau by refusing, after more discussion, to revoke the decree of Nov. 1789 on the noneligibility of its members for the ministry.

While the court was displeased by some of Mirabeau's outbursts and by his "incurable mania of running after popularity," Mirabeau for his part was enraged to see a new ministry formed under the influence of his rivals Lafayette and Alexandre, comte de Lameth. By the end of Nov. 1790 his relations with the court were severely strained. He restored them by submitting to Montmorin a "Plan" concocted for bringing pressure to bear by various means on the assembly, on Paris and on the provinces, so as to co-ordinate "the means of reconciling public opinion with the sovereign's authority." In Mercy d'Argenteau's opinion the plan was perfect in theory but very difficult to put into practice. From Jan. 1791 it was clear that Mirabeau had no intention of doing anything that might compromise his own popularity, though he was willing enough to "spike" the assembly by getting it to adopt ill-considered measures of religious persecution and was eagerly and adroitly working to discredit Lameth's faction. His popularity rose to its zenith, and the eyes of all Europe were on him. As spokesman of the diplomatic committee, on Jan. 28, 1791, he made a speech that bore the unmistakable stamp of statesmanship: anxious to avoid anything that might compromise France's relations with neighbouring countries, particularly with England, he yet would not repudiate any of the Revolution's political victories or allow any necessary military precautions to be overlooked. On the following day he at last became president of the assembly for a fortnight. In this office, from which he had been so long excluded, his control of the debates was masterly.

Mirabeau's problem was to know how and for how long his Machiavellian game could be continued without his being exposed or giving himself away. The people of Paris were restless, worried

by rumours. Mirabeau's position was made difficult by his intervention on behalf of the king's aunts, Mme Adélaïde and Mme Victoire de France, who had fled from Paris, by his hostility to the law against the *émigrés* and by his harsh words against the Lameths and their satellites in the assembly ("Silence to the factious! Silence to the 33!"). On Feb 28 he was sorely pressed to justify himself to the Jacobins after a pitiless attack by Alexandre de Lameth. The newspapers of the left redoubled their accusations of treason against him, and in March he sustained some notable reverses in the assembly. Death may have saved him from political defeat. Gravely ill since his presidency of the assembly, he worsened his condition by excessive indulgence, took to his bed on March 27 and died on April 2, 1791. The people's grief for him was boundless; he was given a magnificent funeral; and it was for him that the new church of Ste. Geneviève was converted into the Panthéon for the burial of great men. In the insurrection of Aug. 10, 1792, however, proofs of Mirabeau's relations with the court (the papers of the intendant A. de Laporte) were found in an iron chest in the Tuileries palace; and on Sept. 21, 1794, his remains were dislodged from the Panthéon by order of the Convention.

As a statesman, Mirabeau failed in his main object, that of reconciling the monarchy with the Revolution and a strong executive with national liberty: he was too much of a monarchist for the Revolution, too revolutionary for the monarchy. As an orator he was unsurpassed. Even though his eloquence was fed by material gathered from every quarter and by a "workshop" of collaborators, it was Mirabeau who found the striking images and expressions that give to his speeches their brilliant individuality. Generally bad at extemporizing, he could be moved by anger or injured pride to an impassioned tone that would carry the assembly with him. Barnave described him as "the Shakespeare of eloquence." There are editions of his speeches by E. Méjan in five volumes (1791–92) and by P. Blanchard in ten volumes (1819–22). His letters to the court are printed as *Correspondance entre le comte de Mirabeau et le comte de La Marck*, edited by A. F. de Bacourt, in three volumes (1851).

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**MIRABEAU, VICTOR RIQUETI,** MARQUIS DE (1715–1789), French political economist, the forerunner and later the great patron of the Physiocratic school, was born at Pertuis in Provence on Oct. 4, 1715. He abandoned a military career, which his father wanted him to pursue, for literature. He first attracted general notice with *L'Utilité des états provinciaux* (anonymous, 1750). This marked an important stage in the movement for the reform of French local government by its radical criticism of Louis XIV's centralized bureaucracy and by its suggestion that provincial estates, which then existed only in *pays d'états*, should be set up throughout the kingdom. His prestige as a political thinker and economist was finally established by *L'Ami des hommes, ou traité de la population* (1756), which reflected the ideas of Richard Cantillon but also anticipated some of the fundamental doctrines of the Physiocrats (*see* PHYSIOCRATIC SCHOOL), especially their conception of the primacy of agriculture in economic affairs. Mirabeau then associated himself, under the influence of François Quesnay, with the Physiocrats' attempts to reform the system of taxation. In his *Théorie de l'impôt* (1760) he attacked the system of farming out the indirect taxes, recommending instead the establishment of direct taxes on land and on personal income. This led to his imprisonment at Vincennes and to his temporary exile to his estate at Bignon, near Nemours. Thereafter, despite trouble with his wife (Marie Geneviève de Vassan, whose protracted suit for judicial separation undermined his health and ruined his personal fortune) and with his son (*see* MIRABEAU, HONORÉ GABRIEL RIQUETI, Comte de), he devoted his efforts to the advancement of physiocracy. He died at Argenteuil on July 10, 1789.

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**MIRACLE,** generally defined by the etymology of the word (Gr. *thaumasion*, Lat. *miraculum*) as that which causes wonder and astonishment, being extraordinary in itself and inexplicable by normal standards, or as a sign (Hebrew *'oth*, Gr. *semeion*) indicating something other than itself. Extraordinary and astonishing happenings become specifically religious phenomena when they express, reveal or signify a religious reality, however defined. This article discusses miracles mainly as seen, experienced and interpreted in the religious context, irrespective of the scientific or philosophical judgment passed on them from the outside.

**Types.**—The mythological accounts of the origins of the gods and their activities in the primeval past should not be classed as miracles, and the term is better reserved for outer events (as distinct from inner experiences, visions, etc.) regarded as divine interventions or as manifestations of divine, that is to say numinous, powers (*e.g.*, in the case of impressive natural phenomena). Man can be the object of miracles, as for instance when his disease is miraculously healed, or their subject, when he performs miracles in whatever "power" he experiences as moving him. The founders of religions are all at the centre of great miracle cycles, and miracles occur, as a rule, in connection with holy men, holy places and holy objects (relics, holy images, sacraments). Theologically, miracles serve as credentials for claimants to religious leadership or prophecy (*cf.* Ex. iv, 1–9, 30–31; Deut. xviii, 21–22), as demonstrations of the superior powers of a particular God (*e.g.*, Ex. vii, 9–12) or as evidence of the truth of a particular religion.

**Diffusion.**—The incidence of miracles is universal. Although primitive cultures lack a fully developed scientific conception of natural causality—and hence also the notion of a "supernatural" miracle—they know of extraordinary events, forces and operations. These are integrated in various ways, such as ritual, magic or shamanism, with the more "ordinary" modes of behaviour. Similarly the religions of the ancient world (*e.g.*, Babylonia and Egypt) had few formal miracles, precisely because certain kinds of divine action or cosmic operation (*e.g.*, oracles) were part of the normal order of things, even if priests and shamans did resort to deception. Ancient Indian mythology, like all mythologies, abounds in fantastic accounts of the doings of the gods, but the Upanishads and Brahmanas evince an increasing indifference to miracles. Like other forms of higher mysticism, they consider the spiritual experience of religious insight and transformation as the only "miracle" worth talking about. Nevertheless Hindu popular religion sets no bounds to the miraculous powers of ascetic yogis, and India has become the classic land of wonders. There is little room for the miraculous element in Confucianism, but Taoism has produced a rich crop of thaumaturgy and magic on all levels of Chinese folk religion. Miracles are taken for granted throughout the Old Testament: God "does wondrous things" (Ps. lxxii. 18; *cf.* Job v, 9) especially in the history of his people Israel (*e.g.*, the ten plagues of Egypt). In the Greco-Roman world miracles were not uncommon; there were miraculous cures (*e.g.*, at the sanctuary of Asclepius in Epidaurus), moving statues of gods, resurrections of the dead, virgin births and the like, though philosophical criticism too was articulate. Cicero in the *De divinatione* denied the possibility of miracles.

According to the earliest Buddhist accounts, Gautama Buddha deprecated the miraculous powers that he possessed as a matter of course, being "the greatest of all yogis," as utterly devoid of spiritual significance. Nevertheless miraculous accounts of his birth and life (and those of later Buddhist saints), as well as miracles in connection with his relics, proliferated as time went on, particularly in the Mahayana tradition. The Christian New Testament records various miracles of healing and of providing abundantly for specific human needs performed by Jesus Christ, and miracles did not cease after the New Testament period. They form part of the career, in life as well as after death, of the Christian saints,

and their occurrence continues (*e.g.*, Lourdes); duly established miracles are among the requirements for a process of canonization. (For the special problems of miracles in the Christian faith, *see* below.) Mohammed was the only great founder who renounced miracles and miraculous powers as a matter of principle—the Koran was the great miracle—but subsequent hagiography invested his life with superlatively miraculous details. Muslim popular religion, particularly under Sufi influence, abounds in miracles, pilgrimages to the tombs of wonder-working saints and the like.

**Significance.**—The paragraphs above show both the universal incidence and the reserve—in varying degrees—of the great founders (Buddha, Jesus, Mohammed) with regard to the performance of miracles. Miracles belong to the level of popular religion, which is the same everywhere and at all times. The tension between popular and "higher" religion is complicated by the fact that the representatives of higher religions often feel compelled to subscribe to the belief in miracles, even when their actual philosophy inclines them to dispense with it, simply because miracles are recounted in their hallowed scriptures or traditions. Although the paradox on which Christianity is founded (God-man, incarnation) almost logically implies certain miraculous expressions (virgin birth, resurrection), yet many modern theologians felt the need to integrate their rational criticism of miracles into their religious thought. This criticism may be religious (*e.g.*, the truly spiritual has no need of miraculous props), philosophico-scientific (*e.g.*, there are no miracles, but only as yet unexplained natural phenomena), historical and philological (the actual occurrence of miracles is said to be unproved, and the composition of the texts reporting them is critically analyzed) or psychological (reasons are advanced why people tend to believe in miracles). One suggested solution of the dilemma was the assertion that everything is a miracle (*i.e.*, the term does not describe an objective event but a subjective mode of experience). The Roman Catholic Church, on the other hand, insists not only on the factuality of miracles, as distinct from natural events, but also on the possibility of an objective determination of miraculous facts.

The prominent place of miracles in the history of religions is ultimately due to the fact that the encounter with the reality posited by religion (*i.e.*, God, the gods, the holy or sacred, the numinous, etc.) is essentially wonderful, extraordinary and transcending "normal" reality; hence the experience tends to crystallize in miraculous accounts. This basically religious pattern of experience easily combines with the primitive yearning after the miraculous, born of the human desire to master ordinary reality, with its needs, fears and sufferings, by means of a magical short cut to greater powers. Whereas some theological systems maintain that miracles both produce and confirm faith, the student of religion inclines to agree with Goethe's description of the miracle as "the dearest child of faith." (R. J. Z. W.)

**Miracles in the Bible and in Christianity.**—In the Old Testament, the phenomenon of miracle can be characterized through the concepts "sign," "portent," "wonders." In the New Testament these terms are also used, though the predominant accent falls on "signs" and on "power" or "mighty work." Such mighty works are usually exhibited through events in nature or personal existence, such as healing, which have bearing on historical and human destiny. Hence biblical miracles are not significant in themselves. While they have to do with nature, they are associated primarily with events and happenings that have a particular meaning for a community, such as the exodus from Egypt or the complex of events in the advent, life, crucifixion and resurrection of Jesus Christ. They are confirmatory signs of more fundamental events, which, while not dependent upon miracle, are themselves the matrix in which miracle is said to have occurred. The sign or pointing character of biblical miracles indicates their significance. They do not rest upon themselves. The Greco-Roman world was full of miracles. The setting or context provided the clue for distinguishing between miracles. Without the context, miracles were magic. The admonition of Jesus not to tell others of his healing activities is testimony that the community of faith was not to rest upon miracles, but rather that miracles were signs of the new reality manifest in him. The miracles surrounding the life of Jesus can be considered testimony that men believed that the anticipated Messiah or Deliverer had arrived, that the new age was manifest in the old, that the expectations were being fulfilled and that the mighty power of God was manifest. In biblical literature, miracles are signs of God's unique and redemptive visitation.

For the biblical writers a miraculous event was distinguished from other events simply by its extraordinary character. The question of the credibility of miracles—that is, whether or not they happened—had not arisen for them. That problem arose in the early church where the biblically oriented church confronted Greek thought. In the latter, miracle stories abounded and an attempt was made to distinguish between the authentic and the incredible. But the actual occurrence of miracles was not doubted. Generally, the Church Fathers accepted the biblical miracles both because they accepted the accuracy of Scripture and because these miracles usually had a setting and dignity that distinguished them from pagan or classical parallels. Moreover, the Fathers did not view nature primarily as a realm controlled by inflexible laws. For them, the natural world was one in which extraordinary happenings occurred in the midst of the ordinary course of events. Both aspects were conceived as anchored in the activity of God, though the extraordinary occurrences testified particularly to God's special and redeeming activity in the world. But the ordinary course of events was as mysterious as the extraordinary. It was no more self-evident than the extraordinary. For Augustine, the orderly or natural was also miraculous. Hence, it is important to note that while miracle stood beyond or above the order of nature as ordinarily conceived, it was not assumed that miracle stood against nature. It became possible to speak of nature and of super-nature or of the supernatural.

Until the 17th century, men might differ on what event was properly a miracle, but none denied that miracles occurred. The strides made by modern science in the period from Galileo through Newton brought the Christian community face to face with a conception of a mechanically ordered world that apparently admitted of fewer and fewer exceptions to its rigid order. As that happened, Christians were in the position of having either to abandon the traditional conception of miracle or to defend miracles against the new science. Initially, scientists and theologians alike held the view that since the order was created by God it could also be suspended by him. At that juncture, nature and super-nature became two different orders, each demanding the suspension of the other. But as natural science developed, the orderliness of nature in its vastness and complexity impressed men more than any possible exceptions to it could. Moreover, both Roman Catholics and Protestants in the 17th and 18th centuries generally believed that the drama of redemption, recorded in the biblical books, could be defended only through a firm stress upon prophecy and miracle. A vast literature on the evidences for Christianity developed in Protestantism, one of the chief pillars of which was the authenticity of Christianity on the basis of the occurrence of the miracles as recorded in Scripture. Protestants, particularly the English Puritans, were divided as to whether or not miracles still occurred. But they were agreed that they had happened in the past, and precisely as recorded in Scripture. Hence, much attention was given to the credibility of the biblical witnesses to miracles.

Those who interpreted the new science developed a philosophical outlook that excluded dimensions essential to a full, classical Christian understanding. Christians, on the other hand, largely defended the accuracy of the Scriptures as a book of knowledge with reference both to miracles and to science. Hence, an inevitable conflict resulted in which both parties made unwarranted claims. On the eve of the 19th century, the philosopher Kant and the theologian Friedrich Schleiermacher attempted to push into new directions. Schleiermacher accepted the ordered Newtonian world and maintained that miracles affected the domain of neither physics nor psychology. Miracle, he declared, was the religious name for natural event, and the more religious one was, the more would one see miracle everywhere. In effect, Schleiermacher had identified miracle and a religious understanding of

any aspect of the world. The distinctiveness of miracle had disappeared. But this was more the product of Schleiermacher's defective Christian understanding than it was of his particular view of miracles. Aspects of the latter view, set into another context, may indeed be feasible. Liberal Protestantism generally abandoned the traditional view of miracles and stressed the evidences for Christianity in a different form, namely the transformation of the moral and religious lives of people.

In the early decades of the 20th century the character of both science and Protestant theology changed drastically. The rigid conception of order in the atomic levels of physics had been severely challenged. Regardless of what this new situation meant in physics, it brought a new tentativeness into science and undermined the philosophical views of the world allegedly extrapolated from a rigidly ordered conception. At the same time, the change in Protestant theology brought about a fresh appreciation of the biblical dimensions in their own terms. In that development, the reality attested to through biblical miracles was again more central than the miracles themselves, as it had been in the early church and in the Reformation. Some interpreted the change in science as warranting the acceptance of the biblical miracles as recorded. But that view was probably a misinterpretation both of science and of Scripture.

Since the early decades of the 20th century, Protestants generally have accepted the concept of miracles as standing for dimensions of reality in which God's directing presence is encountered in the intensity of redemptive deliverance. But such happenings are understood as not directly discernible on the level of nature. Roman Catholics, on the other hand, have generally accepted miracle in the more traditional sense of impingement upon the domain of nature. (J. Di.)

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**MIRACLE PLAY:** *see* Drama: *Medieval Drama.*

**MIRA DE AMESCUA, ANTONIO** (1574?–1644), Spanish dramatist and author of one of the most powerful of Spanish religious plays, *El esclavo del demonio* (before 1613), was born at Guadix, where he returned as archdeacon after many years at Granada, Naples and Madrid. His masterpiece, based on the Faustian legend of the 13th-century Portuguese St. Aegidius, treats the favourite Spanish antitheses of reality versus appearance and free will versus compulsion, displaying curious insights into the psychopathology of guilt. Among the imitators of Mira's highly original plots are Calderón, Agustín Moreto, Pierre Corneille and Jean de Rotrou.

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**MIRAGE,** any of a number of different kinds of atmospheric optical illusion in which the observer sees nonexistent bodies of water, oversize or inverted images of distant objects and various other distortions. A mirage is formed by the refraction, or change in the direction of travel, of light on its passage through an atmosphere having an unusual distribution of air density (*see* Refraction). An increase in density of the air decreases the velocity of light passing through it; thus as the light goes through a layer, or stratum, of marked density change, its wave front is refracted and a displaced image is likely to appear.

**Inferior Mirage.**—This phenomenon, very common in desert regions on calm, clear summer days when the surface of the ground is strongly heated, gives the appearance of an extensive horizontal reflecting surface below the level of the observer's eyes. Often, low-lying distant objects are mirrored. The observer unfamiliar with this illusion instinctively attributes it to reflection by the surface of a lake or other body of water whose wave-lapped shore is only a mile or so distant. But it is a curious body of water, ebbing as far and as fast as the observer may approach it and similarly following him if he should retreat from it, and completely hiding everything below its apparent surface. Distant hills rising from a flat plain often appear as if they were islands or promontories.

Normally, in the atmosphere the density decreases steadily with height. This type of mirage occurs when, owing to the excessive heating of the ground, the density increases upward for the first 20 ft. or more, then decreases in the normal manner above that height. Under this circumstance, light originating along the horizon follows a curved path upward over the observer's head and the light which comes to him horizontally when he is above the level of maximum density also originates above that level. Distant objects may be of such a height that their upper part is seen from a path of light that goes deep downward convexly toward the earth and their lower part from a less deep path, thus producing the inverted effect of a mirrored image.

*Road and Street Mirage.*—This illusion of people, perhaps splashing unconcernedly through puddles and streams, is a miniature inferior mirage.

*Lateral Mirage.*—On close observation it is sometimes possible to see along a strongly heated, vertical wall a mirage of the same origin and having the same explanation as that so common along roads.

**Superior Mirage.**—A superior mirage is the simultaneous appearance in the low sky of a distant low object in the form of two images, one above the other, the lower one being inverted while the upper is not. This occurs under certain conditions, especially over cold waters when the lower air is very much colder and therefore denser than the air immediately above it. In this case the apparent mirror surface is above the observer at the level where the density exhibits a sharp decrease with height.

**Fata Morgana.**—This is the inferior-superior double mirage, involving a combination of the two types of density distribution described above. Under perfect conditions objects such as cliffs or a distant, simple cottage look like a wondrous castle, half up in the air, half down in the sea.

It is of rare occurrence, though well known, especially in the Strait of Messina between Italy and Sicily, where it received its name from its fancied reflection of a submarine palace of Fata Morgana (*q.v.*), or Morgan le Fay. It has also been seen over Toyama bay on the western coast of Japan and is sometimes observed over the Great Lakes in North America.

For explanatory diagrams, illustrations and references, *see* W. J. Humphreys, *Physics of the Air* (1940). (W. J. Hu.)

**MIRAMÓN, MIGUEL** (1832–1867), Mexican soldier, president and marshal of Maximilian's empire, was born in Mexico City on Sept. 29, 1832. He fought against the United States in 1847. In 1856 he helped establish Félix Zuloaga as Conservative president in opposition to the Liberals led by Benito Juárez. In the bitter Three Years' War which followed he led the Conservative forces and finally succeeded Zuloaga as president only to be overthrown by the victorious Liberals in Dec. 1860. He took refuge in Cuba and then went to Europe. Following various maneuvers he offered his services to Napoleon III and re-entered Mexico as a grand marshal of Maximilian's empire. He served as Mexican minister in Berlin (1864–66), but returned home and again entered the army to bolster the tottering throne. Defeated by Juárez, he fell back to defend the remnant of the court at Querétaro. After the capture of that city in May, he was taken prisoner and executed there with his emperor on June 19, 1867. (W. H. Ca.)

**MIRANDA, FRANCISCO** (c. 1750–1816), Venezuelan revolutionist, belongs to the generation of men who paved the way for independence in South and Central American nations. In the history of the hemisphere his title is "el precursor," the forerunner. Born and educated in Caracas, at the age of 21 he sailed for Europe to enter the Spanish army. During this journey he began to keep a diary, a habit which remained with him to his last days, and the bulk of which forms the 15 volumes of his *Archivo*. His career in the Spanish army was not a success; he was charged with disobedience and sent to prison. In 1780, however, he was released and sent to Cuba to participate in the Spanish fight against Great Britain. There he was accused of misuse of funds. Protest-

ing his innocence, Miranda fled to the United States, arriving in June 1783.

This event was the turning point of his life. He became a rebel and an adventurer whose aim was to gain partisans and supporters for the liberation of South and Central America from the yoke of Spain. In the United States he met and became the friend of Washington, Paine, Hamilton and others. Hounded by Spanish agents, he went to London, and from there to Germany, Austria, Italy, Turkey and, finally, to Russia, where Catherine the Great showered him with her favours. Miranda's personality matured during these travels. He became proficient in languages, speaking three and reading four others. He was impulsive, opinionated, authoritarian and aggressive.

The French Revolution gave him the first opportunity to advance his revolutionary aims. To William Pitt he outlined a plan for an independent empire stretching from the Mississippi to Cape Horn, under the leadership of a hereditary emperor, called Inca, with a law-giving body of two houses. When the English prime minister showed no interest in his projects, Miranda joined the revolutionary forces of France (1792). He had not changed his goal, only the means to reach it. He fought with distinction for the Revolution, surviving terror and accusation. By 1798 he was once more in England. He tried desperately to convince the British that an attack on the Spanish colonies would be to their advantage, but in 1805 when he realized that his words fell on deaf ears, he set out to liberate Venezuela singlehandedly. The Spaniards, however, aware of his plans, were ready for him. He was twice repulsed and returned to England.

Miranda's last opportunity came in 1810. At that time Venezuela was in rebellion against Spain and Simón Bolívar had been sent to London to secure British support for the nascent state. The two men met and Bolívar persuaded Miranda to return to Caracas. He was made a general, and when the young republic proclaimed its independence on July 5, 1811, he became its dictator. But the Spanish counterattack showed Miranda weak and vacillating. Rather than make Venezuela the scene of a long and bloody war, he surrendered and signed an armistice that other revolutionaries denounced as treasonable. His attempts to escape were thwarted by his compatriots under the leadership of Bolívar. He was thrown into prison and eventually handed over to the Spaniards, who considered him still "a very dangerous man." His ankles in chains, he was transported to the Prison of the Four Towers in Cádiz, where he died in 1816.

Miranda's master plan, the liberation of the Spanish colonies with the help of the great powers, had miscarried, and his own action ended in catastrophe. His failure was the result of a personal ambition to which his abilities could not rise. Orator, general, schemer and organizer, he lacked the relentless drive that the revolutionary must have if he hopes to succeed. Miranda was a man of the 18th century. He believed in a world that daily apprehended more fully the dignity of mankind. His all too human private life also derived its character from the century; his many love affairs were pursued with the sensual energy of a Casanova. He is reminiscent at times of his contemporary, Mirabeau. Energetic, epicurean, dynamic, unscrupulous, identifying a great cause with his own personality, he seemed to have all the talents save the ability to put them to good use. Although temporary failures and frustrated ambition may dim his reputation, he is marked by greatness of purpose and by his unquenchable belief in the freedom of man.

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**MIRANDA,** a state of Venezuela on the Caribbean sea, lies east of the state of Aragua and southeast of the Federal District. Area 3,070 sq mi. Pop. (1961) 492,349. The coastal range there reaches its highest elevation. Embracing parts of both agricultural and pastoral Venezuela, Miranda ranks among the leading states, being a producer of bananas, cacao, corn, coconuts, coffee, sugar cane and yuca. The mineral possibilities are little known and have been only slightly exploited. Sugar milling and saw milling are relatively important. The state benefits by proximity to the Federal District, particularly to Caracas. It is well served by highways. The capital, Los Teques (pop. [1961] 34,874) lies southwest of Caracas on the main hard-surfaced highway to the important cities to the west—Maracay, Valencia, Barquisimeto and others. (L. We.)

**MIRBEAU, OCTAVE HENRI MARIE** (1850–1917), French writer of harshly satirical novels and plays, and one of the ten original members of the Académie Goncourt, founded in 1903 (*see* GONCOURT). He was born at Trevières (Calvados), on Feb. 16, 1850, and was educated at a Jesuit school at Vannes. After journalism in Bonapartist and royalist newspapers, he fell a prey to his native pessimism, both as a novelist and a playwright. He made his mark as a *conteur* with tales of the Norman peasantry, *Lettres de ma chaumière* (1886) and *Le Calvaire* (1887), a chapter of which on the defeat of 1870 aroused much rancour. They were followed by *L'Abbé Jules* (1888), the story of a mad priest, and *Sebastien Roch* (1890), a merciless picture of the Jesuit school he had attended. Henceforward all his novels were bitter social satires, from *Le jardin des supplices* (1899) and *Les Mémoires d'une femme de chambre* (1901) to *La 628-E8* (1907) and *Dingo* (1913). His dramatic work was of a finer quality and *Les Mauvais Bergers* (1897) was compared with the work of Henry Becque (*q.v.*). He achieved his greatest success as a playwright with *Les affaires sont les affaires* (1903), his portrait of a modern Turcaret (the hero of Le Sage's comedy). He died in Paris on Feb. 16, 1917.

(Re. L.)

**MIRFIELD,** an urban district in the Dewsbury parliamentary division of the West Riding of Yorkshire, Eng., 10½ mi. E.S.E. of Halifax and 8¼ mi. W. of Wakefield by road. Pop. (1961) 12,289. It is on the river Calder and is served by the Calder canal.

The principal industries are carpet and blanket manufacturing, cotton spinning, light engineering, coal mining and chemicals; it is a railway centre. A theological college is attached to the Home of the Community of the Resurrection, a clerical fraternity, founded by Charles Gore (*q.v.*).

**MIRFIELD FATHERS,** as the Anglican COMMUNITY OF THE RESURRECTION is known, were founded in Oxford, Eng., by Charles Gore (*q.v.*) in 1892. The members are celibate priests and laymen living under a common rule, and their work is pastoral and evangelistic, literary and educational. The community's first two superiors, Gore, philosopher and theologian, and Walter Frere, historian and liturgist, both became bishops. Among its scholars were J. N. Figgis and L. S. Thornton. In 1898 the community moved its headquarters to Mirfield, Yorkshire, where a theological college was set up for young men who, for lack of private means, were debarred from priesthood. In 1955 the community founded a theological college in Barbados, and it carries out extensive missionary and educational work in South Africa. Its concern with the social implications of Christian faith is expressed in its attitude to race relations as illustrated by Trevor Huddleston, who, during his service as provincial of the order in South Africa (1949–55), was a constant opponent of apartheid and worker for the improvement of conditions among Africans.

*See* P. F. Anson, *The Call of the Cloister* (1955). (A. MacD. A.)

**MIRIM, LAKE** (Portuguese, LAGOA MIRIM; Spanish, LAGUNA MERÍN), on the border between Brazil and Uruguay, covers about 1,542 sq mi., and is 118 mi. long and as much as 30 mi. wide at its widest point. The lake drains through the São Gonçalo canal to Lagôa dos Patos.

It is a typical coastal lagoon, separated from the ocean by a sand bar about 10 to 35 mi. wide, on which there are numerous smaller lagoons and marshes. It is navigable for small lake boats. The international boundary between Brazil and Uruguay crosses the southern part of the lake from the mouth of the Rio Jaguarão to the southern end west of Chuí. (P. E. J.)

**MIR JAFAR** (MIR MOHAMMED JAFAR ALI KHAN) (d. 1765), first ruler of Bengal under English influence, was of obscure origin. His father was an Arab, Sayyid Ahmad Najafi. First heard of in Bengal in 1734, he attached himself to Ali Vardi Khan, and when that general seized the government of Bengal in 1740, became his principal military officer. Mir Jafar was an able soldier but lacked decision of character and became indolent in old age. Discontented

under Ali Vardi's grandson, Siraj-ud-Daula, who succeeded in 1756, he aspired to the Bengal government with the support of Robert Clive and the English East India company. Mir Jafar was irresolute at the battle of Plassey (1757) and thereafter was embarrassed in fulfilling his financial promises to the English, the treasure at the capital proving smaller than expected. His payments, public and private, and the concession of free passes (*dastaks*) for the English merchants' private trade, started the ruin of Bengal and the demoralization of the company's servants that marked the early years of British rule. After Clive's departure in 1760 he was deposed in favour of Mir Kasim. He was restored in 1763 and died on Feb. 5, 1765, allegedly aged 74. *See* INDIA-PAKISTAN, SUBCONTINENT OF: *History*.

*See* A. C. Roy, *The Career of Mir Jafar Khan* (1953).

(T. G. P. S.)

**MIRKHOND** (MIRKHWAND; MOHAMMED IBN KHWANDSHAH IBN MAHMUD) (1433–1498), Persian historian, author of the voluminous and famous *Rauzat-us-Safa*, belonged to an old family of sayyids (descendants of the Prophet), established in Bukhara. His father lived in Balkh (northern Afghanistan). Mirkhond spent most of his life in Herat, where he enjoyed the protection of Mir 'Ali Shir Nava'i, a celebrated patron of literature, who acted as minister to the last Timurid ruler of Herat, Sultan Husain Baiqara (1468–1506), and was himself a writer of great distinction. He died at Herat on June 22, 1498. It was at Mir 'Ali Shir's request that Mirkhond began about 1474 his general history, *Rauzat-us-Safa*, which comprises seven large volumes and a geographical appendix, sometimes considered as the eighth volume. The seventh book (on the reign of Sultan Husain and some later events down to 1523) must have been added by Mirkhond's grandson Khwandamir (Khondamir), whose *Khulasat al-akhbar* is, moreover, merely an abridgement of his grandfather's *Rauzat*. In the 19th century Riza Quli Khan (1800–72) wrote a supplement to the *Rauzat* in eight volumes.

Although he did not examine his sources critically and wrote in a florid and bombastic style, Mirkhond was for a long time the chief source of information on the history of the Persian dynasties, and European scholars published separate chapters of his work accompanied by their commentaries. In modern times, when many of Mirkhond's sources have been published in the original, his summaries have lost their importance, except for Books v and vi which contain the history of the Mongols and Timurids and give much independent and valuable information.

BIBLIOGRAPHY.—For an account of the numerous editions and translations of Mirkhond's work *see* H. M. Elliott, *History of India*, vol. iv, pp. 127–140 (1867); C. A. Storey, *Persian Literature*, ii/1, pp. 92–101 (1935) and i/2, pp. 1236–37 (1953). *See* also E. G. Browne, *A History of Persian Literature Under Tartar Dominion* (1920); V. V. Bartol'd, *Turkestan Down to the Mongol Invasion*, 2nd ed. (1928). (V. F. M.)

**MIRÓ, GABRIEL** (1879–1930), Spanish writer, distinguished for the finely wrought, sensual style of his essays, stories and novels, stands apart, in his preoccupations, from his contemporaries known as the generation of '98. Born in Alicante on July 28, 1879, he studied law at the universities of Granada and Valencia, afterward holding various small sinecures. He was hired to edit a religious encyclopaedia in 1914, but the enterprise failed in the following year. In 1922 he became secretary of the Concursos Nacionales de Bellas Artes in Madrid, where he died on May 27, 1930.

Through the creation of a literary alter ego, the character Sigüenza, Miró first found the means of releasing his artistic energies in *Del vivir* (1904), the theme of which, man cut off from God and other men, underlies all his works, notably *Corpus* (1905), *Nómada* (1908), *Figuras de la Pasión del Señor* (1916–1917), *Libro de Sigüenza* (1917), *Nuestro Padre San Daniel* (1921), *El obispo leproso* (1926) and *Años y leguas* (1928). Miró's difficult style permits maximum fidelity to his particular experience of reality through the use of a rich vocabulary, the excision of merely informative verbal tissue, the exploitation of peculiarly Spanish grammatical devices, and the manipulation of chronology so as to deny time and enhance sensorial and qualitative values in an atmosphere of pathos, comedy, irony and wonder.

*See* V. Ramos, *Vida y obra de Gabriel Miró* (1955). (E. I. KL.)

**MIRÓ, JOAN** (1893– ), Catalan painter, one of the foremost exponents of 20th-century art, was born in Barcelona on April 20, 1893. He began drawing at the Lonja in his native city, where he was taught by Modesto Urgell. Miró made his first visit to Paris in 1919. Thereafter he lived in that city, in Barcelona and at his farm in Majorca. His first manner is characterized by an *avant-garde* and antiacademic attitude, with highly stylized and rounded forms. Between 1916 and 1923, however, he began to allow a certain representational element in his paintings, which at the same time are distinguished by an unmistakably passionate use of simple and violent colour; "La Masia" (1921–22) is an important picture of this period.

From 1923 onward Miró discarded the representational element more and more and got free of it through colour and through creating simple and extremely effective forms. His colours are pure, sometimes primary colours only; his line is based mainly on the curve. Influenced by André Breton's doctrines, Miró shows a strong sense of humour, which gives him his special place among the surrealists. "Dutch Interior" (1928) is one of the outstanding examples of the art of his time. From 1930 his work became even less representational, as he substituted outline drawings and schematic figures reminiscent of children's drawings or the art of primitive peoples. His feeling for decoration and contrasting masses of strong colour are dominant features of his work. As well as easel-paintings and murals, Miró did sculpture and engraving and also illustrated books and painted on pottery. (J. GL.)

**MIRROR.** A mirror can be considered as an optical instrument that produces images of objects by reflection.

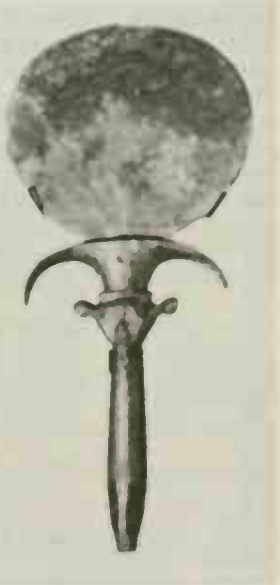
## HISTORY

The earliest mirrors of the Etruscans, Greeks and Romans usually consisted of a thin disk of metal, generally bronze, slightly convex and polished on one side, the other being left plain or having a design incised upon it. Mirrors made from glass coated with tin or silver are mentioned by Pliny as having been made at Sidon, but they appear to have been little used.

Greek mirrors dating from shortly before 400 B.C. have been found. They were usually provided with a handle, which sometimes took the form of a statuette, often of Aphrodite, or consisted of two metallic disks fitting into each other and sometimes fastened together with a hinge.

Small metallic mirrors with highly polished surfaces were largely used during the early centuries of the Christian era, pocket mirrors or small hand mirrors carried at the girdle being indispensable adjuncts to ladies' dress. In 625 Pope Boniface V sent Queen Aethelberg of Northumbria a present of a silver mirror, and in early Anglo-Saxon times mirrors were well known in England.

The method of backing glass with thin sheets of metal for mirrors was known in the middle ages, at a time when steel and silver mirrors were almost exclusively used. A guild of glass-mirror makers existed in Nürnberg in 1373, and small convex mirrors were commonly made in southern Germany before the beginning of the 16th century. It was in Venice, however, that the making of glass mirrors on a commercial scale was first developed. In 1564 the mirror makers of Venice formed themselves into a corporation, and their glass mir-



BY COURTESY OF THE EGYPTIAN EXPEDITION, THE METROPOLITAN MUSEUM OF ART, NEW YORK

EGYPTIAN MIRROR OF BRONZE DATING FROM 1900 B.C. THE HANDLE OF THE MIRROR BEARS A SCULPTURED LIKENESS OF THE GODDESS HATHOR, FIGURED WITH THE HORNS AND EARS OF A COW AND THE FACE OF A WOMAN

rors quickly supplanted those of polished metal. The coated glass mirrors were made from blown cylinders of glass, which were slit, flattened on a stone, carefully polished, the edges frequently bevelled and the backs silvered by an amalgam of tin and mercury. A sheet of tin foil was laid on a horizontal blanket lying on a flat surface; then clean mercury was spread on the foil, a sheet of paper being laid over the mercury. The sheet of very clean glass was allowed to fall slowly on the paper and the paper drawn off just as the glass reached the mercury, so that a clean surface of the mercury came into contact with the glass. Heavy weights were then laid on the back of the glass and the whole was left for the excess of mercury to be squeezed out, after which the amalgam of tin and mercury adhered to the glass.

These mirrors had a high reflecting power. The glass was remarkably pure and uniform, the silvering bright and the sheets sometimes of considerable dimensions. In the inventory of the effects of the French minister Colbert, a Venetian mirror, 46 in. by 29 in., in a silver frame, was valued at 8,016 livres, while a picture by Raphael was put down at 3,000 livres.

A considerable improvement came in France in 1691 when the art of making plate glass was introduced. The chemical process of coating a glass surface with metallic silver, now called silvering, was discovered by Justus von Liebig (*q.v.*) in 1835 and was put into practice five years later. *See* also FRAME DESIGN.

## REFLECTION BY MIRRORS

A mirror is usually associated with the reflection of visible light, though there are also mirrors for the reflection of sound, radio waves, etc. The human eye can receive light directly from an incandescent source or by scattering or reflection of the light from some source. This page scatters or diffusely reflects the light incident on it, some of which may enter the human eye. A mirror, made from a highly polished metal or a smooth surface of glass coated with silver, reflects the light in a definite manner called regular or specular reflection. The surface of a mirror must be smooth or have irregularities that are small compared with the wave length of the light being reflected. For visible light the wave lengths associated with the different colours are of the order of $\frac{1}{10000}$ in., while sound waves have wave lengths of the order of a few feet and low-frequency radio waves of the order of fractions of a mile. Thus a surface that can act as a mirror and regularly reflect sound waves can be so rough as to be of no value for reflecting visible light waves. When light falls on a body some of the light may be reflected, some absorbed and some transmitted through the body. In order for a smooth surface to act as a mirror for visible light, its surface must be bright so as to reflect as much of the light as possible and transmit and absorb as little as possible.

**Law of Reflection.**—Let us consider the reflection of light from a smooth and highly reflecting flat surface such as MM′, fig. 1. An eye at E receives light from a source S by the paths SA and AE, SA being the incident ray and AE the reflected ray. Actually the eye receives more than a single ray of light from the source. The pupil of the human eye is about three millimetres in diameter, so it can receive a bundle or cone of rays. For simplicity we shall consider a single ray that does not invalidate the result. If the lines SA, AE are drawn and a line AN is drawn at right angles or normal to the mirror, then it is found that the angle $i$ made by the incident ray with the normal is equal to the angle $r$ made by the reflected ray with the normal. Thus the fundamental law of reflection by a mirror is that the angle of incidence $i$ is equal to the angle of reflection $r$.

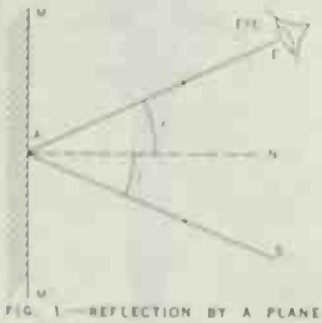


FIG. 1.—REFLECTION BY A PLANE MIRROR

Fig. 2 shows two rays forming the boundaries of the cone of light that the eye can receive. The two incident rays SA, SA′ are reflected along AE and A′E′ respectively so that their angles of reflection are equal to their angles of incidence. If the two reflected rays are projected backward they intersect at I, the image of the source S; that is, at a point as far behind the mirror as the source S is in front. The position of I can be found experimentally by placing behind the mirror a tall pin, the top of which can be seen over the mirror, and using as the source S a smaller pin. The pin behind the mirror is then moved around until it coincides with the image of S seen in the mirror, and thus directly it can be shown that the image of an object seen in a plane mirror is as far behind the mirror as the object is in front. Notice that the image I is never actually formed, or the rays of light do not actually pass through I. For this reason the image I is said to be a virtual image. That the image I is as far behind the mirror as the object is in front can be proved geometrically from the fundamental law of reflection.

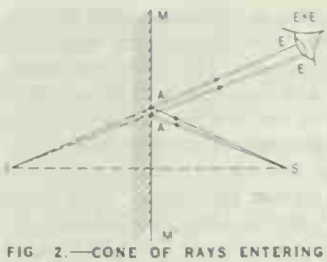


FIG. 2.—CONE OF RAYS ENTERING THE EYE APPEARING TO COME FROM IMAGE I

As shown in fig. 3, a plane mirror gives an image that is the reversal of the object. Consider the object OO′ with a projection, which is on the left-hand side when the object is viewed directly. This projection appears on the right-hand side of the image II′ seen by the eye. When a printed page is viewed in a mirror this reversal can be seen.

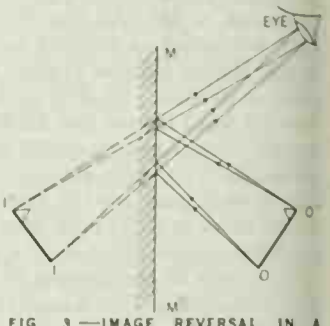


FIG. 3.—IMAGE REVERSAL IN A PLANE MIRROR

By using a combination of two plane mirrors set at right angles to one another, this reversal can be eliminated. An object OO′ is placed in front of the two mirrors shown in fig. 4. On looking into the mirrors three images can be seen. The images $I_1I_1'$, $I_2I_2'$ are produced by reflection in one mirror and show the reversal, while the image $I_3I_3'$ is produced after reflection in both mirrors and there is no reversal. The rays producing these reflections can be readily drawn. If the mirrors are set at 60° with one another, then five images may be seen, a result that can be generalized easily.

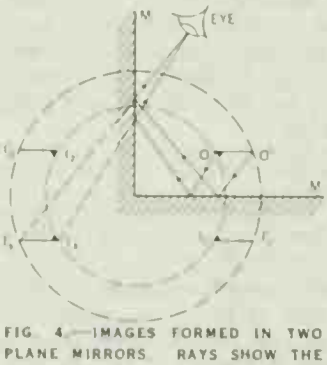


FIG. 4.—IMAGES FORMED IN TWO PLANE MIRRORS. RAYS SHOW THE IMAGE FORMED BY TWO REFLECTIONS

An interesting result follows when three mirrors are set up so that they are mutually perpendicular to each other and meet to form the apex of a tetrahedron. On looking into such a mirror system each eye sees itself in a line, and no change seems to take place when either eye is closed. This mirror system returns a beam of light from any direction back in exactly the same direction from which it came. In order to show this, consider a sphere whose centre O is at the apex of the mirrors. As shown in fig. 5, three mutually perpendicular lines are drawn, Ox, Oy and Oz, which intersect the sphere at $x$, $y$ and $z$. The three mirrors lie in the $xOz$, $xOy$ and $yOz$ planes and intersect the sphere in the great circles $yz$, $zx$ and $xy$.

Let a beam of light parallel to PO fall on the mirrors. This beam strikes the mirror $zOy$, is reflected onto the mirror $yOx$ and is again reflected so as to fall on the mirror $zOx$ from which it is again

FIG. 5.—SPHERE WITH THREE MUTUALLY PERPENDICULAR MIRRORS (xOz, xOy AND yOz) HAVING THEIR VERTEX AT O THE CENTRE OF THE SPHERE

reflected so that it comes from this mirror parallel to the direction of the incident beam PO. Draw a great circle through xP (point P is considered to be on this great circle). This meets the mirror zOy in M. Continue this great circle to P′ of such a length that MP′ is equal to MP. From the construction it follows that the angles OMP and xOM are right angles. For the ray of light parallel to PO, incident on the mirror zOy, its angle of incidence is xOP. Since MP is equal to MP′ and PO is equal to P′O, it follows that the angles POM, P′OM are equal. Thus the incident ray PO is reflected along the direction P′O. It can be shown easily that the angle P′Ox, which the reflected ray makes with the normal Ox, is the supplement of the angle of incidence POx, that is, angle P′Ox is equal to 180° minus angle POx. Reflection in any mirror changes the angle with its normal into its supplement. Successive reflections in all three mirrors will change all the angles made by OP with the normals Ox, Oy, Oz into their supplements.

Now the sum of the squares of the cosines of the angles made by PO with the normals Ox, Oy, Oz is equal to unity. Since the square of the cosine of any angle is equal to the square of the cosine of its supplement, it follows that the sum of the squares of the supplements of the angles made by PO with Ox, Oy, Oz is also unity. Thus the beam of light PO, after reflection in all three mirrors, will return exactly parallel to its incident path. The three mirrors have to be set at right angles to each other with a high degree of precision if the final image is to be single. As the final direction of the beam is simply the opposite of the original direction, it is not affected by rocking the system of mirrors.

Small tetrahedral mirrors are used as reflectors for illuminating roadside signs from the headlights of automobiles at night. The back reflecting surface of these small reflector buttons generally consists of a series of little pits, each one of which is roughly a tetrahedral apex with three perpendicular plane surfaces. Such buttons shine brilliantly when illuminated by the headlights of approaching vehicles, and the intensity of the reflected beam does not vary greatly as the angle of illumination changes.

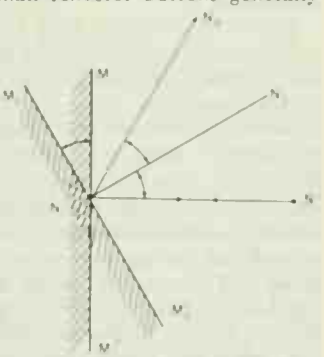



FIG. 6.—ROTATION OF A MIRROR THROUGH A GIVEN ANGLE ROTATES THE REFLECTED BEAM THROUGH TWICE THAT ANGLE

**Effect of Rotation.**—If a beam of light is reflected from a plane mirror as the mirror is rotated through some angle, then the reflected beam is rotated through twice the angle. For simplicity consider a ray of light (fig. 6) that falls perpendicularly on the mirror MM′; that is, the ray is along the normal NN′. Since the angle of incidence is zero, the angle of reflection is also zero and the reflected ray is along NN′. Now rotate the mirror to the position $M_1M_1'$ through the angle $M_1NM$. The incident ray is still N′N while the reflected ray is now $NN_2$. The normal to $M_1M_1'$ is $NN_1$, so that the angle $N'NN_1$ is equal to the angle $M_1NM$ and the angle of incidence of the ray is now $N'NN_1$. This angle is equal to the angle of reflection $N_1NN_2$ where $NN_2$ is the reflected ray. Turning the mirror through the angle $M_1NM$ results in the reflected ray's being turned through twice this angle or through the angle $N'NN_2$.

*See also* LIGHT; OPTICS. (R. J. Sx.)

## ASTRONOMICAL MIRRORS

**Early.**—During nearly two centuries, from 1668 when Sir Isaac Newton made the first reflecting telescope until the advent of the silvered-glass mirror in 1856, astronomical mirrors were thick, solid disks of a white alloy of copper with proportions of tin usually between 25% and 33.4%, on which the concave curvatures required for reflecting the light rays to a focus were ground with emery grains, and polished and finally figured, or precisely shaped, with optician's rouge. These speculum metal mirror disks were difficult to cast, brittle and hard to work, and when finished did not reflect a high percentage of light. Their chief fault was that when they became tarnished the necessary repolishing destroyed their figure, which then had to be wholly recreated. This not only forced the astronomer to acquire as much skill as the expert who figured the mirror, but interrupted his observing for days or weeks. A means whereby tarnished telescope mirrors could be replaced easily and quickly, without affecting their figure, therefore would have been a boon.

**Modern.**—Such a means arrived in 1856 when Karl August von Steinheil developed a method of coating glass telescope disks with suitable reflecting films of silver which, when tarnished and without altering the figured glass, could be removed in seconds with acid and replaced in minutes with brilliant new films by a chemical process. The mirror proper, the reflecting part, now became a film of silver about $\frac{1}{250\,000}$ in. thick; but since such films take their shape from the permanently figured glass to which they adhere and which acts as their rigid support, and also since the creation of the figure on this glass requires much more time than applying the silver film, when telescope makers use the word mirror, they refer mainly to the glass and its figure, of which the film on its surface is a replica.

Quite logically a question is often asked: since glass mirrors, the familiar looking glasses silvered with tin and mercury, were in use long before telescopes, why did astronomers ever use mirrors of speculum metal with all their drawbacks? The answer is because it was essential, as it still is, that the reflecting coating be on the front of the glass and not on the back, since front-surface mirrors obviate losses of light within the glass and at the surface, as well as spurious reflections and aberrations. But the old tin and mercury method of silvering gave only a dull, irregular surface on the front, though modern methods give excellent surfaces.

Most reflecting telescopes have solid mirror disks of glass, about one-eighth or one-sixth as thick as wide, so that the glass from its own weight will not sag the few millionths of an inch that is sufficient to alter the figure temporarily while the telescope is inclined in different positions. Another source of altered figure is the slight temporary warping of the disk caused by unequal expansion or contraction between surface and interior while it is being warmed or cooled by the surrounding air. On the mirrors of crown glass, similar in composition to plate glass, made before the 1930s, this had an effect several times greater than on the low-expansion Pyrex that came into use for mirrors at about that time. The warping caused by transient air-temperature changes was still further reduced in the Pyrex mirror of the world's largest telescope on Palomar mountain, in California, which is 2 ft. thick, nearly 17 ft. in diameter and contains a 30 000-lb. mass of glass. The reduction was accomplished by honeycombing the back of the disk with deep openings to the air. This leaves only a relatively thin front surface and behind it a grid of ribs or partitions, cast integrally and in most places only about four inches thick. Few points within the glass lie more than two inches from the surrounding air, and temperatures that in large solid disks require several hours for equalization are equalized rapidly. The ribbed construction also provides maximum stiffness with a minimum of weight.

The common belief that astronomical mirrors are made of costly optical glass, as are good lenses, is erroneous; there is no necessity for this since astronomical mirror disks are not called upon to transmit light but only to support the film of metal that reflects it. Calling an astronomical mirror a lens is also a common error.

The concave curve in the face of an astronomical mirror is seldom more than one inch in depth even in fairly large telescopes and is less than four inches in the 200-in. telescope on Palomar mountain. The disk is laid flat on a slowly rotating turntable and ground with loose, wet, abrasive grains of sugarlike size beneath a slightly convex disk of metal attached to the lower end of a power-driven vertical shaft. This tool, resembling an inverted mushroom and perhaps one-quarter of one-half the diameter of the mirror, is made to rotate slowly, while a third component is added when lateral motions are given it to keep the curve even. After the glass has thus been roughed out to approximate curve, a convex tool of the same diameter as the mirror, and faced with

squares of metal or glass, is used in grinding for several hours with each of a series of finer and finer abrasive grains, ending with powders of flourlike grain size. This leaves the glass uniformly curved from centre to edge and in fine-textured, smoothly frosted condition.

The full-sized tool is next covered with a quarter-inch layer of pitch, an elastic substance that will flow under pressure and thus continually conform to all changes made in the mirror surface. Against this pitch lap the mirror is polished for hours with wet optician's rouge (ferric-oxide) powder, or other polishing powders of microscopic grain size, until all scratches and tiny pits left by the grinding have been polished away and the surface is perfectly smooth to the eye and magnifier.

The next and most difficult but most interesting process is the figuring, in which the precision optician deals often with single millionths of an inch. With modifications of the means already used in polishing—that is, with pitch laps of varying sizes and shapes—the mirror is first brought precisely to a spherical curvature, one into which a huge sphere of which it is a segment would accurately fit. By further polishing in precalculated zones this sphere is then altered slightly to the paraboloid, which will bring the light rays to a single focus. This process, though the volume of glass removed is relatively infinitesimal, often consumes as much time as all the previous work or even more, especially since the behaviour is not entirely predictable and in removing one imperfection, such as a raised or depressed zone on the glass, others may be introduced. Figuring may be done with the machine described above, with frequent skillful readjustment of stroke, or by hand with small laps of pitch. At mid-20th century no machine had yet been devised to go through this figuring process automatically and to produce a perfect mirror without frequent human intervention guided by judgment based on test.

Prior to 1859 mirror makers enjoyed no satisfactory way of testing the figure of a mirror as it evolved, for the measurements involved are too small to be made by mechanical means. In that year the physicist Jean Bernard Léon Foucault (*q.v.*) invented a delicate test, even more delicate than needed, that reveals, locates and measures, within $\frac{1}{1,000,000}$ in., local surface irregularities, employing nothing more complex than a lamp shining through a tiny pinhole in an opaque screen and the edge of a common knife. To make Foucault's test an illuminated pinhole (artificial star) is placed at the centre of curvature of a spherical mirror. The rays go out from it to all parts of the sphere and are reflected back to a focus at the pinhole, the polished glass reflecting sufficient light for this test. To permit the rays instead to enter the eye the pinhole is displaced slightly to one side of the mirror's axis so that the rays will return slightly to the other side where the eye can be placed, a little back of focus, to receive them. The mirror is then seen to be bright all over. If now the knife edge is moved in from the side to cut the rays, the mirror, if everywhere precisely spherical, will darken uniformly all over; if it is not spherical, no point can be found at which it can be made to do this. Zones of longer or shorter radius of curvature than the rest of the mirror will be revealed by apparent shadows on its face, because the rays reflected from these zones encounter the side of the knife and do not reach the eye. The shadows exaggerate the relief of the surface about 100,000 times, and the mirror maker learns to interpret the code of these shaded areas in quantitative terms of mirror figure. Following these examinations he treats the faulty areas by brief, cautious local polishing and tests again; and thus proceeds until the desired paraboloid, free everywhere from irregularities of surface, is attained. By using an accessory plane mirror of high precision and making Foucault tests at the focus of the concave mirror instead of at its centre of curvature as just described, still greater delicacy may be attained.

Before use, astronomical mirrors must be coated with a metallic reflecting surface. Beginning early in the 1930s, silver deposited chemically on glass gave way to aluminum deposited physically by practical processes developed by John Strong, or chromium followed by aluminum developed by Robley C. Williams. Scraps of the metal are attached to tungsten wires a few inches or feet from the mirror, and the whole is enclosed in a chamber from which the air is pumped out to an almost perfect vacuum. An electrical circuit is closed, the tungsten wires become highly heated and the bits of metal, less refractory than the tungsten, are quickly vaporized. Unobstructed by air molecules, the atoms of vaporized metal fly across to the glass and condense in a highly reflective coating about $\frac{1}{250,000}$ in. thick.

These processes afford tougher, more resistant, longer-lasting coatings than does silver. They also reflect more of the actinic rays that affect the photographic plates used by the modern astronomer in place of visual observation. While the familiar aluminum surfaces are not mirrorlike, those formed by this method may easily be mistaken for a silvered mirror.

When aluminum is deposited on a glass surface which is not adequately cleaned, the adhesion will be inferior to that exhibited by a deposit on a properly cleaned surface. In most cases the mirror will appear to be good at first but will develop countless tiny blisters after standing for a day or so.

**Plane Mirrors.**—These mirrors, plane within $\frac{1}{400,000}$ in. or even $\frac{1}{800,000}$ in. and used as accessories with some astronomical instruments, are much more difficult to make than paraboloidal mirrors of equal diameter. A modification of Foucault's test or a test with Newton's fringes against a plane of known precision governs the figuring process, which consists of local polishing with small pitch laps. The finished plane is vacuum coated with reflecting metal. Since about 1913 glass or fused quartz planes called optical flats, made to the same precision by the same methods but not coated, have been in use throughout the mechanical industries for optically checking the accuracy of the precision gauges that make possible the manufacture of identical, interchangeable parts.

In the United States from time to time these flats, as they wear out of true, are checked at the national bureau of standards against a still more precise master flat, plane within $\frac{1}{4,000,000}$ in. (*See* also TELESCOPE.)

**Astronomical Mirror Making as a Hobby.**—Astronomical mirror making is a hobby for thousands of amateur astronomers who have made their own telescopes. In the 19th century amateurs discovered a scarcity of prepared instructions, partly because secrecy concerning the working methods had long been a tradition among professional makers, even though many of these had themselves begun as amateurs. This hindrance to the hobbyist was removed largely by the writings of W. F. A. Ellison, Russell W. Porter, Albert G. Ingalls and Allyn J. Thompson, beginning about 1920. Within the next decades tens of thousands of astronomical telescopes, principally of the relatively inexpensive reflecting type, were made in home workshops by amateurs, mostly adult.

In the reflecting telescope the mirror is at once the most important, the most difficult and the most interesting part to make. Thus, mirror making is itself a hobby within a hobby. The amateurs' mirrors, usually from 6 to 12½ in. in diameter, are made by modifications of the methods already described and usually by hand. The amateur's mirror disk, instead of being placed face up on a slowly rotating turntable and ground with a metal tool of lesser diameter, is placed face down on another glass disk of equal diameter, attached to the top of a barrel, and stroked with the hands back and forth across the lower disk with coarse, wet abrasive grains placed between the two. (The lower disk, called the tool, is later discarded.) The worker simulates the motions of the professional mirror maker's machine by keeping the mirror in gradual rotation with his fingers between the strokes, at the same time slowly walking sidewise around and around the barrel. The three combined motions keep the near-spherical curve from becoming lopsided.

The longer the grinding is continued the more concave the upper or mirror disk is ground out, the tool becoming convex to match its curvature. The concaving and corresponding convexing occur, instead of a uniform wearing down of the two flat faces, because the pressures automatically increase toward the ends of the strokes when the central areas of the upper disk press on the outer areas of the lower disk.

After a few hours of this preliminary roughing out, the mirror

concavity approaches the desired depth ($\frac{1}{20}$ in. for a typical amateur's mirror 6 in. in diameter). Series of finer and finer grains are then substituted for the coarse abrasive to produce as smooth a ground glass surface as can be had by grinding glass against glass. The tool is then covered with pitch and the mirror is polished five to ten hours against this medium with rouge; the process is essentially as described above for large mirrors made professionally, but the stroking is done by hand. The final figuring, or precise shaping within millionths of an inch, of the geometrically ideal paraboloid by eliminating local irregularities of surface such as zones that are high or low, is done by stroking the mirror in special patterns of motion against the same pitch lap on which it was polished. Foucault's all-revealing test is made every few minutes throughout the figuring, so that the worker may watch closely the new changes in curvature that spontaneously arise locally on the surface and decide on the next stratagem to steer the curve in the desired direction.

Because no two mirrors exhibit the same combinations of these deviations, the treatment cannot be standardized beyond a few general rules, which do not always apply. Within the limits of these general instructions the worker contributes from his own resourcefulness and imagination by devising methods, many of which prove fruitless or worse, forcing him to hours of effort to recover lost ground before he hits on a successful one.

Because the coating of the completed mirror with reflecting aluminum (superior to the more easily applied silver coating) requires too large an investment in high-vacuum apparatus, the amateur sends it to a laboratory to be coated, a brief procedure. He then plans and builds a telescope tube and a mechanical mounting with axes, so that his telescope may be easily pointed at different celestial objects.

*See* also references under "Mirror" in the Index. (A. G. I.)

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**MIRROR WRITING:** *see* HANDWRITING.

**MIRZAPUR,** a city (including Vindhyachal since 1867) and district located in the Varanasi division of Uttar Pradesh, India. The city, headquarters of the district, lies on the right bank of the Ganges (Ganga), 55 mi. E. of Allahabad and 46 mi. W. of Varanasi city, close to the Vindhyan scarp and on a branch of the old Deccan road. Pop. (1961) 100,097. The town has stone ghats on the river, Hindu temples and mosques; there are two small parks, a town hall and a college affiliated to Agra university.

Mirzapur was founded probably in the reign of Shah Jahan (fl. 1627–58), about 7 mi. E. of the ancient Hindu town of Vindhyachal (Bindhachal), notable for the Vindhyeshwari temple, and became a river port. From 1800 to 1850 Mirzapur was the most important trading centre of upper India.

It attracted the cotton trade from the south and was a transit centre for river trade between central India and Bengal. With the advent of the railway to Allahabad in 1864, Mirzapur began to decline, though some local traffic continued. From 1921 its importance as a local trade centre increased, mainly because of its central situation, the introduction of road services and the growth of industries.

Nearly one-third of the population is engaged in trade and transport and about the same in production other than cultivation. Mirzapur is well known for its carpets, brass and metal wares, quarrying and dressing of sandstone. It is the only centre of lac industry in Uttar Pradesh.

MIRZAPUR DISTRICT (area 4,369 sq.mi.; 1961 pop. 1,249,653) extends southward across the Son valley, and is crossed east to west by the Kaimur hills. It falls into two regions, the narrow strip of the fertile Ganges plain and the southern upland which, especially south of the Son river, is a forest-clad, gneissic-metamorphic terrain with potential mineral sources. More than 65% of the land is irrigated by canals, the main crops being rice, wheat and barley. There is a cement factory at Churk and an aluminum factory at Pipri. The Chunar-Churk railway, the Son bridge at Chopan and the development of the Rihand project (started in 1956–57) have improved access to the district. A bus service links the plateau with Mirzapur city. (R. L. Sl.)

**MISAMIS OCCIDENTAL,** a coastal province on the northeastern part of the Zamboanga peninsula, Mindanao, Republic of the Philippines. Pop. (1960) 245,371.

Only 802 sq.mi., it is a small province facing Iligan bay. A narrow coastal plain gives way to rolling hills which partially encircle a mountainous mass centring on Mt. Malindang (7,954 ft.). A provincial highway follows the roughly semicircular shoreline. There are no roads into the rugged interior area. Coconuts and corn are the principal crops. The principal towns are Oroquieta, the capital, and Ozamiz, a chartered city and the principal port. (AS. C.)

**MISAMIS ORIENTAL,** a coastal province on northern Mindanao and including nearby Camiguin Island, Republic of the Philippines. Area 1,512 sq.mi. Pop. (1960) 388,615.

The area includes a narrow coastal plain and rolling to rough hill lands (dissected plateau). Some of the river valleys contain deep deposits of coarse alluvium. The principal products are coconuts, corn, rice and lumber. There is a large modern pineapple cannery at Bugo, but the fruit is grown in Bukidnon province, to the south. Cagayan, the capital and only city (pop. [1960] 68,274), is a secondary port and the principal air centre of Mindanao.

Hibok-Hibok, a volcanic peak on Camiguin Island, was active in 1948 and again intermittently from Sept. 1950 until 1952. (AS. C.)

**MISCARRIAGE,** a folk term for spontaneous abortion, the death and expulsion of a human fetus during the first 24 weeks of life. Expulsion of a dead fetus later in pregnancy is termed stillbirth. *See* ABORTION; STILLBIRTH.

**MISDEMEANOUR,** the term applied in Anglo-American law to an offense not otherwise classified as a felony or treason. In the early English law convictions for misdemeanours, unlike those for felony or treason, did not ordinarily result in forfeiture (*q.v.*) of the offender's goods or lands. Moreover, misdemeanours were not punished by death. In the modern law of England, misdemeanours include certain indictable offenses as well as petty offenses which may be tried summarily before a magistrate sitting without a jury. With the abolition of forfeiture in criminal cases in 1870 and the elimination of the death penalty in most cases of felony, the old distinctions between felony and misdemeanour no longer serve. In general, the law of England punishes misdemeanours less severely than felonies, although this is not true in every instance.

In most U.S. jurisdictions crimes are classified either as felonies or misdemeanours. The federal law provides for a subclassification of misdemeanours, known as petty offenses, to which the constitutional requirement of trial by jury does not apply. In U.S. law the classification of a crime as felony or misdemeanour is ordinarily determined by the penalties attached to the offense. A typical provision defines as misdemeanours those offenses punishable by fine or imprisonment in the county jail. Felonies are those punishable by imprisonment in the state penitentiary. Various consequences follow from these classifications. Thus, deadly force may be used to prevent the escape of one fleeing from a valid arrest for a felony, but such force may not be employed in misdemeanour arrests. On the other hand, the law may require that greater procedural safeguards be afforded one tried for felony than for misdemeanour. Offenses which were misdemeanours by common law or statute in England have sometimes been made felonies in the United States. These include conspiracy, attempt to commit certain crimes such as murder or burglary, perjury and obtaining property by false pretenses. *See also* CRIMINAL LAW; FELONY. (F. A. A.)

**MISE,** an Anglo-French term denoting any outlay of money and in particular the payment of taxation. The mise rolls (*rotuli misae*) of John's reign (1199–1216), which record payments made

from the exchequer to various departments of the royal household, illustrate the first meaning of the word. It was used to denote taxation in the document known as the *Confirmatio cartarum* granted by Edward I in 1297, when the king promised not to treat as customary certain "aids mises and prises" recently levied.

The word was also used to indicate the settlement of a dispute by arbitration. Louis IX's judgment (Jan. 1264) on the quarrel between Henry III and the rebel English barons was called the mise of Amiens, and after Henry's defeat at Lewes in May 1264 an agreement known as the mise of Lewes, of which the text is lost, was made between victors and vanquished.

**MISHAWAKA,** a city of St. Joseph county in northern Indiana, U.S., on the St. Joseph river 90 mi. E. of Chicago and adjacent on the west to South Bend (*q.v.*). Major industries produce rubber footwear, cushions, mattresses, automobile mats, raincoats, foundry supplies, packing products, electric power, sheet metal products and missiles. Bog iron discoveries in 1833 brought industry to the site, building blast furnaces and housing for workers; in 1839 the settlement was incorporated as Mishawaka, named for an Indian princess who lived in the area. In 1899 it was chartered as a city. It has a large Belgian population.

For comparative population figures *see* table in INDIANA: *Population.* (J. J. D.)

**MISHMI,** a hill tribe in the North East Frontier agency of India, inhabiting the valleys of the Dibang (where they are known as Midu) and the Lohit rivers. Those of the Lohit valley (numbering about 15,000 in the 1960s) are divided into two groups, the Miju on the upper Lohit and the Digaru on the lower reaches. The language is Tibeto-Burman, including different dialects. Both groups consist of exogamous patrilineal clans, the same named clans occurring among Miju and Digaru. Settlements are small and frequently shifted, low spurs being favoured sites for villages. There are no chiefs and each virtually autonomous family group, the true social unit, inhabits a long house built on piles. Agriculture is extremely primitive; maize (corn) and buckwheat are the staple crops; barley and wheat grow at higher altitudes, rice in the foothills. Cattle are kept for slaughter and are used as currency. Other occupations include hunting and fishing. Having access to Tibet and Assam, the Mishmi engage in substantial barter exchanging musk, medicinal herbs, paper bark and aconite poison for clothing, salt, copperware and swords. Tribal gods are worshiped with animal sacrifices and offerings, and there is evidence of Tibetan ritual influence. Slavery and head-hunting are no longer practised.

*See* J. P. Mills, "The Mishmis of the Lohit Valley, Assam," *Journal of the Royal Anthropological Institute*, vol. 82 (1952). (C. v. F.-H.)

**MISHNAH** (MISHNE), a collection of Jewish traditional laws, completed early in the 3rd century A.D. and comprising one of the two main parts of the Talmud.

*See* TALMUD: *The Mishnah.*

**MISIC, ZIVOJIN** (1855–1921), commander in chief of the Serbian army in the last year of World War I, was born at Struganik, near Valjevo, on Jan. 19 (new style; Jan. 7, old style), 1855, of a prosperous peasant family. He attended the Belgrade artillery school and received a commission in 1876. In that year and in the next two years he fought against the Turks and also fought in the Serbo-Bulgarian War of 1885. After graduating from the staff college in 1900 and being promoted colonel in 1901, he was for a time professor of strategy at the military academy. He served as head of the operations division of the general staff from 1907, became a general in 1912 and was deputy commander in chief in the Balkan Wars (1912–13). In World War I, when the Austro-Hungarian forces were launched on their second offensive, he was appointed commander of the Serbian 1st army. Then the battle of the Kolubara (Nov.–Dec. 1914) enabled the supreme command to announce: "Save for prisoners, there is not a single enemy soldier left in Serbia." Promoted field marshal, he distinguished himself in the retreat across Albania (Nov.–Dec. 1915). After sick leave (1916–17) he resumed his command at Salonika in 1917 and became commander in chief in 1918, to lead the army to victory. He died in Belgrade on Jan. 7 (N.S.), 1921.

(K. St. P.)

**MISIONES,** the extreme northeastern province of Argentina, bounded by Paraguay, Brazil and the Argentine province of Corrientes. Area, 11,506 sq.mi. Pop. (1960) 391,094. The province is characterized by abundant rainfall (70 in. per year) and a hot climate (mean annual temperature 22.78° C. [73° F.]). The rough terrain is accented by canyons, rivers and low ranges of the Sierra Victoria, Sierra Imán and Sierra Grande, largely covered with pine and broadleaf trees. The area was part of the region occupied by the famous Jesuit Guaraní missions in the 17th and 18th centuries (*see* GUARANI and PARAGUAY: *History*). It became an Argentine territory after several decades of dispute with Paraguay and Brazil and the bloody Paraguayan war of the 1860s.

The principal product is maté (Paraguay tea), followed by lumber and forest products, cotton, corn and tobacco.

The capital, Posadas, pop. (1956 est.) 52,200, established in 1865, is located on the upper Paraná river in the western corner of the province. River steamboats and a railroad from Asunción, Parag., to Buenos Aires link the city with the coast. The spectacular Iguaçu falls on the Brazilian border at the northern tip of the province is perhaps the best-known landmark. (Js. R. S.)

**MISIONES,** a department of southern Paraguay, lies between the Tebicuary and Paraná rivers. Area 3,025 sq.mi. Pop. (1962) 59,454. It was settled, as its name implies, by the Jesuit missionaries of the 17th and 18th centuries. Consisting almost entirely of a great lowland, much of it marshy, its chief economic importance is for cattle raising, although crops of rice, maize and sugar are also significant, and some maté is gathered.

San Juan Bautista (pop. [1960 est.] 6,488) is the capital, and San Ignacio, founded in 1609, an important centre for processing agricultural produce.

Both are on a major highway between Asunción and Encarnación, which bisected Misiones department and increased its importance and settlement. (G. J. B.)

**MISIONES, SIERRA DE,** an undissected piece of the Paraná plateau which forms the divide between the Paraná and Uruguay rivers (*qq.v.*) in the Argentine province of Misiones. It is incorrectly translated as "mountain" since actually it is only the height of land between two valleys, an interfluve. The top of the plateau in this area is about 1,500 ft. above sea level.

(P. E. J.)

**MISKITO COAST:** *see* MOSQUITO COAST.

**MISKOLC,** chief town of Borsod-Abaúj-Zemplén *megye* (county), northeast Hungary, 113 mi. N.E. of Budapest, lies in the valley of the Szinva, a tributary of the Sajó, on the eastern edge of the Avas hills which form part of the Bükk limestone plateau. Pop. (1960) 143,364 (mun.). The town lies partly in the steeper valley of the Bükk plateau and partly on the open plain. It has always been linked historically and commercially with Diósgyör farther up the Szinva valley where there are impressive remains of a 14th-century castle built by Louis the Great, and a small iron field which has supported some heavy industry in Miskolc. The heath country to the south, marked by the villages of Ónod and Muhó, was the site of the great struggle between Mongols and Magyars in 1241 when 80,000–90,000 Magyars were slaughtered as the Mongol horde swept through central Europe.

The established wealth and importance of Miskolc are apparent in some fine old buildings, including St. Stephen's, a 13th-century Gothic church. Miskolc is now the second industrial town of Hungary. It has long been an important market and a production centre for iron and steel, using local ore and lignite, and a variety of manufactures including flour mills, leather goods and wine. The limestone caves are used as cellars by the wine producers. The town has rail and road connections with Budapest and with eastern Hungary, Rumania and Czechoslovakia. (H. G. S.)

**MISPICKEL** or ARSENOPYRITE: *see* ARSENOPYRITE.

**MISPRISION,** a term in Anglo-American law, now almost obsolete, originally signifying a wrongful act or omission. In its surviving meaning the term means especially complicity in a crime, implying a degree of guilt less than that of the principal offender. One guilty of misprision is in effect an accessory. The term appears twice in the United States Criminal code. One owing

allegiance to the United States is guilty of misprision of treason if, having knowledge of an act of treason, he conceals the fact and does not disclose it to the proper authorities. Misprision of felony is the similar concealment of, and failure to disclose, knowledge of any felony cognizable by a court of the United States. Both are felonies, and the punishment for misprision of felony may be more severe than that for the principal offense itself. (B. Ce.)

**MISRULE, LORD OF,** the name applied in England in the late medieval and Tudor period to the master of the Christmas festivities held at court, in the houses of great noblemen, at the Inns of Court and in Oxford and Cambridge colleges. His reign (either from Oct. 31 to Feb. 3 or for the traditional 12 days of Christmas) was a period of wild festivity and buffoonery. The practice probably originated with the licence allowed to slaves at the Roman Saturnalia (*see* SATURN); it is traceable through the earlier medieval feast of fools, whose ruler was sometimes called king of the bean (*see* FOOLS, FEAST OF). Both these figures were in effect the old "winter king" of ancient rite.

The lord of misrule, in Scotland called the abbot of unreason, should not be confused with the Tudor court official called the master of the revels who was responsible for entertainments throughout the year. After the death of Edward VI (1553) there is no record of the election of a lord of misrule, and the Scots suppressed the abbot of unreason in 1555. *See* also BOY BISHOP.

*See* Sir J. G. Frazer, *The Golden Bough*, 3rd ed., vol. vi (1907–15).

**MISSAL,** the book containing the prayers, important chants and necessary instructions for the celebration of the Mass (Latin *missa*, hence also *missal*) in the Latin rite of the Roman Catholic Church. The structure and mode of expression of the Mass is strongly influenced by the Jewish religious world out of which Christianity emerged. This influence is evident particularly in the Foremass, or earlier section of the Mass, and in the preface. Literary evidences of early Christian practice from which a history of the books that lead up to the modern missal may be constructed may be said to begin with the *Didache* (*see* APOSTOLIC FATHERS), a little manual containing, among other things, prayers for the Christian assemblies and dating from around the year 100. A description of the mass as celebrated in Rome around the year 150 is given by Justin Martyr in his *First Apology*. Justin gives no quotations of liturgical texts, perhaps because wide latitude for improvisation was the rule at that time. The *Apostolic Tradition* of St. Hippolytus, a Roman priest of the early 3rd century, exerted considerable influence on the Eastern liturgies while receiving little attention at Rome itself.

The precise origins of the Roman rite are obscure, but its framework is considered to have been essentially fixed by the beginning of the 5th century. At that period, each actor in the sacred drama had his own book. The priest at the altar used the sacramentary, a book containing the orations and prefaces that vary from feast to feast. The fixed prayers which form the Ordinary of the Mass were at first either memorized or written on a separate tablet placed on the altar. Soon, however, they were included in the sacramentary. Among the important extant sacramentaries are the Leonine, traditionally attributed to Pope St. Leo the Great (440–461); the Gelasian, attributed to Pope St. Gelasius I (492–496); and the Gregorian, attributed to Pope St. Gregory the Great (590–604). All three are actually composite works and products of a considerable evolution.

For the scriptural readings used in the Mass, the custom was initially to use a copy of the Bible with the passage to be read marked. Such a copy of the Scriptures was called the Apostolus when used by the lector in chanting the Epistle and the Evangelium when used by the deacon in chanting the Gospel. In time, particularly after the year 1000, a special book, the lectionary (*q.v.*), was developed which contained only the Epistles and Gospels to be chanted on each feast. The soloist who led the congregation in the responsorial singing of the psalms used a book called the cantatorium. Distinguished from this latter was the antiphonary (*q.v.*) used by the *schola cantorum*. This group of singers some time after the 4th century took over the matter contained in the cantatorium, and their book was also called the gradual (*q.v.*) because it now contained the verses traditionally sung by the soloist from the step (*gradus*) below the place from which the Gospel was chanted. Finally, a separate book, the *ordo* (*see* ORDINES ROMANI), of which examples survive from the 7th century, gave the directions for the proper carrying out of the liturgical functions.

As the custom grew, however, from the 8th century onward, of less solemn celebration in which the priest said the whole service, the contents of these separate books came by degrees to be combined into a single volume, the *Missale plenum* ("full missal"), which by the 15th century had replaced the older books. All modern missals are of this type. The *Missale plenum* existed in various forms, the most popular being the missal of the Roman curia, which had developed, chiefly it would appear under Pope Innocent III (1198–1216), a simple, uncluttered Mass rite. This missal was adopted by the Franciscan friars and spread by them throughout Europe, becoming particularly widespread after the invention of printing and paving the way for the reform under Pope St. Pius V. Another form of special importance because of its influence on the composition of the Book of Common Prayer was the slight variant of the Roman curial missal employed in the so-called Sarum use, the rite of southern England in pre-Reformation days.

The multiplicity of liturgical forms led Pope St. Pius V, at the instance of the Council of Trent (1545–63), to promulgate in 1570 a new missal, enjoining its general adoption throughout the Latin rite. This missal subsequently underwent constant though not radical revision under Clement VIII (1604), Urban VIII (1634), Leo XIII (1884), Benedict XV (1920) and John XXIII (1961). The 20th century has witnessed a notable quickening of change under the impact of the liturgical movement (*see* LITURGICAL MOVEMENT, ROMAN CATHOLIC), leading to the revision of the liturgy of Holy Week under Pius XII in 1955 and culminating in the decree of the second Vatican council (1963) allowing the introduction of the vernacular in the variable parts of the mass and ordering a complete revision of the missal to be carried out by a postconciliar commission.

A similar process toward amalgamation of the books used by the celebrant in the liturgy of the Eastern churches has failed to win general acceptance, although the Anthologion, an Eastern semiparallel to the Western missal, enjoyed some popularity beginning in the 15th century, with an edition appearing in Athens as late as 1882. Small hand missals for the use of the faithful, however, are not uncommon in Eastern churches. *See* also MASS.

*See* J. A. Jungmann, *The Mass of the Roman Rite*, rev., abridged ed. (1959). (F. R. Ha.)

**MISSI DOMINICI** (Lat. envoys or commissaries of the sovereign), officials sent by some Frankish kings and emperors to supervise the provincial administration. Under Charlemagne at the beginning of the 9th century they were sometimes also called *missi imperatoris* (envoys of the emperor); in capitularies issued in 861, 862 and 864 by Charles II the Bald, the term *missi rei publicae* (envoys of the commonwealth) was used.

The Merovingians and the early Carolingians had occasionally sent special envoys on particular missions, but the use of *missi dominici* did not become a normal part of the administrative machinery till the time of Charlemagne. At least from 802 onward almost all the empire was periodically divided into *missatica* or inspection circuits, the frontiers of which seem sometimes to have been changed. In theory four months of every year were to be spent on the inspection of each area; but in practice the commissions were probably not sent out very regularly and their work was still occasionally supplemented by the use of special envoys. At least two *missi* were sent to each district, one a bishop or an abbot, the other a layman, probably a count (*q.v.*). During their tour of duty they were, by imperial command, lodged and fed at local expense.

The *missi* had full powers of investigation. No individual or group could evade their searching inquiries, designed to expose all scandals and intrigues. They were to rectify all error and injustice and thus they were the natural protectors of the weak. They could reserve difficult or doubtful cases to the imperial tribunal and could themselves consult the growing collection of capitularies (especially the *capitula missorum*; *see* CAPITULARY) in the palace archives or seek supplementary instructions from

the sovereign. It was their duty to administer the oath of allegiance normally exacted from all freemen on the accession of a new sovereign or a change of title. They informed the local communities of the content of imperial decrees, so that none could plead ignorance of the law. They also invited comment on the decrees. Thus on returning from their mission they could give an accurate account of existing conditions and needs, by reference to which legislation could be framed or modified. The *Admonitio generalis*, a series of instructions issued by Charlemagne in 789, probably followed an inspection of this sort; and the inquiry of 802 certainly led directly to the promulgation of a general capitulary for the guidance of the *missi*, with special instructions applicable in particular conditions.

The *missi* who wielded these powers were men of the great consequence, protected by the same wergild or fine payable for injury to life or limb as was granted to members of the sovereign's family. They were presumed to be men of unquestionable integrity; and, until the reign (814–840) of Louis I the Pious, they were always appointed to serve in districts where they were strangers. But the difficulties which sapped the life of the empire after about 830 paralyzed and finally destroyed this vital institution. After 870 the system showed signs of breakdown, and by the end of the 9th century it had almost completely disappeared.

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(J. De.)

**MISSILES:** *see* ROCKETS AND GUIDED MISSILES.

**MISSION, CONGREGATION OF THE** (VINCENTIANS or LAZARISTS; CONGREGATIO MISSIONIS; C.M.), a Roman Catholic society of missionary priests and brothers with private vows, founded at Paris in 1625 by St. Vincent (*q.v.*) de Paul for the purpose of preaching missions to the poor country people and training young men in seminaries for the priesthood. It was approved in 1632 by Pope Urban VIII. The Vincentians arrived in the United States in 1816 making their first foundation at St. Louis, Mo. They conduct three universities in the U.S.—DePaul (Chicago), Niagara and St. John's (New York)—and staff 20 seminaries. Among other works of the American provinces are missions in Panama and Formosa, preaching, chaplaincies and parishes. The congregation labours in more than 62 countries. *See* also ORDERS AND CONGREGATIONS, RELIGIOUS.
(J. G. Nu.)

**MISSIONARY RIDGE:** *see* CHATTANOOGA, BATTLE OF.

**MISSIONS** is the term used to denote organized efforts for the propagation of a religion. The agents of propagation have been known as missionaries. Though this article deals with the history of Christian missions, Buddhism and Islam are also missionary religions. Some schools of Hinduism have begun missionary activities in modern times. Zoroastrianism and to some extent Judaism were once missionary religions.

Christian missions in the modern period have been divided into "foreign" and "home" categories. Foreign missions indicate evangelistic efforts directed to regions and peoples beyond the boundaries of the nation in which the sending agency is located, but does not normally include pastoral ministry to emigrants from that country. Home, domestic or inner missions indicate church extension and ministry to special groups within the national boundaries.

Younger churches have arisen in almost all countries of Asia, Africa, Latin America and Oceania as a result of former missionary endeavours and they also are beginning to undertake evangelism abroad. Western churches have at the same time come to recognize that their own secularized countries are now properly mission fields.

Consequently the term foreign missions is becoming obsolete and is being replaced by world mission. Missions is increasingly being used to denote the agencies of propagation and the academic study of the subject, also known as missiology.

The traditional organization of the history of missions has undergone considerable change, largely as a result of the studies of Kenneth Scott Latourette. Edward Caldwell Moore demonstrated that expansion had not been continuous but rather characterized by periodicity. Eras of expansion were followed by periods of arrest. Latourette interpreted this periodicity as a pattern of advance and recession in an ascending spiral. Each major wave of expansion has been followed by one of recession. However, each new wave of advance has set a new high mark, has lasted longer and has ascended more rapidly, while each succeeding recession has been briefer in its duration and less severe in its losses. The seeds of each new advance have been planted in the preceding time of retreat. This pattern eventually works out in the future in an almost steadily ascending line of advance. The periods as defined by Latourette were: (1) the first great advance, to about A.D. 500; (2) the first great recession, from 500 to about 950; (3) the second advance, roughly from 950 to 1350; (4) the second major recession, from about 1350 to 1500; (5) the third advance, from 1500 to 1750; (6) the third recession, from about 1750 to 1815; and (7) the "Great Century" of expansion, from about 1815 to 1914. The contemporary period is too close at hand to estimate accurately, but the definite advent of a new period in missionary theory and practice after World War II would indicate that the intervening years are best treated with the preceding century. Even those who on historical or theological grounds cannot accept Latourette's theory about a definite pattern of expansion and his prophecy of the future nevertheless find his periods, or a modification of them, useful for the organization of the history of missions.

## EARLY HISTORY

**First Advance to A.D. 500.**—The Christian world mission arises out of the life and ministry of Jesus Christ, but it has antecedents in universalistic prophetic Judaism, which combined ethical monotheism with the vision of a world community of men, equal as individual creatures before their Creator and sovereign God. Ultimately the origin of the mission is found in the idea of God acting in history for the salvation of mankind. Prophetic universalism culminated in the conviction of the early church that God was in Christ reconciling the world unto Himself. The Gospel, being both the message of Jesus and the message of the early Christians about Jesus, was directed to all men and was free from any national and racial limitation. The heart of this Gospel is the affirmation that Jesus Christ is Saviour and Lord. The church appropriated to itself the Hebrew prophets' concept of the true Israel as a faithful remnant saved to save the world. An evangelistic obligation was recognized as being inherent in discipleship.

From the beginning until modern times, although there have been many subordinate motives from time to time, the chief motivation of the mission has been the church's obedience to the Great Commission given by the risen Lord: "Go therefore and make disciples of all nations, baptizing them in the name of the Father and of the Son and of the Holy Spirit, teaching them to observe all that I have commanded you; and lo, I am with you always, to the close of the age." This obedient witnessing by the church then becomes the agency through which the Holy Spirit convinces men that Jesus Christ is Lord and Saviour.

The Christian faith first expanded through the communities of the Jewish dispersion. After a brief struggle with a Judaizing element within the church, the universal character of the Christian faith and practice was acknowledged and freed from the requirements of Hebrew law and ceremonial. The church spontaneously embarked on its task of winning the nations, a total commitment reflected in the tradition that the 12 apostles each took responsibility for a definite geographic area. There was an officially commissioned roving missionary ministry, of which Paul and Barnabas are examples. However, extensive evangelism was done by ordinary laymen in day-to-day contacts and especially as they traveled. Paul, the greatest and the prototype of all missionaries, evangelized much of Asia Minor and the chief Greek cities and was active in Rome, despite his status as a prisoner. The new religion spread rapidly along the trade routes into all the great centres of population. By the 2nd century the roving missionaries appear to have ceased to exist, and evangelistic responsibility came to rest upon the bishops.

Christianity had spread to all parts of the Roman empire by the

time of Constantine, aided by the prevailing peace, easy communication, the use of Greek as a universal medium of communication, a growing identification of the faith with Hellenism, and the widespread spiritual hunger of the time. Estimates of its numerical strength vary from one-twentieth to one-half of the population. It was strongest in Asia Minor and weakest in the northern and eastern European provinces, Palestine, Phoenicia and Arabia. Persecution by the state aided Christianity's expansion, because "the blood of the martyrs became the seed of the Church." The first totally Christian states arose east of the Roman empire. The city-state of Edessa was first, and became the base for further eastward and northern expansion. Armenia at the end of the 3rd century became the first large country to undergo mass conversion at the command of its king. Gregory the Illuminator was the apostle to this nation. East of the Roman empire, however, the growing alliance of Christianity with Rome and with Hellenistic culture hindered the spread of the faith just as much as it favoured it within the empire.

Mass movements within the Roman empire became increasingly prevalent after Constantine granted toleration and his successors gradually adopted Christianity as the state religion, suppressed paganism with increasing severity and sought religious uniformity. Although paganism lingered long, by A.D. 500 the population of the Roman empire was almost solidly Christian. During this period the real missionary endeavour had moved to the borders of the empire and beyond them. The Germanic tribes were mostly converted before they invaded the empire, and this lessened the destruction and brutality which accompanied the invasions. The outstanding missionaries of the period were: Ulfilas, who evangelized the Goths; Martin of Tours, the great missionary of central Gaul; and Patrick, the apostle to Ireland. Outside the empire permanent Christian communities were established in Ethiopia by Frumentius of Tyre and in India, where the Syrian Malabar Christians still claim the Apostle Thomas as their founder and where the church had certainly been established by the 3rd century. Nestorian episcopal sees were established as far into central Asia as Merv and Herat in the 5th century.

**Losses and Gains to A.D. 950.**—*Losses.*—The church had won the Roman empire, but the disintegration of that empire with which it had become identified threatened the existence of Christianity. Such losses as resulted from the invasions of the Germanic peoples and others out of eastern Europe and central Asia were only temporary, but the Arab invasion of the 7th and 8th centuries established Islam as the dominant religion in about half the area where Christianity had previously claimed all or a majority of the population. The older faith was completely eliminated in north Africa and Arabia and in the territories from Egypt eastward it was slowly strangled. There the churches remained as minority enclaves usually associated with a particular nationality, always under pressure and slowly dwindling.

*Celtic Missionaries.*—Many of the Germanic tribes which invaded western and central Europe held to the Arian form of Christianity, and Catholic Christianity was faced with the twofold task of healing the breach of heretical schism and of converting the pagans. The conversion of the pagan Franks to Catholic Christianity, symbolized by the baptism of their king Clovis (496 or 506?), marks the turning point toward success in both efforts. While losses were occurring in the Mediterranean area, there was steady advance into northern and central Europe. The missionaries in the initial advance, however, did not come from the older centres of the faith, but from its remote northern outpost. They were the Celts, first from Ireland and then from Scotland. These Celts were monks, as all the chief agents of missionary expansion were now to be until the rise of Protestant missions. Their motive seems to have been as much ascetic discipline and renunciation as evangelism, for the self-imposed exile from the beloved homeland plays a part in their actions. A leader who had taken such a vow would frequently associate with him a band of 12 companions in imitation of Christ and the Twelve. Columba (b. 521) established Iona as a centre for the conversion of Scotland, and then brother Celts of that land were recruited for the mission. They went from Ireland and Scotland into England, the Orkneys and Faeroes, the Frankish kingdoms, the Low Countries, the Alpine region, the Danubian lands, and even into Italy. The greatest names after Columba are Columban (b. 543), who after heroic labours in the Vosges and the Burgundian kingdom established the monastery of Bobbio in northern Italy and died there in 615; his companion, Gall or Callech; Aidan, the first bishop of Lindisfarne; and Cuthbert, who evangelized Northumbria from Lindisfarne.

The southward penetration made by the Celtic missionaries brought them into conflict with the growing hegemony of Rome over the western church, because they did not acknowledge Roman claims to special authority, their spontaneity and individualism clashed with the Roman sense of order, they followed a different calendar from that of Rome, and their rite was also considerably different. Just as Celtic leadership in the mission came to an end, it was taken up by the Englishmen whom they had brought to Christianity.

*English Missionaries.*—It was in England that Celtic and Roman claims were resolved in favour of the latter and the two streams merged in a new missionary force. Pope Gregory I sent a mission under Augustine to England in 596, the first instance of such papal initiative. Canterbury, the capital of Kent, was the base of the mission. Theodore of Tarsus completed Augustine's work, and then largely through the efforts of Wilfrid royal support was won for Roman control and customs. The English missionaries to Europe, therefore, extended Roman hegemony in the areas where they laboured. Wilfrid, Willibrord, and the great apostle to the Germans, Wynfrith, renamed Boniface, firmly planted the faith in the Low Countries, East Frisia, Saxony and Bavaria.

Boniface, who began his missionary career in 716, received a papal commission to the Germans east of the Rhine in 719. He converted the pagans, established ecclesiastical order, fostered civilization and established Benedictine monasteries as bases for evangelism and Christian nurture. He was martyred by pagan Frisians in 754. The base of the English mission was sadly weakened by Viking raids and invasions, but Frankish missionaries joined in the work of their teachers. Ansgar (Anskar or Anschar) (801–865) is an example. Visions had called him to a missionary apostolate from the time of his youth. Established as bishop of Hamburg, he initiated a mission to all the Scandinavian peoples.

After the death of Boniface a reaction in Sweden and Denmark wiped out most of the gains. Under Charlemagne the coercive power of the state had been used to complete the conversion of the Saxons.

*Byzantine and Nestorian Missionaries.*—Agents of the Greek church in Constantinople pressed northward into the Balkans. The Bulgars were won by the 9th century. The brothers Cyril and Methodius were sent to Moravia by the patriarch at the request of the ruler, Rastislav, about 863. Their methods and their translation of the Bible and the liturgy into Slavonic were not only successful in Moravia but assisted in the conversion of other eastern Slavs. The western Slavs were simultaneously being evangelized by Roman Catholic agents, and Saxon military pressure favoured their work among the Czechs. Methodius allied with the Latin church. A mission to the Russians was begun about the 9th century. Farther east the Jacobites and especially the Nestorians were active. The Islamic conquest of Persia inflicted a setback of great severity, but the Nestorian penetration of central Asia continued. The Turks were given a patriarch in the latter part of the 8th century, and churches were established in Sinkiang. Alopen introduced the faith in the capital of China, Ch'ang-an, in 635. The mission flourished under imperial favour, and a patriarchate for China was established early in the 8th century. However, the church was crippled by persecution under the emperor Wu Tsung in 845 and thereafter speedily disappeared, although Christianity lingered on west of the frontiers of China.

**Later Middle Ages.**—*Advance in Europe and Asia.*—The flowering of medieval European culture was accompanied by four centuries of missionary expansion, and during this period the conversion of Europe was completed, the Russians were won, missions to Islamic areas were begun, and the faith was taken once

more to China. The most spectacular advance of Christendom against Islam was in the reconquest of the Iberian peninsula and Mediterranean islands and in the crusades. These military ventures were not the result of missionary motivation, however, and they erected a permanent barrier of bitterness between Islam and Christendom.

Contrasted with the militant crusades are the methods of loving persuasion attempted by Francis of Assisi and Ramon Llull (martyred in 1315 or 1316). Both the Franciscan and Dominican orders created special missionary organs and sent their friars throughout the Islamic world. They endeavoured to win the ancient churches of the orient to obedience to Rome in the hope of making them potent missionary agencies to the Muslims.

The conversion of the Scandinavian peoples begun by Ansgar went forward under the active direction of the Viking kings. Canute left Denmark thoroughly Christianized when he died in 1035. Haakon, Olaf I Trygvesson and Olaf II Haraldsson during the second half of the 11th and first half of the 12th centuries completed the Christian conquest of Norway, the islands to the north and Iceland, and under Olaf Trygvesson the faith reached Greenland. Olaf Skotkonung and his sons at the same time used less force and were just as successful in Sweden. The conversion of the remaining peoples of eastern Europe took place during the 10th and 11th centuries. The Magyars were converted fully by the end of Stephen I's reign in 1038, and the Poles had been won at the same time. Unhappily, much coercion by the state then appeared. The Saxons and Poles imposed Christianity on the Wends in the course of conquest, and the Knights of the Sword or *Fratres Militiae Christi* followed the same pattern in East Prussia and the Baltic states.

The Russian ruler Vladimir was converted to Orthodox Christianity *c.* 987, and the progress of national conversion went steadily forward, the church contributing powerfully to the formation of Russian culture. The Mongol invasion of the 13th century temporarily weakened the church in some areas but speeded up its efforts to convert the northern regions of the country beyond Mongol control. Stephen of Perm (1330–90), an outstanding figure in this northward movement, was a missionary to the Finns.

The Mongol invasion devastated the Christian communities of central Asia, but once the Mongols settled down to rule their conquests the prevailing peace favoured missionary endeavour. Nestorian, Franciscan and Dominican missionaries penetrated the Mongol territories, and the first two reached China. The court favoured both the numerous Nestorian agents and the Franciscan mission under Giovanni di Monte Corvino, who arrived in the capital in 1294. However, both forms of Christianity were too closely identified in the popular view with the Mongol rule and were swept away in the Ming restoration. The rise of the Seljuk Turks, newly converted to Islam, and the disintegration of the Mongol power turned the tide against Christianity in central Asia.

*Losses From 1350 to 1500.*—The setback in China and central Asia was the beginning of a serious recession. The Ottoman Turks came to the fore as the dynamic force in Islam, replaced the Arab state with a new empire, destroyed the Byzantine empire, captured Constantinople in 1453, conquered the Balkans, and were turned back only at the gates of Vienna.

Although the Christian churches in the Balkans were not destroyed, Islam became the state religion there and large Islamic elements were introduced into the population. Elsewhere under Turkish rule the old Eastern churches declined still further. The Black Death carried off hundreds of missionaries who were not replaced. There was little concern about evangelism for more than a hundred years.

**Roman Catholic Advance, 1500–1750.**—In this period Christianity first became a world religion. The voyages of discovery resulted in a new world view and expanded the horizons of Europeans. Three new Roman Catholic empires arose and their courts were burdened with a sense of obligation for the evangelism of their subjects—Spain, Portugal and France. The pope divided the dominion of the newly discovered territories between the monarchs of Spain and Portugal and imposed upon them responsibility for sending and maintaining missionaries and for building churches and protecting Christians.

Unfortunately the agreement included awarding ecclesiastical patronage in both areas to the crown, and this was to become a stumbling block to adequate deployment of the missionary force. However, it was not so much the colonial policy of the states as a new spiritual vigour within the Latin church which reformed it internally following the Protestant revolt and recalled it to its missionary obedience. The Franciscans, Dominicans, Augustinians and other older orders took up the mission work again with increased zeal, and a new order, the Society of Jesus, became a major factor in the advance.

The foundation in 1663 of La Société des Missions Étrangères de Paris (the Foreign Missionary Society of Paris) demonstrates that in some parts of the church zeal was not confined to the monastic orders. The object of this organization was—through the work of secular priests, not monks—to raise up quickly a secular indigenous clergy in mission lands. Central direction to the whole vast enterprise was provided by the establishment at Rome in 1622 of the Sacred Congregation for the Propagation of the Faith (*Sacra Congregatio de propaganda fide*), by which papal responsibility for the mission was acknowledged and papal control effected. It was concerned with the assignment of territory, ecclesiastical relationships and the support, training and direction of missionaries. Its value was soon demonstrated not only in the expansion of the mission but also in protecting the local missions from domination by colonial officers.

Evangelization went hand-in-hand with the military conquest of Central and South America, the islands of the Caribbean, and the Philippines, where neither primitive society nor religion could withstand the invaders. The missionaries and their supporters among the Spanish colonists strove valiantly to mitigate the horrors of conquest and to protect the natives against exploitation. Bartolomé de las Casas, appointed protector general of the West Indies, is the best-known missionary. Conversion was superficial but at least nominally complete before the end of the period. French colonial policy in North America, unlike that of the Spanish, sought to interfere with Indian life as little as possible. Evangelization, therefore, was not coercive. Missionary work was perhaps in consequence even more heroic than in Spanish territories, but missionary martyrs were more the victims of involvement in intertribal hostilities than of religious persecution or antagonism.

Portuguese colonial expansion was directed to India and the far east, with the major exception of Brazil. Africa was chiefly regarded as an obstacle to be circumnavigated, although there were some minor colonial and missionary ventures there. A Christian kingdom of the Congo existed in the first half of the 16th century. Although numerous orders served in the east, it was the Jesuits pre-eminently who were associated with major developments. Francis Xavier (1506–52) was the great apostle to these peoples. Commissioned as papal nuncio to India and the east, he arrived in Goa in 1542. He laboured among the Parava pearl fishermen near Cape Cormorin, in Travancore, Ceylon and Malacca, and established at Goa a training college for youths from many lands who would return as missionaries. Then he founded a mission in Japan, and seeking to enter China died on an island near Macao. The mission in Japan flourished, and in 1603 there were about 300,000 Christians. However, a series of persecutions of extreme severity began in 1587 and lasted for a half a century. Christianity was proscribed, thousands were martyred and Japan isolated itself from the western world. Great success attended the mission in China under the able leadership of the great Jesuit Matteo Ricci and his successors. The court favoured the mission, and an edict of toleration was proclaimed in 1692. Interorder quarrels, climaxing in the rites controversy, however, incurred the anger of the emperor and brought disfavour and repression on the Christians. Despite the exclusion of missionaries, persecution and isolation, a community of about 250,000 remained at the end of the 18th century. The Dutch drove the Portuguese from Indonesia and Ceylon and excluded Roman Catholic missionaries. Little was accomplished in Malaya, Burma and Thailand, except that the last of these became the base for a large-scale operation in Indo-

china. A large membership was raised in the states of Cambodia, Cochin, Laos and Annam. The Foreign Missionary Society of Paris was the chief agency there. Through intervention for the protection of the missionaries, French influence became predominant in the area. Throughout the whole of south and east Asia, Spanish and Portuguese claims to control ecclesiastical appointments interfered with effective missionary work. Partly to overcome this difficulty and partly to ensure direct oversight of the missions, the Propaganda created few new sees and appointed vicars apostolic instead of diocesan bishops with full episcopal powers. The vicar apostolic was consecrated as the titular bishop of some extinct see and was invested with the personal privileges and powers of a bishop and was assigned to a region where he exercised episcopal powers, not in his own right, but as the personal representative of the bishop of Rome.

**1750 to 1815.**—Latourette regards the period from 1750 to 1815 as a time of recession. Missionary interest declined, contact with China was cut off, some Indians in South America reverted to paganism; but there was no great loss of territory. This was a time of wars which disrupted the home base, and the disintegration of the Portuguese and Spanish empires adversely affected missions. Another cause of diminished activity was the dissolution of the Society of Jesus.

## PROTESTANT MISSIONS

The Protestant churches were slow to undertake missions. In the 16th, 17th and 18th centuries the expansion of Protestantism outside Europe was through emigration, especially to North America. Efforts were made to provide pastoral care for such emigrants and for soldiers, officials and merchants in colonial outposts. Two British foundations, the Society for Promoting Christian Knowledge (1698) and the Society for the Propagation of the Gospel in Foreign Parts (1701), were established for this purpose. Protestant monarchs and their governments in general were not as zealous as the Roman Catholic monarchs in evangelizing their new subjects. However, the Virginia and Massachusetts charters mentioned the propagation of religion, and the chaplains of the Dutch East India company were required to instruct and baptize natives. Contacts with subject peoples or aborigines in the colonies did inspire some missionary efforts. Thus John Eliot's mission to the Indians in Massachusetts drew support from persons in the colony and in the homeland and led to the creation of the Society for the Propagation of the Gospel in New England in 1649, the first genuine missionary society. The Mayhew family began, in 1641, 150 years of service to the Indians of Martha's Vineyard and Nantucket, and there were other ventures, such as the Stockbridge mission. Added to the influence of such examples as these, the voices of Adrianus Savaria, Justus van Heurn, Justinianus von Weltz and a few other prophets called the churches to their missionary obedience.

It was German Pietism which brought forth continuing missionary activity on a large scale. Philipp Jakob Spener, the father of Pietism, advocated missions, and his successor as leader of the movement, August Hermann Francke, made the University of Halle the centre of missionary zeal and training. The missionaries recruited and trained by Francke were sent to Tranquebar in India by King Frederick IV of Denmark beginning in 1705; this monarch having more zeal for missions than his fellow Protestant rulers. The first two missionaries were Bartholomäus Ziegenbalg and Heinrich Plütschau. A lively correspondence among Francke, the missionaries, persons in England associated with the S.P.C.K. and Cotton Mather and others in America diffused knowledge about the enterprise and stimulated interest. Out of the same Pietist circle came Count Nikolaus Ludwig von Zinzendorf. Under his leadership the Moravian refugees on his estate at Herrnhut recovered the apostolic vision and purpose, and the reborn Moravian Church made the mission the chief reason of its existence. The first missionaries went from Herrnhut to St. Thomas in the West Indies in 1731, and within a decade Moravian missionaries were to be found from Greenland to the Cape of Good Hope. The example and spirit of their work influenced John Wesley, William Carey and the founding fathers of the British missionary societies.

Seeing no hope of persuading the churches officially to accept responsibility, the advocates of missions moved to establish voluntary societies. The publication in 1792 of William Carey's *Enquiry into the Obligations of Christians to Use Means for the Conversion of the Heathens* crystallized sentiment and brought action. Carey and a dozen fellow ministers organized the Baptist Missionary society in Oct. 1792, and the following year Carey and John Thomas went to India as the first agents of the society. The London Missionary society was founded in 1795 by ministers and laymen of several denominations; and the Evangelicals in the Church of England organized the Church Missionary society in 1799. The Netherlands Missionary society began in 1797. Thus by the close of the 18th century continuing organs for missions had been established by Protestants.

### Protestant Missionary Advance, 19th and 20th Centuries

The upsurge of missionary interest so apparent among Protestants during the last decade of the 18th century continued steadily to gain momentum throughout the 19th century, which Latourette called the "Great Century" of Christian expansion. The colonial outreach of Protestant European powers broadened the horizons of their people just as the age of discovery had done for the Roman Catholic portions of Europe. The political and cultural prestige of Europe aided missionaries in penetrating all parts of the globe, as did also the development of communications and the relative prevalence of peace. The Industrial Revolution provided rank and file church members with the means of supporting missionaries in increasing numbers. The chief motive was once again obedience to the Great Commission. The aim was the proclamation of the Gospel, and the program was developed experimentally as need and opportunity demanded.

There was no generally accepted theoretical basis and little attempt to provide it until Gustav Warneck founded the study of *Missionswissenschaft* in Germany in the late decades of the 19th century. Looking at needy humanity through the eyes of Christ, the missionaries reached out hands of compassion and proclaimed the Gospel by deed as well as by word and life example. They gave the people the Bible in their own language, after first reducing many languages to writing; they instructed them in modern knowledge as well as in Christian life and doctrine; they taught them to read and write; and they healed their diseases. The vernacular Bible, the schoolbook, and the medicine bag soon became the constant companions of the missionary. The printing press, the school, and the hospital alongside the church became identifying marks of Protestant mission stations. Ignorance, illiteracy and physical suffering were regarded as belonging to the realm of Satan and to be vigorously assaulted. Converts were gathered into churches, but it remained a weakness of Protestant missions in general that until the fourth decade of the 20th century there was much more stress on winning individual allegiance to a "Christian movement" than on building the corporate community, the church. However, by the middle of the 19th century the aim of the missionary enterprise was, in the terms of Henry Venn in England and Rufus Anderson in the United States, the fostering of "self-governing, self-supporting, self-propagating churches."

Missionary agencies increased with each new decade. In Great Britain the Wesleyan Methodist Missionary society was founded in 1813; it embarked on genuine missionary work as well as pastoral service to colonists; and the Glasgow and Edinburgh societies were replaced by an official Committee on Foreign Missions of the Church of Scotland, an exception to the usual pattern of voluntary societies. The interdenominational Basel Mission society for Switzerland and Germany was established in 1815, and the Leipzig, Berlin, Rhenish and other societies followed.

The foreign missionary enterprise of U.S. churches is popularly held to begin with the foundation of a mission band at Williams college in 1806. When some of these men appealed to the Congregational churches of Massachusetts to be commissioned and supported in missionary service, the American Board of Commissioners for Foreign Missions was founded in 1810. It served several Presbyterian and Reformed denominations also for more

than half a century and then became principally a Congregationalist organ. The American Baptist Missionary union came into being in 1814. The Methodist Episcopal Church created its Board of Foreign Missions in 1819, and other denominations soon took a similar step. The U.S. pattern was to be that of denominational boards of missions through which the denomination officially discharged its missionary responsibility in contrast with the voluntary and unofficial societies of Europe. As the decades passed mission boards and societies, either officially or unofficially representing nearly all the churches, came to exist in Europe wherever there was a sufficient body of Protestants in the United States and Canada, in Australia and New Zealand and in South Africa. By 1900 there were more than 300 such boards and societies, and 60 years later there were more than that number in the United States alone.

Because of the reluctance of the societies to commission women with status equal to that of men and to give sufficient emphasis to special work for women and children, women organized both denominational and nondenominational boards and societies. Examples are the Woman's Union Missionary Society of America (1860), the Zenana Bible and Medical mission (1861) and the Church of England Zenana Missionary society (1880). After general missionary societies gave attention to such work, the women's societies merged with the general agencies or became auxiliary to them.

Nondenominational faith missions, with personnel and funds drawn from individuals and congregations across denominational lines, arose in the second half of the 19th century and became more numerous in the 20th. Unlike the denominational agencies, they promise neither salaries nor fixed allowances to their missionaries, but distribute to them the funds received. There was little difference in theological viewpoint between these societies and the church missions originally, but in the 20th century these faith missions might be characterized as fundamentalist. The prototype and model for faith missions was the China Inland mission, which later changed its name to Overseas Missionary Fellowship. It was founded by J. Hudson Taylor in 1865 in order to carry the Gospel into remote interior regions of China where the older missions had not yet been able to establish new stations.

Wars in Europe and America and economic depressions, such as the great one of the 1930s, might at times curtail missionary support, and local disturbances and major catastrophes like the Boxer uprising might occasionally cause a regional setback; but there was a steady expansion of the missionary force up to mid-20th century. Potent forces in recruitment were the Student Volunteer Movement for Foreign Missions, organized in 1886 in the United States, and the Student Volunteer Missionary union, organized in 1892 in Great Britain.

### Growth of the Churches

The labours of the Protestant missionaries resulted in the gathering of meagre first fruits through much of the 19th century, but toward the end of that century the churches began to grow rapidly. The extent to which mature churches had developed in the 20th century was manifested at the Madras conference in 1938, where half of those present represented younger churches.

**Asia.**—India and China competed for major attention, British societies predominating in the former and U.S. in the latter, and more of the resources of the mission went into India than any other country. William Carey and his associates, Joshua Marshman and William Ward, known as the Serampur Trio, set the pattern for mission work in that country, with an emphasis upon the translation of the Bible, the preparation and printing of Christian literature, schools, and the training of a native ministry. Alexander Duff pioneered in higher education, which became an important medium for introducing Christian principles. A vast system of schools from kindergarten to university was developed. Mass movements from outcaste and low-caste groups were notable.

Ceylon and Burma were closely associated with India in missionary developments, and the types of work were the same. The British societies worked with the Sinhalese and the American Board of Commissioners for Foreign Missions among the Tamils of the Jaffna peninsula. The pioneer in Burma was the U.S. missionary Adoniram Judson, who began work in 1813. The Society for the Propagation of the Gospel came later. Only a small group was drawn from the Burman Buddhists, but large churches were built up among the animistic Karens, Kachins and others. The great Karen Baptist Church proved self-supporting and evangelistic to a remarkable degree from the beginning.

Early missionary ventures in southeast Asia were associated with the Dutch East India company, whose chaplains founded many congregations now more than 300 years old. The Dutch missionary societies made Indonesia the exclusive field of their operations, excepting the Moravian mission in Surinam. The German Rhenish mission also entered and developed the renowned Batak church in Sumatra, the community on Nias, and the church among the Dayaks of Borneo. Many missions worked among the Chinese of the area as long as the Chinese ports were closed to foreigners, but withdrew when the ports were opened. The American Methodists remained to work among the Chinese and also among the animists of British Borneo. In Malaya access to the Malays was denied, and missionary efforts were confined to the Chinese and the later Indian immigrants. The Presbyterian Church in the United States maintained the chief work in Thailand, and the Christian and Missionary alliance was almost alone in Indochina.

In the Philippines the work was carried on entirely by U.S. agencies. When the islands passed under control of the United States, seven boards conferred on the obligation which appeared to rest upon the U.S. churches. Six entered into a comity agreement. During half a century a Protestant community of about 710,000 members and adherents arose. The Philippine Independent Church, with about 1,000,000 communicant members, joined in communion with the Episcopal Church.

China was not open to missionary work until the treaties of 1842–44, and it was a quarter of a century more until toleration was granted. However, Robert Morrison had begun work in Canton in 1807, and he and others like the pioneer Karl F. A. Gützlaff managed to lay the foundation for the vast work to come later. The "protection" afforded missionaries and native Christians by foreign powers did much harm, and local antiforeign movements often caused setbacks. Several hundred westerners and thousands of Chinese Christians died for their faith in the Boxer uprising of 1899–1900.

Protestant schools, literature and hospitals mediated western knowledge; and youths interested in national reform and wanting contact with western culture turned in increasing numbers to these institutions as the revolution gathered momentum. Thus Protestant Christianity exerted an influence far greater than its numbers would have indicated. The churches grew rapidly in the 20th century, and during the war years from 1937 to 1945 indigenous sects not related to the missions began to flourish, such as the True Jesus Church.

As a consequence of Communist government in China all missionaries, except a few in prison or under other forms of arrest, were expelled, and the churches isolated. The church was stripped of all functions but worship and fellowship, and the institutions were taken over by the government. However, there remained considerable evangelistic activity. Much of the leadership of the churches was purged on political grounds, and the churches were put under the corporate direction of a "Three-Self Patriotic Movement" which co-ordinated their activities, marshaled them in support of government policy, and served as their liaison agent with the government.

Following the reopening of Japan and the signing of treaties permitting the residence of foreigners, three U.S. missions working in China simultaneously sent representatives into the country in 1859. Early enthusiastic acceptance of Christianity along with other aspects of western culture ended by 1900 as a strong nationalism began to assert itself. Christianity in Japan is predominantly found among urban and middle classes. Government pressure during World War II resulted in the merger of all denominations into the United Church of Christ in Japan (Kyodan), but after the war some of the churches withdrew. The Kyodan remained the largest ecclesiastical body. Higher education has always been a chief feature of the missionary program, and the

formation of the Japan International Christian university at Tokyo was a notable event after the war.

After several heroic attempts to introduce Christianity into Korea had ended in martyrdom, continuing mission work was begun in 1884 by Henry Appenzeller, Horace N. Newton, and Horace G. Underwood. The Korean churches became renowned for self-support, Bible study and evangelistic zeal. Christianity became under Japanese rule something of a vehicle for the preservation of Korean national aspirations, and Christians were often under great pressure. The Korean War and division of the country multiplied difficulties, but the churches continued to grow.

**Pacific Islands.**—The islands of the Pacific early attracted missionaries, beginning with the London Missionary society's party to Tahiti in 1797. But the vast distances, the thousands of islands and the hostility of many of the native peoples presented formidable obstacles. The roll of martyrs is long, including John Williams and Bishop John Patteson.

**Near East and North Africa.**—Protestant efforts in the near east and north Africa were originally directed toward the Jews and to the revival of the ancient Eastern churches. Education, medicine and literature were emphasized. There were few converts from Islam, and the Armenian and Nestorian Evangelicals in Turkey and Iran were destroyed or expelled after World War I.

**Latin America.**—The Evangelical churches in Latin America were started largely from the United States, although several countries received large Protestant immigrant groups. Brazil has the largest number of Evangelicals; Pentecostals form the largest group in Chile. Two important British missions are the South American Missionary society and the Evangelical Union of South America.

**Africa.**—It is impossible to write anything of consequence in a few lines about the vast continent of Africa south of the Sahara. Although the Moravians began work in south Africa in 1737 and some west African missions were founded in the first half of the 19th century in many parts of east Africa and elsewhere, missionary activity was not undertaken till the 20th century. Missions had to face the problems peculiar to work under a colonial government and later met new problems arising in the African republics. Education has been largely in the hands of the missions, but no university education was introduced. Relatively little was done in raising an adequate ministry for what amounted in many places to a mass movement church. African missions contributed largely to inspiration and support of the whole missionary cause through men like the explorer-missionary David Livingstone and his father-in-law, Robert Moffat.

### Missionary Co-operation

A remarkable degree of co-operation characterized the Protestant missionary enterprise from its beginning. One manifestation of this was the foundation of auxiliary services needed by all across denominational lines, including the Bible societies (British and Foreign, 1804; American, 1816) and the Tract societies (Scotland, 1793; London, 1799; American, 1823). Informal missionary fellowships, of which the earliest was the Bombay Missionary fellowship of 1825, soon became regional and national organizations. India set the example for other areas, and there the regional associations merged into the Decennial Missionary conferences, the first of which was held in Dec. 1872–Jan. 1873. These conferences dealt with recognition, transfer and discipline of members and agents; with common policies; and with the division of territory, which became known as comity. Comity became the general rule except in Japan and it resulted in "denominationalism by geography." Beginning with the negative purpose of guaranteeing noninterference in the affairs of a mission within a recognized area, comity became the basis for positive co-operation and ultimately for the maintenance of union institutions.

Parallel with the conferences in the various fields was a series of international popular conferences in Europe and America. These were New York, 1854; London, 1854; Liverpool, 1860; London, 1878; London, 1888; and the Ecumenical Missionary conference in New York in 1900. Regional conferences were also held in the Scandinavian countries, and a Continental Missions conference met at intervals beginning in 1866. Standing organs for continuous consultation and co-operation among the home base administrators began with the German Ausschuss in 1885 and the Foreign Missions Conference of North America in 1893. These experiments in the field and at the home base led to the World Missionary conference at Edinburgh, Scot., in 1910. John R. Mott traveled around the world on behalf of its continuation committee in order to seek acceptance of the conference's findings and to bring into being national conferences of missionary societies, such as the Conference of Missionary Societies of Great Britain and Ireland, and National Christian councils, in which churches and missions co-operated for common action. These two types of councils and conferences were then brought as daughter councils into the International Missionary council, formally organized at Lake Mohonk, N.Y., in 1921 after a delay caused by World War I. Influential World Missionary conferences were held at intervals by the I.M.C., the first at Jerusalem in 1928. These conferences were occasions for survey, study, shaping policy, devising new strategy, and strengthening co-operation. After the formation of the World Council of Churches (*q.v.*) this body and the International Missionary council entered into formal "association." In Nov. 1961, at the meeting of the general assembly of the World council at New Delhi, India, the two bodies merged, the International Missionary council becoming the Division of World Mission and Evangelism of the World Council of Churches, functioning under a 115-member commission. Thus the world mission of the church was brought into the very centre of the ecumenical movement. (*See* Ecumenical Movement.)

### Orthodox Missions

Missionary efforts by Orthodox Eastern churches during the 19th and 20th centuries were limited to those of the Russian church. Missions were established in Siberia, the Aleutian Islands, Alaska and Japan. The last was founded in 1863 by Bishop Nicolai. Archbishop Innocent founded the Orthodox Missionary society at Moscow to forward these efforts.

Missionary activity ceased with the establishment of Communist control in Russia. Because of its origin, the Orthodox church in Japan suffered severely during World Wars I and II, especially World War II, and was greatly reduced in strength. Assistance was given after World War II by the Russian Orthodox Church in the United States.

### Later Roman Catholic Missions

Roman Catholic missionary efforts had never ceased, although they had reached a low ebb by 1800. They were slow in reviving, but eventually became once more a vast enterprise. The Sacred Congregation for the Propagation of the Faith vigorously directed a world-wide mission, and a new organization came to its support. An Institute for the Propagation of the Faith was formed in Lyons in 1822 for the purpose of raising money for the total work. Eventually a National Society for the Propagation of the Faith, often with diocesan branches, came to be established in most countries where the church is strong. As the result of the crippling effect of World War I on certain European countries, and also because of the growth and power of the Catholic community in the United States, the U.S. churches moved suddenly from the status of a mission field themselves to that of supplying the greatest part of the resources for the worldwide mission. After World War II the preeminent position of the U.S. church was still further enhanced. U.S. missionary personnel remained disproportionately small in comparison with the total body, but U.S. branches of the important missionary orders were organized, and purely U.S. agencies, such as the Catholic Foreign Mission Society of America (Maryknoll, N.Y.), were formed.

The outstanding new development in Roman Catholic missions in the 20th century was the promotion of a native clergy and episcopate, strongly supported by the Roman pontiff (Benedict XV, encyclical *Maximum Illud*, Nov. 30, 1919; Pius XI, encyclical *Rerum Ecclesiae*, Feb. 18, 1926; Pius XII, encyclical *Evangelii Praecones*, June 21, 1951). The movement was given dramatic expression when Pius XI in 1926 consecrated six Chinese bishops

There were more than 100 native bishops, vicars apostolic, and prefects apostolic by the mid-1960s. Moreover, the Sacred College of Cardinals included Asians, Africans and representatives of the middle east and Oceania.

*See* articles on various denominations and biographies of missionaries; *see* also references under "Missions" in the Index.

BIBLIOGRAPHY.—A full outline of the history of missions and extensive bibliography will be found in the encyclopaedic work by Kenneth Scott Latourette, *A History of the Expansion of Christianity*, 7 vol. (1937–45). For a general outline of Roman Catholic history separately, *see* Joseph Schmidlin, *Catholic Mission History*, ed. by Matthias Braun (1933). The two great sources for Roman Catholic history are *Bibliotheca Missionum*, begun by Robert Streit and continued by J. Dindinger, and the annual on current literature, J. Romerskirchen and J. Dindinger, compilers, *Bibliographia Missionaria*, published under the auspices of the Sacred Congregation for the Propagation of the Faith (1933 *et seq.*). *International Review of Missions* (quarterly) of the International Missionary Council (1912 *et seq.*) includes extensive "International Missionary Bibliography." For information on current literature *see* the *Occasional Bulletin, Book Notes, Annual Select List*, and special bibliographies issued by the Missionary Research Library of New York city. (RT. P. B.)

**MISSISSIPPI,** often called the "Magnolia state" after its official flower, is a south central state of the U.S. The state is bounded on the north by Tennessee, on the east by Alabama, on the south by the Gulf of Mexico and Louisiana, and on the west by Louisiana and Arkansas from which it is separated by the Mississippi and Pearl rivers. The total area is 47,716 sq.mi., of which 493 sq.mi. are water surface. It is the 32nd state of the union in size. The state capital is Jackson and the state entered the union Dec. 10, 1817, as the 20th state. The magnolia is the state flower and tree, and the mockingbird is the state's official bird. The state flag consists of three equal horizontal stripes, the top one blue, the centre white and the bottom red. In the upper corner of the hoist is a union patterned after the Confederate battle flag. The state motto is *Virtute et armis* ("By Valor and Arms").

## PHYSICAL GEOGRAPHY

**Topography.**—Most of Mississippi, which is situated between approximately 30° 13′ and 35° N., and 88° 7′ and 91° 41′ W., lies within the Gulf coastal plain. Rolling hills cover the greater part of the state except for a narrow strip along the Gulf coast and an area in the northwestern section lying between the Yazoo and Mississippi rivers. These two sections are low and poorly drained. The highest elevation, about 800 ft., is in the northeastern part of the state in Tishomingo county.

**Climate.**—Its latitude, low elevation and proximity to the Gulf of Mexico produce, in southern Mississippi, a rather mild and equable climate, but northward the climate is more subject to extremes. The normal mean annual temperature for the state is 64° F. (about 18° C.); on the coast it is 67° and on the northern border 61°. Annual precipitation for the state is about 51 in. (southern half, 54 in.; northern half, 49 in.). Nearly one-third of the rain falls in January, February and March, but July is also wet. The driest months are September and October.

**Soil.**—The soils along the Gulf coast are generally unsuited to agriculture because of their lack of fertility and poor drainage. A few miles from the coast, however, the soils support tung-oil groves and some vegetable and truck crops.

The loess uplands include an area in the western part of the state that stretches from Tennessee to Louisiana between the delta on the west and the sandy-clay hills to the east. These uplands are made from fine, wind-blown soils that erode easily but are very fertile and productive if cultivated properly.

The delta soils to the west of the loess uplands are rich alluvial soils. Where the problem of flooding has been solved by levees, this is the most fertile area in the state and is noted for its cotton, hybrid corn and rice production. Native hardwoods, such as cypress, red gum and swamp hickories also grow there.

The section lying east of the loess uplands and north of the coastal meadows is known as the "piney woods." This includes most of the southern half of the state. Pine forests predominate in this region and furnish raw materials for the lumber and pulpwood industries.

In the northeastern part of the state, there are two very different types of soil. The so-called "prairie section" is a rich agricultural area which formerly produced cotton, but which now produces livestock and dairy products. Native Bermuda grass is the basis for most of the pastures. The other section in northeast Mississippi is that of the sandy-clay hills. There, the soil is of low fertility and subject to erosion. There are small areas, however, where the soil supports cotton and dairy production.

**Coast Line.**—The coast line, about 85 mi. long, is bordered by a beach of white sand and is broken by several small and shallow indentations, among which are St. Louis, Biloxi, Pascagoula and Point Aux Chênes bays. Separated from it by the shallow Mississippi sound is a chain of low, long, narrow sand islands, the largest of which are Petit Bois, Horn, Ship and Cat. Channels have been dredged so that Gulfport and Pascagoula have become ports for ocean vessels.

**Drainage.**—There are five major drainage basins within the state. The Tombigbee river basin drains the northeastern section. The Pascagoula river, formed by the junction of the Leaf and Chickasawhay rivers, drains the southeastern part. The Pearl river drains the south central section. The Mississippi river and its tributaries drain the western section. The Yazoo river, made by the junction of several small rivers, flows into the Mississippi near Vicksburg thus draining northwest Mississippi. The Big Black river, also a tributary of the Mississippi, drains the west central section.

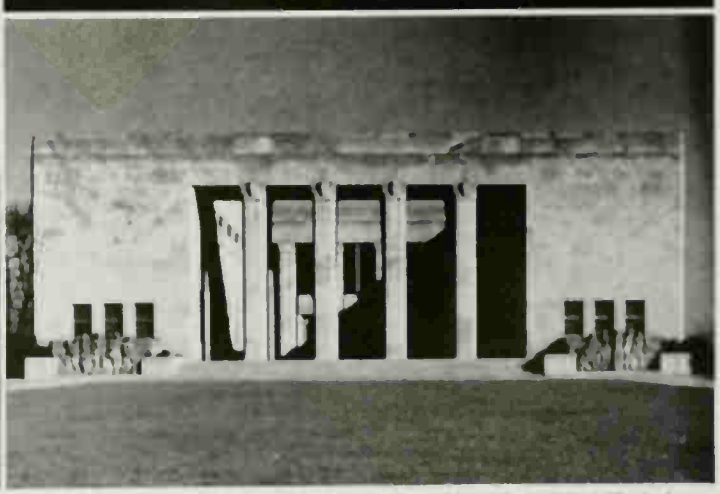
**Plants and Animals.**—More than half of the total acreage of Mississippi is covered with forests. In the piney woods section of the state the longleaf pine is the most outstanding type of tree. Other types of trees found in the state include the live oaks (often hung with Spanish moss), willow, bald cypress, black and sweet gum, white oak, hickory, honey locust, poplar, maple, sycamore and magnolia. National forests in Mississippi include the Homochitto in the southwestern corner of the state, Holly Springs in the north, De Soto in the southeast, and the Tombigbee, Bienville and Delta.

Mississippi woodlands abound in a large variety of flowering trees, shrubs and plants. Magnolias, dogwood, redbud and wild azaleas, commonly called honeysuckle, are among the commonest varieties of the flowering trees and shrubs. Other native flowers include roses, Virginia creeper, black-eyed Susans, violets, wistaria, papaws and primroses. Improved varieties of azaleas and camellias are grown in gardens in the southern part of the state. Roses, iris and all kinds of flowering bulbs thrive in flower gardens. In March many communities set aside days when gardens are open to the public; the city of Natchez observes the whole month.

Formerly, many wild game animals were native to Mississippi, but uncontrolled hunting eliminated most of them. Game animals now hunted include rabbits, foxes, squirrels, raccoons, opossums and deer. Alligators abound in the swampy bayous. Almost all kinds of freshwater fish are abundant. The most commonly caught are black bass, speckled trout, carp, channel and mud cat, bream and perch; in the Gulf-coast area there are also sheepshead, mullet and drum. Chief among the game birds are bobwhite quail, migratory waterfowl, mourning doves and wild turkeys. Coastal birds include the brown pelican, various types of terns, sandpipers and plovers. Among the songbirds are the state's official bird, the mockingbird, bluebirds, brown thrashers, robins, cardinals, blue jays, warblers and sparrows. In the coastal regions and in the delta the egret is fairly common.

**Parks and Monuments.**—The state has developed a system of public parks most of which have facilities for picnicking, water sports and fishing. There are also accommodations for overnight guests and lodges for assemblies. The state parks contain approximately 14,000 ac. of woodland.

National-park areas in the state are the Vicksburg National Military park and the Natchez Trace parkway. The former was established to commemorate the siege of the city in 1863 during the Civil War. In the park are the remains of trenches and gun emplacements that made up the battle lines (*see* VICKSBURG). The Natchez trace is a road that was developed from an Indian



BY COURTESY OF [illegible] CHAMBER OF COMMERCE, [illegible]

## SCENES IN MISSISSIPPI

*Top left:* Bay of Biloxi during the annual Shrimp festival. Biloxi is a leading shipping centre for shrimp and oysters.

*Top right:* The state capitol building in Jackson, dedicated in 1903, is similar in design to the national capitol.

*Centre right:* Ft. Massachusetts, on the western end of Ship Island in the Gulf of Mexico, was erected in the mid-19th century to protect the entrance of the waterway to New Orleans.

*Bottom left:* Picking Spanish moss which hangs in festoons from giant oaks along the Gulf coast.

*Bottom right:* War Memorial Building, Jackson, a monument to Mississippi servicemen who died for their country.

# MISSISSIPPI

[illegible] (CENTRE RIGHT, BOTTOM LEFT) MISSISSIPPI AGRICULTURAL & INDUSTRIAL BOARD, (BOTTOM RIGHT) MISSISSIPPI STATE UNIVERSITY; [illegible] (CENTRE LEFT) [illegible]

## VIEWS OF MISSISSIPPI

*Top:* The Mississippi river at Natchez. At the foot of the bluffs is the first lumber mill opened in the state (1809).

*Centre left:* Oystermen at daybreak off the shore of Pass Christian, where there are about 30 sq.mi. of shell-fishing banks.

*Centre right:* Stanton hall, one of more than 40 historic homes in Natchez, was built in the classic style typical of ante-bellum architecture in Mississippi.

*Bottom left:* Connelly's tavern or Ellicott's Inn, Natchez, built in 1795 in the Spanish Provincial style.

*Bottom right:* Farmer dumping mechanically picked cotton into wagon in which it will be sent to the gin. Cotton is the chief product of the state

trail which followed the watershed from Natchez northeastward between the Big Black and Pearl rivers to the foothills of the Pontotoc ridge. There it left the divide and struck more eastwardly across the Tombigbee river, meeting the Tennessee river near Muscle shoals. Brices (often Brice's) Cross Roads National Battlefield site commemorates the battle fought June 10, 1864, near the town of Baldwyn. Another national battlefield site is at Tupelo where the last major battle of the Civil War to be fought in Mississippi took place in July 1864. Nearby Ackia battleground, where the Chickasaw Indians defeated the French in 1736, a national monument until 1961, is part of Natchez Trace parkway. Around Natchez are grouped approximately 30 antebellum mansions which are open to visitors in the spring of each year. Other places of historical interest include Beauvoir, the last home of Jefferson Davis, near Biloxi, and Friendship cemetery at Columbus where the idea of Memorial day is believed to have had its origin. The Old Spanish Fort in Pascagoula, now a museum, is considered the oldest building in Mississippi; the old state capitol in Jackson, built in 1839, has been restored and is a museum.

## HISTORY

**The Indians.**—The principal Indian tribes living in Mississippi when the white men came were the Chickasaws, the Choctaws and the Natchez. The Chickasaws lived in the northern part of the state, the Natchez in the southwestern portion and the Choctaws in the remainder. It has been estimated that there were 20,000 or 30,000 Indians living within the present boundaries of Mississippi. At first the white men were most interested in trade and in converting the Indians to Christianity, but later they became interested in settling the area for permanent homes, which brought on conflict.

In the second half of the 20th century, a few Indians still lived in Mississippi on reservations provided by the federal government. Physical remains of the prehistoric Indians, such as arrowheads, pottery and mounds, are still frequently seen. One of the best-known mounds is Nanih Waiya, the sacred mound of the Choctaws, which is located in the southern part of Winston county. Mounds in the western part of the state have furnished artifacts for archaeologists. A group of four mounds near the site of old Selsertown in Adams county has been especially productive in supplying relics.

**Exploration and Settlement.**—In the first half of the 16th century the Spanish began the exploration of Mississippi. The most important expedition was led by Hernando de Soto in 1540. He entered Mississippi near the present site of Columbus and spent the winter near Pontotoc. Early in March 1541 hostility between the Spaniards and the Indians flared into open warfare in which the Spanish defeated the Indians and moved westward to make the great discovery of the Mississippi river in May. Successfully crossing the river, the Spanish passed through parts of Arkansas, Louisiana and Texas. In 1542 the expedition returned to the Mississippi river at a point near Natchez, where De Soto died and was buried in the river. Later the remainder of the expedition made its way to the Spanish settlements in Mexico, but their failure to find any precious metals caused the Spanish to lose interest in the area.

More than 100 years later, explorers went down the Mississippi river from the French colony in Canada. Father Jacques Marquette and Louis Jolliet, a trader, explored the river as far south as the Arkansas river. The accounts given of this trip fired the imagination of René Robert Cavelier, sieur de La Salle, who received permission from Louis XIV, king of France, to explore the Mississippi river valley and to build forts. In 1682 La Salle explored the Mississippi river to its mouth and named the territory Louisiana in honour of his sovereign. The explorer met his death in an attempt to establish a colony at the mouth of the river. His death and the involvement of France in a European war caused a postponement of attempts at colonization.

A successful French colonizing expedition led by Pierre le Moyne, sieur d'Iberville, arrived off the coast of Mississippi in 1699. After the exploration of the lower reaches of the Mississippi river and the coast line, Le Moyne decided to settle on Biloxi bay. There the colonists built a fort and named it Fort Maurepas. In 1702 Fort Louis, on Mobile bay, was established and ten years later Mobile was founded. Soon other settlements were begun near the mouth of the Pascagoula river. The oldest house now standing in Mississippi, called Old Spanish Fort, dates from this period. Fort Rosalie, now known as Natchez, was established in 1716.

The development of French Louisiana passed into the hands of the Mississippi company which was promoted by John Law (q.v.). Law's vigorous policies and the transfer of the colony's capital to New Orleans brought about a rapid development. Trouble arose between the French and the Natchez Indians over ownership of the land, however, and on Nov. 28, 1729, the Indians attacked Fort Rosalie and killed or took prisoner the entire population whereupon the French made preparations to punish the Natchez and their allies, the Chickasaws. The French forces attacked the Chickasaws at Ackia, a village near Tupelo, but were defeated. Continued difficulties with the Indians and unwise administration made the colony unprofitable. When the English won the French and Indian War (1754–63), the French were forced to cede all of their territorial claims east of the Mississippi river, except New Orleans, to England.

The British colony of West Florida included the lands west of the Apalachicola river and those south of the 31st parallel, but later the northern boundary was extended to 32° 28′. Pensacola was the capital, but Mobile the principal settlement. Fort Rosalie, renamed Fort Panmure, was not important until a new wave of immigrants came into the area in the 1770s to escape the unrest on the eastern seaboard. West Florida prospered under British rule, but it was occupied by the Spanish during the American Revolution. When the British signed the treaty of peace with the 13 colonies in 1783, the southern boundary was fixed at 31° though Spain did not recognize this boundary. The area was in dispute until the Treaty of San Lorenzo between the United States and Spain was signed in 1795.

**Statehood.**—The Territory of Mississippi, organized in 1798, included land between the Chattahoochee and Mississippi rivers on the east and west and between 32° 28′ and 31° on the north and south. The Indians held the land to the north. About 5,000 people lived in Mississippi territory at that time. The United States set up a territorial government with Winthrop Sargent as governor and Natchez as the first capital. In 1802 the capital was moved to Washington, a small town near Natchez, and it remained the seat of government throughout the territorial period. An important event that affected the people of Mississippi territory was the Yazoo land fraud by which the Georgia legislature sold to speculators most of the land now making up the state of Mississippi (then a part of Georgia's western claims) in 1795. The following year a new legislature rescinded the sale of the land and in 1802 Georgia ceded the land to the federal government. Other important events of the period were the Louisiana Purchase in 1803 and the War of 1812.

Troubles with the Indians increased during the War of 1812 and Gen. Andrew Jackson was sent to subdue them. By the Treaty of Fort Jackson, Aug. 9, 1814, the Indians were forced to cede valuable lands to the federal government. Mississippi territory was then expanded, but congress decided that the area was too large for one state and divided the territory to make the states of Mississippi (1817) and Alabama (1819).

David Holmes, who had served as territorial governor from 1809, became the first governor of the new state of Mississippi. The early years of statehood brought many changes. In 1822 a new capital, located on the Pearl river near the centre of the state, was named for Andrew Jackson. The United States signed several cession treaties with the Indians: Doak's Stand, in 1820, and Dancing Rabbit Creek, in 1830, with the Choctaws; and the treaty of Pontotoc, in 1832, with the Chickasaws. By 1840 Mississippi had 60 counties, and the entire state was in the hands of white settlers. The state had grown so much that a new capitol building was built and occupied in 1839.

This period of development brought prosperity. Roads and railroads were built, and steamboat navigation played an im-

portant part in getting the ever increasing cotton crop to market. The settlement of new lands and the growing demand for cotton made that crop the most important factor in the economy of the state. Negro slaves were brought in to produce the cotton, and by 1840 they outnumbered the white people.

**Civil War and Reconstruction.**—The period between 1850 and 1860 was marked by an intensive discussion of the slavery question. The Whigs and the Democrats united in support of slavery and its extension into the territories. In 1859 the Democratic state convention adopted a resolution favouring immediate secession if a Republican were elected to the presidency. The Democratic candidate for governor was John J. Pettus, who was elected by a large majority. In the presidential election of 1860 Mississippi voted for John C. Breckinridge, the nominee of the southern wing of the Democratic party.

After Lincoln's election Mississippi took immediate steps to withdraw from the union. A convention which met in Jackson on Jan. 7, 1861, passed two days later an ordinance of secession by a vote of 84 to 15. Mississippi was the second state to pass such an ordinance, and it joined other southern states to form the Confederate States of America. The legislature took immediate steps to prepare for defense, and Earl Van Dorn became commander of the Mississippi troops. Jefferson Davis, one of Mississippi's most distinguished citizens, became the president of the Confederacy.

Many battles and skirmishes of the American Civil War were fought on Mississippi soil, but the most important campaign was the fight for Vicksburg, which involved many months of planning and three campaigns. Gen. U. S. Grant led the third campaign which culminated in the siege and capture of the city (July 4, 1863). (For details of the campaign *see* VICKSBURG.) Federal troops, under the command of Gen. B. H. Grierson, moved across the state from Tennessee to Baton Rouge, La. During this raid, the Federals burned public buildings, destroyed factories and wrecked railroads. Other Federal troops, under the command of Gen. William Tecumseh Sherman, moved across Mississippi from Vicksburg to Meridian destroying property and confiscating livestock and provisions. The war ended in Mississippi when Gen. Richard Taylor surrendered his command on May 4, 1865.

In the summer of 1865 a convention met in Jackson to change the constitution. This convention abolished slavery, but refused to ratify the 13th amendment to the constitution of the United States or to make any changes in the state's voting laws which would enable Negroes to vote. Gov. Charles Clark had already been arrested by federal government troops, and the legislature stayed in session only a few hours because of fear that its members would be arrested. However, there was a political campaign in the fall of 1865. Gen. Benjamin G. Humphreys was inaugurated as governor in Oct. 1865 and served until he was removed by federal troops in 1868. Political conditions were chaotic because the federal congress refused to recognize the government of the state. In 1867 congress put into effect its plan of reconstruction, and Mississippi was placed in the fourth military district. The federal soldiers registered voters who took the oath of allegiance to the union and especially encouraged the Negroes to register. Delegates selected by the newly registered voters framed the constitution of 1869. James L. Alcorn, a Republican, was elected governor in 1869, and Mississippi, after meeting all of the requirements of the reconstruction act, was readmitted into the union. The same year the 14th and 15th amendments to the federal constitution were ratified. From 1870 to 1875 the government was under control of the unscrupulous carpetbaggers, Negroes and that part of the white population that was without political experience. Taxes were increased—expenditures had increased nearly threefold between 1869 and 1871—and there was much official corruption, but the state escaped the heavy burden of debt imposed on some of the other Southern states, by reason of constitutional inhibitions.

Political and economic conditions were very unsettled, and race riots broke out in a few communities. By 1875, however, the Democrats had reorganized themselves and were able to win control of the state legislature.

When the legislature assembled in Jackson in Jan. 1876 impeachment proceedings were begun against the governor, Adelbert Ames; the lieutenant governor, A. K. Davis, a Negro; and the superintendent of education, T. W. Cardoza, also a Negro. Davis was convicted and removed from office, and Cardoza and Governor Ames were allowed to resign. John M. Stone, acting president of the senate, became governor. The Democratic legislature instituted a program of economy and reorganized the government. A constitutional convention drew up a new constitution in 1890 which insured the control of the state to the white people.

**The 20th Century.**—The history of Mississippi in the 20th century has been characterized by progressive legislation. The passage of the direct-primary election law in 1902 placed in the hands of the electorate the nomination of public officials. Reforms were effected in the management of the penitentiary; in care of the ill, the handicapped and the indigent; in transportation; and in the provision of educational opportunities. Politically the state supported the Democratic party in every national election from 1876 until 1948, when the electoral vote went to the States' Rights party with Mississippi's governor Fielding L. Wright as the nominee for vice-president. Democratic again in 1952 and 1956, in 1960 the state's presidential electors, unpledged, voted for Sen. Harry F. Byrd of Virginia, and in 1964 Mississippi voted Republican for the first time since 1872, supporting Barry Goldwater over the Democratic candidate, Pres. Lyndon B. Johnson. The Republicans also elected one representative, the first time in 81 years that Mississippi had sent a Republican to congress.

A new predominantly Negro Democratic party had been organized in the early summer of 1964. Its delegates challenged the seating of the Mississippi delegation in the Democratic national convention. In November, it staged an election in which unregistered Negroes expressed their preference for the Democratic candidate for president.

The Council of Federated Organizations (C.O.F.O.), a civil rights coalition, increased its activity during the summer of 1964. Approximately 850 student volunteers set up community libraries, taught literacy and elementary classes, and encouraged Negro voter registration. The workers found a barrier of suspicion, fear, and apathy among the Negro community and opposition in the white community. There was a resurgence of organizations resorting to Ku Klux Klan methods of intimidation. Crosses were burned, churches were bombed and other methods of terrorism were used. The most tragic event was the murder of three of the volunteers in Neshoba county. The enactment of the Civil Rights law of 1964 increased tension but was followed by what appeared to be a strong movement for acceptance of its provisions.

## GOVERNMENT

Mississippi has had four constitutions in its history. The first was drawn up in 1817 when the state was admitted to the union. The constitution of 1832 was more democratic than the first in that it provided for the election of most of the executive and judicial officers. The third constitution was drawn up in 1869 to make it possible for Mississippi to be readmitted into the union after the Civil War. A fourth constitution was written in 1890.

The 1890 constitution has been amended many times. One of its principal objectives was the establishment of qualifications for voting; these provided that a person must live in the state at least two years and in his election district a minimum of one year before becoming eligible to vote. The prospective voter must also be able to read any part of the constitution or be able to understand it when it is read to him. Voters were further required to register four months prior to an election.

The 1890 constitution also provides that the responsibility for state government should be divided among legislative, judicial and executive departments. The legislature consists of two houses, the senate and house of representatives, both elected for four-year terms. The senate has 52 members and the house of representatives, reapportioned in 1963, has 122 members. The legislature meets biennially in even-numbered years for regular sessions and in special session at the call of the governor.

The judicial system consists of justice of the peace courts,

county courts, circuit courts, chancery courts and a supreme court. There is at least one justice of the peace in each of the five supervisors' districts in every county. Some counties that exceed a specified population have county courts, which have exclusive jurisdiction over eminent domain and juvenile cases as well as civil cases of less importance. The circuit courts are the courts of intermediate or general jurisdiction. They serve as appellate courts for cases from justice of the peace and county courts and hear both civil and criminal cases. The chancery courts are specialized courts which deal with divorce cases, deeds, wills, estates and the guardianship of minors. The number of circuit and chancery courts is fixed by statute. The judges of all these courts are elected for four-year terms.

There are nine judges on the supreme court, which is the highest tribunal in the state and hears cases appealed from the chancery and circuit courts. The state has been divided into three supreme court districts, each with three judges, serving eight-year terms. The member with the greatest seniority is the chief justice.

The members of the executive department who are elected by the people are the governor, the lieutenant governor, the secretary of state, the attorney general, the treasurer, the superintendent of public education, the auditor of public accounts, the commissioner of agriculture and commerce, the tax collector, the commissioner of insurance and the land commissioner. All serve four-year terms and all may immediately succeed themselves except the governor, the treasurer and the auditor. There are more than 100 boards and commissions which administer the state's business. Some of these are elected while others are appointed by the governor with the consent of the senate.

**Finance and Taxation.**—In its early history the state received most of its income from the property tax, but in the 20th century there began a decline in the importance of that tax as a source of state income, though it was still important in financing local governments. Mississippi has a homestead exemption law which exempts homes, not to exceed $5,000 and 160 ac., from taxation. Personal and excise taxes have increased in importance as sources of revenue. Personal taxes include income and estate taxes. Business taxes include franchise taxes, licences, corporation net income taxes and the sales tax. The sales tax provides nearly one-half of the revenue for the general fund.

A state tax commission, composed of three members, has important financial responsibilities. It equalizes tax assessments among the counties, assesses all public utility property, administers the homestead exemption law and collects revenue under tax laws designated by the legislature. These taxes provide 90% of the revenue for the general fund. However, the administration of the revenue system is divided among many agencies.

In the second half of the 20th century, the state's general revenue amounted to more than $225,000,000 annually. Of this sum, slightly more than one-fifth was derived from the federal government. The state's expenditures totaled about $225,000,000 annually, and the gross debt stood at more than $100,000,000. Approximately 33½% of the state's revenue was being spent on education, about 23% on highways, approximately 16% on public welfare and slightly more than 5% on health and hospitals. The state's income was nearly four times as great as it had been prior to World War II. State expenditures had increased about the same amount. Though Mississippi had the lowest per capita income of any of the states, such income was about four and one-half times as great as it had been prior to World War II.

## POPULATION

The population of Mississippi in 1820, three years after it had obtained statehood, was 75,448. Its population ranked 22nd among the 27 states and territories that then composed the union, and was classified as 100% rural. The decade between 1830 and 1840 was the period of most rapid growth after achieving statehood—the population increased 175% during that ten-year span. Immediately before the Civil War, in 1860, the state had a population of 791,305 and was 14th in population size among the 42 units of the government at that time; it was about 97% rural in character. At the beginning of the 20th century, the state had slipped to 20th in rank of population (out of 45 units) with a total of 1,551,270 by the 1900 census. It was still largely rural as 92.3% of the people were classified as nonurban dwellers. From 1910 to 1920 the population declined 0.4% and from 1940 to 1950, 0.2%. The trend continued between 1950 and 1960, there being a 0.04% decline in that ten-year period. In 1940, for the first time in 100 years, the white population (1,106,327) of the state outnumbered the Negro population (1,074,578); in 1960, the preponderance of whites over Negroes had grown larger (57.7% native white, 42.3% nonwhite, practically all Negro).

In 1960 Mississippi had a population of 2,178,141, a decrease of 773 from 1950; it was 29th in population size among the states. The population per square mile in 1960 was 45.1 as compared with 49.6 for the U.S. as a whole. The 1960 urban population was 820,805, or 37.7% of the total, continuing the trend toward increasing urban residence. There was one standard metropolitan statistical area (Jackson; comprising Hinds and Rankin counties; pop. [1960] 221,567). In line with the rest of the U.S. the percentage of persons 65 years old or more was 8.2% in 1960. The percentage of the population 14 years old and over that was in the labour force was 51.1% in 1950 and 51.6% in 1960.

*Mississippi: Places of 5,000 or More Population (1960 Census)**

| Place | Population | | | | |
|---|---|---|---|---|---|
| | 1960 | 1950 | 1940 | 1920 | 1900 |
| Total state | 2,178,141 | 2,178,914 | 2,183,796 | 1,790,618 | 1,551,270 |
| Aberdeen | 6,490 | 5,208 | 4,745 | 4,071 | 3,434 |
| Amory | 6,424 | 4,998 | 3,727 | 2,801 | 1,211 |
| Bay St. Louis | 5,073 | 4,821 | 4,336 | 3,311 | 2,872 |
| Biloxi | 44,053 | 37,425 | 17,471 | 10,937 | 5,467 |
| Brookhaven | 9,665 | 7,801 | 6,242 | 4,598 | 2,078 |
| Canton | 9,367 | 7,948 | 6,933 | 5,472 | 3,454 |
| Clarksdale | 21,009 | 18,538 | 12,868 | 6,592 | 1,773 |
| Cleveland | 10,132 | 6,242 | 4,150 | 3,674 | 479 |
| Columbia | 7,337 | 6,324 | 6,064 | 2,826 | 507 |
| Columbus | 24,771 | 21,672 | 18,645 | 10,301 | 6,484 |
| Corinth | 11,455 | 9,765 | 7,456 | 5,498 | 3,065 |
| Greenville | 41,502 | 28,930 | 20,602 | 11,560 | 7,642 |
| Greenwood | 20,456 | 18,063 | 14,762 | 7,261 | 3,028 |
| Grenada | 7,954 | 7,368 | 5,651 | 3,402 | 2,568 |
| Gulfport | 30,204 | 22,659 | 15,195 | 8,327 | 1,900 |
| Hattiesburg | 38,989 | 29,474 | 21,926 | 13,250 | 4,975 |
| Holly Springs | 5,623 | 5,276 | 4,750 | 3,613 | 2,613 |
| Indianola | 8,734 | 6,569 | 3,604 | 2,132 | 630 |
| Jackson | 144,422 | 98,271 | 62,107 | 22,817 | 7,816 |
| Kosciusko | 6,400 | 6,233 | 4,261 | 2,256 | 2,024 |
| Laurel | 27,899 | 25,034 | 20,598 | 10,843 | 8,184 |
| Lelland | 6,797 | 4,736 | 2,500 | 2,003 | 782 |
| Louisville | 5,966 | 5,242 | 4,451 | 3,772 | 905 |
| McComb | 12,598 | 10,481 | 9,008 | 7,223 | 4,477 |
| Meridian | 49,374 | 41,568 | 35,487 | 25,598 | 14,050 |
| Moss Point | 6,831 | 5,262 | 3,042 | 1,410 | — |
| Natchez | 23,791 | 22,789 | 18,296 | 12,998 | 12,210 |
| New Albany | 5,189 | 4,868 | 3,607 | 2,511 | 1,033 |
| Ocean Springs | 5,025 | 4,054 | 1,883 | 1,212 | 1,295 |
| Oxford | 5,283 | 3,998 | 3,411 | 2,338 | 1,625 |
| Pascagoula | 12,155 | 10,468 | 5,509 | 2,982 | 709 |
| Pearl | 5,063 | — | — | — | — |
| Philadelphia | 5,011 | 4,472 | 3,711 | 1,869 | — |
| Picayune | 7,874 | 6,910 | 5,128 | 2,478 | — |
| Starkville | 9,041 | 7,107 | 4,990 | 2,598 | 1,986 |
| Tupelo | 11,299 | 10,237 | 8,212 | 5,055 | 2,918 |
| Vicksburg | 29,143 | 27,989 | 24,689 | 18,072 | 14,834 |
| West Point | 9,190 | 6,432 | 5,627 | 4,400 | 3,183 |
| Yazoo City | 11,236 | 9,746 | 7,258 | 5,244 | 4,944 |

*Populations are reported as constituted at date of each census.
Note: Dash indicates place did not exist during reported census, or data not available.

In 1870 a uniform system of public education was organized. At that time, each county in the state and each city of 5,000 population was made a district in which free public schools were to be maintained for at least four months of the year under the supervision of a board of school directors. Prior to the Civil War there were no public schools for Negroes, but by 1869 there were more than 80.

With the coming of the 20th century there were many changes in the development of public education. In 1910 the consolidation of schools was begun. At first, wagons, and later, school buses, transported students to school. Colleges began to offer courses in education and two teachers' colleges were established. Schools were graded and standards for teachers were raised. A textbook commission was appointed to select uniform textbooks. In the 1940s the state began buying textbooks for children in grammar and high schools. School buildings were improved and school terms were lengthened.

The legislature of Mississippi embarked upon a new chapter in educational history in 1952. It appointed a recess committee on education whose purpose was to study the public-school system and to make recommendations for equalizing and improving educational opportunities. As a result of its study the committee recommended, and the legislature passed, the necessary legislation for a complete reorganization. A state educational finance commission was created with the purpose of receiving and reviewing plans for the consolidation or reorganization of Mississippi's school districts. The commission could also disburse funds made available by the legislature for school construction and equipment. The plans submitted to the finance commission were drawn up after surveys had been made by experts in school administration. When the reorganization plan was complete, Mississippi had only 151 school districts compared with the more than 4,000 it had had formerly. Negro and white children were in the same districts, but in separate schools. Each county's board of education is elected by vote of the qualified electors of each supervisor's district. The county superintendent of education serves as executive secretary of the county school board.

A system of publicly supported junior colleges grew out of the agricultural high schools which had been started in 1908 to improve educational facilities for rural children. The first agricultural high schools to add junior-college work were Pearl River county and Hinds county in 1922. The popularity of the program led to rapid expansion and in the second half of the 20th century there were 17 junior colleges (14 for white students and 3 for Negroes) to provide educational opportunities beyond the high school. In addition there were four private junior colleges for white students and six for Negroes.

**Colleges and Universities.**—Of the many colleges established in Mississippi before 1860, two were still in existence in the second half of the 20th century. Mississippi college at Clinton (affiliated with the Baptist Church), established as Hampstead academy in 1826; and the state University of Mississippi, chartered in 1844 and opened in 1848 at Oxford. Other state-supported schools for white students are Mississippi State university (1878) at Starkville, Mississippi State College for Women (1884) at Columbus, University of Southern Mississippi (1910) at Hattiesburg and Delta State college (1924) at Cleveland. For Negroes there are Alcorn Agricultural and Mechanical college (1871) at Lorman, Jackson State college (1877), which became a four-year degree-granting tax-supported institution in 1940, at Jackson and Mississippi Vocational college (1946) at Itta Bena. Among the privately supported four-year colleges for white students are Belhaven college (Jackson, Presbyterian, 1894), Millsaps college (Jackson, Methodist, 1891), William Carey college (Hattiesburg, Baptist, 1906) and Blue Mountain college (Blue Mountain, Baptist, 1873). A private senior college for Negroes is Tougaloo Southern Christian college (Tougaloo, Congregational Christian and Disciples of Christ, 1869). A scholarship program is financed by the state for Negro students who need to go outside of the state for additional training that the state does not provide.

In 1962, following refusal by Mississippi authorities to obey a federal court order to admit James Meredith, a Negro, to the University of Mississippi, Meredith enrolled in the school under the protection of U.S. marshals. Rioting, which broke out on the campus and in nearby Oxford, was quelled only by the intervention of U.S. army troops and units of the federalized Mississippi national guard.

## HEALTH AND WELFARE

The Mississippi state board of health was organized in 1877, but it did not become an important factor in public health until the 20th century, when the legislature increased its support and expanded its facilities and duties. The board's educational program has been effective in the control and eradication of communicable diseases.

The state's hospital program includes hospital licensing, the allocation of funds to, and the inspection of, hospitals that care for charity patients, and hospital planning as well as construction. The state also provides hospitals at Laurel, Meridian, Natchez and Vicksburg for the care of the indigent. The University hospital, at Jackson, also provides care for such patients. The state sanitorium near Magee provides for tuberculosis patients.

After the Hill-Burton act was adopted by the federal congress in 1946, the Mississippi commission on hospital care formulated a complete plan for hospital construction in the state. These new hospitals and health centres were financed by federal, state and local funds. Within ten years the number of available beds had increased 55% and hospital admissions 117%.

The state legislature established the department of public welfare in 1936 with funds provided by the federal and state governments. The department, operating through the county welfare departments, provides assistance to the indigent aged, the physically disabled, dependent children and the indigent blind. Blind children can be sent to state schools for the blind and there is also a college fund for the aid of the blind. The state also maintains schools for the deaf. The state cares for its mentally retarded at the Ellisville state school and for the mentally ill at hospitals in Meridian and Whitfield.

The department of public welfare supervises probationers; that is, children who have appeared before juvenile courts but were not sent to a training school. Mississippi maintains two training schools for delinquent children, one at Columbia for white children and the Oakley training school, near Raymond, for Negro children.

The Mississippi state penitentiary at Parchman operates farms and shops to provide for the needs of the penitentiary. It also provides vocational training as part of its rehabilitation program as well as an elementary education for those who need and want it.

## THE ECONOMY

**Agriculture.**—Throughout its history Mississippi's economy has been based upon agriculture. Although the percentage of agricultural workers was decreasing, about one-half of the total working population was still employed on the farm in the second half of the 20th century. Cotton has always been the most important single crop, but in the 20th century the boll weevil threatened to destroy the cotton economy. This threat was met by the development of improved varieties of cotton seed and the use of insecticides. The increased use of machines, such as tractors and cotton pickers, and improved agricultural practices also helped cotton maintain its dominance. The value of the cotton crop has been materially increased by the use of the seeds for the manufacture of cottonseed oil and feed. Nevertheless, in spite of these improvements the harvested acreage of cotton has gradually decreased over the years. The production of livestock and livestock products has increased so that they rank next to cotton in cash income. Other crops include hay, soybeans, and corn.

**Industry.**—In the 1930s the state started the "Balance Agriculture With Industry" (B.A.W.I.) plan to promote the development of industry. Under this plan communities gave financial aid to new industries. Such industries were so located that approximately a third of the nonagricultural workers were employed in manufacturing. Since more than one-half of the area of the state is classified as forest lands, it is natural that the manufac-

ture of wood and wood products is the most important industry. After World War II the manufacture of clothing became one of the fastest growing industries. Other important manufacturing industries include food processing, chemicals and textiles.

Electricity furnished by the Tennessee Valley authority has been an asset in the industrial development of northeast Mississippi.

**Minerals.**—Oil and gas are the principal minerals found in Mississippi. In addition to the gas wells within the state, gas pipelines from Louisiana and Texas cross Mississippi making natural gas easily available to a large percentage of the population. Gas extraction plants located in the Cantield and Brookhaven fields produce gasoline and butane and propane gas.

The oil industry had its beginning in 1939 when the Tinsley field in Yazoo county was discovered, and within 20 years there were more than 2,000 producing wells in the state. More than one-third of the land is under lease for oil and gas development. Refineries produce gasoline, kerosene, fuel oil, lubricants and asphalt.

Other natural resources include sand, gravel and limestone suitable for the manufacture of cement; and clay and clay minerals, including deposits usable in the manufacture of brick, tile and pottery, bentonite and fuller's earth.

**Transportation.**—The Mississippi river is one of the most important routes of transportation within the state. The United States government improved navigation on the river by dredging the channel, by providing navigation aids and by flood control. Coal, steel, grain, automobiles, sugar and oil are the principal commodities carried by river freight. Greenville, Vicksburg and Natchez are the leading river ports.

Railroad construction began in Mississippi in 1831 when the first line connected Woodville with St. Francisville, La. At the time of the Civil War, there were two east-west lines and two north-south lines across the state. There was little new construction after the war until the rise of the lumber industry in the early part of the 20th century stimulated the construction of additional lines. The coming of motor transportation and improved highways, however, caused some rail lines to be abandoned.

In 1930 the state highway system was placed under the control of a highway commission. The state built and maintains a primary system of highways which includes the main highways across the state. A secondary system of hard-surfaced farm-to-market roads affords good transportation to the rural areas.

Commercial airplane transportation first came to Mississippi in 1929 when passenger service was begun from Dallas, Tex., to Atlanta, Ga., via Jackson. Later, another route from Chicago to New Orleans also stopped in Jackson. These flights made Jackson an important airport. The Gulf-coast area is served by flights from New Orleans to Jacksonville, Fla. Local service lines operate within the state and provide travel by air between principal cities.

*See* also references under "Mississippi" in the Index.

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**MISSISSIPPI RIVER,** the "Father of Waters," was named Mishipi by the Ojibwa Indians (*Mis*, "great"; *sipi*, "river"). On some of the early French maps it was so named, and it is eminently deserving of the name. The source of the river was not known until 1832, when Henry Rowe Schoolcraft discovered its origin in a lake he named Itasca (Lat. *veritas*, "true"; *caput*, "head"). (*See* ITASCA, LAKE.) In this northern Minnesota lake district, 1,475 ft. above sea level, three great river systems, the Red, St. Lawrence and Mississippi, have their origin.

The length of this great river can only be approximated due to imperfect drainage in the north and meanders in the south; the U.S. department of the interior, geological survey, gives it as 2,348 mi. The least accurately measured portion is from the mouth of the Ohio to Head-of-Passes below New Orleans, where for 954 mi. the Mississippi flows over land of its own making. The greatest fall in the river is in the 500-mi. stretch upstream from Minneapolis-St. Paul, a drop of 700 ft.

With its two great tributaries, the Ohio and the Missouri, the Mississippi drains an enormous area; water from 31 states and two Canadian provinces flows into the Gulf of Mexico by way of this system. This embraces approximately 1,243,700 sq.mi. or one-eighth of all North America. Expressed another way, its longitudinal expanse is 1,900 mi. and its latitudinal 1,400 mi.

Physiographically the Mississippi drainage basin embraces parts of the Laurentian, Central lowland, Great Plains, Appalachian and Central highlands, Rocky mountains and Gulf coastal plain provinces. Climatically it also includes a diverse group: from humid continental short summer in the north to humid subtropical in the south; from humid continental long summer in the east to steppe and mountain in the west. Mineral endowment and soils represent a similar diversity.

The Mississippi empties into the Gulf of Mexico an estimated 724,000,000,000 cu.ft. of water each year. This is about 1½ times the discharge of the St. Lawrence, 5 times that of the Rhine and

AERIAL VIEW SHOWING THE CONFLUENCE OF THE MISSOURI AND MISSISSIPPI RIVERS A FEW MILES NORTH OF ST. LOUIS. THE MISSOURI IS THE MUDDIER RIVER SHOWN ENTERING THE MISSISSIPPI RIVER FROM THE LEFT

177 times that of the Thames. The Ohio is the greatest contributor to the water of the Mississippi, being about 3½ times that of the Missouri, the next greatest. It is not necessary to view the waters from the air to see that the silt in the Missouri identifies its contribution for miles downstream.

**Tributaries.**—One way of evaluating the Mississippi's contribution to American life is to examine its tributaries. The Mississippi may be resolved into three major regions—headwaters and northern tributaries; the very large tributaries of the middle section; and the lower Mississippi—each region with its distinctive characteristics. For a time during the days of early settlement, the river was a bond that tended to unify these physical regions, but with the westward movement and an occupied continental heartland, the uniqueness of the three tributary regions asserted itself in the character of river use; the unifying effect of the river began to increase again after 1940.

**Northern Region.**—Except in southwestern Wisconsin, the headwaters and northern tributaries flow through an area of comparatively recent release from the continental ice sheet; much of the character of drainage and soil derives from this fact. Physiographically it is essentially the West lakes section of the Central lowland and the Superior upland portion of the Laurentian shield. The prevalence of lakes of all sizes and swamps, plus the fact of flow over a plain of alluvial fill, gives a meandering course to the headwater streams and even to the upper Mississippi itself. The lakes and swamps also greatly reduce the number and stage of floods and limit the usefulness of streams to local commerce.

The larger tributaries from the east are the Wisconsin, Black, St. Croix and Chippewa, names redolent with memories of upper lakes' lumbering. There is but one major tributary from the west, the Minnesota. The better lands of the basin lie to the west, but there are none of the minerals that figure so prominently in the east. The level plains of old Lake Agassiz support an important grain-livestock economy. On the upper Mississippi and its northern tributaries are extensive areas of marshland that support a specialty crop, wild rice, the harvest of which is largely in the hands of Chippewa Indians (who serve as guides or lumbermen for the remainder of the year). Over much of the area there are the marks of three successive exploitations: lumbering, mining and generally subsistence farming.

**Middle Region.**—The middle section of the Mississippi drainage basin is the region that gives the basin its continentality. Two great river systems, the Ohio and Missouri, embrace very extensive areas to the east and west, respectively. This section of the Mississippi and the tributaries has virtually none of the youthful landscape characteristics noted in the headwaters. The river is more deeply entrenched, with the banks generally no more than a mile apart; the names of some of the towns and cities—Council Bluffs, for instance—suggest this.

Tributaries from the east include such important streams as the Rock, Illinois and Kaskaskia; from the west come the Cedar and Des Moines rivers. In considering the apparent paucity of tributaries in this section, it must be remembered that both the Ohio and the Missouri are great river systems, each with many important tributaries.

The middle section of the Mississippi is much more subject to flooding than the northern, owing in part to the absence of lakes but mostly to the rainfall distribution and percentage of runoff of its far-flung eastern and western tributaries. There the Rockies and the Appalachian and Central highlands introduce an entirely different reason for changes in the volume of water moved by the rivers; the timing of their floods can be disastrous to the lower Mississippi river plains. The accessibility of this portion of the Mississippi river valley is one of the three bases of its economic dominance. East of it lie the lower Great Lakes and St. Lawrence river, the only deep-water outlet to the Atlantic; to the east also are the important corridors through the north and Appalachian highlands that give access to the middle Atlantic port cities. Far to the west are the passes through the Rocky mountain barrier. South of it is the route to the Gulf of Mexico, oldest and most important of the water outlets for the heartland of the United States.

**Southern Region.**—The southern portion, below the confluence with the Ohio, has tributaries that differ markedly from those of either section of the river to the north. For almost a thousand miles, the Mississippi, swollen by the waters of the Ohio, pursues a meandering course over its flood plain built upon the underlying coastal plain. As in no other part of the river valley, it may be characterized by its tributary river basins, which tend to parallel the Mississippi itself. From the north they are the St. Francis, Yazoo and Tensas basins, with the Yazoo as the only major eastern tributary; and the Atchafalaya, which was made a distributary. The St. Francis, Yazoo and Tensas basins virtually monopolize the tributaries of the main stream; the major exceptions are, from the west, the Arkansas and Red, two of the longest tributaries to the lower Mississippi.

A third drainage feature is the series of short placid Louisiana streams, which, at least in times of high water, act as distributaries of the lower Mississippi. Among the larger ones are the Teche and La Fourche.

1. Yazoo Basin. In the southern region, longest of the three, the features common to the four parallel tributary basins are far greater than those that distinguish one from another. The only important tributary basin to the east of the Mississippi is the Yazoo, lying between Memphis and Vicksburg. The Yazoo river follows a very meandering course on this alluvial plain, with a fall of only 7½ in. per mile or about twice that of the Mississippi a few miles to the west. Prior to the completion of the system of levees in 1886, the Yazoo basin was subject to overflow by the larger stream; after that time it became one of the major cotton-growing regions in the south.

2. St. Francis Basin. The St. Francis is the northernmost and largest of the alluvial basins on the west side of the Mississippi; the Black and St. Francis rivers follow nearly parallel courses along the major axis of this basin. The southern end of the basin is hard to determine since the Arkansas flows in from the Rockies and merges its alluvial plain with the St. Francis as it makes its difficult entry into the Mississippi. In most respects the St. Francis basin is similar to the Yazoo, although interrupted by Crowley's ridge.

3. Tensas Basin. The Tensas basin comprises the flood plain on the west side of the Mississippi from the Arkansas to the Red river. It, too, has a vaguely defined southern boundary where it merges with the flood plain of the Ouachita river coming in from the Ozark highlands. In all essential respects, this basin is similar to the Yazoo. The long Red river, which makes a doubtful entrance into the Mississippi, has a very low gradient, much silt and a number of meandering tributaries on both sides. Several of these tributaries long ago were dammed by logs to form lakes of varying sizes; its waters merge with the Atchafalaya river on the south.

4. Atchafalaya Basin. The fourth and final alluvial basin is that of the Atchafalaya, west of Baton Rouge and New Orleans. While similar to the other three alluvial basins of the lower Mississippi, this river was naturally an independent stream; engineers made it a distributary of the Mississippi to use when the need arises in times of flood.

**Use.**—Earliest to discover the low divide separating the Mississippi from the Great Lakes and to evaluate the usefulness of the river were the French from the St. Lawrence valley, whose fur traders, traveling with a priest, started many Mississippi valley villages before the English appeared. Among them were: Peoria, 1680; Detroit, 1701; New Orleans, 1718; and St. Louis, 1764. Ohio was the only state in the old Northwest Territory with no French land claims at the time the public domain was established. In a sense the French were not true colonists since their economy never passed the fur-trading dominance; fur trade tends to discourage the evolution of a permanent economy. To these French trappers, the river was the final link in the St. Lawrence-Great Lakes-Mississippi waterway to the warm Gulf of Mexico and the Caribbean. They recognized its geographical advantage and unifying influence in terms of continental development, but they were numerically and economically inadequate to secure and hold it. After the treaty of Paris in 1763, French

settlements in the St. Lawrence valley became part of the British North American colonies.

The British tidewater colonies along the middle Atlantic coast were forbidden to expand westward across the Appalachian highlands into the Mississippi valley by the British North America act. To the American continental congress and its successors, the Mississippi river was at first a threat and then an invitation; the purchase in 1803 of the Louisiana territory ended the threat. Lacking the power to protect lives or land titles in the old Northwest territory, the nation's first public domain, the continental congress forbade settlement in this part of the Mississippi valley; after enactment of the ordinance of 1787, however, settlement was permitted. This territory developed into the nation's first corn and wheat belt; it soon found a ready market for its surplus farm products in the old cotton-growing south. The Mississippi's big eastern tributary then gathered the commodities for shipment down the Mississippi; until the Civil War peak of steamboating, commerce on the Mississippi grew rapidly. By 1840 one-half of all commercial vessels under American registry were in use on the Mississippi river system. After the Civil War, steamboat traffic declined; the railroads gave better service.

The emergency in transportation incident to World War I resulted in such rail congestion that the federal government attempted to stimulate river transport; the cessation of hostilities did not end this effort. The Federal Barge Lines were established in 1918 to demonstrate the economy of barge traffic; 40 years later, river barge traffic had grown so spectacularly on all parts of the Mississippi system that the Federal Barge Lines were sold to a private carrier.

**Improvements.**—Factors accounting for the increase in traffic on the Mississippi are many and varied. Improvements in the river and in transportation equipment lagged prior to 1928, but thereafter, and especially after World War II, great strides were made. The process of levee maintenance, straightening of the channels, desilting, devices for flood alleviation (if not always control), and dredging of channels, especially below New Orleans, have always been in progress.

Most Mississippi locks, like those in its busiest tributary the Ohio, measure 600 ft. by 110 ft., making double locking necessary. The Falls of St. Anthony (Minneapolis-St. Paul) are bypassed by canals constructed by the corps of engineers. The lower lock is 1,200 ft. long and has a rise of 25 ft.; the upper lock has a rise of 50 ft. (highest on the river). This particular lock illustrates a significant change in river improvements, a change that attempts to integrate river transport with the recentralization of the nation's manufacturing. Above the upper lock a harbour 3½ mi. long was constructed to serve the commerce of and through the Twin Cities. Adjacent to the harbour a 3,000-ac. tract of reclaimed land was developed to serve as an "industrial park" for newly located factories.

Farther south, New Orleans constructed an industrial canal linking Lake Pontchartrain with the river and offering planned industrial sites for new factories. St. Louis built a terminal for river traffic, with the result that tonnage handled nearly tripled between the late 1940s and late 1950s. Near Keokuk, Ia., the locks are 1,200 ft. long, 110 ft. wide and 38 ft. deep, a type planned for all locks subsequently constructed.

Improvements in towboats and barges proceeded more rapidly than did river facilities. Specialized barges were developed for certain commodities—molten sulfur, petroleum, new automobiles, acids and alkalis—and the size of barges, power of towboats and aids to navigation also increased. A barge 300 ft. long holds 1,000,000 gal. of petroleum; a railroad tank car holds 13,000 gal. An oil-fired, air-conditioned excursion steamer carries 4,000 passengers. A St. Louis firm built a towboat with diesel engines generating 8,500 h.p., ten rudders and five decks carrying a crew of 17; it could move 40-barge tows from St. Louis to New Orleans in ten days at rates, depending upon the commodity, from 12% to 50% lower than railroad rates. Such a tow moves more than twice the tonnage of most ocean freighters. Not many of the 4,200 modern diesel towboats on the Mississippi river system are as large, but the trend is upward. Approximately 8% of intercity freight is moved over these waters.

Manufacturing industries began to be attracted to Mississippi river sites, particularly after World War II. In this choice of location, though improvements in the river were influential, the prime factor was expanding markets and rising freight costs. These industries consume a diversity of raw materials and produce a variety of commodities, but the most important, perhaps, are those that require much power in processing. In the south the chemical industries have come to dominate the Intracoastal waterway, which contributes much tonnage to commerce on the Mississippi above New Orleans. St. Louis, Memphis, Baton Rouge and New Orleans have all become important manufacturing cities, each with a wide market area. Among the smaller cities that might be named are Dubuque, Davenport, Vicksburg and Chalmette.

**Problems.**—It is to be expected that there will be problems connected with the regular use of such a large river as the Mississippi. Some of these problems, in fact most of them, stem from the physical circumstances of the river; historically, there are the difficulties of using the Mississippi as a boundary between states. The changing course of the main channel is a periodic problem for counties and states, particularly in the southern third of the river, though some stabilization has been achieved.

Floods have always been a very serious problem, not only to navigation on the river, but to riparian occupance as well. Experience since the early 19th century, together with the findings of the Waterways Experiment station operated by the federal government near Vicksburg, resulted in a vast system of river controls and harbour improvements. Aside from the flood control measures established on tributary rivers (for instance, the Tennessee Valley authority, Miami Valley Conservancy district and Missouri Valley authority), the several Mississippi engineering districts constructed a complex pattern of reservoirs, floodways, spillways, distributary channels and levees in the lower third of the river system.

Despite these improvements, the regular commercial use of the Mississippi is attended by serious hazards. Ice and high water are perennial problems. Channels shift and bars are formed. The river functions as a commercial artery only if dredging is constantly underway at several points, notably in the channels below New Orleans. The devices for reducing flood damage in themselves give rise to risk of property damage.

The chief economic problem centres around financial support of river navigation, flood control measures, etc. The channel is maintained and lighted, levees are built, locks are operated and personnel are licensed at federal expense; only the transportation equipment is taxed. Even on the busiest river of the Mississippi system, the Ohio, if the hidden costs are considered, traffic is partly subsidized by the tax-paying public.

*See* separate articles on the chief tributaries, as OHIO RIVER; MISSOURI RIVER, etc.; *see* also RIVER AND RIVER ENGINEERING. *See* also references under "Mississippi River" in the Index.

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(A. J. WR.)

**MISSISSIPPI RIVER STEAMBOAT.** Few phases of 19th-century North American life had so wide and vivid an influence on the region and people around it as the Mississippi river steamboat. For 50 years, from about 1820 to 1870, this "swimming volcano," as one passenger called it, dominated the economy, agriculture, commerce and social customs of the middle area of the United States.

These "palaces on paddle wheels" made possible the golden age of the central south and Mississippi valley during the days before the Civil War. They gave its greatest growth to New Orleans, queen city of the Mississippi, and determined the direction of development of other cities, towns and rural areas. They made fortunes for their owners and for plantation masters; they brought

much of the old south in touch with the world and aided in the growth of slavery and the cotton economy.

In a region still not far removed from its frontier period, the steamboats provided a primary contact with other people and other ways of life for thousands of men and women. They gave to American tradition such figures as the waistcoated Mississippi gambler, the Negro roustabout who dragged cargoes on and off, and emotion-charged incidents such as the bizarre explosions on the river and the great Mississippi races.

Steamboat pioneering began in America in 1787 when John Fitch of Connecticut made a successful trial. Robert Fulton's profitable experimentation followed, but not until 1811 was a vessel built especially for the "western waters," the lower Mississippi—the "New Orleans," built at Pittsburgh, Pa., under the direction of Nicholas J. Roosevelt, agent for Fulton and Robert R. Livingston. Most observers predicted disaster when Roosevelt, with his wife, started down the Ohio. The way was dangerous and the Mississippi an especially hazardous stream, with eddies, rapids, hidden snags and sand bars.

The trip began in May and did not end until Jan. 10, 1812. The vessel had many difficulties, again and again it tied up for repairs. After traversing the Ohio falls it continued downriver; at New Madrid, Mo., a violent earthquake made the earth open and river banks crumble away, but the "New Orleans" survived. After wild excitement at many points, it arrived at the Creole city.

There Fulton and Livingston began in early 1812 the operation of a service between New Orleans and Natchez, Miss., under a monopoly contract with the territory of Orleans, one of a number of such contracts obtained in various states. The vessel traveled eight miles an hour downstream, three miles up. Within two years the "New Orleans" sank, though her engine was rescued. Fulton and Livingston continued operations in this western area, but the former wrote soon afterward of his weariness and disgust at the expense and losses.

Nevertheless J. G. Flügel, an observant passenger on a second "New Orleans" steamer of 1817, described the "elegance" of the boat, with "red bombazette curtains and fringes and mosquito bars," sofas, chairs and looking glasses. Despite Fulton's gloomy remarks, Flügel claimed that on one such Natchez-New Orleans trip net proceeds reached $4,000. "There is within the bounds of knowledge," he asserted, "no business in any part of the globe which is more lucrative than this . . ." ("Diary of J. G. Flugel," *Louisiana Historical Quarterly*, published by the Louisiana Historical Society, July 1924.)

Yet the Mississippi remained a treacherous stream. In 1816 Henry Miller Shreve of Shreveport, La., made history by launching his "Washington"; before long it made the trip from New Orleans to Louisville in a phenomenal time of 25 days. In so doing Shreve flouted the Fulton-Livingston claim to an exclusive right to navigate the river. For several years the two sides fought the matter in courts, and eventually the monopoly was rejected there.

Shreve's work has given him the title of father of Mississippi navigation. An engineer-boatman-inventor, he had realized that vessels planned for clear, deep eastern waters would never do well on the Mississippi. He made radical changes in design; drawing up the engine, he mounted it on a hull as shallow as that of a barge. The engine itself was high pressure, capable of making progress against the Mississippi's might.

A tall second deck was added and paddle wheels placed at the side. Though many hooted at the strange-looking thing, so tall in the air, so light in the water, Shreve's experiment became the prototype of all Mississippi steamboats.

From then on the people of the Mississippi valley and tributaries turned to the steam vessels. In 1814 New Orleans, near the mouth of the river, had counted hardly 20 steamboat arrivals. Within 20 years the figure had reached 1,200. Cotton was spreading over the south and southwest; sugar had become the major crop of the area below New Orleans. For the south a new day had begun.

About New Orleans the steamboat-cotton wealth was crystallizing. By the 1830s its banking capital exceeded that of New York city; its port competed with New York as the nation's largest, and in exports it frequently ran ahead of its eastern rival. In a single decade New Orleans' population doubled.

Upriver the steamboats brought soaring prosperity to Memphis, Tenn., St. Louis, Mo., Natchez and other points. Along the Mississippi and its tributaries the roads were short and undependable; the rivers were the highways of the day and they ran south to New Orleans and the ocean below it. "The master street of the world," one enthusiast called the New Orleans water front; nowhere else, it was said, could be found such a concentration of steamboats. They stretched for four or five miles, curving with the river itself, sometimes two and three deep.

Lady Emmeline Wortley described the procession of the river boats on the lower river: "By night the scene is one of startling interest and magical splendor. Hundreds of lights are glancing in different directions from the villages, towns, farms and plantations on shore, and from the magnificent 'floating palaces' of steamers, that frequently look like moving mountains of light and flame, so brilliantly are these enormous leviathans illuminated, outside and inside . . . steamer after steamer coming sweeping, sounding, thundering on. . . ." (Lady Emmeline Stuart Wortley, *Travels in the United States*, Harper & Brothers, New York, 1851.)

Vessels grew larger, engines more powerful, paddle wheels bigger. The double smokestack became the symbol of the steamboat, and between them many a boat carried a gilded ornament or a flamboyant design of some kind—a cotton bale, a star, an anchor. Paddle boxes had their own ornamentation. Inside all might be white "gingerbread," wood curlicued and gilded, knobbed and flowered. Eventually exteriors were similarly trimmed until, as more than one person noted, they looked like wedding cakes afloat.

All steamboats of any size ultimately had "lounges" or central cabins in the style of ornate hotel lobbies, with rich rugs, oil paintings and lines of chandeliers. Chefs were taken from famous restaurants and had large staffs to assist them. A number of boats had large orchestras, and there were maids and butlers to assist cabin passengers. Surviving menus show scores of dishes, with choices of as many as 7 soups and 15 desserts. Now and then a vessel printed its own newspaper as it went up and down the river. For the men there were bars, long and mirrored and almost always jammed, barber shops and lounging quarters.

Eliza Ripley in her *Social Life in Old New Orleans* tells how one imaginative owner decorated stateroom doors (and flattered particularly good steamboat patrons) with views of some of the great plantation homes along the Mississippi. Nevertheless, Mrs. Ripley makes clear that, with all the display, such trips might be arduous. On the popular "Grey Eagle," berths were so narrow that, in trying to turn over, she fell out and landed in the washbasin on the opposite side. Her sister, sitting on the lower berth to braid Eliza's pigtails, "then sent me forth so that she could braid her own." Service proved negligent, meals confused and disorganized.

Outside the cabins a simpler, rougher life went on. Roustabouts and crew stretched on the decks, and with them deck passengers

PADDLE WHEEL STEAMBOAT

who might be poor traders trying to sell wares in the hinterlands, new settlers and their wives, immigrants from Europe or flatboatmen going upriver. (The latter continued to flourish for downriver trips, in spite of the arrival of steam power.) In the social caste system of the south such passengers received little heed and almost no care; they sat or lay wherever they could.

The captain became an omnipotent person, a man with vast authority over life, commerce or well-being. He could remove a passenger at a word, and tales are told of luckless ones dropped at marsh edges. He lived in splendour on land and water, often a man of many anecdotes, perhaps of prodigal hospitality when in good mood, but of sulfurous rages and thundering orders when others crossed him.

The steamboat pilot was a man deferred to by all on board, including the captain. He received top pay, and generally deserved it. On him depended the safety of passengers and crew, day and night. His was a rare ability, part long training, part detailed knowledge of an unbelievably complicated subject, part a quality approaching instinct.

The Mississippi remained treacherous, filled with snags, with driftwood, with shoal points just below the surface. Perched high above the steamboat, the pilot operated in darkness, depending on memory, on years of accumulated skills and on informed guesswork, for the river changed constantly and the pilot had to take chances at every point.

Mark Twain (Samuel Clemens) in his *Life on the Mississippi* has an inspired, often-quoted description of his interview with a pilot, while a cub on the river. Clemens was told he must "get this entire river by heart . . . know it just like ABC. . . . It is all there is left to steer by on a very dark night. Everything else is blotted out and gone." (*Life on the Mississippi*, Hillcrest ed., *The Writings of Mark Twain*, vol. ix, Harper & Brothers, New York, 1904.) Moreover, the cub had to learn that on a clear starlit night black shadows had special qualities that must be understood and that a certain line on the surface meant an obstruction, while another only a wind. But how could he know the difference? His teacher could not explain precisely; Clemens must watch and learn. It was no wonder that the cub said, at one point, that he wished he were dead. He later became an expert, however.

The blowing of the steamboat whistle, signaling an approach to a town, could electrify a river community. Hundreds would race to the riverbank to watch the excitement, to see who arrived, what news the crew brought, how high the cotton bales towered on the deck. (Sometimes the cotton filled every foot of space, blotting out light from cabin windows, so that candles had to be used by day.) The steamer carried foodstuffs and manufactured goods; it took produce and materials for transshipment.

At other points hundreds watched the procession of the steamboats. Since the engines swallowed fuel hungrily, men cut down vast supplies of cordwood and stacked them for quick pickups when needed. At isolated spots, tiny settlement points or the edges of plantations, individuals or clusters also stood on the banks for hours with flares to await the next vessel. Most steamboats would halt anywhere for business, even performing casual errands.

Smaller vessels, the showboats, were also moving along the Mississippi and tributaries with plays and vaudeville, little companies of entertainers with a staple line of melodramatic favourites. The showboats made their greatest successes at towns which had no other theatre. About them, as about the steamboats, went colonels, ministers, lawyers, prostitutes, thieves, schoolgirls, housewives—a cross section of the population of the day.

Repeatedly stories were whispered of well-dressed individuals, soft-mannered, hard-eyed, who struck up acquaintances with young travelers or others new to the river. After a few minutes at the bar the conversation went to cards; a game followed and in the morning the river gambler might leave with $10,000, a year's plantation profits. Other accounts describe games that went on for 36 or more hours, whole estates being lost by the lift of a card. Some gamblers operated singly, others in pairs, many maintaining that they operated "fairly and honestly."

The average life span of a vessel was four to five years. Not built to last long, the vessels' engines sometimes were poorly constructed and maintained, and the steamboats fell victim to obstructions in the river, to exploded boilers or mishandling in the engine room—or simply the yearning for speed. Time schedules constantly quickened. In Shreve's day the New Orleans–Louisville run was 25 days; in 1853 the "Eclipse" shortened it to less than 4½.

From 1810 to 1850 an estimated 4,000 persons died in steamboat disasters. Classic accounts describe the drowning of scores, the hurling of bodies across banks; many lingered on, horribly burned, others were never found. A large proportion of such disasters could be traced to the custom of races on the river. Captains of two vessels leaving a city about the same time or meeting in the river, would frown and shout at one another; from crew and passengers a cry would go up, "Beat 'm!" From then on hysteria would seize men and women. Shouting, waving, they would stare intently as one, then the other took the lead.

Safety precautions would be flouted, engines pushed beyond capacity, and then tragedy sometimes followed. Again, however, such races were also carefully prearranged, with thousands learning of them in advance and looking on from shore. The winning vessel would gain a new popularity, a great commercial advantage, if it survived.

Meanwhile, little heeded by the proud steamboat interests, two potent rivals were in the making. Railroad construction began early at Baltimore, Md., in the upper south, with the launching of the Baltimore and Ohio railroad in 1828. Bad times of 1839, however, deterred other large-scale southern railways, and along the Mississippi leaders scoffed at the new medium. Canal construction also started in 1828, between Baltimore and Cumberland, Md., yet few river people saw a reason for concern. Nothing could be faster or cheaper than the steamboats, they insisted.

Nevertheless by the 1850s patterns were changing. The new methods of transport were tapping the old steamboat market. River trade continued to thrive, often reaching new high totals; at the same time, however, railroads and canals took an ever greater share. The Civil War of 1861–65 played havoc with river transportation; for many miles gunboats replaced steamboats and the railroads proved their growing efficiency.

The postwar period saw a revival of steamboating, with new vessels and new spurts of prosperity. After dark years of neglect, the streams were improved, levees built higher; transportation became safer, and for a time many felt that old times had come back. The year 1870 witnessed a steamboat excitement such as the nation had never known, the greatest race of all.

Almost annually the time upriver had been reduced in successive competitions. The distance from New Orleans to Natchez had taken Henry Shreve five and one-half days; by 1835 it required only a day and 21 hours. In 1853 the "Natchez" (one of many bearing the name) cut the time to 17½ hours. On June 30, 1870, another "Natchez" under Capt. T. P. Leathers, faced the "Robert E. Lee," Capt. John W. Cannon commanding. The two would race up to Natchez and beyond to St. Louis.

Along the river tens of thousands planned to watch; newspapers printed elaborate details and telegraph wires carried information to the world. Men bet unprecedented sums; reputations and fortunes were in the balance. The result was a raging contest and also a bitter controversy. Cannon stripped down his "Lee," rejecting freight, ripping out rigging, upper works, even doors and shutters to cut wind resistance, carrying jute knots and fat side meat to feed the fires. Leathers, more confident for his "Natchez," quietly took on some small freight, otherwise everything would be as usual, he said.

The race began at New Orleans at 5 P.M. A short way upriver at Baton Rouge, La., Cannon made a surprise maneuver; he had arranged to have a fast boat loaded with additional fuel. The "Lee" did not stop to load as expected, but slowed up while the other vessel lay alongside under full steam, and the transfer was thus made. The "Natchez" had to use the usual method. Yet thousands were certain that the latter boat would make up the gap. At Memphis, Vicksburg, Miss., Cairo, Ill., and other points the interest boiled high, but the "Lee" won, reaching St. Louis in 3 days, 18 hours and 14 minutes.

Slowly the old-time steamboats retired from the river. Today

towboats and barges move in a heavy stream along the Mississippi and its tributaries; inland waterways development has brought a new prosperity, but of a different sort. The days of glamorous passenger service, of arrogant "palaces," colourful crews and roustabouts live on only in story and song.

BIBLIOGRAPHY.—E. W. Gould, *Fifty Years on the Mississippi* (1889); Samuel Clemens (Mark Twain), *Life on the Mississippi* (1883); Harnett T. Kane, *Natchez on the Mississippi* (1947). (H. T. K.)

**MISSOULA,** a city of western Montana, U.S., on the Clark fork of the Columbia river, at the mouth of the Bitterroot; the seat of Missoula county and the seat of the state university, opened in 1895. The city lies at the foot of the mountains in a broad valley which is the bed of a glacial lake, at an elevation of 3,223 ft. Missoula valley is the hub of five great western valleys —lower Flathead, Bitterroot, Hellgate, Blackfoot and St. Regis. The city is a regional headquarters for the U.S. forest service and is the training centre for the famous smoke-jumping crews of forest fire fighters. Ft. Missoula, a pioneer fort now inactive, is located near the city. The Flathead Indian reservation is about 30 mi. N.W. The federal laboratory for the study and control of Rocky mountain spotted fever and similar diseases is at Hamilton, 35 mi. S.

The lumber industry is represented by a large mill at Bonner, 10 mi. E., and a paper pulp mill west of the city. A large beet sugar refinery is located in the city. Dairy products are also important.

The first settlement in the region was made in 1841, when Father Pierre Jean de Smet founded St. Mary's mission at the present Stevensville, 30 mi. S. of Missoula. The area now included by Missoula county was successively a part of Oregon, Washington and Idaho territories before Montana territory was formed in 1864. The city was founded in 1865 and incorporated in 1885; the name is from an Indian word of uncertain meaning. Missoula adopted a commission-manager form of government in 1954, but returned to the mayor-council form in 1958. For comparative population figures *see* table in MONTANA: *Population.*

(M. G. Bu.)

**MISSOURI,** popularly known as the "Show Me" state, one of the west north-central states of the United States. Its area is 69,686 sq.mi., including 548 sq.mi. of inland water, making it 19th in size among the states. Its greatest width is 282 mi., length 304 mi. On the east the Mississippi river separates it from Illinois, Kentucky and Tennessee; on the north is Iowa and a short stretch of the Des Moines river; on the south is Arkansas; and on the west are Oklahoma, Kansas and Nebraska, with the Missouri river bend on the northwest. The state takes its name from the Missouri river, called by explorers after a neighbouring Indian tribe; the meaning of the word is not known. Missouri was admitted to the union in 1821 as the 24th state; its capital is at Jefferson City. The state flower is the downy hawthorn (*Crataegus mollis*), the tree the dogwood and the bird the bluebird. The state motto is a quotation from Cicero, *Salus populi suprema lex esto* ("Let the Welfare of the People Be the Supreme Law"); "Missouri Waltz" is the official state song. The state flag, adopted in 1913, has three horizontal bars of red, white and blue, on which is a circular device enclosing the state coat of arms surrounded by 24 stars.

## PHYSICAL GEOGRAPHY

**Physical Features.**—The area that is now Missouri (between 36° and 40° 35' N. lat. and 89° 5' and 95° 45' W. long.) was alternately sea bottom and dry land at many times during its geologic history. Only large bodies of water could have deposited such huge and uniform areas of rock. Ripple marks are common in the sandstone of the Ozarks, and fossils in the rock show remains of coral and other sea organisms. Marine sediments probably covered even the ancient granite and porphyry hills, though later erosion has removed some overlying rock, exposing the igneous strata. At one time molten rocks formed the entire surface of the state; as these cooled, stream erosion created a vast plain interrupted by occasional knobs, mountains and valleys. Into the primeval sea rivers emptied mud and clay which became shale; sand turned into sandstone; gravel became conglomerate; and the remains of sea organisms helped form limestone (calcium carbonate) and dolomite (calcium magnesium carbonate). Factors in the formation of the state's four geologic regions were glaciation, uneven arching of bedrock, and erosion and weathering of various types of rocks.

*Glaciated Plains.*—Two major glaciers covered most of north Missouri; a third glacier entered from Illinois, affecting St. Louis and St. Charles counties. To the west of Jefferson City glaciation crossed the Missouri river to the northern edge of Pettis county; to the east it stopped a few miles short of the present river bed. Glaciers forced streams out of their valleys in the bedrock with deposits of clay, sand, gravel and boulders.

*Ozarks.*—Great springs, caves and sinkholes are common in the Ozarks and bordering areas where ground water has dissolved soluble dolomites or limestone. Springs also flow from beds of permeable material, such as sandstone. The Missouri Geological survey defines this region of hills, plateaus and deep valleys as extending to the north bluffs of the Missouri river valley as far west as Glasgow. The eastern margin spills over into Illinois from St. Charles county, returning to Missouri at Cape Girardeau and running southwest through Poplar Bluff and into Arkansas. The western edge stops short of Sedalia, Osceola and Springfield, which are in the western plains region, thence extends southwest to the tip of Oklahoma. Some streams follow courses cut thousands of years ago through sediments, occasionally encountering hard knobs of granite or porphyry, with a consequent narrowing of the valley to form what are called locally shut-ins. In the course of time the Ozarks were worn down to a plain, on which sluggish streams meandered in crooked channels similar to those of the present Mississippi. When the Ozarks were again uplifted, the streams stayed in their old channels, cutting deep valleys, some as much as 400 ft. below the adjacent uplands. The state's highest point is Taum Sauk mountain in Iron county, 1,772 ft. While large areas of the Ozarks reach 1,400 ft. in altitude, parts are less than 1,000 ft. above sea level; elsewhere in the state elevations above 1,200 ft. are not unusual. (*See* also OZARKS.)

*Western Plains.*—The bedrock of the plains adjacent to the Ozarks is cherty or flinty limestone with lower layers of shale. Large limestone quarries are common around Springfield, Osceola and Sedalia; pure, brittle limestone that takes a marblelike finish is found in the vicinity of Carthage and Joplin. The bedrock is younger west of a line through Jasper, Cedar, St. Clair, Benton, Pettis and Saline counties; in these sediments are deposits of coal, oil and gas.

*Southeastern Lowlands.*—Long after the seas had permanently withdrawn from the rest of Missouri, an arm of the last sea to reach the state extended from the present Gulf of Mexico, covering the lowlands that were in the process of sinking. This sea deposited a thick accumulation of sand, clay and shale, later easily eroded by the Mississippi river. This area includes Stoddard, Dunklin, New Madrid, Mississippi, Pemiscot and parts of Butler, Bollinger, Scott and Cape Girardeau counties; altitude 230 ft.

**Climate.**—The weather in general is changeable, but there are many periods when it is settled and moderate; winters are fairly brisk, with occasional short periods of extreme cold; excessively warm summers are the exception. Average number of days with temperatures below 32° F. ranges from about 105 in the north to about 65 in the extreme southeast. Average annual precipitation ranges from about 50 in. in the southeastern lowlands to 32 in. in the extreme northwest, about 42% falling in the crop-growing months, May through August. Occasionally, summer thundershowers are accompanied by hail and high winds. Tornadoes, usually with narrow paths, dip down once or twice a year, often disintegrating after a few miles. Extremes of heat, cold, drought and moisture occur. Winters in the Ozarks are milder than in the upland plain and prairie section, largely due to differences in latitude, but summers average cooler because of the higher altitude.

**Soil.**—A blanket of wind-blown dust or loess spread over much of the state during the glacial period. This thick yellow silt caps the bluffs on the Missouri and the Mississippi upstream from the central part of the state, in the northwest, to depths of 50 to 75 ft. Bands of alluvium in the bottom lands of the larger streams form

another area of productive soils. Glacial till, clay with a small mixture of sand and gravel, found in the north, varies in fertility, depending on plant organic material. In the Ozarks bedrock is mainly cherty limestone and dolomite, which tends to gravelly or stony soils low in fertility. Shales are the most important soil-forming materials in the prairie region of the southwest. Most upland areas have a heavy or claylike subsoil, favourable to retention of water in ponds but reducing absorption and increasing runoff and erosion. Depth of surface or topsoil ranges from one to three feet for most alluvial or bottom-land soils to four inches or less on severely eroded hillsides. Loess soils in the northwest are 18 in. or more deep. Approximately ten inches is normal throughout the northeastern, central and southwestern sections, and six to eight inches in most of the Ozarks. Deepest soils are in the drainage area of the southeast lowlands and in the Missouri and Mississippi bottoms.

**Vegetation.**—Forests (mostly oak-hickory type) once covered more than two-thirds of Missouri, although the prairie lands of the north and west had trees only in the valleys. Most of this was cut over during the period of ruinous lumbering in the 19th and early 20th centuries (see *Lumbering*, below), and the lush grass of the original prairies has disappeared. Even today, however, black willow, sycamore, red cedar, American elm, oak, hickory, ash, walnut, hazelnut, linden and maple trees may be found throughout the state, as well as honey locust, dogwood, redbud, sumac, hackberry, persimmon, papaw, wild plum, cherry and crab apple. Many kinds of berries grow wild, as do wild flowers; from spring to late autumn, forests and pastures are bright with goldenrod, milkweed, spiderwort, sweet William, roses, bloodroot, columbine, verbena, shooting star, jack-in-the pulpit, trumpet vine, bittersweet, asters and many others. The swamp regions that remain have characteristic vegetation, including bald cypress, corkwood, water locust, swamp cottonwood, etc.

**Animal Life.**—The large game animals—buffalo (bison), elk, black bear, panther, antelope, badger—that once were numerous in Missouri have all disappeared past recall. Others, such as snakebird, deer and beaver, whose numbers were reduced by hunting, lumbering and land cultivation, are being brought back by conservation efforts. A nonpartisan conservation commission, first provided for in 1936 and financed largely from sale of hunting and fishing permits, has co-operated in habitat development, restoring food, cover and water for animal life. Encouragement of farm pond construction, erosion control plantings of shrubs and a program of education have increased the numbers of principal small species—quail, rabbit, squirrel and doves. Live trapping and redistribution multiplied beaver from a few colonies to populations permitting an annual open season on all major streams. Deer were similarly increased to an estimated 250,000 animals, distributed state-wide, with a legal harvest of about 14,000 annually. The commission developed over 30 areas for waterfowl shooting, warm-water fishing, trout fishing, general hunting and natural production of wildlife for trapping and redistribution. Lying in the heart of the great Mississippi flyway, Missouri is visited by more than 400 kinds of birds, and waterfowl-hunting opportunities have been increased by public shooting areas.

**Parks.**—The state park board of the department of conservation maintains cabins, camping grounds and dining lodges in many of the 30 state parks, approximating 70,000 ac. The most popular of these are around the large springs in the Ozarks. Alley Spring State park, in Shannon county, has an old mill and a pool fed by an average flow of 80,800,000 gal. of water a day. Bennett spring, near Lebanon, is larger, and Big spring, the largest single spring in the U.S., near Van Buren, pours 252,000,000 gal. daily into Current river. Similarly picturesque parks are Montauk, in Dent county; Roaring River, in Barry county, and Round Spring, in Shannon county.

Lake of the Ozarks State park, near Osage beach, the largest of the parks, has 89 mi. of shore line and about 4,000 ac. of water. The lake itself, formed by a hydroelectric power dam on the Osage river, is the largest lake in Missouri, with a shore line totaling 1,372 mi. Several streams flowing in deep valleys have been dammed, providing extensive multiple-purpose reservoirs combining facilities for water recreation with flood control, municipal water supply and electric power production: Taneycomo and Bull Shoals lakes (White river); Clearwater reservoir (Black river); Wappapello reservoir (St. Francis river). Preservation of the swift-flowing Current, Jack's Fork and Eleven Point rivers in their natural state has been the objective of conservationists and the national park service.

Tourism is an important business in Missouri. The $500,000,000 spent annually by tourists places it 11th among the states in this regard. Points of interest are the Truman library, at Independence; the Harry S. Truman Birthplace Memorial shrine, at Lamar; the George Washington Carver National memorial, near Diamond; and the boyhood home of Gen. John J. Pershing at Laclede.

## HISTORY

Numerous Indian mounds scattered about the state and discoveries of almost every type of arrowhead and spear point indicate an early and varied prehistoric population. Perhaps the largest mound is one found in Pemiscot county that is 400 ft. long, 250 ft. wide and 35 ft. high, surfaced with a sort of soft brick.

Early French explorers, Louis Jolliet and Jacques Marquette, opened communication from Canada by way of the Great Lakes and the Mississippi river in 1673. Although the Spanish Hernando De Soto discovered the Mississippi in 1541, René Robert Cavelier, Sieur de La Salle, who reached the Gulf of Mexico from upstream in 1682, claimed formal possession of the entire valley for France. Though some early historians credited both De Soto and Francisco Vásquez de Coronado with reaching the Missouri country, it is now considered that both stopped short of this.

In a two-day period, March 9–10, 1804, upper Louisiana, which in 1812 became the territory of Missouri, was successively under three flags, Spanish, French and American. The Louisiana Purchase of 1803 did not end the power struggle over the mid-continent. Spanish policy thereafter was directed toward dismemberment of the United States or at least prevention of southwestward expansion toward Mexico, or New Spain. Large Spanish land grants west of the Mississippi had been given to American settlers in a mistaken effort to encourage disaffection, and some Americans in high places were on the pension list of the Spanish king. During the earlier period of French control fabulous reports of silver deposits near the Meramec river resulted by 1720 in mining operations by the Company of the Indies, a part of John Law's Mississippi bubble (*see* LAW, JOHN), in what became the world's greatest lead field.

Under the same speculative auspices Ft. Orleans was built on the Missouri river in what now is Carroll county. This trading post was designed to cultivate Indian relations as a countermove to a Spanish advance that had met disaster in what now is Nebraska. This farthest west outpost was abandoned by 1728 or 1729. Missouri's first permanent settlement, Ste. Geneviève, dates from about 1735, when French-Canadian habitants of Kaskaskia crossed the Mississippi from the Illinois country to work the lead mines.

Founding of St. Louis (*q.v.*) as a fur-trading post by Pierre Laclède Liguest came in 1764. Nearby, at the mouth of Des Pères river, as early as 1700, French Roman Catholic missionaries had set up a short-lived station with a large Indian population. A trading post that became St. Charles was established 21 mi. N.W. of St. Louis in 1780; this was the first state capital, 1821–26.

**American Migration.**—Encouraged by the Spanish ambassador to the United States, Col. George Morgan of New Jersey in 1789 gathered a party of 70 Americans to found a model city, New Madrid, across from the mouth of the Ohio, where two French-Canadians had a trading post. Failing to receive concessions, including self-government, from the governor general at New Orleans, Morgan returned east, though many of his associates remained. Development of this southeastern area was impeded for years by the severe earthquake of 1811–12, which turned much land into swamp. Upriver, on higher ground, Louis Lorimier prior to 1793 received a grant to what became Cape Girardeau, where a small post had been established several years before.

Most of the newcomers were Americans.

A landmark near Defiance, in St. Charles county, is the house built by Nathan Boone, in which his father, the frontiersman Daniel Boone, died in 1820. The elder Boone having lost his Kentucky land claims welcomed the offer (1795) of Spanish Lieut. Gov. Zenon Trudeau to provide 845 ac. in Femme Osage district, where Daniel Morgan Boone, his eldest son, previously had settled. A party of settlers, including his youngest son, Nathan Boone, came with the famous pioneer, who was given a magistrate's office. That central Missouri district popularly called the Boonslick country was connected with St. Charles by Boonslick road, a main trail for settlers by 1822. At the terminus of Boonslick road was the town of Franklin, long since washed into the Missouri river, an early outfitting point for the Santa Fe trail and boyhood home of the scout Kit Carson. There a government land office had first year sales (1815–19) exceeding 662,000 ac., valued at $1,894,000, less than $3 an acre. By 1830 the Boonslick country had a population of 43,394 out of the state total of 140,455.

Moses Austin in 1797, with a background in lead mining in Connecticut and Virginia, obtained a Spanish grant to Mine à Breton (or Burton), where the town of Potosi developed, in Washington county. Improving on older methods, Austin sank the first mine shaft, built furnaces, a shot tower and sheet lead plant in the woods, as well as a sawmill, flour mill, roads and bridges. Involvement in failure of the Bank of St. Louis in the panic of 1819 led him to attempt to recoup his fortunes in Texas, then a part of New Spain, where he was to settle 300 families. His death in 1821 left his son, Stephen F. Austin, to carry on as the "Father of Texas," one of the long line of Missourians whose further migrations gave the state the name "Mother of the West."

**Indian Relations.**—When the white man came, the Osage and the Missouri were the main Indian tribes, apparently numbering about 15,000. Sauk and Fox war parties had almost destroyed the Missouri by 1789. Early exploration of the upper reaches of the Missouri by Meriwether Lewis and William Clark (1804–06) and two expeditions by Zebulon M. Pike, sent by Gov. James Wilkinson to the north and the southwest, encouraged trade relations, as well as added to geographic knowledge. During the War of 1812 Indian unrest stirred by the British and the Tories who had fled to Canada menaced outlying settlements. The governorship of Clark (1813–20) and his later administration of Indian affairs developed confidence among the chiefs, who often visited him in St. Louis, the administrative centre. Friction with remaining tribes was lessened by giving them lands farther to the west before settlers swarmed in.

In a final treaty with the Big and Little Osage nations in 1825, Clark awarded them a 50-mi. square tract in Kansas; a $7,000 annuity for 20 years, in money, merchandise, provisions or domestic animals, as desired; 600 head of cattle, 600 hogs, 1,000 domestic fowls, 10 yoke of oxen and 6 carts, farming implements and a blacksmith paid by the government to keep the tools fit; and comfortable and commodious houses for the principal chiefs. The proceeds of 54 sections of land were to support an Osage school, and reservations were to be established for mixed Indians-whites.

**Building a State.**—Desire for self-government was realized on Aug. 10, 1821, when Missouri was admitted to the union as the 24th state. (The struggle that took place in congress before the state's admission is described in the article MISSOURI COMPROMISE.) The population was 70,000. Southerners, comprising the first wave of settlers after statehood, took over fertile bottom lands as farmers, unlike their French predecessors, who had gathered in communities and tilled only small common fields, living mainly on the fur trade. No taxes had been collected by France or Spain; by 1805 U.S. authorities announced that taxes could be paid in shaven deerskins at the rate of three pounds to the dollar before a certain date. A shortage of currency made lead, as well as pelts, a medium of exchange.

Opening of steamboat transportation on the Mississippi in 1817 (two years later on the Missouri) quickened and expanded the fur trade. Trappers worked more than 1,000 mi. up the Missouri, also reaching the Green river, and perhaps Great Salt lake, and opening South pass to California and Oregon. It was estimated that 250,000 buffalo were killed in 1848, and 25,000 buffalo tongues were shipped to St. Louis. The western branch of John Jacob Astor's American Fur company brought back 67,000 buffalo robes in 1840. Cargoes of tallow from bear and buffalo, a substitute for lard, sometimes were poured into hollowed-out boats and towed to market. Finally the development of the silk hat and an accompanying fashion for other furs diminished the market, much of which had been for manufacture of felt or beaver hats.

In much the same way the day of the steamboat passed. The first steamboat reached St. Louis in 1817, and the traffic expanded rapidly. In 1860 more than 5,000 vessels arrived at St. Louis. But the American Civil War played havoc with river traffic, and after the war the frantic interest in railroading also led to the decline of the steamboat. (*See* also MISSISSIPPI RIVER STEAMBOAT.)

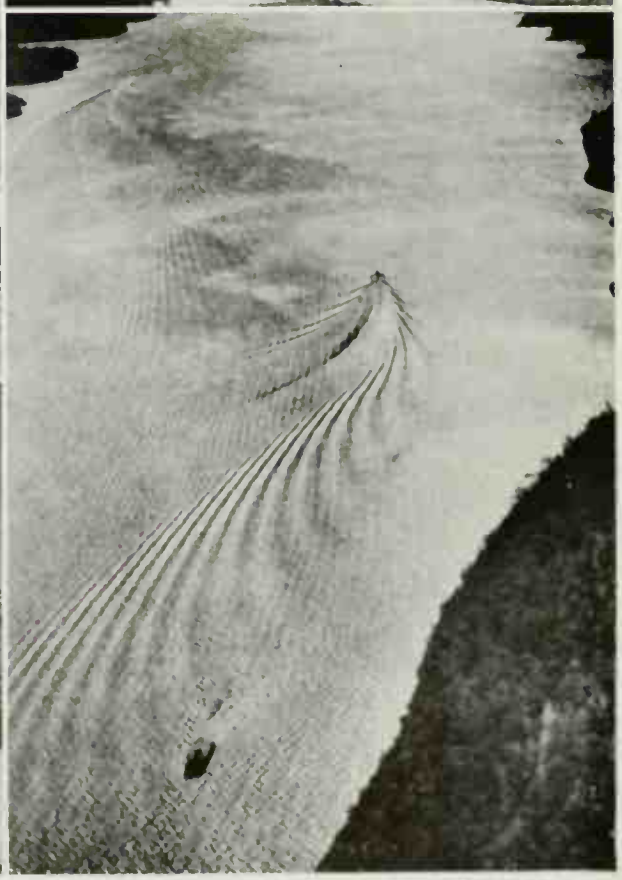
Bonds issued to promote rail lines during the period of intensive speculation cost the state treasury $25,000,000; many towns and counties bonded themselves for lines never built. The first railroad across the state, the Hannibal & St. Joseph (1859), short-cut Missouri river traffic and was connected with St. Louis by the North Missouri line at Macon. Four years earlier the Pacific railroad had been extended from St. Louis to the capital, Jefferson City; by 1865 this reached Kansas City on the western border. By 1858 the St. Louis & Iron Mountain railroad had an 86-mi. line to the Pilot Knob mining district; another line had reached Rolla by 1861. The great Eads bridge across the Mississippi at St. Louis was completed in 1874, a lower deck for rail traffic competing with the ferries; since 1857 a railroad from Cincinnati had disembarked passengers on the east bank of the river.

In the meantime overland trade with Santa Fe, N.M., had boomed from its opening in 1821, when Mexico had freed itself from Spain. The first expedition, by William Becknell and 21 men, started from Franklin. By 1827 the take-off had shifted west to Independence, and in the '40s to Westport, later a part of Kansas City. Traffic in cotton goods, cutlery and easily freighted products reached a value of $250,000 by 1831. A good part of this was in Mexican silver dollars, which were cut into halves, quarters and half-quarters, or bits, as preferable to wildcat paper. The exchange also laid the foundation of Missouri's extensive mule trade; in 1832 the caravans brought back 1,300 mules, jacks and jennets, or female burros. (*See* also SANTA FE TRAIL.)

**Slavery and Politics.**—Well-to-do southerners moving west for cheap land chose Missouri in preference to the Northwest territory, where slavery was forbidden. Slave labour also had been used extensively in French lead mining. At the outbreak of the American Civil War there were 144,000 slaves and 29,000 masters in a total Missouri population of 1,182,000; these Negroes were taxed as property, assessed at $44,000,000 in 1860. The traditional southern institution came under question by later arrivals from the north and by the German immigrants who began to arrive in the 1830s. To a certain extent free labour was discouraged by slave competition, but the growing abolition movement was based on moral rather than economic grounds, while defense of slavery was involved in the emotional issue of states' rights.

The controversy mounted after statehood was granted under the Missouri Compromise (*q.v.*). Sen. Thomas Hart Benton as early as 1828 sought backing for gradual emancipation allied with an educational program. Elijah P. Lovejoy in 1837 was forced to leave St. Louis by a mob that pillaged the print shop from which his abolitionist *The Observer* was issued; five weeks later he was killed across the river, in Alton, Ill. The difficulties experienced by the Mormons in Independence and later in Daviess and Caldwell counties (1831–39) were based partly on the fact that the Mormons, mostly northerners and easterners, were abolitionists while their neighbours, many from southern states, were not. (*See* also LATTER-DAY SAINTS, CHURCH OF JESUS CHRIST OF.) The legislature in 1847 established penalties for teaching any Negro to read or write and forbade any free Negro to enter the state. Benton's refusal to push the slavery cause ended his 30 years in the senate in 1851.

The Dred Scott case, originating in St. Louis in 1846 and calling into question the constitutionality of the Missouri Compromise limitation on slavery, sharpened the issues. Annexation of Texas,



BY COURTESY OF (TOP LEFT, TOP RIGHT, CENTRE LEFT, BOTTOM RIGHT) MISSOURI RESOURCES DIVISION; (CENTRE RIGHT) MISSOURI PACIFIC LINES; (BOTTOM LEFT) DAVID P. JOHNSON FROM A. DEVANEY

## VIEWS OF MISSOURI

*Top left*: "The Scout," a bronze statue of a Sioux Indian by C. E. Dallin (1917) in Penn Valley park overlooking Kansas City.

*Top right*: Lafayette county courthouse, Lexington. A cannon ball fired during the Civil War in the battle of Lexington (1861) is lodged in the pillar in the foreground.

*Centre left*: Tobacco storage barn near the village of Weston, an important Missouri tobacco market.

*Bottom left*: Mark Twain's (Samuel Clemens) house and museum, Hannibal. At the right is the fence of the whitewashing episode in "The Adventures of Tom Sawyer."

*Bottom right*: Boats on the Lake of the Ozarks, one of the largest artificial lakes in the U.S., formed by damming the Osage river.

# MISSOURI

## SCENES IN MISSOURI

*Top left:* Bronze equestrian statue of St. Louis the Crusader, in front of the City Art Museum, Forest park, St. Louis.

*Top right:* The state capital, Jefferson City. In the right foreground is the governor's mansion.

*Centre left:* Blockhouse of Fort Osage, Sibley, established in 1808 as a military and trading post by William Clark of the Lewis and Clark expedition.

*Bottom left:* Picking cotton near Kennett, business centre of Dunklin county. Cotton is a major agricultural product of the state.

*Bottom right:* Marble quarry, Carthage, an area rich in marble, zinc and lead.

war with Mexico and the Kansas-Nebraska act of 1854 found Missouri officially on the slavery side. The Kansas-Nebraska act, leaving the question of free soil or slavery to residents of the territories, led to persistent border troubles between Missouri and Kansas (*q.v.*), in which peaceful citizens suffered. Emancipation was advocated by the Free-Soil movement in 1856, led by Francis P. Blair, Jr., and B. Gratz Brown. In the first summer of the war Gen. John C. Frémont from headquarters in St. Louis proclaimed the freedom of all slaves owned by active secessionists in the state. This was reversed by President Lincoln's policy, which sought to compensate border-state slaveowners in advance of unpaid emancipation in the Confederate states. Nothing coming of this, the state legislature in 1863 voted for gradual emancipation and abolition by 1870. The new state constitution, proclaimed by Gov. Thomas C. Fletcher, a radical Republican, on Jan. 11, 1865, abolished slavery.

**Civil War and Reconstruction.**—Of all Missourians of military age 60% served in the war, 109,000 in the Union army and 30,000 in the Confederate. Federal casualties reached 14,600 dead. While many engagements were fought in the state, that of greatest magnitude was the battle of Wilson's Creek, Aug. 10, 1861, in which Gen. Nathaniel Lyon was killed and his outnumbered Federal troops forced back toward Springfield. Governor Jackson, who advocated secession, had fled from Jefferson City before Lyon's advance, and a provisional government, headed by Judge Hamilton R. Gamble as governor, was established through action by a delegate convention that had voted against secession. Efforts to take St. Louis, stronghold of Union strategy, were defeated by Gen. U. S. Grant at Belmont, Mississippi county, and by Gen. Thomas Ewing at the battle of Pilot Knob in Sept. 1864. In the latter attack Gen. Sterling Price lost 1,000 men out of the Confederate force of 12,000; Union losses were 200. Ruins of the earthworks of Ft. Davidson, the Federal stand, are visible along the Iron county highway. Swerving back across the state, Price finally was defeated in the battle of Westport, three days' losses amounting to 1,000 on each side, putting an end to Confederate hopes in Missouri.

Guerrilla warfare ravaged Missouri throughout the war, particularly along the Kansas border. Gen. Thomas Ewing, of the 11th Kansas volunteers, by his drastic order no. 11 in 1863 compelled all residents of several Missouri border counties except those within a mile of principal towns to leave their homes within 15 days. Those proving loyalty could stay at any military station or move to the interior of Kansas. All grain and hay not delivered to the nearest post was destroyed. A famous painting by the Missouri artist George Caleb Bingham depicts a family leaving their looted and burning home, a picture indicating the reaction to the deportations even by Union sympathizers.

Similar revulsion arose at the end of the war to a new state constitution listing 86 acts that a citizen must deny under oath in order to vote. No person who had aided or sympathized with the Confederacy could function as a lawyer, teacher or minister. The constitutional convention also ordered all court officers removed in order to forestall legal obstruction. The radical Republicans could not realize that the war was over, and it was 1870 before Sen. Carl Schurz, supported by conservative Republicans among his fellow Germans and with the aid of the reorganized Democratic party, elected B. Gratz Brown governor and obtained repeal of the loyalty test (its clause disqualifying professional men from practice had previously, in 1867, been declared unconstitutional by the U.S. supreme court). In 1872 Democrats assumed control of the state and in the ensuing 88 years were interrupted by only five Republican governors. The period closed with a new constitution drawn up in 1875, putting a limit on taxes, requiring a two-thirds majority in bond elections and limiting state debt to $250,000 in any one year, a reference to heavy losses in railroad financing.

Major historical developments in the 20th century have included the framing and adoption in 1945 of a new state constitution, including the nonpartisan plan for electing judges that came to be known as the "Missouri plan" and was followed by several other states; the general trend toward increasing urban population and declining rural population; the successful integration of public and parochial schools; the development of public health and welfare programs; and economic developments marked by increasing farm mechanization and expanding industrial and mineral production, all discussed in more detail below.

Mid-20th-century sessions of the general assembly authorized watershed conservation districts; tightened regulation of nursing homes for the aged (after loss of 72 lives in a fire); and widened the powers of the Bi-State Development agency to own and operate facilities, from bridges to airports and transportation, in the metropolitan area adjacent to St. Louis in Missouri and Illinois.

## GOVERNMENT

Under the constitution adopted in 1945 six executive officers are elected for four-year terms: governor, lieutenant governor, secretary of state, state auditor, state treasurer and attorney general. Election of the auditor is held independently, at mid-term. All other heads of departments are appointed by the governor. There are 114 counties, plus the city of St. Louis, which ranks as a county in itself. Each county is entitled to at least one member in the house of representatives, the more populous counties having more, all elected for two-year terms. There are 34 senatorial districts, each elects one senator for four years, half of the body coming up for election every two years. The general assembly meets in the capital, Jefferson City, in odd-numbered years.

Under a nonpartisan court plan the governor appoints one of three persons named by a special commission to fill vacancies in the supreme court and courts of appeals. The chairman of this nonpartisan commission is the chief justice of the state supreme court; members of the bar in each appeals district elect one member, and the governor selects one citizen, not a member of the bar, from each of the three appeals districts. At the next general election after the appointee has been on the bench for at least one year the people vote on a special ballot as to whether he shall be retained in office. Vacancies in circuit courts of the city of St. Louis and in Jackson county (Kansas City) are filled similarly. Upon expiration of a judicial term an incumbent wishing to succeed himself is listed on a ballot without party designation, and voters vote yes or no on the question as to whether he shall be retained in office.

Sales tax receipts provide about 61% of the state's general revenue, income tax 23%, liquor taxes 4.44% and general property tax 1.25%. A gasoline tax is earmarked for highway use.

## POPULATION

The 1960 census recorded a population of 4,319,813, an increase of 9.2% over the 1950 population of 3,954,653. Population in 1810 was 19,783; in 1860, 1,182,012; and in 1900, 3,106,665. Allowing for area adjustments in 1963, the state's four standard metropolitan statistical areas—Kansas City (shared with Kansas), St. Joseph, St. Louis (shared with Illinois) and Springfield—had a 1960 total population of 3,414,071 (including 457,198 in Illinois and 329,287 in Kansas). Only 33.4% of those enumerated constituted the rural population.

In 1960 nonwhites in the state were 9.2%, almost all Negro. Foreign-born white were 1.8%, mainly from Germany. Italy and the United Kingdom ranked next, and there were considerable numbers of Irish, Austrians and Poles.

The population per square mile in 1960 was 67.0, as compared with 57.1 in 1950 and with 49.6 for the U.S. in 1960. The number of occupied dwelling units (or households) in 1960 was approximately 1,360,000, as compared with 1,190,000 in 1950. The average household size had declined from 3.3 in 1950 to 3.2 in 1960.

There were 97.2 males per 100 females in the 1960 population, as compared with 96.4 in 1950. Of the population 14 years old and over, 53.7% was in the labour force. 13.0% of employed males were engaged in agriculture, 7.8% in construction, 26.4% in manufacturing, 5.8% in transportation, 17.6% in wholesale and retail trade and 11.2% in service activities of all kinds.

The most conspicuous population trend is that toward increase in urban and comparative decline in rural population, but the latter is real as well as comparative. In 1960, with 786 places of less

*Missouri: Places of 5,000 or More Population (1960 Census)**

| Place | Population | | | | |
|---|---|---|---|---|---|
| | 1960 | 1950 | 1940 | 1920 | 1900 |
| Total state | 4,319,813 | 3,954,653 | 3,784,664 | 3,404,055 | 3,106,665 |
| Ballwin | 5,736 | — | — | — | — |
| Bellefontaine Neighbors | 13,451 | — | — | — | — |
| Berkeley | 18,670 | 5,268 | 2,557 | — | — |
| Bonne Terre | 7,000 | 6,686 | 6,089 | 4,665 | 4,377 |
| Breckenridge Hills | 6,299 | 4,063 | — | — | — |
| Brentwood | 12,230 | 7,504 | 4,383 | — | — |
| Bridgeton | 7,820 | 202 | 169 | 121 | 178 |
| Brookfield | 5,694 | 5,515 | 6,174 | 6,304 | 5,484 |
| Cape Girardeau | 24,947 | 21,578 | 19,426 | 10,252 | 4,815 |
| Carthage | 11,264 | 11,188 | 10,585 | 10,068 | 9,416 |
| Carutherville | 8,613 | 8,614 | 6,612 | 4,750 | 2,315 |
| Charleston | 5,911 | 5,501 | 5,182 | 3,410 | 1,893 |
| Chillicothe | 9,236 | 8,694 | 8,812 | 6,772 | 6,905 |
| Clayton | 15,245 | 16,015 | 13,069 | 3,028 | 76 |
| Clinton | 6,925 | 6,675 | 6,041 | 5,098 | 5,061 |
| Columbia | 36,650 | 31,974 | 18,399 | 10,392 | 5,651 |
| Crestwood | 11,100 | 1,645 | — | — | — |
| Creve Coeur | 5,122 | 2,040 | — | — | — |
| De Soto | 5,804 | 5,357 | 5,121 | 5,003 | 5,611 |
| Dexter | 5,519 | 4,624 | 3,108 | 2,635 | 1,862 |
| Excelsior Springs | 6,474 | 5,888 | 4,864 | 4,165 | 1,881 |
| Farmington | 5,618 | 4,490 | 3,758 | 2,685 | 1,778 |
| Ferguson | 22,149 | 11,573 | 5,724 | 1,874 | 1,015 |
| Festus | 7,021 | 5,199 | 4,620 | 3,348 | 1,256 |
| Florissant† | 38,166 | 3,747 | 1,369 | 682 | 732 |
| Fulton | 11,131 | 10,052 | 8,297 | 5,595 | 4,883 |
| Gladstone | 14,508 | — | — | — | — |
| Glendale | 7,018 | 4,930 | 2,526 | 749 | — |
| Grandview | 6,027 | 1,556 | 596 | 410 | — |
| Hannibal | 20,028 | 20,444 | 20,865 | 19,306 | 12,780 |
| Hazelwood | 6,045 | 336 | — | — | — |
| Independence | 62,348 | 36,963 | 16,066 | 11,686 | 6,974 |
| Jefferson City | 28,228 | 25,099 | 24,268 | 14,490 | 9,664 |
| Jennings | 19,965 | 15,282 | — | — | — |
| Joplin | 38,958 | 38,711 | 37,144 | 29,902 | 26,023 |
| Kansas City | 475,539 | 456,622 | 399,178 | 324,410 | 163,752 |
| Kennett | 9,098 | 8,685 | 6,335 | 3,622 | 1,509 |
| Kinloch | 6,501 | 5,957 | — | — | — |
| Kirksville | 13,124 | 11,110 | 10,680 | 7,213 | 5,966 |
| Kirkwood | 29,421 | 18,640 | 12,132 | 4,422 | 2,825 |
| Ladue | 9,166 | 5,386 | 3,981 | — | — |
| Lebanon | 8,220 | 6,608 | 5,025 | 2,848 | 2,125 |
| Lees Summit | 8,267 | 2,554 | 2,263 | 1,467 | 1,453 |
| Liberty | 8,909 | 4,709 | 3,598 | 3,097 | 2,307 |
| Malden | 5,607 | 3,396 | 2,673 | 2,098 | 1,362 |
| Maplewood | 12,552 | 13,416 | 12,875 | 7,431 | — |
| Marshall | 9,572 | 8,850 | 8,533 | 5,200 | 5,086 |
| Maryville | 7,807 | 6,834 | 5,700 | 4,711 | 4,577 |
| Mexico | 12,889 | 11,623 | 9,053 | 6,013 | 5,099 |
| Moberly | 13,170 | 13,115 | 12,920 | 12,808 | 8,012 |
| Monett | 5,359 | 4,271 | 4,395 | 4,206 | 3,115 |
| Neosho | 7,452 | 5,290 | 5,318 | 3,968 | 2,725 |
| Nevada | 8,116 | 8,009 | 8,181 | 7,139 | 7,461 |
| North Kansas City | 5,657 | 3,886 | 2,688 | — | — |
| Olivette | 8,257 | 1,761 | 987 | — | — |
| Overland | 22,764 | 11,566 | 2,934 | — | — |
| Papendale | 5,106 | 3,866 | — | — | — |
| Perryville | 5,117 | 4,591 | 3,907 | 1,763 | 1,275 |
| Pine Lawn | 5,943 | 6,425 | — | — | — |
| Poplar Bluff | 15,926 | 15,064 | 11,163 | 8,042 | 4,321 |
| Raytown | 17,083 | — | — | — | — |
| Richmond Heights | 15,622 | 15,045 | 12,802 | 2,136 | — |
| Rock Hill | 6,524 | 3,847 | 1,821 | — | — |
| Rolla | 11,132 | 9,354 | 5,141 | 2,077 | 1,600 |
| St. Ann | 12,155 | 4,557 | — | — | — |
| St. Charles | 21,189 | 14,314 | 10,803 | 8,503 | 7,982 |
| St. John | 7,342 | 2,499 | — | — | — |
| St. Joseph | 79,673 | 78,588 | 75,711 | 77,939 | 102,979 |
| St. Louis | 750,026 | 856,796 | 816,048 | 772,897 | 575,238 |
| Sedalia | 20,874 | 20,354 | 20,428 | 21,144 | 15,231 |
| Sikeston | 13,765 | 11,640 | 7,944 | 3,613 | 1,077 |
| Springfield | 95,865 | 66,731 | 61,238 | 39,631 | 23,267 |
| Trenton | 6,262 | 6,157 | 7,016 | 6,951 | 5,396 |
| University City | 51,249 | 39,892 | 33,023 | 6,792 | — |
| Warrensburg | 9,689 | 6,857 | 5,868 | 4,811 | 4,724 |
| Washington | 7,961 | 6,850 | 6,756 | 3,142 | 3,015 |
| Webb City | 6,746 | 6,919 | 7,033 | 7,807 | 9,201 |
| Webster Groves | 28,990 | 23,490 | 18,394 | 9,474 | 3,895 |
| Wellston | 7,929 | 9,396 | — | — | — |
| West Plains | 5,836 | 4,918 | 4,026 | 3,178 | 2,902 |
| Woodson Terrace | 6,048 | 616 | — | — | — |

*Populations are reported as constituted at date of each census. †Returned until 1918 as Florissant, from 1920 to 1940 as St. Ferdinand and from 1940 as Florissant.
Note: Dash indicates place did not exist during reported census, or data not available.

than 2,500 population, offering little employment opportunity, a heavy migration, particularly of younger people, to industrial centres, some outside the state, was under way. Most counties have experienced a population decline, and many of them had fewer people in 1960 than they did in 1890; in the northwestern half of the state all counties without major cities had fewer people than they had in 1890. The six southeastern counties are the only rural counties to show upward trends. The percentage of persons 65 years of age and older was 2.2% higher than the national average, explainable largely by the emigration of younger persons.

## EDUCATION

Efforts to obtain a standard level of educational opportunity in both urban and rural schools led to the establishment of a foundation program of equalization in 1955. It was successful in reducing the number of school districts, which numbered 8,400 in 1947, to fewer than 3,000 by the late 1950s. In addition to consolidation, the foundation program offered incentives and means for improved teaching. The state constitution requires that at least one-fourth of general revenue be apportioned for support of public schools; to this a cigarette tax was added under the foundation program. Legal limitations prevent use of state school funds for children under 6 years of age and for persons 21 or over, and this interferes with kindergarten and adult educational activities. A state board of education composed of lay members appointed by the governor performs routine functions, with an administrator in charge.

Special schools include the State School for the Deaf, at Fulton, and the State School for the Blind, at St. Louis.

**University of Missouri.**—The University of Missouri, first state university west of the Mississippi, was established in 1839. It later became the first land-grant college in the west through its school of agriculture and mechanical arts on the main campus at Columbia and the school of mines and metallurgy at Rolla. In the early 1960s there were 14 schools and colleges on the 900-ac. main campus, with an enrollment of more than 11,000 full-time resident students, and 3,000 additional students at Rolla, a centre of scientific research and engineering. More than 10,000 correspondence students were enrolled annually, and 1,160 were in extension courses for college credit. The agricultural extension service reached thousands of persons for farm and home programs, and the agricultural experiment station conducted research, teaching and field work on more than 23,000 ac. of farm lands and timberlands, as well as in laboratories.

The school of journalism, established in 1908, was the first of its kind; it operates a newspaper and provides a staff for the radio and television stations. The college of arts and science includes the school of social work. The schools of forestry and of home economics are allied with the college of agriculture. There are also colleges of education and of engineering; a graduate school; a school of business and public administration; a school of law; a school of medicine, including a school of nursing and a separate school of veterinary medicine.

The university library contains nearly 1,000,000 volumes.

**Other Institutions of Higher Education.**—Broadening of the curriculum of state normal schools led to renaming these, each under its regional board of regents: Northeast Missouri State Teachers college (founded 1867), Kirksville; Southeast Missouri State college (1873), Cape Girardeau; Central Missouri State college (1870), Warrensburg; Northwest Missouri State college (1905), Maryville; and Southwest Missouri State college (1906), Springfield. Lincoln university, established for Negroes in 1866 at Jefferson City, has been integrated racially, as have other state schools. In 1808 Ste. Genevieve academy was chartered, and such private or church-related schools reached 204 by 1850. Ten denominational colleges, chiefly Protestant, belonged to the Missouri College union in the early 1960s. These were included among 19 senior colleges, of which St. Louis university (Roman Catholic; 1818) and Washington university (nonsectarian; 1853), both of St. Louis, were the largest (*see* ST. LOUIS). The University of Kansas City (nonsectarian), chartered in 1929, enrolls nearly 2,000 students annually and has a library of approximately 200,000 volumes. There were also 14 junior colleges, including several operated as part of the public-school system of some communities, and a number of religious seminaries.

## HEALTH AND WELFARE

Missouri has pioneered in the mothers' pension plan (aid to dependent children originated in Jackson county in 1911); in special education for handicapped children; and in harmonizing its juvenile court code with modern conditions. It also integrated its schools in prompt and orderly fashion after the supreme court decision of 1954 declared racial segregation in public schools to be unconstitutional. Such progress seldom has come suddenly by passing laws—Roman Catholic parochial schools ended segregation before the public-school system did—reform originating, in-

stead, in the responsible concern of large groups of citizens. Among such factors are the Missouri Association for Social Welfare, the League of Women Voters, and religious agencies such as the Metropolitan Church Federation of St. Louis, with its counseling service, training programs and interpretation of current needs through radio, television, press and pulpit.

Although hospital facilities have been poorly distributed about the state, St. Louis and Kansas City provide outstanding medical centres. The department of health and welfare, set up under the state constitution of 1945, operates a cancer hospital at Columbia and a tuberculosis sanatorium at Mount Vernon. Its division of mental diseases has hospitals at Fulton, St. Joseph, Nevada, Farmington and St. Louis, in addition to the Missouri State school at Marshall for the care and training of mentally retarded and epileptic children, and the St. Louis Training school for mental defectives between 5 and 20 years of age. The division of welfare assists persons over 65, dependent children, victims of calamity, the disabled and the blind and also administers direct relief and child welfare service. The state department of correction controls a penitentiary for men at Jefferson City and an auxiliary for women at Tipton and the Intermediate Reformatory for Young Men at Algoa Farms, near the capital. There are also several prison farms, with two canneries, two dairies, a pickle factory, a slaughterhouse and two quarries. In 1957 the site for the medium security prison was acquired near Moberly. A training school for boys is at Boonville, that for girls at Chillicothe.

## ECONOMY

Nearly half the counties by the 1960s had no village with a population as large as 2,500, and only 18 counties had towns larger than 10,000. Increasing farm mechanization had resulted in two-thirds of rural youth, mainly those of greater aptitude, both men and women, leaving to seek economic opportunity in larger centres. The result was a reservoir of unskilled labour at wages slightly below the national level. Four distinct rural areas stem from interacting economic, social, cultural and physical characteristics. Largest is that north of the Missouri river, extending south along the western border to Jasper and Lawrence counties; this has a relatively high level of living, with emphasis on education and commercialized farming. Another begins with Cole county, extending along the Missouri and Mississippi to Cape Girardeau, including early French settlements but with a German background, dating to 1837, at Hermann. Here are Lutheran and Catholic parochial schools, less attendance at high school, lower relief expenditures and some off-farm employment. A third division is the Ozarks, populated by descendants of southern highlanders, with much subsistence and part-time farming and a higher birth rate, altogether reminiscent of early America. Six counties in southeast Missouri form the fourth area, with a high percentage of Negro labour, tenant farming, with little permanent tenure, and fixed social classes.

**Agriculture.**—Fewer but larger farms have resulted from increasing mechanization. The bureau of the census in the second half of the 20th century reported a total of about 200,000 farms in Missouri, a decline of 17.5% during and after World War II. The census of 1930 listed 55,000 more farms and an average acre value of $53.23, as compared with $81.45 in the 1950s. Though total acreage in use remained approximately unchanged, average farm size increased in 25 years from 132.2 ac. to 169.6 (28%). Missouri ranks third in farm co-operative membership, following Minnesota and Illinois. The Missouri Farmers association, centred in Columbia, marketing crops and processing and distributing supplies ranging from seeds to tractor fuel, reported over 155,000 members in the second half of the 20th century, operating three feed mills, three fertilizer plants, two plants processing poultry, eight handling milk, and a packing house. The Consumers Co-operative association of Kansas City, a regional supply agency operating in 11 states, reported $130,000,000 of supplies distributed annually, mainly petroleum, fertilizer and feed. Loans from the Rural Electrification administration, chiefly to co-operatives, by the early 1960s had provided power to nearly all the state's farms. The number of tenants decreased from a peak of 91,000 in 1940 to 35,000 in a period of 15 years. Factors favourable to better rural living included the soil conservation service (through erosion control and water management) and the Farmers Home administration, both in the U.S. department of agriculture; the latter provided loans to family-sized operators to improve living and operating conditions and for purchase, enlargement or development of farms.

Cash farm income from cattle, hogs, milk, poultry and eggs represents well over 60% of total farm income. Chief crops, in order of cash value, are corn, wheat, soybeans, cotton (flat, an excellent long-staple variety) and hay.

**Industry.**—Of states west of the Mississippi, Missouri ranks third in manufacturing, after California and Texas. A tendency toward decentralization, notably in the shoe and clothing industries, has supplemented the basic food processing and lumber operations usually seen outside metropolitan areas. Wide diversity is reflected in the more than 6,000 industrial establishments, with nearly 400,000 employees, an annual payroll of $1,600,000,000, and a $3,200,000,000 value added by manufacture annually in the second half of the 20th century, the latter sum having nearly doubled in the ten-year period following World War II. The leading industries, in order according to value added by manufacture, are transportation equipment, food and kindred products, chemicals and kindred products, machinery (excluding electrical), fabricated metal products and leather and leather products. Of the 448 classifications used by the federal census of manufactures, nearly 400 are represented in Missouri. The rapidly growing tourist industry, especially after World War II, contributed substantially to the state's economy (see *Physical Geography: Parks* above).

**Mining.**—Mineral production by the early 1960s was valued at about $150,000,000 annually. Missouri leads the states in production of lead, as it has since 1906, and barite; it is the second largest producer of lime and the third of fire clay. Its five principal minerals, in order of value, are cement, stone, lead, lime and coal. Nonmetals account for 63% of the total mineral value, metals 29% and mineral fuels 8%. A notable increase in iron ore potential accompanied drilling discoveries in the Pea ridge district near Sullivan of high-grade deposits estimated at 100,000,000 tons, located at great depths. Government aid in financing exploration for strategic minerals led to discoveries of lead in the Vibernum area of southeast Missouri, said to exceed the old lead belt, which it parallels at a lower level. Bituminous coal is produced in numerous small mines scattered over the state, the largest being found in Henry, Macon, Bates, Barton and St. Clair counties; 96% of the tonnage is supplied by strip mines. Metals in small production include cobalt, copper, nickel, manganese and silver, with less amounts of cadmium, gallium, germanium and indium.

**Forestry.**—Through a system of reforestation, fire protection and tax concessions to owners of well-managed forest croplands, much of the damage of earlier unrestricted lumbering has been offset. While most of the stands were immature in the early 1960s, trees grew on more than 15,000,000 ac., more than one-third of the state. In addition to state forests, comprising 170,000 ac., the Clark and Mark Twain National forests, in the southern Ozarks, protected 1,359,000 ac.

Damage created by open-range livestock in several counties was an obstacle to pulp mill establishment, although protected areas showed possibilities of increased growth. Replanting of 50,000 ac. mainly in shortleaf pine added a new wood to the commoner oak and hickory.

**Trade and Finance.**—Missouri is the only state with two federal reserve banks, one in St. Louis and another in Kansas City, reflecting the central geographic location, with large terminal farm markets and processing and distribution facilities. St. Louis also is a centre of farm credit agencies set up by the federal government but passing into farmer ownership—a land bank, a production credit association and a bank for co-operatives. Many communities have established industrial development corporations to attract new industries.

**Transportation and Communication.**—From the founding

of the first newspaper, the *Missouri Gazette*, by Joseph Charless in 1808, at St. Louis, journalism has developed an aggressive tradition carried on by many noted editors. In the second half of the 20th century the press was supplemented by about 20 television stations and 100 radio broadcasting establishments. The two largest cities were main airline terminals, others being served by regional feeder lines. There were 23 trunk-line railroads, and federal and state highways crisscrossed the state, leaving no point more than a few miles from a modern highway. Many pipelines carrying natural gas, oil and gasoline crossed the state from the southwest. Waterways to the Gulf of Mexico from Kansas City and above had been supplemented by access to the St. Lawrence seaway through the Illinois river canal. Modern towboats made the round trip from St. Louis to New Orleans in 16 days, comparing favourably with schedules of river packets of old days. Whereas a modern tow consisted of 8,000 to 10,000 tons of freight, packets had been hard pressed to handle 600 tons, though some had carried 2,000.

*See* also references under "Missouri" in the Index.

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Current statistics on production, employment, industry, etc., may be obtained from the pertinent state departments; the principal figures are summarized annually in the *Britannica Book of the Year*, American edition. (PL. G.)

**MISSOURI COMPROMISE,** a term referring to the compromise measures worked out in the U.S. congress that prepared the way for admission of Missouri as the 24th state. The immediate issue was whether slavery should be permanently legalized in the new state; a second issue was the policy of congress toward slavery in the territories west of the Mississippi river.

In Dec. 1818 congress received a petition to authorize Missouri to form a state government. When this was considered in the house of representatives on Feb. 13, 1819, James Tallmadge of New York introduced an amendment providing that no additional slaves should be admitted into Missouri and that children of slaves already there should be freed at the age of 25. Debates on this amendment revived the sectional controversies between north and south which had appeared periodically in the preceding 40 years. The amendment was accepted by the house, but rejected by the senate. Congress adjourned March 4, 1819, without acting on the Missouri bill.

The following summer a considerable body of public opinion in the north was rallied in support of the Tallmadge proposal. Much of this anti-Missouri sentiment, as it was called, arose from a genuine conviction that slavery was morally wrong. Political expediency was mixed with moral convictions. Many of the leading anti-Missouri men had been active in the Federalist party which seemed to be in the process of disintegration; it was charged that they were seeking an issue on which to rebuild their party. The Federalist leadership of the anti-Missouri group caused some northern Democrats to reconsider their support of the Tallmadge amendment and to favour a compromise that would thwart efforts to revive the Federalist party.

The 16th congress assembled in Dec. 1819 and on Jan. 3, 1820, the house voted to enable Maine to form a state government. The senate amended the bill to authorize both Maine and Missouri to frame state constitutions, the latter without restriction as to slavery. To this the senate added an amendment offered by J. B. Thomas of Illinois to exclude slavery from all other parts of the Louisiana Purchase north of the latitude 36° 30′, the southern boundary of Missouri. When the house refused to accept this compromise, Henry Clay took active leadership of the compromise group. Even with all his skill, the compromise proposals probably could not have passed the house as a single bill. A large majority of northern congressmen still were opposed to the unrestricted admission of Missouri while a larger proportion of southern congressmen opposed any limitation on the extension of slavery. Clay forced separate votes, however, and all the controversial measures passed by slender majorities and were signed by President James Monroe on March 3 and 6, 1820.

Final admission of Missouri faced one more hurdle. The constitution of the new state included a provision excluding free Negroes and mulattoes, and a majority in the house was unwilling to vote for the admission of Missouri until that clause was stricken from the constitution. Again Clay worked for compromise and won over enough votes by a proposal to make the admission of Missouri contingent on an act by its legislature agreeing never to impair the rights of the citizens of any state. This is sometimes known as the second Missouri Compromise.

Debates on the admission of Missouri raised constitutional as well as political questions. In the final action congress accepted the southern contention that it could impose no restrictions on new states which did not apply equally to all states. It also accepted the argument of northerners that it did have the power to regulate slavery in the territories. More significant however was the impact upon attitudes toward slavery and sectional interests. The debate alerted extreme antislavery groups in the north to the implications of the extension of slavery, but northern Democrats preferred continued co-operation with southern Democrats to the espousal of a strictly sectional issue. In the south the attack on slavery solidified sectional determination to defend slavery. No southern leader thereafter could support any restriction on slavery and remain in public life; within a few years southern spokesmen were defending the thesis that slavery was essential to the welfare of the south and was indeed morally defensible. In 1854 the Missouri Compromise was repealed.

*See* also UNITED STATES OF AMERICA: *History*.

*See* Glover Moore, *The Missouri Controversy, 1819–1821* (1953). (H. W. Bv.)

**MISSOURI RIVER,** longest of the tributaries of the Mississippi, is formed by the confluence of the Jefferson, Madison and Gallatin rivers in the Rocky mountain area of southwestern Montana, 8,000 ft. above sea level. Flowing at first northward onto the high plains, the Missouri then turns eastward before assuming its winding, unstable course southeasterly to the Mississippi. For most of the way the river flows through its two major physiographic sections, the high and the low Great Plains, finally debouching into the Mississippi over its own alluvial plain 2,466 mi. from its source.

**Basin.**—The area drained by this great river system is about 529,400 sq mi., of which 2,550 sq mi. are in Canada. Elevations within the basin are extreme: from 14,000 ft. above sea level in the Rockies near the continental divide to 400 ft. where the Missouri joins the Mississippi.

In general the northern plains are lower than the southern Great Plains. Four areas stand out in contrast with the prevailing surface of the Great Plains. In north central Nebraska are the Sand hills, a region of low sand hills, small enclosed basins and intermittent streams, principally affording pasture for cattle. A second area of rolling terrain with thin limestone soils fitted only for grazing is the Flint hills in east central Kansas. The third hill area is the concentration of erosional land forms in west central South Dakota known as the Bad Lands, where, even under the most favourable climatic conditions, grazing is generally the highest use of the land. The most verdant of the hill or mountain areas on the plains is the Black hills of western South Dakota. Most of this area is national forest, and recreation is the

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CONFLUENCE OF THE MADISON, JEFFERSON AND GALLATIN RIVERS NEAR THREE FORKS, MONT., FORMING THE MISSOURI RIVER

source of most of its income. A final hill area is the Ozark highland in the far southeastern part of the Missouri basin. Although well-watered and once forested, the steep slopes and thin soils preclude crop agriculture except in the valley bottoms. Recreation is the major source of income over most of the highlands.

The apparent uniformity of the remainder of the Missouri basin is deceptive. The badland type of topography is found on a smaller scale in many places, particularly in the middle valley of the Little Missouri and along the upper courses of most of the longer rivers. Continental glaciation has also resulted in differentiating the land surface in the northern and northeastern portions of the basin where old glacial channels that once were the beds of glacial lakes, plains, morainic deposits and till plains are found. (*See* also PLEISTOCENE EPOCH.) In east central Nebraska are rolling plains of wind deposition; this loess soil is productive when watered. Most extensive of all subdivisions of the basin are the high plains on the west formed by outwash from the cordilleran glaciation of the Rockies. In the main, soils are fairly deep and fertile. Their ability to absorb and hold water varies widely and is, perhaps, their most critical quality from the viewpoint of agriculture.

The climates prevailing over the basin are arid, with the extreme temperature ranges characteristic of a mid-latitude, continental interior. Most of the larger cities are in the drier western portion, including Denver, Colo., Laramie and Cheyenne, Wyo., and Great Falls and Helena, Mont. Tornadoes, blizzards, torrential rains, heavy snows, sustained high temperatures (perhaps three weeks) and searing droughts have discouraged permanent settlement. In no other part of the interior U.S. are average wind velocities so high as on the Great Plains. The high rate of air movement increases evaporation and promotes dust blowing on fields that are or have been cultivated. Hail insurance is commonly taken on about half of the wheat acreage on a representative farm or ranch on the western Great Plains.

The population of the Missouri basin is about 7,000,000; these states have shown a decline in population since 1930 whereas the nation has significantly increased.

**Flow.**—The flow of the Missouri and of most of its tributaries is exceedingly varied, with the lowest on the Missouri in winter and the greatest from April to June, the flood season. The average flow near the mouth is 64,000 cu ft. per second; the minimum is 4,200 cu.ft., and the maximum is 900,000 cu ft. With unprotected slopes and with such violent fluctuations in flow, erosion and silting are major problems.

**Tributaries.**—The tributaries of the Missouri are nearly all from the west; chief among them are the Yellowstone, Platte, Milk, Kansas, James, Little Missouri, Big Sioux, Niobrara, Osage and Grand, all but the last are essentially Great Plains rivers. Unlike the tributaries of the Ohio, those of the Missouri rarely afford natural corridors through hill or mountain terrain.

**Navigation.**—The mouth of the Missouri was discovered in 1673 by Jacques Marquette and Louis Jolliet while they were coming down the Mississippi. Early in the 18th century French fur traders began to ascend the river, and in 1764 St. Louis was established as a depot; but the first exploration of the river from its mouth to its headwaters was made in 1804–05 by Meriwether Lewis and William Clark. Until many years later the commerce on the river was restricted to the fur trade, and was carried on with such primitive craft as the canoe, the pirogue, the bullboat and the keelboat. The river was little used during the early movement to the west; instead the central route over South pass in west central Wyoming, an important link in the Oregon trail, was followed until railroads were constructed farther south. The first attempt to navigate the Missouri with steamboats was made in 1819. The American Fur company began to use steamers in 1830 and flat-bottomed Mackinaw boats, keelboats and small steamboats were in use on the Missouri below Fort Benton, Mont., 2,285 mi. from the Mississippi, between 1840 and 1870. Steamboat traffic was at its height in 1855, when no fewer than 60 regular packets were engaged in it, but its decline began in the following year with the completion of the Hannibal and St. Joseph railway to St. Joseph, Mo., and by the end of the 19th century it had almost disappeared.

For the first 150 years after settlement along the river little was done to render the Missouri more useful as a waterway or as a source of water for agriculture or power. In 1944 congress authorized a comprehensive program for flood control and water resource development in the Missouri river basin. It embraced a system of more than 100 dams and reservoirs on the Missouri and certain of its tributaries. Local flood protection, involving levees and bank stabilization, and a deeper channel were provided for from Sioux City, Ia., to the Mississippi, a distance of 760 mi. By the time a more ambitious plan, the Missouri River Basin program, or simply the Pick-Sloan program, was presented early in the 1950's, a substantial part of the channel and regulatory reservoir undertaking had been completed or nearly so. Commercial barge lines began operations on the Missouri in 1953 and within a few years their tonnage amounted to more than 400,000 a year—about twice the total at the peak of the old steamboat days.

**Irrigation.**—Irrigation does not stand as a remedy for the drought problem in Great Plains agriculture. In the eastern part of the basin many farmers are by no means certain that its cost is justified in the long run. Rainfall fluctuates so widely around a critical point for crop production that even a slight reduction in moisture affects crop yields seriously. In the larger, drier western portion, it is a physical rather than an economic problem generally. Nearly all of the functioning irrigation districts are on the upper reaches of rivers along the Rocky mountain front. Largest of these districts is the Colorado piedmont from Denver to Fort Collins. Others are in the Big Horn basin of Wyoming, along the larger rivers in Montana, on the North Platte near Scotts Bluff, and on the South Platte from Ogallala to Grand Island, Nebraska. These districts account for the greater part of the 5,000,000 ac. under irrigation in the Missouri basin. The 30 units of the Missouri River Basin program involve 2,500,000 ac. of newly irrigated land and 250,000 ac. with a supplementary water supply. Most of these irrigated districts are on the eastern or low Great Plains, many of them on the shorter rivers which follow generally parallel courses to the Mississippi. On these streams the pattern of irrigated districts is similar to beads on a string. Three large areas of concentrated irrigation development are in eastern Nebraska and the Dakotas. In any such program for conservation in the harsh but relatively simple environment of the western Missouri basin, land use is subject to most of the physical and economic hazards of the humid east, plus others more or less restricted to the higher, drier lands of the west. Hay and sugar beets are most prevalent in irrigated areas. There are other crops important in several districts, including potatoes, fruits and vege-

tables. Prime requisite in these cash crops grown under irrigation is a high return per acre. Beets are grown in rotation with small grains, alfalfa, and sometimes corn, depending upon the elevation; they rarely are the major crop in any of the districts.

Livestock-feeding operations are integrated into the farm program, with beef cattle and lambs being fattened, in part on the feed crops, sugar beet tops and beet pulp.

**Power.**—In addition to irrigation, power development and flood protection are goals of the larger projects. There is no single, integrated power system to serve the entire basin, as in the TVA. At the beginning of the second half of the 20th century there were 9 federal hydroelectric installations and 17 operated by nonfederal and private agencies, with a total capacity of 500,548 kw. The basin program includes 36 federal installations, with a total capacity (including the 17) of 3,000,000 kw. By states their distribution is: Montana 8, North Dakota 6, Wyoming 5, South Dakota 3, Colorado 3 and Kansas 2.

**Floods.**—The paucity of large cities in the basin probably reduces the news value of Missouri basin floods to eastern newspapers. However, on the 6,000,000 ac. of agricultural land subject to flood, the federal government has reported damage of $200,000,000 in a single year. Visible manifestations of attempts to alleviate the flood problem are the huge dams and reservoirs which have been constructed, nearly all of them on the Missouri. Among them are Fort Peck, Garrison, Fort Randall, Oahe, Gavins Point, Harlan County (Republican River) and Lake of the Ozarks. (*See* also DAM.)

**Mineral Resources.**—Historically the mining centre of the Missouri basin has been the Black hills, where gold, silver and lead have been mined since 1874. Bituminous coal and lignite are mined at several places in North Dakota, Montana and Wyoming. A relative newcomer to basin mining is in northern Montana and North Dakota where the big Beaver Lodge and Tioga petroleum fields are developing in the Williston basin lying athwart the international border.

**Manufacturing.**—Except for Denver, dominant manufacturing city in the Missouri basin, the industrialization of the region has been based upon the conversion of the agricultural surplus. The production of flour, beet sugar, stock feeds, meat, leather, canned fruit and dairy products are most widespread. The manufacture of cement is established at a few places, and a beginning has been made in petroleum refining and petrochemical products. With the established manufacturing of the east north central states and the rising importance of Denver and Salt Lake City, the prospect for industrialization in the thinly populated Missouri basin is not great. *See* also UNITED STATES (OF AMERICA): *Physiography; Rivers and Harbours: Great Plains Province;* and references under "Missouri River" in the Index.

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**MIST,** a light fog or hydrometeor (*q.v.*) which reduces horizontal visibility at the earth's surface to not less than 1 km. (⅝ mi.). The *International Cloud Atlas* (1956) defined mist as "a suspension in the air of microscopic water droplets or wet hygroscopic particles, reducing the visibility at the earth's surface." Mist forms a generally thin, grayish veil covering the landscape; the relative humidity is generally lower than 100%, and the air does not feel raw or clammy. In some parts of the United States drizzle (*q.v.*) is called "mist," as is haze (*q.v.*) in British countries. *See* FOG. (R. G. SE.; X.)

**MISTINGUETT** (stage name of JEANNE MARIE BOURGEOIS) (1873–1956), the most famous and popular French comedienne of her time. The daughter of an upholsterer, she was born at the village of La Pointe-Raguet, near Montmorency, on April 5, 1873. The name Mistinguett (Miss Tinguiett), derived from a song in a musical show, *Miss Helyett*, was suggested by her allegedly English-looking, protruding front teeth. Her greatest fame was achieved in Paris in spectacular revues at the Moulin Rouge and the Casino de Paris. She often partnered Maurice Chevalier, and her best-remembered songs are "C'est mon homme" and "J'en ai marre." She wrote two books: *Mistinguett and Her Confessions* (1938) and *Mistinguett, Queen of the Paris Night* (1954). After a long career, during which she appeared in London and toured the Americas, she died at Bougival, near Paris, on Jan. 5, 1956.

Mistinguett was not highly talented as a dancer, nor did she have a good voice, but she had vitality, conviction, a winning personality and a pair of legs celebrated for their beauty; even in old age she was able to play young parts.

**MISTLETOE,** common name for many species of semiparasitic green plants belonging to the Loranthaceae (*q.v.*) or mistletoe family. In Europe the commonly known species, the traditional mistletoe of literature, is *Viscum album*, found native from Great Britain to northern Asia. In the U.S. the common mistletoes are in the genera *Phoradendron* and *Arceuthobium*.

JOHN H. GERARD

AMERICAN MISTLETOE (PHORADENDRON FLAVESCENS) PARASITIC ON VARIOUS DECIDUOUS TREES

Pliny the Elder is the authority for the reverence in which the mistletoe was held by the druids. Prepared as a draft, it was used as a supposed cure for sterility and a remedy for poisons. Later, the mistletoe became esteemed as a traditional Christmas decoration. In modern times branches of *Phoradendron flavescens*, especially those with berries, are gathered for sale during the Christmas holidays. The traditional mistletoe, bound in a religious and sentimental aura, gave rise to the pleasant custom of kissing under the mistletoe, thought by some to lead to inevitable matrimony.

**Traditional Mistletoe.**—In England *Viscum album* is most abundant on the apple tree and is rarely found on the oak. Poplars, willows, lindens and hawthorns are its favourite habitats. Mistletoe forms a drooping yellowish evergreen bush, two to three feet long, particularly noticeable in winter when it contrasts with the naked limbs of deciduous trees or with the deep green of evergreen trees serving as hosts. The thickly crowded, forking branches bear opposite leaves about two inches long and oval to lance shaped. Small flowers, male and female on different plants, yellower than the leaves, appear in late winter and soon give rise to white berries, which when ripe are filled with a viscous semitransparent pulp.

Most fruit-eating birds eat the berries and thereby distribute the seed; this is accomplished when the bird wipes its beak, to which seeds adhere, against the bark of a tree. The viscid pulp soon hardens, affording a protection to the seed; in germination the sucker root penetrates the bark of the susceptible host and establishes a connection through which nourishment and water are derived from the host (mistletoes, being green, manufacture some of their own food).

Mistletoes, one of the few groups of higher plants parasitic on both deciduous and evergreen trees and shrubs, are slow in growth but very persistent; their natural death is determined by the death of the host. Sometimes merely pests, they may, if abundant, kill desirable trees. They may be controlled by removing the brittle green growth as completely as possible.

**American Mistletoes.**—*Phoradendron flavescens*, very similar to the traditional mistletoe of Europe, occurs especially on deciduous trees from New Jersey to Florida and westward to Texas and Kansas. The larger *P. macrophyllum* grows in bushy clumps two to eight feet in diameter and parasitizes chiefly poplar and willow from Texas to central California. Along the Pacific coast *P. villosum* occurs chiefly on oak; *P. juniperinum*, with scalelike

leaves, grows on junipers and incense cedar; *P. bolleana*, with pearllike berries, occurs on cypress; and the mesquite mistletoe (*P. californicum*), with slender pendulous branches, parasitizes mesquite, creosote bush and cat's-claw. In eastern North America *Arceuthobium pusillum* is a very small parasite on coniferous trees. Many species of the genus *Loranthus* inhabit the tropical regions of the eastern hemisphere.

*See* also PLANT DISEASES: *Causes*.

**MISTRA** (MISTRAS), a ruined Byzantine city in Greece, built on a prominent spur of Mt. Taygetus 7 km. (4 mi.) W. of Sparta. Founded as a fortress in the Frankish principality of the Morea by Guillaume de Villehardouin in 1248–49, it was handed over to the Byzantine emperor Michael VIII Palaeologus in 1262 by the treaty of Constantinople. In 1348 it became the capital of the Byzantine despotate of the Morea, being ruled by members first of the Cantacuzeno family (1348–80) and then of the Palaeologan dynasty (1382–1460). Mistra was the lively centre of a brilliant court life, comparable to that of contemporary Renaissance cities in Italy. Its shining ornament was the Neoplatonist George Gemistus Pletho (*q.v.*). Mistra was handed over to the Turks in 1460 and became their administrative centre for the Morea.

It declined in numbers and importance after its occupation by the Venetians (1687–1715) and was already practically deserted when Greece won independence from Turkey in 1829. The few remaining families were evacuated in 1952 because Mistra became an archaeological area, but the Pantanassa, a small convent for women, is still inhabited. Fine Byzantine frescoes survive in the chief churches: the cathedral (metropolis) of St. Demetrius, SS. Theodore and the Aphentiko (both belonging to the former convent of Brontocheion), Hagia Sophia, Peribleptos and Pantanassa. Many other buildings remain, including the walls of the palace of the despots, and the ruined Villehardouin fortress crowns the hill.

*See* D. A. Zakythinos, *Le Despotat grec de la Morée*, 2 vol. (1932–53); M. Chatzidaki, *Mystras*, 2nd ed. (1956, in Greek).

**MISTRAL, FRÉDÉRIC** (1830–1914), Provençal poet, the leader of the 19th-century revival of Provençal language and literature, who was awarded the Nobel prize for literature in 1905, was born at Maillane (Bouches-du-Rhône), on Sept. 8, 1830. His father was a well-to-do farmer and he was given a good schooling at the Collège Royal of Avignon (later renamed the Lycée Frédéric Mistral), where he had Joseph Roumanille (*see* PROVENÇAL LITERATURE) as teacher. He took a degree in law at the University of Aix in 1851. Wealthy enough to live without following a profession, he early decided to devote himself to the rehabilitation of Provençal life, and especially of the language, and this, with his literary activities, was his main occupation throughout a long life. In 1854, with several friends, he founded the *Félibrige*, an association for the maintenance of the Provençal language and customs, extended later to include the whole of southern France ("le pays de la langue d'oc"), and was its chief organizer and inspirer till his death at Maillane, on March 25, 1914.

Galled by the contempt in which Provençal was held and inspired by its past glories when, as the language of the Troubadours (*q.v.*), it was the cultured speech of southern France and was used by poets in Italy and Spain, Mistral threw himself into the literary revival of *langue d'oc* which was taking place all over the south of France. His charm, intelligence, commanding presence and great poetic gifts soon placed him at its head in Provence itself, and eventually throughout the Midi. By encouraging the composition of prose and verse in the language, by publishing popular magazines and almanacs, by organizing local games and dance and costume festivals, he sought to restore to the Midi the sense of nationhood which he claimed it had once possessed and which had been crushed by the tyrannical influence of Paris as the centre of culture. He based his activity on the countryside, where the language was most alive, but centres were established also in the towns. He undertook the preparation of a scholarly dictionary of *langue d'oc*, *Lou Tresor dóu Felibrige* (2 vol., 1878), to which he devoted some 20 years' work.

His poems were only one aspect of his campaign for Provençal culture, but it is as a poet that he is remembered. His attempts to restore *langue d'oc* to its ancient position were not entirely successful, but his poetic genius has given it some enduring masterpieces and he is one of the greatest of French poets.

His literary output consists of four long narrative poems: *Mirèio* (1859), *Calendau* (1867), *Nerto* (1884), *Lou Poèmo dóu Rose* (1897); a historical tragedy, *La Reino Jano* (1890); two volumes of lyrics, *Li Isclo d'or* (1875; definitive edition 1889) and *Li Oulivado* (1912); and many short stories, collected in *Proso d'Armano* (three volumes, 1926–29). His first narrative poem *Li Meissoun*, written in 1845, was posthumously published in the *Revue de France* (July–Aug. 1927). His volume of memoirs, *Moun espelido* (*Mes origines*, 1906; English translation 1907), is his best-known work, but his claim to greatness rests on his first and last long poems, *Mirèio*, and *Lou Poèmo dóu Rose* (Eng. trans. *The Song of the Rhône*, 1937), both full-scale epics in 12 cantos. *Mirèio*, which is set in the poet's own time and district, is the story of the love of a rich farmer's daughter and a poor basketmaker's son, thwarted by the girl's parents and ending with her death in the church of Les Saintes-Maries-de-la-Mer. Into this poem Mistral poured his love for the countryside where he was born. Narration, dialogue, description and lyricism are skilfully combined, and the poem is a blend of spontaneity and artistry, most clearly perceptible in the springy, musical quality of its highly individual stanaic form. The vivid evocations of the landscape, and of the moments of each day and of the seasons of the year make this love story also a great nature poem. Its idealization of people and places is never allowed to become excessive and it avoids the weakness and falsity of much pastoral literature.

*Lou Poèmo dóu Rose* is about navigation on the Rhône about 1830, just before the introduction of steam. The poem moves downstream from Lyons to Beaucaire with the barge "Lou Caburle," on board which there come, at different stages of the voyage, a romantic young prince of Holland and the daughter of a poor ferryman. The romance between them is cut short by the disaster which closes the poem, when the first steamboat to sail on the Rhône accidentally sinks "Lou Caburle" and, though the crew swims ashore, the lovers are drowned. The poem is written in unrhymed lines of ten syllables, a verse of great strength and variety. Less musical and more dense in style than *Mirèio*, this epic is just as full of life and colour. It reflects, however, a feeling of longing and loss; though it is not a confession of personal failure, an intuition grows upon the reader that Mistral, as he looks back, realizes that his aim has not been reached and that much of what he loves is, like his heroes, doomed to perish.

Mistral's lyrics, impersonal in their themes for the most part, include some exceptionally beautiful songs.

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**MISTRAL, GABRIELA** (1889–1957), pseudonym of LUCILA GODOY ALCAYAGA, Chilean poet, who won the Nobel prize for literature in 1945, was born in Vicuña, Chile, April 7, 1889. Her prize winning "Sonetos de la Muerte" ("Sonnets of Death") made her poetic ability known in 1914. *Desolación* (1922) includes "Dolor"—the aftermath of a love affair tragically ended by the suicide of her lover. *Ternura* (1924, enlarged in 1945) and *Tala* (1938) evidence a broader interest in mankind; but love—of children, the downtrodden, nature and God—remained her principal theme. Her verse, more often virile than feminine and frequently coloured by figures and words peculiarly her own, is characterized by great warmth of feeling and strong emotional power, but in the poems for children there is a haunting, wistful strain of maternal tenderness. Her poetry has been translated into English, French, Italian, German and Swedish. Her prose is simple, discreet, and at times tense with emotion, but does not surpass her verse. She died on Jan. 10, 1957, at Hempstead, N.Y.

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**MISTRAL:** *see* WIND: *Local Winds*

**MITCHAM,** a borough of Surrey, Eng., which under the London Government Act 1963 was to be amalgamated on April 1, 1965, with the borough of Wimbledon and the urban district of Merton and Morden to form the new London borough of Merton (*see* LONDON). Mitcham borough (1934) is a residential area with some light industries 8 mi. S. of Charing Cross. Pop. (1961) 63,653. Area 4.6 sq mi. Mitcham is a parliamentary constituency. It is mentioned in Domesday Book as Mitchelham. In the 18th and 19th centuries it was known for its cultivation of lavender and peppermint.

**MITCHELL, DONALD GRANT** (1822–1908), U.S. author, won his greatest vogue by blending the moods of gentle fancy and tender sentiment which characterized popular taste in the 1850s, making his pseudonym, "Ik Marvel," a household name. Born in Norwich, Conn., April 12, 1822, he graduated from Yale in 1841, and was U.S. consul at Venice, Italy (1853–54). His best known books, *Reveries of a Bachelor* (1850) and *Dream Life* (1851), occupy the border line between fiction and essay. Their evocation of rural delights, their treatment of youthful love and sorrow, and their escapism to a dream world have perennial charm. Most significant among his later works are *My Farm at Edgewood* (1863), recording his interest in agriculture, and *Dr. Johns* (1866), a novel reflecting his religious liberalism.

*See* Waldo H. Dunn, *The Life of Donald G. Mitchell* (1922).
(H. R. Bs.)

**MITCHELL, JOHN THOMAS WHITEHEAD** (1828–1895), a dominant figure in the English co-operative movement, was born in Rochdale, Lancashire, Eng., on Oct. 18, 1828. Becoming interested in the co-operative movement at an early age, he joined the Rochdale Society of Equitable Pioneers in 1853 and was appointed its secretary in 1857. He shaped the policy of the Co-operative Wholesale society, which was established in 1863, and was its chairman from 1874 until his death at Rochdale on March 16, 1895.

Mitchell's great contribution was to crystallize the concept of consumer's co-operation. He emphasized the fundamental importance of the role of the consumer, and his ideas constitute the theoretical and practical basis of the co-operative movement in Great Britain. An essential feature of the Rochdale system, which was subsequently adopted in many other countries, was the return of dividends on all purchases to members of the society. *See* also CO-OPERATIVES.

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(GA. S.)

**MITCHELL, MARGARET** (1900–1949), U.S. novelist, author of *Gone With the Wind*, was born in Atlanta, Ga., in 1900. She attended Washington seminary in Atlanta and Smith college, Northampton, Mass. Called back from college by her mother's death, she wrote for the *Atlanta Journal* from 1922 until, in 1926, an ankle injury forced her retirement from the paper. It was then that she began to write her one book, *Gone With the Wind*, a novel about the American Civil War and the Reconstruction as seen from a southern point of view. She worked on the book for ten years, and it was published in June 1936. In 1937 Miss Mitchell received the Pulitzer prize for fiction. After the motion-picture rights were sold for $50,000, the picture made from the novel received an Academy award in 1940.

*Gone With the Wind* was almost certainly the largest selling novel in the history of U.S. publishing. A million copies were sold in the first six months after its publication, 50,000 of them in one day. Two million copies had been sold in the U.S. by 1939, and over 8,000,000, in 40 countries, before her death.

Margaret Mitchell married John R. Marsh in 1925. She died on Aug. 16, 1949, after having been struck by an automobile in Atlanta.

**MITCHELL, MARIA** (1818–1889), U.S. astronomer who made photographs of the sun and a special study of Jupiter and Saturn, was born on Nantucket Island, Mass., Aug. 1, 1818. In 1865 she became professor of astronomy and director of the observatory at Vassar college; and in 1888 professor emeritus. She died at Lynn, Mass., on June 28, 1889.

*See* Phebe Mitchell Kendall, *Maria Mitchell: Life, Letters and Journals* (1896); Helen Wright, *Sweeper in the Sky* (1949).

**MITCHELL, REGINALD JOSEPH** (1895–1937), British aircraft designer who produced the Spitfire fighter, was born at Talke, near Stoke-on-Trent, Staffordshire, on May 20, 1895. He was apprenticed to an engineering firm at Stoke and, after a period as assistant engineer there, joined the Supermarine Aviation works at Southampton in 1916, becoming chief engineer and designer in 1920. In 1922 he collaborated with Hubert Scott-Paine in producing a flying boat which won the Schneider trophy. Continuing this collaboration, he designed a number of marine craft ranging from large flying boats to small racing float seaplanes. In 1925 his S-4 floatplane raised the world speed record to 226.752 m.p.h. and in 1927, 1929 and 1931 his aircraft won the Schneider trophy on three successive occasions.

In 1931, Flight Lieutenant Stainforth raised the world speed record to 407.5 m.p.h. in Mitchell's S-6B. Mitchell's last aircraft was the famous eight-gun Spitfire fighter (1936) which contributed much to victory in the battle of Britain during World War II, and of which nearly 19,000 were built. He died at Southampton on June 11, 1937.
(D. CR.)

**MITCHELL, SILAS WEIR** (1829–1914), U.S. physician and author, who excelled in novels of psychology and historical romance, was born in Philadelphia, Pa., Feb. 15, 1829. He studied at the University of Pennsylvania and Jefferson Medical college (M.D., 1850), both in his native city. As an army surgeon during the American Civil War he became interested in nervous diseases, and was soon renowned for his "rest cure." In 1866 he published "The Case of George Dedlow," a story notable for its psychological insights and realistic war scenes. He wrote some 170 medical monographs on topics ranging from snake venom to neurasthenia, doing valuable pioneering work in several fields. *Wear and Tear* (1871) and *Fat and Blood* (1877), medical popularizations, were best sellers.

Mitchell also wrote juvenile stories, verse and prose fiction. Perhaps his most notable works are: *Roland Blake* (1886); *Hugh Wynne* (1898); *The Adventures of François* (1899); *Circumstance* (1901); *Constance Trescott* (1905); and *The Red City* (1907). His complete works were published as "The Author's Definitive Edition" in 16 volumes (1913–14). Mitchell died in Philadelphia, Jan. 4, 1914.

*See* Anna Burr, *Weir Mitchell: His Life and Letters* (1929); E. P. Earnest, *S. Weir Mitchell: Novelist and Physician* (1950); David Rein, *S. Weir Mitchell as a Psychiatric Novelist* (1952).

**MITCHELL, SIR THOMAS LIVINGSTONE** (1792–1855), British explorer of Australia, was born at Craigend, Stirlingshire, Scot., on June 16, 1792. A distinguished surveyor in the Peninsular War, he was appointed surveyor general of New South Wales in 1828. Mitchell explored northern and western New South Wales (1831 and 1835); discovered "Australia Felix," the western district of Victoria (1836); and attempted to travel overland from Sydney to the Gulf of Carpentaria (1845–47). He published the journals of his explorations (1838), an Australian geography (1851), texts on surveying and military exercises and a translation of *Os Lusiadas* by L. de Camões (1854). He was knighted in 1839, and died in Sydney on Oct. 5, 1855.
(T. M. Py.)

**MITCHELL, WESLEY CLAIR** (1874–1948), U.S. economist, who made pioneering studies of the money economy and became the world's foremost authority on business cycles, was born in Rushville, Ill., on Aug. 5, 1874. He attended The University of Chicago, where he came under the influence of Thorstein Veblen and John Dewey. Though his life was devoted primarily to economic research, he also taught economics at various universities, principally at Columbia.

In 1920 Mitchell helped to organize the National Bureau of Economic Research and was its director of research until 1945. He served as chief of the price section of the War Industries board during World War I, as chairman of Pres. Herbert Hoover's Research Committee on Social Trends, as a member of the National

Planning board in 1933 and of the National Resources board in 1934–35. For many years Mitchell played a leading role in the Social Science Research council and the Bureau of Educational Experiments. Under his leadership quantitative studies of economic behaviour developed rapidly in the United States and abroad. Mitchell died in New York city on Oct. 29, 1948.

Among his publications are *Business Cycles* (1913), *Business Cycles: the Problem and Its Setting* (1927), *The Backward Art of Spending Money and Other Essays* (1937) and *Measuring Business Cycles*, with A. F. Burns (1946). (A. F. Bs.)

**MITCHELL, WILLIAM** (1879–1936), U.S. army officer, pioneer in military aviation, was born Dec. 29, 1879, in Nice, France, of American parents. His father, John Lendrum Mitchell, later became U.S. senator from Wisconsin. Young Mitchell attended Racine college in Wisconsin and Columbian (later George Washington) university in Washington, D.C. He left college to enlist as a private in the infantry at the outbreak of the Spanish-American War in 1898. Shortly after, he received a commission as a second lieutenant in the signal corps and embarked on a military career that lasted for more than a quarter of a century.

Mitchell served in Cuba, the Philippines and Alaska and in 1909 he graduated from the Army Staff college at Ft. Leavenworth. In 1915 he was assigned to the aviation section of the signal corps. He learned to fly during the winter of 1915–16 at a school located in Newport News, Va., to which he commuted on week ends from Washington. When the U.S. entered World War I, Mitchell was already in Europe as an observer. By the time Gen. John J. Pershing arrived in France as commander of the American expeditionary forces on July 4, 1917, Mitchell had become the best-informed American aviation officer in Europe.

Always a man of action, Mitchell became the outstanding U.S. combat air commander of the war. In Sept. 1918 he commanded a French-U.S. air armada of almost 1,500 planes, the largest concentration of air power up to that time. This powerful force helped the U.S. 1st army wipe out the St. Mihiel salient. In the subsequent Meuse-Argonne campaign, Mitchell, promoted to brigadier general in Oct. 1918, used formations of up to 200 planes for mass bombing of enemy targets. His aggressive tactics reflected not only his character but also his ideas on the use of air power. In the latter, he was influenced by the great British air commander Maj. Gen. Hugh Trenchard, the foremost advocate and practitioner of strategic air bombardment during World War I.

Mitchell returned to Washington after the war to be appointed assistant chief of the air service in 1919. He became a strong proponent of an independent U.S. air force and of unified control of air power, both of which were opposed by the army general staff and the navy. Mitchell challenged the concept of the navy as the first line of defense and mobilized congressional and public opinion to induce the navy to permit him to carry out bombing tests against old battleships. In July 1921 he commanded air service bombers that sank the former German dreadnought "Ostfriesland" in 21½ minutes off the Virginia coast. When air service bombers sank two obsolete U.S. ships in tests off Cape Hatteras in Sept. 1923, the navy took the lesson to heart and began to build its forces around the aircraft carrier.

As Mitchell's hopes for recognition and appreciation of the future of air power failed to materialize, he became increasingly outspoken in his criticism of the military hierarchy that did not accept his views. At the expiration of his term as assistant chief of air service in April 1925 he was sent to San Antonio, Tex., in his permanent grade of colonel, as air officer of the 5th corps area. But this departure from the seat of government did not silence him; he continued to write and speak in behalf of his views. The climax came in Sept. 1925 when the loss of the navy dirigible "Shenandoah" in a storm inspired Mitchell to publicly accuse the war and navy departments of "incompetency, criminal negligence and almost treasonable administration of the National Defense." In Dec. 1925 an army court-martial convicted him of insubordination. Sentenced to suspension from rank and duty for five years, he resigned from the army as of Feb. 1, 1926, and devoted the remaining ten years of his life to propagating his gospel of air power.

Mitchell died Feb. 19, 1936. He did not witness the vindication of much that he stood for. Had Mitchell lived through World War II he would have seen the fulfillment of many of his prophecies of air warfare: strategic bombardment, mass air-borne operations, the strategic importance of Alaska and the polar areas and the eclipse of the battleship by the airplane. During his life he was awarded many decorations and honours both by his own and other countries. In 1946 congress authorized a special medal in his honour; it was presented to Mitchell's son in 1948 by the chief of staff of the newly created U.S. air force.

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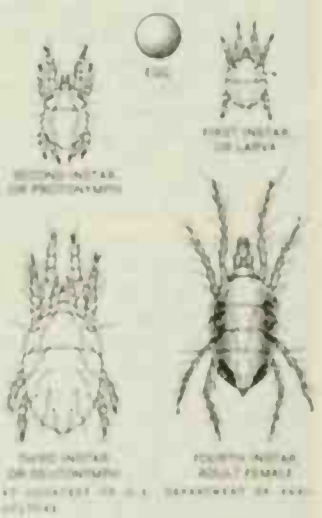
**MITCHELL, MOUNT,** a peak of the Black mountains, a short cross range extending north from the Blue Ridge through Yancey county, North Carolina, and a part of the Appalachian mountain system. It is the highest (6,684 ft. above sea level) peak in the United States east of the Mississippi river. In the same region there are about a dozen summits above 6,000 ft., the noblest of them being Blackstock Knob (6,359 ft.), Big Craggy Mount (6,105 ft.) and Balsam Cone (6,611 ft.). The mountains of North Carolina were not subject to glaciation and are, therefore, covered with a mantle of soil to the top, except for rocky precipices. They are covered with hardwood and pine forests in the lower elevations, and in the upper parts with an unbroken mantle of spruce and balsam.

*See* also BLUE RIDGE; APPALACHIAN MOUNTAINS.

**MITCHELSTOWN** (BAILE AN MHISTEALAIGH), a town and agricultural centre of County Cork, Republic of Ireland, lies southwest of the Galtee mountains and 32 mi. N.E. of Cork city by road. Pop. (1961) 2,655. It has large creameries with ancillary industries manufacturing cheese (Galtee) and chocolate crumb.

The Mitchelstown caves, about 8 mi. N.E. in County Tipperary, are among the finest limestone caves in the British Isles. They extend for miles underground and are divided into two groups—the double-chambered Old or Desmond caves (where the earl of Desmond hid in 1601) and the New caves discovered in 1833. The latter are a maze of galleries and chambers, with names such as the House of Lords, Lot's Wife, etc., containing stalactites and stalagmites. (A. McC.)

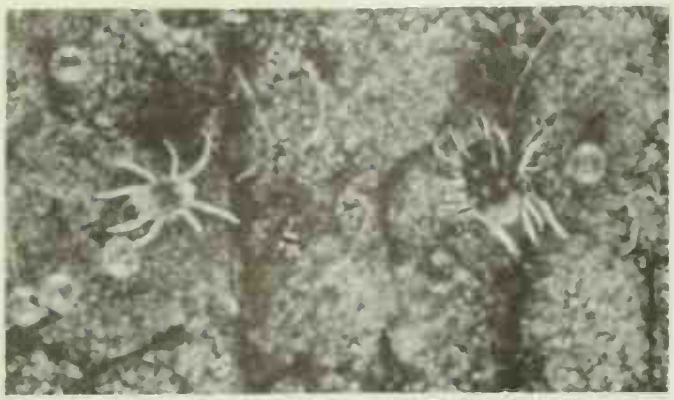
**MITE,** any of the small spider relatives that constitute several orders of the Acarina (Acari), a subclass of arachnids that includes also the ticks (*see* ARACHNIDA for another classification). The Acarina live in varied habitats, being found in brackish water, fresh water, hot springs, in soil and on plants, and are parasitic on and in animals. Some of the parasitic kinds may be found in such diverse habitats as the nasal passages, lungs, stomach and deeper body tissues. A few of the mites, and many of the ticks, are carriers of diseases to man and animals, and can cause enormous losses, especially in the case of ticks transmitting cattle diseases. Plant-feeding mites cause damage by feeding on the leaf tissues, or by transmitting virus diseases to the plants.



LIFE STAGES OF A COMMON RED SPIDER MITE, TETRANYCHUS TELARIUS

The Acarina are distinguished by small size (mites up to ¼ in.; ticks to about 1½ in.), and a non-segmented body, in which the head, thorax and abdomen are broadly joined, only the mouth-parts being separate. There are usually four pairs of legs. In general mites and ticks breathe by means of air tubes or tracheae, although many have no breathing apparatus and respiration takes place through the skin alone.

Although mites have been known since the time of Aristotle,



EUROPEAN RED MITE (PANONYCHUS ULMI): EGGS, YOUNG AND ADULTS ON UNDERSIDE OF APPLE LEAF

they were studied only sporadically until World War II, when mite-borne scrub typhus caused sickness and death to the troops in the south Pacific. Also, interest has been spurred because insecticides such as DDT have eliminated many mite and insect predators, and have fostered the development of acaricidal resistance. Furthermore some mites are carriers of virus diseases of important crops such as wheat and peaches.

The subclass Acarina may be divided into seven orders, the Notostigmata, Tetrastigmata, Metastigmata, Mesostigmata, Cryptostigmata, Astigmata and Prostigmata.

The Notostigmata and Tetrastigmata consist of a few species of primitive mites of no economic importance to man.

The Metastigmata comprises the ticks (*q.v.*).

The Mesostigmata, a large group, includes the well-known chicken mite, the northern fowl mite and the rat mite (all of which will attack man), the nasal mites of dogs and birds, the lung mites of monkeys and the predatory mites found on foliage of trees and plants. These predatory mites are at times of great benefit in controlling plant-feeding mites.

The Cryptostigmata (beetle mites) occur in soil and humus, and occasionally on tree trunks and foliage. In general, they are not considered harmful, and may play a significant role in the breakdown of organic matter, since they constitute a large part of the soil fauna. A few species transmit tapeworms to ruminants; the mite ingests the tapeworm egg and is then in turn eaten along with herbage by stock.

The Astigmata contains the grain and cheese mites (Acaridae), itch mites (Sarcoptidae) of man and animals, scab mites (Psoroptidae), feather mites of birds, mites associated with insects and many free-living forms. Grain mites not only damage stored products but can also cause dermatitis to handlers of infested products. Itch mites burrow into the dermal layers of the skin of man, as well as into the hides of dogs, pigs, sheep and goats, causing injury. Scab mites are found on sheep and cattle, sometimes causing serious injury. Others are found in the air sacs of bird lungs, or in the nasal passages and stomach of bats.

The Prostigmata contains the plant-feeding mites and the chiggers, as well as many predators; it is a large group found in soil, on plants and as parasites of animals. These mites may have from one pair of degenerate legs to the usual four pairs. The bud or gall mites (Eriophyidae), about $\frac{1}{150}$ of an inch long, cause injury to plants either by distortion of leaves and fruit through injection of a toxin, by damaging leaves by feeding, or by transmitting a virus that kills the plant. An infestation of common plant-feeding spider mites or "red spiders" (Tetranychidae) can, at times, completely defoliate the hosts; this family is becoming increasingly difficult to control because of the development of resistance to acaricides. Of great interest to man are the harvest mites or chiggers (Trombiculidae), which cause irritation by their bites, both to man and animals, or sickness or death to man by transmitting tsutsugamushi disease or scrub typhus in the far east and south Pacific (see TYPHUS FEVER). The chigger (*q.v.*) is of interest biologically because only the larval form is parasitic, the nymphs and adults being predaceous on small arthropods and their eggs. In this order are some tiny wormlike follicle mites (Demodicidae) that live in the pores of man and animals, at times causing irritation, and in the case of domestic animals, serious injury or death if not treated. A large group of prostigmatic mites live in fresh water (Hydrachnidae, Limnocharidae, Eylaidae, etc.) and can be found in lakes, streams and hot springs; another group (Halacaridae) is found in brackish water along the coasts.

*See* also ARACHNIDA and references under "Mite" in the Index.

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**MITFORD, MARY RUSSELL** (1787–1855), English dramatist, poet and essayist, chiefly remembered for her delightful sketches of village life, was born at Alresford, Hampshire, on Dec. 16, 1787. She was the only daughter of George Mitford, a dashing, irresponsible character fond of fast living, whose extravagance compelled the family, in 1820, to leave their house in Reading (built when Mary, at the age of ten, won £20,000 in a lottery) for a labourer's cottage in the nearby village of Three Mile Cross. Thereafter, until his death in 1842, his daughter struggled to provide for him and to pay his gambling debts out of her literary earnings. In 1810 she published *Miscellaneous Poems* (2nd ed., 1811); her narrative poem *Christina* (1811) was revised by Samuel Taylor Coleridge, who inserted some lines; other volumes of mild romantic verse followed. She then turned to the theatre, with some success, her greatest triumph being *Rienzi*, which had 34 performances at Drury Lane in 1828 and also met with acclaim in the United States. An unrelieved blank verse tragedy in classical style, it still has power.

Her reputation, however, rests on the sketches that fill the five volumes of *Our Village* (1824–32; ed. by Sir John Squire, Everyman's Library, 1936). These sketches, based on her observation of life in and around Three Mile Cross, catch the pleasant atmosphere of the English countryside and the quaintness of village characters. As Elizabeth Barrett Browning wrote, "through all the beauty there is a clear vein of sense, and a quickness of observation. . . ." But the unpleasant aspects of country life are omitted.

In the last volume of *Our Village* and in the ensuing books—the best of which are *Belford Regis* (1835), a picture of Reading, and *Country Stories* (1837)—there are signs of exhaustion, and the wit is replaced by a gentler humour. However they do contain numerous passages that illuminate English provincial life in the late 18th and early 19th centuries.

Her friends included Coleridge, Charles Lamb and, in later life, Elizabeth Barrett Browning. She considered letter writing an art, and some of her delightful correspondence survives in the *Life* (1870, ed. by A. G. K. L'Estrange) and the *Letters* (1872, ed. by H. Chorley). Her *Recollections of a Literary Life* (1852), intermingles pleasant chat about her favourite books with autobiography. In 1837 she received a civil list pension. She died at Swallowfield, near Reading, on Jan. 10, 1855.

*See* V. Watson, *Mary Russell Mitford* (1949); W. L. Bond, "The Incomparable Old Maid: the Letters of M. R. Mitford," *English*, ii (1939) (W. L. G. JA.)

**MITHILA,** an ancient city and a medieval kingdom of India. The city (perhaps modern Janakpur in southern Nepal) flourished in the time of the Upanishads and during the period described by the *Ramayana*, perhaps the 8th and 7th centuries B.C. It was the capital of Videha, a kingdom which at its greatest extent lay between the Ganges river and the Himalayas, the Gandak and the Kosi rivers in northern Bihar and southern Nepal. It had been swampland before its colonization by the Aryan tribes who built Mithila, and the city prospered, owing partly to the fertility of the region. To the court of King Janaka came Yajnavalkya and other Upanishadic philosophers; and Sita, heroine of the *Ramayana*, was the daughter of a King Janaka of Mithila, a city then well-planned and spacious, boasting of beautiful gardens and buildings. The early kings of Mithila claimed descent from the sun through Ikshvaku. By the 6th century B.C. the Videhas had

formed an aristocratic republic, and had joined a confederacy of republican tribes, the Vajjis, whose boundaries were those of greater Videha. They were subjugated about 450 B.C. by Ajatasatru of Magadha. The old city decayed, and Mithila in later times was a name of greater Videha, also known as Tirabhukti (modern Tirhut), long noted for its conservatism and the learning of its Brahmans. Among its rulers were a learned dynasty of Brahman kings who reigned from the 14th to the 16th centuries; at the court of the most famous, Siva Simha, Vidyapati (fl. A.D. 1400) wrote the Maithili lyrics still sung in northeastern India.

(R. THI.)

**MITHRADATES,** less correctly MITHRIDATES, a Persian name derived from Mithra, the sun-god, and the Indo-European root *da*, "to give," *i.e.*, "given by Mithra." The name occurs also in the forms Mitradates and Meherdates. It was borne by a large number of oriental kings, soldiers and statesmen. The most important are three kings of Parthia of the Arsacid dynasty (*see* PERSIAN HISTORY: *Parthian Empire*) and six kings of Pontus (*q.v.*). There were also three kings of Commagene, two of the Bosporan kingdom and one of Armenia (A.D. 35/36–51).

**Kings of Parthia.**—MITHRADATES I (Arsaces VI), successor of his brother Phraates I, came to the Parthian throne at an uncertain date between 174 and 160 B.C. Before 160 he seized Media from Timarchus, who was the governor of the eastern provinces of the Seleucid empire. Turning to the east he won two provinces from the Bactrian king Eucratides (*q.v.*). After conquering Elymais he occupied Babylonia (142 or 141 B.C.); by this time he controlled most of the former Seleucid satrapies to the west of Bactria as far as the border of Mesopotamia. The Seleucid king Demetrius (*q.v.*) II Nicator recaptured Babylon (141 or 140 B.C.) but was defeated and made prisoner shortly afterward; Mithradates detained him in honourable captivity, giving him his daughter Rhodogune in marriage. Mithradates died about 138. Diodorus Siculus praised him as a mild ruler; and the fact that from 140 his coins carry the epithet *philhellen*, "Greek-loving" (till then he only called himself "the great king Arsaces"), shows that he tried to conciliate his Greek subjects.

MITHRADATES II (*c.* 124–*c.* 87 B.C.) succeeded his father Artabanus, who was killed in battle against the Saca nomads invading Iran from the northeast. He recovered the eastern provinces that had been overrun by the Sacae, and, in the west, conquered Mesopotamia and defeated the Armenian king Artavasdes. The most successful and perhaps the greatest of the Parthian kings, he died about 87 B.C.

MITHRADATES III usurped the throne from his elder brother Orodes in 56 B.C. but was driven out the next year. He took refuge with the Roman governor of Syria, Aulus Gabinius. Returning to Parthia he was defeated and put to death (54).

**Kings of Pontus.**—The Mithradatids of Pontus were descendants of an ancient Persian noble family. The details of their origin and the system of numbering them have been involved in some obscurity since the loss of the historical works of Hieronymus of Cardia, on which classical writers relied. The following account conforms to the view of M. Rostovtzeff (*see Bibliography*).

MITHRADATES I, to whom (rather than to his son) the epithet CTISTES ("founder") seems to belong, was ruler of Cius on the Propontis (in succession, it is said, to two of his kinsmen, an earlier Mithradates and Ariobarzanes) from 337/336 B.C. till his death in 302/301. Suspected of treachery by Antigonus I Monophthalmus, he may have been escaping to the east with his son when he was killed.

MITHRADATES II, to whom scholars before Rostovtzeff commonly assigned the title Mithradates I Ctistes, was the son of the foregoing. Warned by his friend Demetrius Poliorcetes, the son of Antigonus, that he had incurred the same disfavour as his father, he fled to Paphlagonia, where he seized Cimiata, a fort at the foot of the Olgassys range (modern Ilgaz Daglari). Joined by the Macedonian garrison and by neighbouring populations, he conquered Cappadocian and Paphlagonian territories on both sides of the Halys river to form the nucleus of his kingdom of Pontic Cappadocia or Pontus (*q.v.*). He died in 266/265 B.C., leaving the kingdom to his son Ariobarzanes.

MITHRADATES III was very young when he succeeded his father, Ariobarzanes (*c.* 255 B.C.). Early in his reign the Gauls of Galatia (*q.v.*) invaded Pontus. Mithradates was at the battle of Ancyra (*c.* 240), in which he assisted Antiochus (*q.v.*) Hierax against the latter's brother, the Seleucid king Seleucus II Callinicus. His wife, their sister Laodice, had brought him Greater Phrygia as her dowry; and his daughter, also named Laodice, married a later Seleucid king, Antiochus (*q.v.*) III. He attacked Sinope (Sinop) (*c.* 220) but it was not taken until after his death (*c.* 185). His son and successor Pharnaces I took Sinope (183), which he made the capital of the kingdom instead of Amasya (Amasia), and tried also to extend his power into the Tauric Chersonese (Crimea).

MITHRADATES IV PHILOPATOR PHILADELPHUS, a younger son of Mithradates III, may have reigned for a time conjointly with his brother Pharnaces and then occupied the throne in a form of regency (*c.* 170–*c.* 150) for the latter's son. He assisted Attalus II of Pergamum to resist Prusias II of Bithynia.

MITHRADATES V EUERGETES, the son of Pharnaces, appears to have become sole ruler of Pontus *c.* 150 B.C. At first a friend of the Romans, he sent them a contingent during the Third Punic War and helped them to get possession of Pergamum (bequeathed to them by Attalus III, but claimed by Aristonicus, a natural son of Eumenes II). Nicomedes II of Bithynia also helped the Romans in this affair (133–131 B.C.), and both he and Mithradates expected to be rewarded with Phrygia. A commission awarded it to Mithradates, but the Roman senate refused to ratify the bargain on the grounds of bribery. Mithradates appears to have taken Phrygia without waiting for a new award. He invaded Cappadocia and married his daughter to the young king Ariarathes VI Epiphanes. He acquired the succession of Paphlagonia from its last king, Pylaemenes, and obtained a kind of protectorate over Galatia. At the height of his power, in 121 or 120 B.C., he was assassinated by his courtiers during a banquet in his palace at Sinope.

MITHRADATES VI EUPATOR, called THE GREAT (d. 63 B.C.), succeeded his father Mithradates Euergetes *c.* 121 B.C. He was then only a boy and for a few years his mother ruled in his place. About 115 she was deposed and thrown into prison, and Eupator ruled alone. He began his long career of conquest by dispatching successful expeditions to the Crimea and to Colchis (on the eastern shore of the Black sea). Both districts were added to the Pontic kingdom. To the Greeks of the Tauric Chersonese and the Cimmerian Bosporus (Crimea and Straits of Kerch) Mithradates was a deliverer from their Scythian enemies and they gladly surrendered their independence in return for the protection given to them by his armies. In Asia Minor, however, the royal dominions had been considerably diminished after the death of Mithradates V.: Paphlagonia had freed itself, and Phrygia (*c.* 116 B.C.) had been linked to the Roman province of Asia. The king's first move there was to partition Paphlagonia and Galatia between himself and Nicomedes III of Bithynia; but next he quarreled with Nicomedes over Cappadocia. Successful at first on two occasions, he was on both deprived of his advantage by Roman intervention (*c.* 95 and 92). While appearing to acquiesce, he resolved to expel the Romans from Asia. A first attempt to depose Nicomedes IV of Bithynia, who was completely subservient to the Romans, was frustrated (*c.* 90). Then Nicomedes, instigated by Rome, attacked Pontic territory, and Mithradates, after protesting in vain to the Romans, finally declared war (88).

Nicomedes and the Roman armies were defeated and flung back to the coasts of the Propontis and the Aegean. The Roman province of Asia was occupied and most of the Greek cities in western Asia Minor allied themselves with Mithradates, though a few held out against him, such as Rhodes, which he besieged unsuccessfully. He also sent large armies into Greece, where Athens and other cities took his side. But the Roman generals, Sulla in Greece and Fimbria in Asia, defeated his forces in several battles during 86 and 85. In 88 he had arranged a general massacre of the Roman and Italian residents in Asia (80,000 are said to have perished), in order that the Greek cities, his accessories in the crime, should feel irrevocably committed to the struggle against Rome. As the war turned against him his former leniency toward the Greeks

changed to severity; every kind of intimidation was resorted to—deportations, murders, freeing of slaves. But this reign of terror could not prevent the cities from deserting to the victorious side. In 85 when the war was clearly lost he made peace with Sulla in the treaty of Dardanus, abandoning his conquests, surrendering his fleet, and paying a fine of 2,000 talents.

In what is called the Second Mithradatic War, L. Licinius Murena invaded Pontus without any good reason in 83, but was defeated in 82. Hostilities were suspended, but disputes constantly occurred, and in 74 a general war broke out. Mithradates defeated M. Aurelius Cotta, the Roman consul, at Chalcedon; but Lucullus worsted him outside Cyzicus (73) and drove him in 72 to take refuge in Armenia with his son-in-law Tigranes. After two great victories at Tigranocerta (69) and Artaxata (68), Lucullus was disconcerted by the defeat of his lieutenants and by mutiny. (*See* LUCULLUS, LUCIUS LICINIUS.) In 66 he was superseded by Pompey, who completely defeated both Mithradates and Tigranes. Mithradates established himself in 64 at Panticapaeum (Kerch) on the Cimmerian Bosporus and was planning an invasion of Italy by way of the Danube when his own troops, led by his son Pharnaces II, revolted. After vainly trying to poison himself, Mithradates ordered a Gallic mercenary to kill him. So perished (63 B.C.) Rome's greatest enemy in Asia Minor. His body was sent to Pompey, who buried it in the royal sepulchre at Sinope.

Mithradates was a man of great stature and physical strength, a brave fighter and a keen hunter. The ancient historians have invested him with a halo of romance and many strange stories are told of his life. Whatever their truth, there can be no doubt that he had some of the worst traits of the oriental despot, cruelty and sensuality in particular. On the other hand, it cannot be denied that he was a ruler of astonishing energy and determination, or that he possessed political skill of a high order. The fact that he was one of the few men to offer a serious challenge to the Roman republic is sufficient testimony to his ability. He organized the forces at his disposal very effectively and he had a good grasp of strategy. He was unlucky in having to face three exceptionally brilliant Roman generals; unlucky, too, in coming to power at a time when the Hellenistic world was in the final stage of its collapse. It is quite conceivable that had he been born a century earlier he could have constructed an enduring Greco-Asiatic empire after the fashion of the Parthian kings. A cunning, brutal tyrant, he concerned himself solely with maintaining and strengthening his own power. He posed as the champion of Hellenism, the "new Dionysus," but this was in furtherance of his political ambitions; it is no proof that he was deeply imbued with Greek culture or that he felt a mission to promote its extension within his domains. Hellenism made advances in Pontus during his reign, as it had under his predecessors, but this was a natural process. He treated all alike. Greek, Roman and Asiatic were welcome at his court provided that they could be of use to him (his military subordinates were mostly Greeks, though in later years he employed several Roman renegades); but he trusted no one. Just as it is impossible to speak of his favouring one religion or culture above another, so it is impossible to believe that he had any notion of bringing Greeks and Asiatics closer together in a new kind of political and social system. His posing as a liberator of the Greeks from Roman oppression and, later, his encouragement of social revolution in the Greek cities of the province of Asia were in both cases the actions of an opportunist seeking immediate political advantages.

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**MITHRAISM,** the worship of the Indo-Iranian god of light Mithra (Sanskrit *Mitra*), which spread from Persia to Asia Minor and thence to Rome and many parts of the Roman empire. One of the last of the oriental mystery cults to reach the west, Mithraism was also one of the most vigorous, and in the final death struggle of paganism it emerged as a chief rival and opponent of Christianity.

**History.**—The position of Mithra in Iran, though greater than that of Mitra in Vedic India, held little promise of the god's future career in the west. He is not mentioned in the *Gathas*, which suggests that he was deliberately ignored in the monotheistic reforms of Zoroaster. Later Zoroastrianism found room for him, though only as subordinate to the supreme god Ormizd (Ahura Mazda). He appears with Ormizd and Anahita, the goddess of waters, in royal inscriptions of the 4th century B.C., and Achaemenid kings of the period seem to have regarded him as their special patron. The Avestan hymns, notably *Yasht* x, depict him as the god of heavenly light, all-seeing, the guardian of oaths, protector of the righteous in this world and the next, and above all as archfoe of the powers of evil and darkness and hence god of battles.

It was not, however, this national cult of Mithra that was to attract the west, but rather an amalgam, in effect a new creation, that sprang up abroad in the wake of the Persian conquests. The scanty information available does not make it possible to trace the development in detail, but it was almost certainly in eastern Anatolia, where Persian traditions survived longest, that the new religion took its definitive form. Babylonia contributed, as it did to most forms of late paganism, the fatal allure of its pseudo science, Chaldaean astrology, while Greek artists and Greek religion and philosophy provided the models, at least indirectly, for Mithraic iconography and the Mithraic mysteries. Yet despite its veneer of Hellenization, the cult had little appeal for Greeks, and only scattered traces are found in Greece and the Greek east.

A passage of Plutarch (*Pompey*, 24) may imply that the rites were first brought to the attention of the west by Cilician pirates captured in 67 B.C., but it was not until late in the 1st century A.D. that Mithraism took firm root in the west, and it began to expand rapidly only in the following century. Rome itself, and its seaport Ostia, always remained a great centre of the cult, which reached to Numidia in the south and as far north as the Roman wall in Britain. It was, however, in the Danubian provinces and along the Rhine that Mithra was most popular, apart from Rome; in western Gaul and the Spanish peninsula he seldom appears.

The new religion owed its diffusion primarily to the army, many of whose recruits were drawn from the Anatolian centres of Mithraic worship, and also to the traffic in oriental slaves; trade routes too played a part, since the stern probity of the god was attractive to the mercantile classes. The cult's chief appeal was at all times to the lowly and humble, and the influence and extent of imperial interest probably has been overemphasized by some scholars. The initiation of the emperor Commodus (A.D. 180–192) was a passing fancy without lasting effect. The institution by Aurelian (A.D. 274) of a state cult of the "unconquerable Sun," *Sol invictus*, may have contributed incidentally to the prestige of Mithra, who also bore this proud title, but Mithra never achieved a place in the public cults of the state, and it is not until *c.* 307, under Diocletian, that an imperial dedication to Sol Invictus Mithra, acclaiming him as "a protector of the empire," is found. Yet in fact Dacia, long a stronghold of Mithraism, had already been abandoned to the barbarians (*c.* 270)—the first Roman province to suffer this fate.

With the advent of the Christian emperors, imperial favour gave way to hostility and even to persecution. The victory of Theodosius in 394 effectively put an end to the cult, but not before the pagan revival under Julian the Apostate (360–363) and the final rally of the pagan aristocracy at Rome had for a few decades made the Persian god a principal symbol of the dying past.

**Monuments, Myth and Ritual.**—In the absence of liturgical works or extensive literary accounts, the interpretation of Mithraism depends chiefly on archaeological evidence, above all the sculptures that adorned the sanctuaries. Dedicatory inscriptions, in Latin or Greek, provide some significant details, and the polemic of Christian writers is often suggestive.

The Mithraic chapels, referred to as *spelaea* ("grottoes"), were sometimes actual caves, more often small underground crypts. A narrow aisle was flanked on both sides by a broad raised bench, on which the worshipers, rarely more than 50 in number, could kneel or recline. At one end, often apselike, stood the representation of Mithra slaying the bull, evidently the crowning episode in Mithraic myth and perhaps in the ritual. The scene normally

includes a pair of torch bearers flanking the central figures, a scorpion attacking the genitals of the bull, a serpent drinking its blood and a dog springing toward the wound in its side. Sun-god, raven (perhaps the messenger of the sun-god), tree, lion and ewer are sometimes added, and, framing the scene, the signs of the zodiac. Finally, this whole unit may be surrounded by a series of smaller panels, filled with mythical scenes or symbolic figures.

On the basis of the sculptures, eked out with references from the literature, attempts have been made to reconstruct the Mithraic theology and legend. Though probably subordinate both to the first principle, Zurvan Akarana (Infinite Time), and to Ahura Mazda, Mithra, as the creator and as mediator between man and the higher gods, was clearly the chief deity of the cult as practised. A curious lion-headed human figure, about which a serpent coils, has usually been identified as Zurvan Akarana, but it seems more likely that he is instead Ahriman, the power of death and darkness, who was perhaps regarded as the prince of this world. Mithra's own legend is depicted in detail, though the interpretation necessarily remains dubious. Among the events that appear certain are the birth of Mithra from a rock, his shooting an arrow at a cliff to bring forth water, his adventures in pursuit of the sacred bull, ending with his reluctant (?) sacrifice of the animal, his alliance with the sun-god, the banquet shared with him and his ascent to heaven in the chariot of the Sun. According to Persian sources the bull, apparently in origin a vegetation spirit, by its death gave birth to all living things; thus Mithra became the creator of life, as by his other exploits he was its protector against evil.

As to the organization of the mysteries, it is known that there were seven degrees of initiation open to the adept, perhaps corresponding to the seven planetary spheres to be traversed by the soul in its upward progress: *Corax*, Raven; *Nymphius*, Bridegroom; *Miles*, Soldier; *Leo*, Lion; *Perses*, Persian; *Heliodromus*, Courier of the Sun; *Pater*, Father. (Except that *Pater* is the highest and *Leo* somewhere in the middle, there is no certainty as to the order.) Those in the lowest ranks were called servants, those in the ranks of *Leo* and above, participants, perhaps with reference to the sacred meal of bread and water, which Christian writers likened to the Eucharist.

Initiation was open to men of all ages, even boys; women were excluded. Intensive purifications, including perhaps a sort of baptism, were prerequisite to initiation, and at each degree the initiate underwent certain ordeals, which however crude or fearsome were charged for him with symbolic meaning; thus the *Miles* was branded on the forehead, to mark him henceforth as a recruit in the army of Mithra, sworn to combat all evil. At the head of each group was either a *Pater* or priest. The latter was designated, in usual Roman fashion, as *sacerdos* or *antistes*; there is no hint of the Persian *magus* or anything resembling a priestly caste. Despite the fixity of the iconography and, presumably, of the doctrines, there was no ecumenical organization or hierarchy; at most in each large centre there was a *pater patrum*, as it were, an overseer or bishop. Since Mithraism never became, officially, a recognized cult of the Roman empire, the separate groups of worship remained, like other nonpublic cults, private associations, administered by their own nonclerical officials and supported by private contributions. The numerous dedications, together with the simplicity of the sanctuaries, attest the fervid piety of the worshipers and no less their prevailingly modest circumstances. In fact the cult knew no social distinctions, and slave, freeman, rich, poor, labourer and noble met here as equals.

Like the other oriental mystery religions, but perhaps with more cause, Mithraism offered the appeal of an exotic and ancient wisdom. It professed to explain the origins of the universe and also its end; and Mithra, who had created once and was now man's defender and helper, would in those final days inaugurate a new order in which the faithful would enjoy forever a blessed immortality. Mithra, like the other oriental gods, offered man deliverance, but unlike such others as Attis or Osiris he could also serve as an ideal, a heroic leader for man to follow and emulate in the struggle against evil. A vigorous and positive morality characterized Mithraism throughout its career and constituted one of its chief attractions.

"THE GOD MITHRA SACRIFICING A BULL." ROMAN BAS-RELIEF IN THE LOUVRE, PARIS (HEAD HAS BEEN RESTORED)

**Relations to Christianity.**—The oft-quoted opinion of Ernest Renan, that if the growth of Christianity had been stopped early in its history the world would have been Mithraic, has less value, perhaps, as a historical judgment than for its evocation of how the religious conflict might have seemed to a 3rd-century Christian or Mithraist. Superficially, at least, the two religions had much in common: a divine Lord by whose deeds, performed once (unlike the annual passion of an Attis or an Osiris), man was assured of salvation; a sacramental meal; a ritual of baptism; a concept of religion that could liken the religious life to enlistment and service under a divine commander, *militia Christi* or *militia Mithrae* (though in the case of Mithraism this perhaps did not imply the cosmic struggle between good and evil that appears in both Christianity and Zoroastrianism); not dissimilar ideas of heaven and hell and of a Last Judgment; and a moral code considerably higher and more rigid than that found in contemporary society or required by most other cults. It is not surprising that pious Christians regarded these traits of the rival religion as satanic inventions, parodies of the rites and beliefs of the true church. The last stages of paganism did indeed witness some conscious borrowing of Christian religious patterns, but the more deeply rooted similarities are best explained in terms of a common oriental background.

The similarities were in any case outweighed by the differences, and in these Christianity generally had the advantage. In a period when philosophic and popular thought was increasingly tending to monotheism, Mithraism, for all its exaltation of Mithra, was securely bound to its polytheistic traditions. Mithraism suffered, too, in comparison by having as its redeemer a mythical figure, whose appeal could never match that of the historical Jesus worshiped by Christians as God incarnate. And Mithraism was fatally weak in its exclusion of women. Its distribution, except in the metropolitan centres, is significant: it flourished chiefly where particular conditions, military or mercantile, created a "man's world," and it was weakest where ordinary civilian patterns prevailed. Mithraism failed to use the family as a source of religious strength and continuity. This failure may help to explain why, when the circumstances favourable to its growth at last changed, the imposing edifice of Mithraism collapsed so suddenly and disappeared with such surprising rapidity.

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**MITO,** historic Japanese city and capital of Ibaraki prefecture in central Honshu. A commercial and railroad centre, it is about 60 mi. N.E. of Tokyo on the northern edge of the Tokyo plain. Between 1940 and 1960 its area increased from 13 sq.km. (5 sq.mi.) to 146 sq.km. (56.4 sq.mi.) and the population from 66,300 to 139,389. An ancient castle town, Mito became the seat of one of the three main branches of the Tokugawa family in 1606.
(C. A. Mr.)

**MITRE, BARTOLOMÉ** (1821–1906), was an Argentine statesman, soldier and author who contributed much to his nation's progress in the second half of the 19th century. Born in Buenos Aires on July 26, 1821, Mitre moved with his family to Uruguay in the 1830s. He entered military school and joined the liberal exiles from Argentina in their literary opposition to the dictator Juan Manuel de Rosas. Because of his liberalism, Mitre became an exile from Argentina. From Uruguay he traveled to Bolivia, Peru and Chile, where he studied, wrote, served in military campaigns and plotted against Rosas. When Rosas was finally defeated at Caseros (1852), Mitre played a prominent role as commander of Uruguayan artillery.

After the fall of Rosas, Argentina desperately needed constitutional government to unify the nation and develop the economy. Mitre believed that the port city and fertile agricultural province of Buenos Aires must lead the country. Therefore, he worked to split his province away from the new Argentine Confederation; as governor and commander of the provincial army he defeated the forces of the confederation at Pavón (1861). He then moved the national capital to Buenos Aires and was elected president of Argentina, serving from 1862 to 1868. An informed believer in the doctrines of European liberalism, Mitre created and strengthened instruments of civil administration, suppressed provincial *caudillos* and encouraged foreign immigration and investment. He also led the allied forces for a time during the Paraguayan War.

After his presidency Mitre was elected to the senate, where he long served. In 1874 he led an unsuccessful revolution, claiming that he had been defrauded of the presidency by the government in the elections of that year. In 1891, in another unfortunate venture into presidential politics, he became the candidate of the new middle class Unión Cívica party, only to withdraw in favour of the conservatives, thus assuring the continued political domination of the oligarchy.

Despite these events Mitre in the last years of his life came to hold a high position in Argentine hearts as a wise and honest elder statesman, a link to the turbulent past and a guide in the booming present. He died in Buenos Aires on Jan. 18, 1906.

His contributions to Argentine cultural development were also of first importance. He was founder and proprietor of the newspaper *La Nación* (1870). He wrote much poetry and many prose works and did considerable translating, including Dante's *Divine Comedy*. His major accomplishments were his historical studies. He wrote the multivolume works *Historia de Belgrano* and *Historia de San Martín*, and he was the founder of the Argentine Academy of History. (T. F. McG.)

**MITRE,** a liturgical headdress of the Western Church, generally proper to bishops. The word is derived through the Latin from the Greek *mitra*, "turban."

In the Roman Catholic Church its actual form is that of a sort

BY COURTESY OF MUSÉE GROENINGE, BRUGES. PHOTOGRAPH, ART REFERENCE BUREAU

DETAIL OF ST. DONATIAN WEARING MITRE AND BANDS FROM "MADONNA WITH CANON VAN DER PAELEN." PAINTED FOR THE CHURCH OF ST. DONATIAN IN BRUGES, BELG., BY JAN VAN EYCK, 1436. IN MUSÉE GROENINGE (MUSÉE COMMUNAL DES BEAUX-ARTS), BRUGES

of folding cap consisting of two halves which, when not worn, lie flat upon each other. These sides are stiffened and when the mitre is worn rise in front and behind like two horns pointed at the tips. From the lower rim of the mitre at the back hang two bands (*infulae*), terminating in fringes. Mitres are divided into three classes: (1) *mitra pretiosa* (precious mitre), decorated with jewels, gold plates, etc.; (2) *mitra auriphrygiata* (golden or orphreyed mitre), of white silk, sometimes embroidered with gold and silver thread or small pearls or of cloth of gold plain; (3) *mitra simplex* (simple mitre), of white silk damask, silk or linen, with the two falling bands behind terminating in red fringes. Mitres have been since the 12th century the distinctive headdress of bishops, but the right to wear them, as in the case of the other episcopal insignia, is granted by the popes to other dignitaries. Bishops alone (including of course the pope and his cardinals) are entitled to wear the *pretiosa* and *auriphrygiata;* others wear the *mitra simplex*.

The original form of the mitre was that of the early papal tiara (*q.v.*); *i.e.*, a somewhat high conical cap. The stages of its general development from this shape to the high double-horned modern mitre are clearly traceable though it is impossible exactly to distinguish them in point of date. The most characteristic modifications may be said to have taken place from the 11th to the middle of the 13th century. About 1100 the conical mitre begins to give place to a round one; a band of embroidery is next set over the top from back to front, which tends to bulge up the soft material on either side; and these bulges develop into points or horns. Mitres with horns on either side seem to have been worn until the end of the 12th century. The custom of setting horns over the front and back of the head instead of the sides, however, was already growing and with this the essential character of the mitre during the middle ages was established.

In most of the Reformed churches the use of mitres was abandoned with that of the other vestments. They have continued to be worn, however, by the bishops of the Scandinavian Lutheran churches. In the Church of England the liturgical use of the mitre was discontinued at the Reformation but was revived in the latter part of the 19th century and has come to be fairly widespread.

In the Orthodox Eastern Church the mitre is proper only to bishops. Its form differs entirely from that of the Latin Church. In general it rather resembles a closed crown, surmounted by a cross. In Russia the cross usually lies flat, only certain dignitaries having the right to have the cross upright. In the Armenian Church priests and archdeacons as well as bishops wear a mitre. In the Syrian Church only the patriarch wears a mitre, which resembles that of the Greeks. The *burnā* of the Chaldean Nestorians, on the other hand, worn by all bishops, is a sort of hood ornamented with a cross. Coptic priests and bishops wear the *ballin*, a long strip of stuff ornamented with crosses, etc., and wound turban-wise around the head. The patriarch of Alexandria has a helmetlike mitre, the origin of which is unknown, though it perhaps antedates the appearance of the *phrygium* at Rome. The Maronites and the Uniate churches have adopted the Roman mitre.

*See* also VESTMENTS, ECCLESIASTICAL.

**MITROPOULOS, DIMITRI** (1896–1960), Greek-U.S. symphony and opera conductor, was born in Athens, Feb. 18, 1896. After serving as assistant conductor of the Berlin State opera from 1921 to 1924, he was director of the Athens conserva-

tory until 1930, then appeared as guest conductor and pianist with leading European orchestras.

He went to the U.S. in 1936 as guest conductor of the Boston Symphony orchestra, and was director of the Minneapolis Symphony from 1937 to 1949. Rejecting the traditional social obligations of the position, he adhered to an austere routine. However, he won a devoted following. He became a U.S. citizen in 1946.

He served as musical director of the New York Philharmonic-Symphony society from 1951 to 1955. In 1954 he began a new career as a conductor of the Metropolitan Opera, and became the Metropolitan's principal conductor in 1958. He died Nov. 2, 1960, in Milan, Italy, following a heart attack sustained at an opera rehearsal at La Scala. (J. Av.)

**MITSCHER, MARC ANDREW** (1887–1947), U.S. naval officer, who with conspicuous success commanded the aircraft carrier force, the famous task force 58, in the Pacific during World War II. He was born in Hillsboro, Wis., Jan. 26, 1887, and graduated from the United States Naval academy in 1910. On June 2, 1916, he qualified as the 33rd U.S. naval aviator. Mitscher had an important share in the development of naval aviation and in the integration of aviation into the U.S. fleet. Early in World War II he commanded the aircraft carrier "Hornet" in the battle of Midway. As a rear admiral, he commanded all aircraft in the Solomon Islands during bitter fighting there in 1943. As a vice admiral he commanded the fast carriers from Jan. 6, 1944, leading this task force in air strikes on Truk, in the battle of the Philippine sea, the battle for Leyte gulf, and the captures of Iwo Jima and Okinawa.

Mitscher died on Feb. 3, 1947, while serving as commander in chief of the U.S. Atlantic fleet, having held the rank of admiral from Sept. 13, 1946. (J. B. Hs.)

**MITTAG-LEFFLER, MAGNUS GÖSTA** (1846–1927), Swedish mathematician who founded *Acta Mathematica*, was born at Stockholm on March 16, 1846. He studied at Uppsala and later became lecturer at the University of Uppsala (1872–77), professor at Helsingfors (1877–81) and finally professor at Stockholm, being rector of the university in 1886, 1891 and 1893. Mittag-Leffler founded the journal *Acta Mathematica* in 1883, set up an editorial staff from the four Scandinavian countries, gained the patronage of Oscar II of Sweden and acted as chief editor for 45 years.

Mittag-Leffler made a number of contributions to analysis. He worked on the general theory of functions and gave a proof of Cauchy's theorem. He also dealt with the problem of the analytic representation of a one-valued function a result of which was the well-known Mittag-Leffler theorem. A good deal of his researches laid the foundation of later work of the Swedish school of function theoretical studies. He died at Stockholm on July 7, 1927, leaving his estate and mathematical library to the Mittag-Leffler Mathematical institute at Djursholm near Stockholm. (O. Oe.)

**MITTELLAND CANAL** (Ems-Weser-Elbe-Kanal), a German waterway begun in 1905 and completed in the late 1930s. It runs from the Dortmund-Ems canal east of Rheine and eastward along the northern border of the Central Uplands, to the Elbe north of Magdeburg (a distance of about 290 mi.), linking there with the Havel canal eastward to Berlin. Side canals connect it with Osnabrück, Hanover, Salzgitter (the new iron and steel centre) and Hildesheim. Peine (iron and steel works), between Brunswick and Hanover, and Wolfsburg (Volkswagen plant) are both on the main canal, which carries barges of up to 1,000 tons. It is closed by ice for two to three weeks in winter. Locks connect it with the Weser and Elbe rivers. A large part of the traffic consists of coal and iron ores. *See* also Ems River; Weser; Elbe. (R. E. Dl.)

**MIVART, ST. GEORGE JACKSON** (1827–1900), English biologist, known for his studies of comparative vertebrate anatomy, was born on Nov. 30, 1827, in London. In 1851 he was called to the bar, but devoting himself to scientific studies, he was appointed lecturer at St. Mary's hospital medical school in 1862, and from 1874 to 1877 was professor of biology at the short-lived Catholic University college, London. In 1871 his essay *On the Genesis of Species* brought him into the controversy then raging round the theories of Darwin, and ultimately led to his estrangement from both Darwin and Huxley. Though admitting evolution in general, Mivart emphasized the distinction between organic and inorganic matter, minimized the importance of natural selection, and, especially in his *Nature and Thought* (1882) and *The Origin of Human Reason* (1889), denied the evolution of the human intellect.

Among the scientific works of Mivart are: *Lessons in Elementary Anatomy* (1873), *Man and Apes* (1873), *The Common Frog* (1874) and *The Cat: an Introduction to the Study of Backboned Animals* (1881). Some articles published in the journal *Nineteenth Century*, while he was professor of the philosophy of natural history at Louvain, advocated the claims of science even where they seemed to conflict with religion, and were placed on the *Index*. Other articles in Jan. 1900 confirmed his unorthodoxy and led to his excommunication by Cardinal Vaughan, with whom he had a curious correspondence about holding liberal opinions while remaining a Catholic. He died of diabetes shortly afterward, in London, on April 1, 1900.

See *Dictionary of National Biography*, vol. xxii (Supplement), pp. 1051–53.

**MIXE-ZOQUE** (Zoquean), a family of languages spoken by Mexican Indians, comprising Mixe (in eastern Oaxaca), Zoque (chiefly in northwestern Chiapas) and Popoluca (in east central Veracruz). The extinct Tapachulteca (of southern Chiapas) was apparently a dialect of Zoque. Genetic relationships among these languages have been clearly demonstrated; more distant affinities have been suggested as possible between Mixe-Zoque and the Mayan and Totonacan families. The 1950 census showed 46,101 Mixe and 18,023 Zoque; Popoluca was listed with the linguistically unrelated Popoloca of Puebla with a combined figure of 17,163.

*See* R. L. Beals *Ethnology of the Western Mixe* (1945); S. S. Hoogshagen and W. R. Merrifield, "Coatlán Mixe Kinship," *Southwestern Journal of Anthropology*, vol. 17 (1961). (W. L. Wo.)

**MIXTEC,** a Mexican Indian people occupying much of the western half of the state of Oaxaca as well as adjacent areas of the states of Guerrero and Puebla. They are culturally and politically important in the history of pre-Columbian Mesoamerica (*see* Middle America). Ranging from mountainous highlands to the Pacific coast, they did not achieve political unity—although four main centres of Mixtec power eventually emerged. On their eastern frontier the Mixtecs fought with the Zapotecs for the possession of border areas. Such centres as Monte Albán (now an archaeological site and tourist attraction outside Oaxaca city) presumably changed hands between Zapotecs and Mixtecs several times. On their western frontier the Mixtecs fought the Aztecs (*q.v.*), who finally subdued them not many years before the Spanish conquest. Surrounding peoples (such as the Mazatecs) were under Mixtec domination at certain times. The last independent Mixtec "kingdom" was conquered by the Spaniards over a quarter of a century after the conquest of Mexico City (1521).

The Mixtec language, along with Cuicatec and Trique, belongs to the Mixtecan language family. This family is, in turn, a branch of the Oto-Manguean stock of which Popolocan, Amuzgoan, Zapotecan, Otopamean, Chinantecan and Chiapanec-Mangucan are other branches. Like most Oto-Manguean languages and dialects, Mixtec has an involved system of musical pitches or tones that are lexically significant. In the 1960s about 155,000 people spoke Mixtec. *See* also Oaxaca.

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**MIYAGI,** a prefecture (*ken*) in northeastern Japan, is the centre of communications and trade for the Tōhoku (northern Honshu) region. Area 2,813 sq.mi. Pop. (1960) 1,743,195. Miyagi was formed from sections of Rikuzen and Iwaki provinces which were part of Mutsu province before the restoration of 1868.

Its western mountains are part of the central range of Honshu. Its coastal range is broken by Matsushima bay, a beauty spot famous since Tokugawa times, and Sendai plain which contains Sendai, capital of the prefecture. Considerable effort has been made to develop sea trade by improving the harbours of Ishinomaki and Shiogama. (C. A. Ma.)

**MIYAZAKI,** a Japanese prefecture (*ken*) in southeastern Kyushu, was formed from the province of Hyūga after the restoration of 1868. Area 2,986 sq.mi. Pop. (1960) 1,134,590. Miyazaki is mountainous with a small coastal plain. A long growing season and the presence of the Japan current along its coast make two crops of rice possible in one year. The chief products are chemicals, wood pulp, bamboo goods and charcoal.

Miyazaki city (pop. [1960] 158,328), communications centre and capital of Miyazaki prefecture, is located on the largest agricultural plain of southeastern Kyushu. Miyazaki shrine commemorates the legend that the travels of the first emperor of Japan, Jimmu Tennō, started there (*see* SHINTŌ: *Primitive Shintō*).

(C. A. MR.)

**MIZO,** an autonomous district of Assam, India, was formerly known as the Lushai Hills district. It is the largest district of the state (area 8,134 sq.mi.) and is situated in the extreme south between Burma on the east and south and the Sarti hills of East Pakistan on the west. To the north lies the state of Manipur and the districts of Cachar and Tripura. Geologically the Lushai hills form a part of the Arakan arc which consists of compact parallel ridges with a north-south axis formed of Tertiary sandstone, limestone and shales. The ridges reach up to 7,000 ft. Pop. (1961) 266,063.

The hills are covered with thick evergreen forest containing valuable timbers and wild animals including elephant, rhinoceros, tiger, bear and deer. In the intermontane valleys *jhum* tillage (whereby tracts are cleared by burning and sown with mixed crops) and terrace cultivation are practised. Rice, maize (corn), cotton and vegetables are the main crops. Aijal and Lungleh are connected by a motor road with Silchar in Cachar district. With the independence of India in 1947 a road-building program was undertaken with the primary object of completing a north-south route from Silchar through Aijal to Paletwa in the Arakan district of Burma.

The area was originally inhabited by a small tribal group of Tibeto-Burman stock. Between 1750 and 1850 the Lushais migrated from the Chin hills and subjugated the aborigines, assimilating these similar tribes into their own society. The Lushais have a well-developed system of chieftainship and the whole district is divided into about 300 hereditary chieftainships. The Lushais are of the same kin as the Kukis, who are their neighbours but are fewer in number. More than 40% of the Lushais of this district are literate, the majority of these being Christians. The most powerful political organization of the Lushais is the Mizo union. It stands for the liquidation of the chieftainship and the establishment of a democratic land administration. At first Lushai Hills was divided into two administrative units, the southern unit administered by the government of Bengal and the northern by that of Assam. In 1898 the two parts were amalgamated into one administrative district and put under the government of Assam. A district council, as in other hill districts, administers Mizo under the Indian constitution. There are two subdivisions in the district: Aijal (pop. [1961] 14,257), the district headquarters, and Lungleh, the subdivisional headquarters. *See* also LUSHAI.

(M. BA.)

**MIZPAH** (MIZPEH) is the name of several places in the Old Testament: (1) the Hurrian land of Mizpah near Mt. Hermon (Josh. xi, 3, 8); (2) Ramath-mizpeh of Gilead (Josh. xiii, 26), probably the same as the Mizpah attacked by the Ammonites (Judg. x, 17) and the residence of Jephthah (Judg. xi, 11, 29, 34); (3) Mizpeh of Moab (I Sam. xxii, 3); (4) Mizpeh of southern Judah, probably near Lachish (Josh. xv, 38); (5) Mizpeh of Benjamin (Josh. xviii, 26), a point of assembly of the tribes (Judg. xx, 1–3, xxi, 1–8; I Sam. vii, 5–12, x, 17) and a holy place (Hos. v, 1).

The last is by far the most important. Asa of Judah fortified it against Israel (I Kings xv, 22), the border of Israel and Judah ran very near it. It was the residence of Gedaliah, appointed governor of Judah by the Babylonians after the fall of Jerusalem (II Kings xxv, 23–25; Jer. xl, 10, 15) and there Gedaliah and his companions were murdered by Ishmael (Jer. xli). Mizpah was occupied in the time of Nehemiah (Neh. iii, 7) and gave its name to the district (Neh. iii, 15) governed by the "ruler of Mizpah" (Neh. iii, 19). In the Maccabean period it was a place of assembly, the memory of its sanctuary still surviving (I Macc. iii, 46). Traditionally located at the hill of Nebi Samwil, about six miles northwest of Jerusalem, Mizpah is more probably identified with Tell en-Nasbeh, about eight miles north of Jerusalem. The site, excavated by W. F. Badè in 1932–35, disclosed massive fortifications from the 10th century B.C., in particular a well-preserved revetment, burial vaults and a Canaanite high place.

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(J. L. MCK.)

**MIZRAIM** (Hebrew MISRAYIM) is the Hebrew name for Egypt. In the Authorized version of the Bible, at Gen. x, 6 and 13, "Mizraim" is given as the name of one of the sons of Ham ("Mesram" in the Douai version). The Revised Standard version uses "Egypt" everywhere.

**MJÖSA, LAKE,** in Oppland and Hedmark *fylker* (counties) and the largest lake in Norway, is situated to the south of the Gudbrandsdal (*q.v.*). It is about 62 mi. long and 1–10 mi. wide, covering an area of 141 sq.mi., and has a maximum depth of 245 fathoms; it contains the small island of Helgøy. The Lågen river (*q.v.*) empties into its northern end, and it is drained south by the Vorma into the Glomma (*q.v.*) river. Mjösa abounds in fish (trout, fresh-water herring) and is a popular boating area. The surroundings of the lake vary from open cultivated landscape to forested hills; Lillehammer, at the northern end of the lake, is a noted tourist centre. Hamar and Gjøvik on the eastern and western shores, respectively, are industrial and commercial towns.

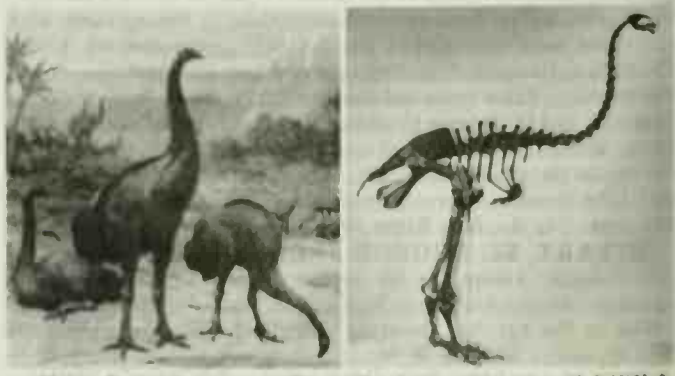
(L. H. HG.)

**M.K.S.** (GIORGI) **SYSTEM:** *see* PHYSICAL UNITS.

**MNEMONICS,** or *memoria technica*, the general name applied to devices for aiding the memory. The principle is to enable the mind to reproduce a relatively unfamiliar idea, and especially a series of dissociated ideas, by connecting it, or them, in some artificial whole, the parts of which are mutually suggestive. Among the most famous examples of metrical mnemonics are the "gender rhymes" of the Latin grammars, the hexameter lines (especially that beginning "Barbara Celarent") invented by logicians and the verse for remembering the number of days in the months ("Thirty days hath September, April, June and November"). *See* also MEMORY.

**MNESICLES,** the architect of the great Propylaea of the Athenian Acropolis, set up by Pericles about 437 B.C.; *see* PROPYLAEA. Mnesicles is also thought to have been the original architect of the Erechtheum (*q.v.*).

**MOA,** the Maori name of the extinct, flightless, ostrichlike birds comprising the New Zealand order Dinornithiformes (*see* BIRD). In the North Island the moas seem to have died out about 500–700 years ago, probably before the arrival of the Maoris. In the South Island moas of the genus *Emeus* lingered much longer, possibly in the unexplored interior even down to the



BY COURTESY OF CHICAGO NATURAL HISTORY MUSEUM (LEFT) FROM A MURAL BY CHARLES R. KNIGHT

MOA (DINORNIS ROBUSTUS), EXTINCT FLIGHTLESS BIRD. AT LEFT, RESTORATION DRAWING. AT RIGHT, SKELETAL CAST OF RECENTLY EXTINCT NEW ZEALAND MOA (EMEUS)

time when Capt. James Cook visited New Zealand (1769).

Numerous bones of the moa have been found in caves, swamps and kitchen middens, and some pieces of bodies with skin and feathers. The wings and shoulder girdle, except for a few vestiges in one species (*Anomalopteryx dromaeoides*), had entirely disappeared. There is no trace of a keel on the sternum. The hind limbs were very strong and ended in four toes. The bill was short and stout and the feathers had a large aftershaft. The moas varied from the 12-ft.-high *Dinornis robustus* to the size of a turkey (*Anomalopteryx parva*). Their affinities are with the kiwis. Moas are known only as far back as the Pliocene, and seem to have been herbivorous. *See* also KIWI.

**MOAB,** the name of an ancient people and occasionally of their country; *i.e.*, the highlands east of the Dead sea. Apart from the Moabite stone and some fragmentary inscriptions, no Moabite literature has survived. The main source of information about Moab is the Old Testament, supplemented by a few data from Assyrian and Egyptian documents and the results of modern archaeological research. The latter revealed a dense occupation of the plateau during the Bronze Age, from the 23rd to the 20th century B.C., with a highly developed agricultural civilization. This seems to have come to a sudden end and there follows a gap of about six centuries in the history of the country. Toward the end of the 14th century B.C. a new civilization appeared, that of the Moabites.

Nothing is known about the descent of this people. Representing Moab and Ammon as "sons" of Lot, the nephew of Abraham (Gen. xix, 30–38), Israel expressed its conviction that those two peoples belonged to the same ethnic group as itself. It also maintained the tradition that the Moabites were already settled and organized into a kingdom while the Israelites were still on their journey to the country God had destined for them (*cf.* Deut. ii, 29 with 9 and 19). From the fragmentary traditions about their route through Moabite territory as preserved in Numbers it may be gathered that, while the southern border of Moab was always the wide valley with precipitous sides now called Wadi al Hesa (probably the brook Zered of Num. xxi, 12), separating Moab from Edom, the northern frontier was fluctuating. It is said that the Amorite king Sihon threw the Moabites back southward behind the Arnon (Num. xxi, 26; *cf.* Judg. xi, 18, 22). Israel defeated Sihon and therefore could camp in the Jordan valley opposite Jericho, in the so-called steppes of Moab. The story of the Moabite king Balak who asked Balaam (*q.v.*) to curse Israel (Num. xxii–xxiv) seems to suggest a domination of Moab north of the Arnon, as does the narrative from the time of the judges about King Eglon, who even extended his power over the region of Jericho where he was murdered by Ehud (Judg. iii, 12–30). There is a mention of Saul's fighting against the Moabites (I Sam. xiv, 47), who granted asylum to the family of young David (I Sam. xxii, 3–4). There may be some connection between this fact and the tradition which gives the Moabite Ruth a place among David's ancestors (Ruth iv, 17–22; *cf.* I Chron. ii, 11–15). Later David fought a successful war against Moab and extracted a heavy tribute (II Sam. viii, 2). Solomon, as a sign of his authority, took Moabite princesses into his harem and built them a sanctuary for their national god, Chemosh, near Jerusalem (I Kings xi, 1, 7). It is probable that the Moabites took part in the movement of revolt which followed Solomon's death and that they again took possession of the territory north of the Arnon that they had lost since the time of David.

It was Omri, king of northern Israel (*c.* 884–*c.* 875 B.C.), who drove the Moabites again southward and conquered some of their cities, such as Ataroth, Kiryathaim, Baal-Peor and Medeba. This is known from the Moabite stone, a stele that the Moabite king Mesha erected some 40 years later in his important city of Dibon (Dhiban), just north of the Arnon. This black basalt stone, a little over one metre high, was discovered intact in 1868, but was subsequently broken by the population. It was taken to the Louvre in 1873, where it was mended and the inscription in the Moabite language restored, thanks to a cast made before it was broken. This text of 35 lines, graphically and linguistically very similar to contemporary Hebrew inscriptions, is the only written document of any length which survives from Moab and the only

ARCHIVES PHOTOGRAPHIQUES

STELE OF MESHA, THE MOABITE STONE, 9TH CENTURY B.C., IN THE LOUVRE

royal stele known from Israel's neighbours. Though some details are not entirely clear, it gives a valuable supplement to the six verses the Bible devotes to King Omri (I Kings xvi, 23–28). Mesha tells that Omri's victory took place during the reign of his father. He himself had still to pay the heavy tribute to Israel's king, "a hundred thousand lambs, and the wool of a hundred thousand rams," according to II Kings iii, 4. Mesha probably started his rebellion under Ahab, Omri's son, completing his action after the latter's death (II Kings i, 1). On his stele Mesha ascribes the Israelite domination over Moab to the anger of Chemosh. This god then roused Mesha:

> and Chemosh said to me "Go, take Nebo from Israel!" So I went by night and fought against it from the break of dawn until noon and I took it and slew them all, seven thousand men, boys, women, girls and maid-servants, for I had devoted them to destruction for Ashtar-Chemosh. And I took from there the [vessels] of Yahweh, dragging them before Chemosh. And the king of Israel had built Jahaz, and he dwelt there while he was fighting against me, but Chemosh drove him out before me . . . " (lines 14–18).

According to the narrative of II Kings iii, Ahab's son Jehoram tried to subjugate Moab, attacking it from the south with the help of Judah and Edom. This raid does not seem to have had a lasting success. During the reign of Jehoram's successor, Jehu, the Aramaeans are said to have got control over the whole of Transjordan up to the Arnon (II Kings x, 32–33). That was taken over from them by the strong Jeroboam II (II Kings xiv, 25; but the expression "as far as the Sea of the Arabah" is not clear).

From the Assyrian records it appears that King Salamanu of Moab paid tribute to Tiglath-pileser III in 732 B.C. Later Moab

joined the revolt against Assyria with Judah and Philistia, which was suppressed by Sargon II in 711 B.C. Ten years later, as Hezekiah of Judah tried to rebel, Moab remained loyal to Assyria and its King Kammusunabdi "brought sumptuous gifts" to Sennacherib. Subsequently both Esarhaddon and Ashurbanipal received tribute from the Moabite king Musuri ("the Egyptian"). During the reign of Ashurbanipal Moab helped to repulse the invasion of the Nabayati and nomads of Kedar. Later, Moab joined the coalition against Babylonia (Jer. xxvii, 3) and was condemned for its joy at the fall of Jerusalem (Zeph. ii, 8–10), though it harboured fugitive Jews (Jer. xl, 11). According to Josephus the Babylonians subdued Moab in 582 B.C. Nothing certain can be said about the following centuries, except that the territory probably suffered from nomadic invasions. It came finally under the domination of the Nabataeans. Moabites were excluded from the Jewish community (*cf.* Deut. xxiii, 3–6), where the name Moab became a typical denomination for the enemies of God (Isa. xxv, 10).

As the Moabite stone proves, Moab had reached a high state of civilization by the 9th century B.C. Its language differed only dialectically from Hebrew; its religion and culture were very closely akin to the Israelite. The relation of Chemosh, the national god, to his "children" (Num. xxi, 29) was that of Yahweh to Israel (Judg. xi, 24). Apart from the religious cult suggested in the name Mount Nebo, there were local cults of the Baal of Peor and the Baal of Meon; and Mesha's allusion to Ashtar-Chemosh, a compound deity, has been taken to point to a corresponding consort whose existence might naturally be expected upon other grounds (*see* ASTARTE). The fertility of Moab, the wealth of wine and grain and the temperate climate supplied conditions which directed the form of cult. Nature-worship, as in Israel, prevailed, and the rites of Shittim and Baal-Peor (Num. xxxi, 16; Ps. cvi, 28) cannot have differed materially from practices condemned by the Israelite prophets.

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**MOAT,** a depression surrounding a castle, city wall or other fortification, usually, but not always, filled with water. The existence of a moat was a natural result of early methods of fortification by earthworks, for the ditch produced by the removal of earth to form a rampart made a valuable part of the defense system. When, in the middle ages, earthworks gave way to masonry walls, the moat was retained, and became even more valuable than before as it prevented moving towers or battering rams from being brought up to the ramparts until the moat had been filled. With the development of firearms the moat lost much of its importance, but was occasionally retained into the 18th century as an obstacle against infantry attacks. Dry moats or ditches as parts of modern earthworks, still occur spasmodically. *See also* CASTLE; FORTIFICATION.

For a thorough consideration of medieval moats, *see* E. Viollet-le-Duc, *Dictionnaire Raisonné*, articles "Architecture Militaire" and "Château."

**MOBILE,** a city of southwestern Alabama, U.S., at the head of Mobile bay on the Gulf of Mexico, a river port and the state's only seaport; the seat of Mobile county. Maritime industry is extensive, including five shipyards in Mobile and the immediate vicinity. Brookley air force base is a major logistic installation of the U.S. air force and is one of the chief employers of labour in Mobile. Pop. (1960) city 202,779; standard metropolitan statistical area (Mobile and Baldwin counties) 563,864. (For comparative population figures *see* table in ALABAMA: *Population*.)

**History.**—The Mobile area was explored by Spaniards under Alonso Alvarez de Piñeda (1519), Panfilo de Narvaez (1528, with Nuñez Cabeza de Vaca), Francisco Maldonado (1540), Guido de las Bazares (1558) and Tristán de Luna (1559). French colonists under Jean Baptiste le Moyne, Sieur de Bienville, established Mobile at its present site in 1711, the first permanent European settlement in Alabama; and Mobile was the capital of French Louisiana (1711–20). Its name is a French adaptation of the name of an Indian tribe in the area.

French rule was followed in 1763 by British rule. During the American Revolution, Spanish forces under Bernardo de Gálvez captured Mobile. The United States occupied the city in 1813 and clarified its title by the Florida purchase (1819). In antebellum times Mobile became one of the leading ports in the export of cotton, and the Mobile and Ohio railroad was of major commercial importance in supplementing the river system.

During the American Civil War, trade with the West Indies and Europe was kept up despite a Federal blockade begun in 1861. In 1864 Adm. David G. Farragut entered the channel, captured the Confederate ironclad ram "Tennessee," destroyed one gunboat and drove another aground; in the engagement he lost the Federal monitor "Tecumseh." Ft. Gaines, on Dauphin Island, surrendered on Aug. 7, 1864; Ft. Morgan, on Mobile point, on Aug. 23. In the spring of 1865 Gen. E. R. S. Canby laid siege to Ft. Blakely and Spanish Fort, on the east side of the bay. After 25 days the forts, and then the city, were evacuated, and the Federal forces entered the city on April 12, 1865. In 1879 the municipality went bankrupt and in 1887 Mobile was again chartered as a city.

Banana importing commenced in 1893, supplementing the old export trade in lumber and cotton. Foreign and coasting trade was especially stimulated by the opening of the Panama canal. The opening of the system of locks and dams on the Warrior-Tombigbee rivers in 1915 proved to be a major event in the history of Mobile, as did the development of the Gulf Intracoastal waterway and the Federal Barge lines and the construction of the Alabama state docks, commenced in 1923. Cochrane bridge across Mobile bay (extending 10½ mi.) was completed in 1927 and Bankhead tunnel under the Mobile river in 1941. Bridge and tunnel together added materially to the trade area of Mobile by improving access to Baldwin county, which has the largest area of all Alabama counties.

Controlling depth of the ship channel has been a vital factor in the commerce and history of the city. Originally the minimum depth was only 5½ ft. In 1839 the channel had a minimum depth of 10 ft. but by 1867 the controlling depth was only 7 ft. A 13-ft. channel was opened in 1876. By 1888 the depth was 17 ft. and by World War I the channel was 27 ft. After World War II the channel's minimum depth was 36 ft. and width 400 ft.

**Population Characteristics.**—The population of Mobile in 1960 was 69.5% native-born white, 0.4% foreign-born white and 30.1% nonwhite, almost all Negro. From 1820 through 1900 Mobile was the most populous city in Alabama, but since 1910 each census has shown Birmingham in first place. For a time during World War II Mobile was the fastest-growing city in the nation.

**Commerce and Industry.**—Manufacturing was less important than commerce during most of the history of Mobile, but this ceased to be true in the 20th century. Textiles and food industries have long been significant. During World War I shipbuilding and other manufactures received considerable impetus. This was even more marked during World War II, when 196 ships were built in Mobile yards. One shipyard pioneered in welded hull construction, a process which proved of world-wide significance. Among the varied industries of Mobile are the manufacture of paper, aluminum, transportation equipment, lumber, food, textiles, chemicals, iron and steel. Factors in the growth of manufactures include the availability of electricity, water and petroleum; an adequate labour supply; and excellent transportation facilities. The principal oil field in Alabama is that at Citronelle in Mobile county. Manufacturing establishments in the county number over 200. In 1956 the total income in Mobile county was $229,072,000, as compared with $55,743,000 in 1939. These statistics summarize much of the economic history of the area during and after World War II.

**Education.**—Mobile is the site of Spring Hill college, a Roman

Catholic coeducational college, established in 1830 and chartered in 1836. There is also an extension centre of the University of Alabama.

**Parks and Recreation.**—Mobile has a number of city parks, including Bienville square in the business section. Other points of interest in Mobile and the immediate vicinity include Bellingrath gardens, an estate a few miles south of the city, noted for its collection of azaleas and japonicas; a statue of Adm. Raphael Semmes, the Confederate naval hero; numerous antebellum homes and churches; the U.S. Marine hospital building; waterfront scenes including the oyster dock, the banana wharf and shipyards located on Pinto Island, Blakely Island and at Chickasaw; Fort Morgan at Mobile Point (a state park); Fort Gaines and other scenes on Dauphin Island, 23 mi. S. of Mobile; and the U.S. quarantine station on Sand Island. Meaher and Gulf state parks are also nearby.

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**MOBILIZATION, ECONOMIC.** Economic mobilization is the vast and complex process by which all the productive resources of a nation are organized and directed in support of a major war effort. It is the transformation of the economic system into a supporting base for the armed forces of the nation. It is far more than the nation in arms in the traditional sense (*see* CONSCRIPTION; MOBILIZATION AND DEMOBILIZATION, MILITARY). It is the redirection of the entire productive effort of a nation in support of a maximum and sustained war effort. Considered within the context of military science it is logistics writ large. In the older meaning of the term, logistics (*q.v.*) related simply to the transport, quartering and supply of troops. It was usually limited to supply operations in the field, taking for granted not only the production but also the procurement of munitions, equipment and supplies. More recently the concept of logistics has expanded to the point where some authorities define it so comprehensively as to include the entire industrial and economic base of military operations.

Economic mobilization is essentially a 20th-century phenomenon, although anticipations of it may be found in earlier wars. The experience of the Confederacy in the U.S. Civil War, for example, represents a groping, incomplete and largely ineffective effort to mobilize the economy of the South in the struggle against the North with its far greater wealth and resources. The Confederacy was greatly inferior in manpower, in finances, in transportation and shipping facilities and, above all, in productive capacity for turning out the munitions, supplies and equipment required by the armed forces. In the effort to make the most of these limited resources, Confederate and state governments resorted to a variety of extraordinary measures, which eventually included some degree of control over manpower, materials, transportation, foreign trade and prices as well as numerous government-owned and government-managed manufacturing establishments. Jealousy and friction between state and central governments, the poverty of administrative resources in a region where the role of government had extended little beyond the maintenance of order and, most importantly, the understandable failure adequately to grasp the nature and requirements of the situation combined to defeat the efforts to mobilize and manage a war economy.

### 20th-CENTURY MILITARY REVOLUTION

Both as concept and as process, economic mobilization is an outgrowth of the radical changes in the character and magnitude of warfare that have taken place since 1900. In all ages war has affected and been influenced by the prevailing economic system. Armed forces must be raised, trained, equipped, supplied and paid. The costs of war must be met in one way or another. Part of the product of the economy must be diverted from peacetime uses to the destructive purposes of war. The extent of such diversion rests at bottom on the ability of the economic system to produce a surplus beyond the bedrock requirements of the civilian population and the economy itself and upon the ability of the government to capture this surplus by taxation, borrowing or requisitioning. Paradoxically, the usual effect of war has been to stimulate rather than depress the economy. Business improves, prices rise, production and employment increase and opportunities for profit making multiply. War periods in modern times have typically been periods of high production and relative prosperity, however unfortunate the consequences for particular segments of the economy, such as foreign trade, and however distorted the pattern of normal production and of business relationships. Yet with all this stimulation, disturbance and distortion, prior to the 20th century the capitalist economy of the western world continued to function during war substantially as in peacetime.

The reasons for this are clear. The scale and intensity of military operations in earlier wars were very limited, however prolonged and burdensome the conflict. Armies moved on foot and fought with hand weapons; engagements were infrequent and of brief duration; firepower was low; food and forage presented the major problems of supply. The demands of the military were correspondingly small in relation to the total output of the typically agricultural economy. Military requirements were added to those of the civilian population without any significant change in the organization and functioning of the economy as a whole. Under such conditions, military supplies were obtained largely by an intensification of normal procurement procedures, operating within the free market, although often greatly hampered by the widening gap between supply and demand, by multiplying shortages and by spiraling prices. Occasionally there would be resort to the more drastic methods of forced requisitions of supplies but such measures, except in enemy territory, were exceptional. There was no direct intervention by government in the functioning of the economy, as such, by the control of prices, wages, profits and rent, distribution of scarce materials through systems of priorities and allocations or rationing and the control of credit and investment.

All this was changed as the result of the impact upon warfare of the extraordinary technological and industrial developments culminating in the generation before 1914. Industrialization was the keynote of economic advance in all the great powers. Large-scale organization and mass production were the characteristic features of the new industry. Mechanization proceeded rapidly in all branches of economic life, stimulated by new sources of power such as electricity and the internal-combustion engine, new fuels such as petroleum and natural gas, new materials such as steel, rubber and aluminum. Combined with new methods of organization and direction, the new technology brought great increases in productive capacity and efficiency. Applied to the art of war, the new means of production made possible the equipment of large military forces with weapons hitherto available only in small quantities and introduced novel weapons and matériel that gave new dimensions to combat. The result was a new kind of warfare, based on the mechanization of combat and the industrialization of supply. The breech-loading rifle and metallic cartridge, the machine gun, the rapid-fire, breech-loading field gun and comparable weapons in the naval field, especially the submarine and the self-propelled torpedo, raised warfare to an unprecedented level of intensity. Military operations were further mechanized by the introduction of the airplane and the tank, both made possible by the internal-combustion engine. The railroad and steamship were supplemented for the first time by motor truck and the older methods of communication by motor vehicles and field telephones. The superior efficiency of the new industrial to the traditional agricultural economy made possible a greatly increased diversion of materials and manpower to the purposes of war.

### WORLD WAR I

The attempt of Germany in 1914 to force a quick decision was frustrated in the first battle of the Marne and the conflict soon settled down to a stalemate of trench warfare on fronts hundreds of miles long with the opposed forces numbered in the millions. The huge numbers engaged, the long sustained actions rising to

periodic climaxes in great offensives, and the high rates of fire of mechanized weapons resulted in enormous expenditure of ammunition and correspondingly heavy consumption of other supplies. The scale of the resulting supply problem far exceeded anything anticipated by any of the great powers. Not one of the belligerent nations had plans for any such contingency. Efforts to cope with the emergency produced a disorganization not only of antiquated military supply systems that soon verged on chaos but of the supporting economies as well. National production declined rather than rose. The armed services competed with each other in the market as also did allies, compounding the confusion. The traditional methods of producing and procuring munitions within the framework of the free market, price incentives, private enterprise and competitive bidding, proved hopelessly inadequate. The gap between skyrocketing military requirements and limited sources of supply could not possibly be bridged. Spiraling prices were more productive of inflation than of badly needed goods.

Faced with supply crises that became worse with each passing week, the belligerent governments reluctantly accepted the necessity of extraordinary action. In the absence of both experience and plans and handicapped by the deeply embedded doctrines of individualism and *laissez faire*, the necessary directive action and controls came slowly and only under the compelling pressure of successive crises. The overriding need was to channel scarce materials, goods, manpower and productive capacity where they were most needed to advance the war effort, reducing or cutting off the flow to less essential or nonessential uses. Beginning usually with controls over the distribution of critically short supplies of raw materials, governments gradually brought under their direct management or regulatory control transportation, food, fuels, manpower, foreign trade, prices, wages, credit and profits.

Price inflation was a major threat to the entire war effort. Spiraling prices interfered with getting desperately needed production by introducing elements of uncertainty, risk and speculation in business activities at all levels. Inflation favoured the speculator as against the producer, seriously affected fixed-income groups and lowered the take-home pay of workers and soldiers alike faster than adjustments could be made in wage and pay rates. Profit appeared to take precedence over patriotism; public indignation was aroused and national unity and morale undermined. Price stabilization was the key to the stability and productive efficiency of the economy.

The compelling need for munitions in ever-larger quantities focused attention upon the manufacturing industries producing them and upon the measures for channeling industry into military production. The task was twofold: the conversion of plants making civilian-type products to the production of the far more exacting specifications and very different articles of war matériel; and the large-scale expansion of production of all goods and services required to meet the tremendous needs of the military added to civilian requirements. Conversion and expansion alike were difficult, time consuming and costly in scarce labour and materials. The term "industrial mobilization" was shortly coined to describe this industry-centred process. (*See* MOBILIZATION, INDUSTRIAL.) Adapted from the familiar military phrase for assembling and readying conscript armies for action, the term was apposite, for, as it seemed to manufacturers and businessmen generally, the extraordinary measures adopted by government amounted to scarcely less than the militarization of industrial production. Actually, not only production but the entire economic system became quickly and deeply involved in the war effort. Since industrial production takes place within the economic framework of such institutions as money, credit, prices and wages, the market, risks and investment, the mobilization of the one inevitably entails the mobilization of the rest.

## COMPARISON OF PEACE AND WAR ECONOMIES

Broadly considered, economic mobilization is the process by which the normal economy of peacetime is transformed into the war economy. The distinctive character of the war economy can best be understood by noting the effects of this transformation upon certain basic institutions of the private enterprise economy which, prior to World War II at least, was the ruling economic system among the great powers. In the typical war economy, private property is kept but loses something of its privacy since the owner's freedom to use it is restricted in numerous ways. The pursuit of self-interest and profit continues as the driving force of the economy but it becomes subject to many restraints and restrictions, as, for example, the multiplying regulatory controls. Property is made to bear a greatly increased burden of taxation, some of which is avowedly aimed at the recapture of the excessive profits usually accompanying wartime prosperity.

In two major respects, however, the war economy differs significantly from that of peacetime in nations where private enterprise prevails. In peacetime the basic decisions in the economy, that is, the decisions as to what goods and services are provided, of what quality, in what amounts and at what prices sold and bought, are made by private individuals or private business organizations, whether as producers, consumers, investors, workers or middlemen. In a war economy, on the other hand, these basic decisions and many other closely related ones are made by government agencies and government officials. They determine what is and what is not to be produced, in what quantities and for whom, and in what order of priority. Government takes the driving seat in the war economy and directs the operation of the vast and complicated productive machine of the nation so as best to support the national military effort. Businessmen and business organizations, workers and consumers still make decisions in a great many matters but they do so within the framework and limits of policies established and high-level decisions made by government.

Secondly, because the normally automatic stabilization of the economic system through the mechanism of prices and the free market breaks down as a result of the wide and continuing divergence between supply and demand in wartime, the government must step in and provide artificially the stability (or equilibrium) which the economic system no longer affords. It is significant that prices, the controlling and directing mechanism in peacetime, become themselves a primary object of control in the economy mobilized for war.

## WORLD WAR II

Economic mobilization from 1914 to 1918 was simply a prelude to the vaster and more complex mobilization of resources set in motion by the outbreak in 1939 of World War II. Blitzkrieg as conducted by Germany in Poland, the Low Countries and France was carried out with a surprisingly small commitment of military forces and with no mobilization of resources in the proper sense of the term. The fall of France and the evacuation of Dunkirk marked the beginning of the full-scale military effort. Thereafter the mobilization of the economies of the belligerents proceeded at a pace directly proportioned to the gravity of their military situations.

Mobilization and management of the war economy in World War II were in fundamental respects very similar to the experience of World War I. The differences resulted in the main from the far greater scale and intensity and the somewhat longer duration of the second war. In contrast with the continental scale of the first war, the second was global in extent, with military operations carried on in two major and a number of lesser theatres. Total direct war costs rose tenfold and more above those of the first war against increases of national product and income that were far less. The more fully committed nations, especially Britain, Germany and the U.S.S.R., devoted close to half their national incomes to the prosecution of the war, and the United States was not far behind.

On the technical side, World War II marked advances beyond World War I almost as striking as those that separated World War I from the wars of the 19th century. A highly mobile warfare on land and sea and in the air employed weapons and matériel of rapidly accelerating complexity and cost. The scientific and technological resources of the great powers that had played but a minor role in the first war were in the second as systematically and fully mobilized as industry. The resulting achievements greatly increased military effectiveness but at a cost both in the

productive resources allocated to research and development and in the strain which producing the new devices placed upon the economy. Air warfare both figuratively and literally added a new dimension to warfare. Mass bombing of population and production centres carried the war directly to the source of the enemy's military strength and compelled the diversion of scarce resources to the work of repair, rehabilitation and civil defense.

With the benefit of World War I experience and with advances in the understanding of the economy and the arts of government and administration, the belligerents began the mobilization of resources in 1939–40 in a far better position than 25 years earlier. However fumbling and haphazard some of the early efforts toward mobilization, governments in World War II had a far clearer grasp of the nature and requirements of a planned and managed war economy. That mobilization of industry was only part of the larger task of mobilizing the economy for war was understood from the outset. In the democratic nations there was at first a reluctance on the part of both businessmen and the general public to face up to the demands of total war, but informed men in industry and government alike clearly envisaged the general character and problems if not the magnitude of the task ahead. The general extension of governmental activities in the interwar years, especially in response to the crisis of the great depression, had both increased the understanding of the economy and its management and enlarged greatly the administrative machinery and skills of government. Governments were thus far better equipped to deal with the war emergency.

While the mobilization tasks of World War II were fundamentally much the same as in the earlier war, the greater scale and intensity of the war placed a far greater load on the supporting economies. It was necessary to develop tighter, more elaborate and more highly refined systems of controls, adding tremendously to the administrative burdens of the central authorities. In respect to such vital materials as steel, copper and aluminum, a system of priorities—preferential paper claims on materials—proved quite inadequate. Priorities had to be largely replaced by systems of allocations in which specific quantities of each material were allocated to specific production programs and uses. Eventually, shortages of materials and goods tended to resolve themselves into shortages of labour. Such shortages had to be met by new and more stringent manpower controls.

Stabilization of prices presented unusually difficult problems caused by the wide and growing gap between the purchasing power of a labour force enjoying full employment, with high wages increased by overtime, and the greatly diminished quantity of consumer goods. Systems of direct controls over prices, including wages, profits and rents, were supplemented by a variety of measures for absorbing purchasing power, including taxation, forced loans and government savings bond campaigns. Great ingenuity was shown in devising fiscal measures for supporting stabilization and meeting the problems of war financing.

### "COLD WAR" ERA

In the years after 1945, continuing international tensions, kept high by local wars and the unrelieved pressure of the "cold war" between the western and Soviet blocs, resulted in a new and greater emphasis upon civil defense and upon measures of economic readiness. The latter included government stockpiling of scarce materials, the establishment of reserves of production facilities and equipment and the building up of productive capacity in essential industries to serve as a mobilization base. Some beginnings were made in the dispersion of industrial capacity and the establishment of underground facilities as means for reducing vulnerability to aerial attack in future wars.

All such planning and preparedness measures were overshadowed by the advent of nuclear weapons. The relation of economic strength to military potential entered a phase in which only those nations with the capability of producing and delivering nuclear weapons in numbers could hope to qualify as great powers. The two leading nuclear powers were presumed to have the capability of delivering in a single massive attack on enemy population and production centres thousands of miles distant scores and possibly hundreds of nuclear bombs with a destructive power reckoned in millions of tons of TNT equivalent per bomb. Attacks of this magnitude could cause casualties numbered in tens of millions, destroy a substantial segment of a nation's productive capacity and seriously disorganize its entire economy for many months. Full recovery of the economy would require years.

Such massive nuclear strikes and counterstrikes, whether by manned bombers or by missiles, might bring the active phase of the war to an end in a matter of weeks if not days. The outcome would depend primarily upon the state of mobilized readiness of the striking and defensive forces of the combatant powers. Under such conditions, economic mobilization could hardly get started before the war would be over, let alone contribute to its outcome, however indispensable it would prove in the massive and prolonged task of rehabilitation and recovery.

The concept of mobilized readiness in the 1960s envisaged not only substantial military forces in being, with primary emphasis upon the strategic air arm, but also a level of military production capable of continuously replacing obsolescent weapons and weapons systems with new and more effective ones, with the possibility of continuing a limited output of key military items in the wake of a nuclear strike. Increasing attention was given to the possibility that general nuclear war with its catastrophic destructiveness might be avoided by mutual forbearance if not mutual consent. If wars should be in fact limited, either in the weapons used, in the manner of their use or in the extent of national and territorial involvement, some degree and form of economic mobilization for war in the future was considered probable.

*See* R. Elberton Smith, *The Army and Economic Mobilization* (1958); W. K. Hancock and M. M. Gowing, *British War Economy* (1949).

(L. C. H.)

**MOBILIZATION, INDUSTRIAL.** Industrial mobilization is a term that has come to be applied to the transformation of a nation's industry from its normal peacetime activity to the production of the weapons and supplies needed to support a major military effort. It is distinguished from economic mobilization in being limited to industrial aspects and not including the whole economy of a nation (*see* MOBILIZATION, ECONOMIC). It embraces a multitude of actions: conversion of factories from the production of civilian goods; extension of existing plants and construction of new facilities; the reconditioning, building and installation of machine tools and other industrial equipment; curtailment of the output of nonessential products; imposition of priorities, allocations, rationing and conservation measures to assure the effective use of manpower, materials and production facilities; and the design of organizational means to marshal a nation's productive resources, direct them in the best interest of the total war effort and co-ordinate the activities of all agencies concerned.

The concept and practice of industrial mobilization emerged from the experience of World Wars I and II. This experience, however, does not necessarily set the pattern for future warfare. Since World War II a wide-ranging "cold war" of indeterminate duration, a high incidence of limited wars and the threat of engulfment of all civilization in thermonuclear war have introduced new conditions and new concepts of national security. To rely on past patterns of mobilization in these circumstances, some think, is to lean on a broken reed.

### THE EXPERIENCE OF WORLD WAR I

The history of efforts to mobilize resources for war is almost as old as war itself. Both ancient and modern times are replete with examples of far-ranging military campaigns with highly disciplined forces supported by well-organized logistics systems. Yet by and large, until comparatively recent years, military operations involved relatively small disruption of normal economic life. Wars had been more in the nature of limited duels rather than struggles to the death. Standing armies and navies were maintained, and they were augmented in wartime, but never to a degree approximating the utmost capacity of nations. Battles were fought without putting all into the balance, and support for the fighting forces was rarely drawn to the point of an all-embracing draft on na-

tional resources. Yet government control of resources for munitions production was not uncommon in earlier wars; in the American Civil War, for example, severe material and industrial deficiencies compelled the Confederacy to resort to mobilization measures that foreshadowed later developments.

World War I is generally recognized as having ushered in a revolution in the relation of war to the internal life of the major belligerents. That war was more than the clash of armed forces in combat. Its prosecution depended first upon the possession of resources—manpower, materials, productive plants and technological skill. Victory in modern war, Woodrow Wilson observed, will come not from mere numbers, mere enthusiasm, mere national spirit, but from "the scientific conduct of war, the scientific application of industrial forces." Bernard M. Baruch, the prime mover of American industrial mobilization in World War I, reflected the same thought in his outline of the purposes and functions of the War Industries board: "It is not enough to mobilize the Nation's military strength. There must be a mobilization of her full economic resources—industrial, agricultural, and financial. These must be organized, coordinated, and directed with the same strategy that governs the operations of the purely military arms of service."

Yet none of the major powers had anticipated a struggle in which the massed resources and facilities of whole populations would have to be pitted against each other. Without exception, preparations for the industrial support of their armed forces had been largely neglected. German army officers, steeped in the tradition of the Teutonic knights, believed that warfare was a matter of combat; and the German general staff showed little interest in industrial matters. Though fully imbued with the concept of a "nation in arms," France had not accepted its industrial implications. England was no better prepared. And the United States, despite its opportunity to observe for three years the events abroad, entered the war, as it had all other wars in its history, virtually unprepared.

The tremendous scale and intensity of military operations confronted all the belligerents with problems of munitions production and supply which could not be solved by the normal functioning of their economic systems. The mobilization of armed forces had to be paralleled by the mobilization of economic resources for their support. It became necessary to establish controls over raw materials, industrial facilities, finance, foreign trade and prices, and to exercise central direction of war production. Industrial mobilization was attended by confusion and waste effort, difficulties of supply, improvisation and reorganization of governmental machinery, and extension of controls to restore the disturbed balance of the economy.

Von Hindenburg, referring to the industrial effort of the United States, observed: "Her brilliant, if pitiless war industry had entered the service of patriotism and not failed it. Under the compulsion of military necessity a ruthless autocracy was at work and rightly, even in this land at the portals of which the Statue of Liberty flashes its blinding light across the seas. They understood war." The fact was, however, that the United States, no less than the other belligerents, found it necessary to improvise under the pressure of actual war conditions. Though United States troops helped to end the stalemate, at the time of the Armistice in Nov. 1918 its munitions had only just begun to flow on a large scale from the factories. It was fortunate, indeed, that the British and French allies were able to supply the American expeditionary force in 1918 with heavy guns, airplanes and other specialized military equipment.

## THE EXPERIENCE OF WORLD WAR II

The redirection of productive plants and resources for war purposes was particularly marked in World War II, with its heavier demands on the nations' economics to meet the requirements of global conflict. World War II was truly a war of supply. Marching men, spectacular sea and air battles, courage and determination, brilliant strategy—all played their noteworthy parts. But it was no coincidence that victory lay with the nations that mustered overwhelming superiority in matériel. Differences in strategic concepts, in economic potential for war, in the psychological makeup of peoples and in prewar economic systems had unique impacts on the course of industrial mobilization among the various belligerents. In many respects, however, their experiences were somewhat similar.

**Readiness for Mobilization.**—Despite the experience of World War I, few of the major belligerents were prepared at the outset of World War II. Within the German army there was from the first a determination to make up for the mistakes and the defeat of World War I. Secret arrangements with German industry were begun as early as 1923. Through a so-called "statistical society," a medium was established for close collaboration between the army and most of the large German industries. Up to 1933, however, little had been accomplished in the way of specific war preparations. With Hitler's advent to power in Jan. 1933, Germany embarked on actual preparations for war. But its rearmament was far less extensive than has generally been supposed. The ensuing years saw a conflict in Germany between demands for the armed forces and demands for continued improvement of the civilian standard of living. Reluctant to give up its social and economic aims, the Nazi regime never resolved the conflict. The success of blitz warfare in 1939 and 1940 demonstrated not the superior mobilization of Germany but rather the utter lack of readiness on the part of its victims.

France was acutely aware of the threat from Germany. It drew detailed plans for mobilizing the nation's manpower, for manning the Maginot line and for moving forces quickly into position along the northeastern frontier. But the crucial years of 1933 to 1939 saw little evidence of industrial preparation for rearmament. In May 1940 the French army had ammunition on hand adequate for only about four months of active warfare, and large-scale production was not expected until at least two years after the beginning of hostilities. Static planning, inadequate readiness measures and internal dissension left France an easy prey for German blitzkrieg.

Sensing the gathering storm, the British war office, in the mid-1930s, accelerated its preparations for mobilization. It conducted surveys of industry, began to correct deficiencies in the military establishment and drafted plans for various economic controls. Until the fall of France in the summer of 1940, however, "business nearly as usual" prevailed in Great Britain. The need for tight regulation was not accepted even for shipping, imports or raw materials; and raw-material control was hampered by the existence of stocks already distributed to users. It was not until the end of 1941 that the essential framework for the full mobilization of British industrial resources was worked out.

Between 1868 and 1940 Japan had spanned the transition from a medieval, feudal society to one of the great powers in the world. With their legend of divinely granted supremacy over all other inhabitants of the earth, the Japanese people, spiritually and psychologically, were well conditioned for war. Aggressive industrial development had taken place in Manchuria, northern China and northern Korea. Priority emphasis was given early to the stimulation of heavy industry. Japan's economic structure, concentrated in a few family groups (the *zaibatsu*), was fostered and dominated by the government. Strategic industries were endowed with subsidies, and imports and exports were controlled to conserve foreign exchange needed to purchase raw materials from abroad. By a subtle system of economic penetration, Japan tapped the far reaches of the world for the things it needed—abaca from the Philippines, vegetable oils from the islands of the South Pacific, iron and steel scrap from the United States and raw cotton from India, South Africa and Brazil. By 1937, at the time of the outbreak of the war with China, national-defense industries accounted for nearly 62% of all new capital investments in Japan. Legislation the following year provided for all-out government control of the national economy.

The Soviet Union's completely controlled economy had assumed a pattern in peacetime that was readily adaptable to war. Since the 1917 revolution the major industries of the country had been planned, constructed and controlled by the government. Out of the development of its planned economy the Soviet government had a number of main industrial centres: Leningrad and

Moscow; the Donets basin; the Caucasus; the Urals; the Kuznetsk basin beyond the Urals eastward; and the central Asiatic Uzbek-Kazakh area. There was in the U.S.S.R. a system of industrial research institutes, all working under the general direction of the academy of sciences, constantly experimenting with new processes and items, and passing information on to other plants in the same or related fields.

In the United States the military services, acting under a legislative mandate of 1920, undertook a comprehensive planning program in which they sought to profit by the lessons of World War I and avoid the recurrence of past mistakes in another emergency. From 1930 to 1939 there emerged four successive editions of an *Industrial Mobilization Plan* which provided an administrative blueprint for the control and direction, under civilian auspices, of the nation's resources in time of war. Paper plans were bolstered somewhat by specific readiness steps—surveys and allocations of manufacturing facilities for the production of anticipated needs; educational orders and production studies for training industry in the manufacture of problem items; arsenal rehabilitation; stockpile accumulations; and the establishment of reserves of special machinery and equipment. Except for the facility allocations, however, the concrete readiness measures came only at the very end of the planning period and were rather limited in scope and coverage. Though this prewar planning was in some ways beneficial, its influence on the actual events of the nation's rearmament was far less than had been anticipated.

**The Resource Base for Mobilization.**—Regardless of their forms of government, all countries came to realize the fundamental importance of a strong base in resources for success in modern warfare. Despite its early start and the unity and resoluteness of its people, Japan's efforts at industrial mobilization were a failure. It mobilized about as fully as the paucity of its resources would permit. Like Germany, Japan drew to some extent on the resources of areas that it occupied and pacified. But Japan underestimated its own needs. The dependence of its islands upon large imports of raw materials and food made Japan especially vulnerable to blockade by sea and by air. Its ultimate defeat was induced primarily by the economic paralysis produced by this blockade.

In the first two years of the war Hitler rejected "armament in depth" as the basis for preparedness. His whole strategy was based upon short, decisive actions on a single front at a time. The campaigns in Poland, Norway, France and the Balkans followed this concept; and for such operations "armament in width" sufficed. Each campaign involved the complete utilization of Germany's land and air might in a blitz attack upon a single opponent. In the interval between each new attack, troop units were reorganized and re-equipped. The necessary supplies for a short campaign were accumulated, but no large reserves were built up and little was done to expand the basic industries upon which quantity production of munitions depends.

With Hitler's forces bogged down before Moscow in Dec. 1941 and with his declaration of war upon the United States, the dreaded spectre of a prolonged, two-front war became a reality for Germany. It was only then that a full-scale effort was made to mobilize the German economy for war. The ensuing "rationalization" of the economy, led by Albert Speer's ministry of armaments and war production, brought a threefold increase in munitions output by the end of 1944. However praiseworthy, the effort came too late. By then Germany was reduced by military defeats to almost its prewar boundaries; and its economy, disrupted by Allied air assaults, was on the downgrade. The war was lost in 1944, even though Hitler refused to see his doom until the bitter end in the spring of 1945.

Unlike Germany, the United States mobilized in depth for prolonged warfare. Between 1939 and 1944 its gross national product rose by more than 50%, after allowance for price changes. The volume of manufacturing nearly tripled, and the output of raw materials increased by 60%. Approximately $15,000,000,000 of new plants and equipment were added to the manufacturing capacity of the country. Two-thirds of the cost of this expansion was borne by the federal treasury, and tax concessions through accelerated amortization under "certificates of necessity" indirectly paid for a good part of the balance. Synthetic-rubber and aviation-gasoline industries were built up virtually from scratch; and others—explosives, guns and ammunition, aircraft, shipbuilding, aluminum, magnesium, tanks and various chemicals—underwent dramatic expansion.

The extended and more intensive use of manpower in the war years contributed greatly to the achievement of this record. The labour force increased almost 20%—from 54,100,000 to 64,000,000. The average workweek increased from 37.7 to 43.2 hours in manufacturing, from 32.4 to 39.5 hours in construction and from 32.3 to 43.9 hours in mining. The withdrawal of over 10,000,000 men for the armed forces was offset by absorption of all but a few hundred thousand of the 9,000,000 who were unemployed in 1939, and by drawing into the labour force housewives, youths, retired persons and the physically handicapped. At the same time, productivity climbed sharply as volume increased, manufacturing methods improved and workers responded to appeals for the faster flow of munitions to the fighting fronts.

America's expanded production for war was greater than the munitions output of its allies, and it was considerably greater than that of its enemies. In the five-year period from July 1, 1940, through July 31, 1945, there was an outpouring of 86,330 tanks; 296,400 airplanes; 15,300,000 rifles, carbines and sidearms; 315,000 artillery weapons (including tank and aircraft weapons and mortars); 4,200,000 tons of artillery shells; more than 41,000,000,000 rounds of small arms ammunition; 64,500 landing craft; 6,500 other navy ships; 5,400 cargo ships and transports; and similarly staggering amounts of other materiel. It was this munitions production that was the decisive factor in the final outcome of the struggle.

Yet it must be recognized that the industrial mobilization of the U.S. also saw much improvisation and fumbling, reluctance to forsake business-as-usual and delays in establishing administrative machinery with the cohesive force and potency required. As in World War I, the United States was again fortunate in being afforded time in which to mobilize its resources for war. When Pearl Harbor brought the United States into the war, the country had seen at least 18 months of partial mobilization. That preparation enabled its armed forces to begin offensive operations on a limited scale nine months later. But it took still another 12 months before the United States was ready to launch sustained attacks upon the enemy. A much too important part of the task of building up to full war production took place long after the war started.

**Problems of Administration and Control.**—In World War II, as in World War I, the mobilization of industry could not be effected through voluntary efforts by business and labour organizations. It required government machinery to direct resources into the most essential effort. Quite generally new agencies were set up for the purpose—in Great Britain, a ministry of production; in Germany, a ministry of armaments and war production; in Japan, a ministry of munitions; in the United States, a war production board. There were decided similarities in the organizations of these agencies, in the tasks they faced and in their means of performance. All had problems—in designing and programming production objectives; in diverting productive resources into appropriate war channels; in enlarging the production base; in establishing adequate industrial statistics; in devising workable priorities and allocation systems for channeling scarce resources to competing claimants; in preventing imbalance within and between production programs; and in achieving the necessary integration of industrial controls with related aspects of economic mobilization.

Problems of civil-military relationships did not lend themselves to easy resolution. In Great Britain separate ministries of supply and aircraft production were established to procure materiel for the army and air force, but naval procurement remained the responsibility of the admiralty. The German armed forces retained their separate supply systems, though after 1942 the Speer ministry guided and co-ordinated their efforts and took direct responsibility for planning, scheduling and controlling their production.

The pattern of relationships in the United States was substantially like that in Germany. Co-ordination in the United States appeared to be more difficult, however, and there was more evidence of controversy between the war production board and the armed services on policy and procedural matters.

The severity with which controls were applied to the civilian economy depended on circumstances in each case. The invasion by Germany interrupted the Soviet Union's third five-year plan, brought heavy losses of resources and necessitated large evacuations of equipment and labour into the Urals and eastward. The strain on the Soviet economy caused the disappearance of many consumer goods from the market and brought severe consumer rationing. The drain on Japan's limited resources also was such as to permit the meeting of only the submarginal requirements of the populace. In Great Britain supply difficulties, coupled with the altered strategic situation upon Italy's entry into the war and the fall of France, brought complete control of industry and increasing checks on the output of consumer goods. Cut off early from the most important sources of various materials, especially oil and rubber, Germany undertook the production of substitutes and imposed rigid restrictions and economy in the use of scarce resources.

In the United States the economy demonstrated a degree of strength, resourcefulness and productivity far greater than many had dared to imagine. Its people, for the most part, were subjected to inconvenience rather than sacrifice. Following its entry into the war the United States stopped passenger-automobile production, reduced the output of other consumer durable goods, and imposed consumer rationing of tires, gasoline, meat, coffee, sugar and other products. The unprecedented increase in the productivity and total output of the United States economy, however, enabled it to carry the heavy burden of mobilization and still permit the enjoyment of a steadily rising level of expenditures for civilian consumption. Larger amounts of soft goods and services made up for the new automobiles, electric appliances and aluminum cooking utensils which had to be denied to the civilian economy. Indeed, at the peak of U.S. war production in 1944, when over 40% of the gross national product was directed to war needs, the level of aggregate consumption of civilian goods exceeded that of 1939.

## COLD-WAR READINESS

Events after World War II demanded of nations a stronger, more flexible and more pervasive type of preparedness than they had ever had before. The postwar era was marked by an intensification of the ideological antagonism between the free world and the communist bloc. It saw, too, the introduction of nuclear weapons of incredibly destructive power. The east-west conflict turned into a gigantic "cold-war" rivalry with the accent on political, economic and psychological warfare. As part of their strategy the Soviets fomented crisis situations and small "brush fire" wars in the hope of attaining their objectives without risking the mutual annihilation that would attend all-out nuclear warfare. To counter this threat, the western allies had to fashion new instruments of policy and to develop and maintain the ability to deter aggression, wage limited war, and plan for survival and recuperation in the event of a massive nuclear attack.

This situation blurred the lines previously drawn between the normal pursuits of peace and the abnormal demands of war. The cold war came to be viewed as a struggle in which the social, economic and political fabric of a nation might be put to the supreme test before, and even barring, the outbreak of actual armed conflict on a major scale. The key to survival in this struggle, in the eyes of responsible planners, lay in assuring the strength of a nation's domestic economy and in seeking to create and maintain in other nations, both friendly and neutralist, the economic climate that would best nourish its own ideological and long-range power objectives. It required measures to help allied and friendly nations to resist economic and political penetration by opponents and to make the maximum contribution to the collective security arrangements of the group. It called further for nonmilitary measures calculated to weaken the capacity of the opposing nation to provide economic support for its national policy (*see* ECONOMIC WARFARE).

United States rearmament following the outbreak of the Korean War in June 1950 reflected recognition of the importance of a strong and ever-growing economy in the cold-war setting. The fighting in Korea was not the signal for full mobilization and attendant heavy demands upon the nation's industrial and civilian strength. In the Korean conflict it was not clear at what point in the future, if at all, it would be necessary to drain that strength for total war. Under these circumstances the safest course seemed to be to embark on a partial or "creeping" mobilization. It involved the buildup of an economic base adequate for fighting the war in Korea, for dealing promptly with emergencies elsewhere in the world, especially Europe, and for getting off to a good start on total mobilization if that should become necessary. The combination of defense preparations with continued growth of the underlying civilian economy was deemed necessary not only for purely economic reasons but also because of the psychological strain involved in carrying a military burden in a democracy without the pressure of an all-out war.

Under this mobilization strategy, a substantial buildup of fighting capability was accomplished for the long pull; and economic controls were so tailored and applied as to minimize the disruption of the civilian economy. Government aids through accelerated tax amortization, loans, subsidies and research and purchase contracts brought a large growth of industrial capacity throughout the economy, from basic material extraction through intermediate products and to assembly plants for the production of finished military equipment. A national stockpile of critical materials, an increase in active forces, sharpened manpower skills, and additional experience in organizing resources and government machinery for defense were still other means whereby the base for war mobilization was strengthened.

Yet there was some feeling that too much of the rearmament effort during and after the Korean War had been keyed to the least likely type of future warfare—a general war patterned after World War II. A large number of industrial facilities were in operation or on standby for quick conversion to war production. There were large government inventories of materials, machine tools and related metalworking equipment. Under an "M-day pool order program" the facilities of toolbuilders could be immediately put into production without awaiting orders from defense contractors. These readiness measures, along with plans for the organization and control of the economy, would help the nation to move more quickly into a World War II-type of mobilization.

There may be situations, however, where this "mobilization base" does not ensure readiness to deal effectively with the conditions of limited war. After the end of the Korean War, military planners directed their attention more and more toward the need for readiness to prevent or promptly scotch brush fires before they fanned into major nuclear conflagrations. The key to success in this type of operation, as was demonstrated in the middle-east crisis in the summer of 1958, does not lie in a base of planned suppliers, machine tools, and stockpiles of strategic and critical materials. It lies rather in forces-in-being; in trained reserves ready for immediate action; in supplies earmarked and ready for shipment; in the preshipment and strategic stocking of heavy equipment; in adequate airlift for high-priority combat, command and supporting elements; and in the speedy water transportation of the follow-up echelons to ensure the full realization of the fighting capabilities of the forces.

Nor is the mobilization base entirely adequate to the needs of a war of survival. Even as the nation bolsters its ability to cope with limited military actions, the possibilities of an all-out nuclear exchange cannot be ignored. Massive enemy attacks would leave millions of people killed or maimed, and the greater part of the nation's industrial potential would be knocked out or paralyzed. Experience contributes little to an understanding of the problems that would be encountered in this type of situation. To ease the impact on peoples and resources, the United States considered certain measures and, to some extent, actually put them into effect —strategic location of industry; protective construction; ar-

rangements for the continuity of governmental operations; provision of shelters in new and existing structures; improved warning, damage-assessment and communications systems; and the stockpiling of food, medicine and other survival supplies and equipment. Nonetheless, the ramifications of the problems of survival and recuperation have been so vast, so complex, so appalling and so demanding in sacrifice as to make inevitable a sense of frustration and futility in past efforts to cope with them. The U.S.S.R. appears to have started earlier and gone further with civil defense, postattack and recovery plans as a component of overall Soviet strength and readiness for war.

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**MOBILIZATION AND DEMOBILIZATION, MILITARY.** In a military sense, mobilization is the assembling and organizing of the armed forces of a nation for active military service in time of war or other national emergency. In its full scope, mobilization includes the organization of all resources of a nation for active military service or for support of the military effort. Demobilization is the reverse of this process—the dismantling of the war organization and return to peacetime activities.

**Mobilization.**—The technological advances of the 20th century, particularly since the advent of the atomic age, have vastly increased the complexities of mobilization planning and mobilization implementation. The ratio of a nation's forces in being, which provide for defense during the mobilization period, to that nation's full war potential has always varied, and has depended on such factors as foreign policy, world tensions, strength and situation of allies and estimates of the time required to implement mobilization. Because of the tremendous power of nuclear weapons, and the speed with which they can be delivered to their targets, it is conceivable that a nation's war potential could be destroyed before mobilization could be started. This situation has increased the need for adequately prepared forces in being—*i.e.*, the standing army, navy and air force—which might be the only means available to continue the defense and launch a counterattack.

Mobilization planners must consider the following contingencies: (1) all-out nuclear war; (2) conventional war (without nuclear weapons); and (3) limited war (limited either in geographic area, strategic aims or by the types of weapons employed). The requirement for maintaining military forces in being at high levels as a deterrent to nuclear war and as a fighting force in the event of a massive nuclear attack has not altered the requirement for the maintenance of detailed, thoroughly co-ordinated mobilization plans to provide for both conventional and limited wars and for a nuclear war that may reach a point of stalemate through failure of either side to win a decision in the first few hours. Any war that continues longer than a few hours thus requires the implementation of mobilization plans.

Military mobilization, for any kind of war, includes the procurement and training of manpower for military purposes; the selection of areas and the construction of facilities for training and other military purposes; and the procurement and issuance of arms, ammunition, uniforms, equipment, vehicles and stores. The procurement of military manpower is in itself a complex task that includes the calling up of reserves; the induction of large numbers of raw recruits; the allocation of manpower to the army, navy and air force and, within these major components, to the respective arms, services and other subdivisions.

The procurement of military manpower during mobilization must be correlated with the procurement of the arms and equipment necessary for training and for combat, and must be synchronized with timetables for training and strategic deployment. Mobilization, to be effective, must not only be well organized but must have "everything in step." The detailed schedules showing size, type and composition of military units to be organized during mobilization are sometimes referred to as the troop basis.

The ramifications of all phases of mobilization and the necessity for organization, synchronization and speed have made it necessary for nations to prepare detailed, comprehensive mobilization plans and to keep them constantly under study and revision. Such plans may embody drafts of stand-by legislation for enactment when necessary.

**Demobilization.**—Just as a faulty, ineffective mobilization may result in a nation's military defeat, so a poor demobilization may result in the loss of objectives obtained by victory on the battlefield. All the military and economic factors that make mobilization so complex are also involved in demobilization, and for many reasons the problems may be even more difficult. Public opinion, which usually supports mobilization as a necessary means for winning a war, may well clamour only for speed in demobilization, even though such speed may jeopardize "winning the peace." Allies who have had unanimity of purpose and objective during mobilization and war may differ in their objectives following the war. The transportation facilities that deployed military manpower during mobilization and war may not be adequate to redeploy that manpower as rapidly as public opinion demands.

The main military tasks during demobilization are the following: (1) Manpower no longer needed in the armed services must be brought home and separated from the service. (2) Surplus war materiel must be disposed of and materiel required for reserve purposes must be properly stored to prevent its deterioration. (3) Requirements for military materiel for peace must be determined. (4) Missions of the armed services must be redefined to include, if applicable, occupation military government and rehabilitation of defeated countries. These factors, together with the economic factors of demobilization, are all related, but each one contains within itself complex problems that require careful advance planning. *See* also ARMY; CONSCRIPTION; MILITIA; MOBILIZATION, ECONOMIC; MOBILIZATION, INDUSTRIAL.

*See* Marvin A. Kreidberg and Merton G. Henry, *History of Military Mobilization in the U.S. Army, 1775–1945* (1955); John C. Sparrow, *History of Personnel Demobilization in the U.S. Army* (1952).

(M. A. Ke.)

**MÖBIUS, AUGUST FERDINAND** (1790–1868), an outstanding German theoretical astronomer and mathematician, was born at Schulpforta, Prussia, on Nov. 17, 1790, and studied at Leipzig, Göttingen and Halle. In 1815 he became professor of astronomy at Leipzig, being chosen director of the university observatory, which was erected (1818–21) under his superintendence. He died in Leipzig on Sept. 26, 1868. *De computandis occultationibus fixarum per planetas* (1815) established his reputation as a theoretical astronomer. *Die Hauptsätze der Astronomie* (1836)

and *Die Elemente der Mechanik des Himmels* (1843) may be noted among his other purely astronomical publications. His labours in pure mathematics appear for the most part in *Crelle's Journal* from 1828 to 1858. These papers are chiefly geometrical, many of them being developments and applications of the methods laid down in his great work *Der barycentrische Calkul* (1827), which introduces homogeneous co-ordinates into analytical geometry. This treatise also deals with geometrical transformations, in particular projective transformations (collineations), and discusses the configuration known as the Möbius net, which later played an essential part in the systematic development of projective geometry. In the *Lehrbuch der Statik* (1837) Möbius gives a geometrical treatment of statics, leading to the null system of points and planes and thence to the study of systems of lines in space. Möbius was also a pioneer in the field of topology; in a memoir presented to the French Academy and discovered only after his death, he discusses the properties of one-sided surfaces, including the now celebrated Möbius strip. His *Gesammelten Werke* (4 vol.) were published in 1885–87.

His son THEODOR, an authority on Scandinavian letters, was born at Leipzig on June 22, 1821. His *Catalogus librorum islandicorum et Norwegicorum aetatis mediae* (1856) and *Verzeichnis der auf dem Gebiet der altnordischen Sprache und Literatur 1855 bis 1879 erschienenen Schriften* (1880) as keys to Scandinavian bibliography and his *Edda-Ausgabe* as a textbook are perhaps the most valuable to students. He died in Leipzig on April 25, 1890.

**MOÇÂMEDES** (MOSSÂMEDES), an Atlantic port of Angola, capital of the district of the same name, 200 mi. S.S.W. of Benguela. Pop. (1960) 7,963. Many of the town's inhabitants are fishermen from southern Portugal. It is the terminus of a railway, and has an airfield.

MOÇÂMEDES DISTRICT is made up of three *concelhos* (municipalities): Moçâmedes, Porto Alexandre and Bibala. Area 13,259 sq.mi. Pop. (1960) 43,419, of whom 6,905 were Europeans. The district lies on a coastal desert strip that extends from the Kunene (Cunene) river to the vicinity of Benguela. Its people live largely on fishing, though certain areas (mainly the Bero valley) produce fruits and vegetables. Many factories prepare fish meal and oil, fish preserves and dried fish. The most important fishing centres, other than Moçâmedes town, are Porto Alexandre, Baia dos Tigres and Lucira. The region is suitable for raising karakul sheep, and the Portuguese government has installed an experimental station to give technical assistance to sheep raisers.

(A. A. G. P.)

**MOCATTA, FREDERICK DAVID** (1828–1905), English Jewish philanthropist and historian, was born in London on Jan. 15, 1828, a member of a distinguished financial family. His grandfather, Abraham Lumbrozo-Mocatta, had founded in 1790 the firm of Mocatta and Goldsmid (*see* also GOLDSMID), of which Frederick Mocatta was a member until his retirement in 1874 to devote himself to works of public and private benevolence.

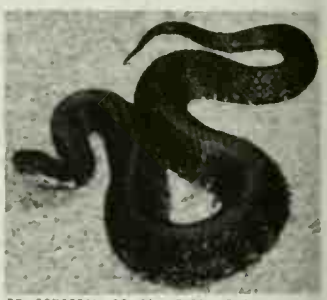
He first began to give his attention to the better housing of the working classes and the administration of charity in such a manner as not to demoralize the poor. He supported almost every hospital in London, and did much to promote education, especially that of the Jewish poor. Mocatta encouraged Jewish literature and research, and in addition was a patron of learning and himself an author. The chief of his historical works was *The Jews of Spain and Portugal and the Inquisition* (1877). On the occasion of his 70th birthday, he was presented with a testimonial from more than 200 philanthropic and literary institutions.

Mocatta died on Jan. 16, 1905, bequeathing his fine library and art collection to the University college of London, in the library of which they are now housed.

**MOCCASIN,** a one-piece shoe made of deerskin or other soft leather, the sole is soft and flexible and the upper part is often adorned with embroidery, beading or other ornament. It was from earliest times the footwear of the North American Indian tribes and was also worn by hunters, traders and settlers. In modern times it has become a popular sport and casual shoe.

**MOCCASIN,** common name for certain poisonous, semi-aquatic snakes, genus *Agkistrodon*, found in North and Central America, especially the water moccasin or cottonmouth (*Agkistrodon piscivorus*). It belongs to the pit vipers, family Crotalidae, which includes also rattlesnakes, copperheads (*q.v.*) or highland moccasins, and many venomous serpents of Asia and one of southeastern Europe. Unfortunately, the term has been used also for various nonpoisonous water snakes, *Natrix*, because of their resemblance to the venomous cottonmouth. The harmless water snake, though it bites as readily as does the cottonmouth, has short solid teeth and no venom. The cottonmouth, on the other hand, has fangs and a powerful venom. Its bite, especially that of a large adult, is usually immediately followed by a sharp, stinging pain at the site of puncture. Antivenins are available and recovery from the bite, if prompt first aid and early medical attention are given, is almost assured.

Cottonmouths, divided into eastern and western subspecies, *A. p. piscivorus* (eastern and southeastern lowlands) and *A. p. leucostoma* (southern central states), are so called because of the cotton-white interior of the mouth. Their habit of threatening an intruder with open mouth, an uncommon reaction among venomous snakes, is a distinguishing characteristic of the cottonmouths. They are found in marshes and along or in streams or ponds where their preferred prey of frogs and fishes abound. Although some individuals exceed 5 ft., adults are more often 3 to 3½ ft. The pattern is dull and inconspicuous, consisting of dark-brown bars or blotches on a somewhat lighter background; in some cases, however, adults may be almost a uniform blackish. The females give birth to five to ten young in late summer. In captivity cottonmouths have lived as long as 18 years. A relative, the Mexican moccasin or *cantil* (*Agkistrodon bilineatus*), replaces *A. p. leucostoma* south of the Rio Grande. It is a more brightly coloured form that inhabits both coasts of Mexico and parts of Central America.



BY COURTESY OF SAN DIEGO ZOO

WATER MOCCASIN OR COTTONMOUTH (AGKISTRODON PISCIVORUS)

*See* SNAKE; VENOM. (L. M. KR.)

**MOCENIGO,** one of the oldest Venetian noble families, which provided the republic with many statesmen and soldiers and with seven doges. The first doge was TOMMASO (1343–1423), who had commanded the crusading fleet to Nicopolis (Nikopol) in 1396. He was elected in 1414, and it was during his reign that Venice's dominion was extended into the Trentino, Friuli and Dalmatia. But Tommaso's policy was peace, not aggression, and he is best remembered for the long deathbed address in which he describes, with great precision, the flourishing state of Venice and admonishes his fellow citizens to avoid warlike adventures in Italy. Tommaso also had the ducal palace rebuilt. His nephew PIETRO (1406–76) was one of the greatest Venetian admirals; he reorganized the Venetian fleet after the defeat of Negroponte (1470) and conducted successful reprisals against the Turks, taking Smyrna in 1472 and raising the siege of Scutari (Shkodër) in Albania. He was triumphantly elected doge in 1474 and, though the war continued, he tried to negotiate peace. A peace was reached, at the cost of losing Scutari, during the reign of Pietro's brother GIOVANNI (1408–85), who became doge in 1478. During the same reign was fought the War of Ferrara, in which Venice acquired Rovigo and the Polesine.

The next outstanding Mocenigo was Giovanni's grandson ANDREA (1473–1542), senator and scholar, who composed a verse history of the Turkish war of 1500 and a prose history of the League of Cambrai (printed 1525).

Andrea's nephew ALVISE I (1507–77) was doge from 1570; his reign was dominated by the war of Cyprus, in which Venice lost Nicosia and Famagusta to the Turks. A great-grandson of his brother Niccolò was doge as ALVISE II from 1700 to 1709. ALVISE III SEBASTIANO, fourth in descent from Alvise I's brother Giovanni, was doge from 1722 to 1732. Finally the reign of his dis-

tant cousin ALVISE IV (1763–78), fifth in descent from Niccolò, was notable for an enlightened commercial policy and a series of measures in restraint of clerical wealth and privilege which provoked a conflict with Pope Clement XIII.

**MOCHA STONE** (Moss Agate), a grayish to milky white variety of chalcedony (cryptocrystalline quartz) containing opaque, dark-coloured inclusions whose branching forms resemble ferns, moss or other vegetable matter. The included materials, mainly manganese and iron oxides, are of inorganic origin. Most mocha stones are found as fragments weathered from volcanic rocks. Long used for ornamental purposes, they are obtained chiefly from India, Brazil, Uruguay, the U.S.S.R., central Europe and the western United States. The best stones are cut in flat or rounded form, and some are dyed to improve their colour.

*See* also AGATE. (R. H. J.)

**MOCKINGBIRD,** a popular name of superb songbirds and mimics belonging to the American family Mimidae. The approximately 10 species of *Mimus*, ranging from southern Canada to Patagonia, are all similar in form—like slender, long-tailed robins—and in colour—like shrikes without the black facial mask. Popular in song and story, mockingbirds are chiefly beneficial, feeding mostly on insects but taking some berries in summer and autumn.

The common mockingbird of North America (*M. polyglottos*) is most abundant in the southern U.S.; the eastern subspecies appears to be a better mimic than the western. About 10 in. long, the common mockingbird is grayish above and dull white below, with white wing and tail patches conspicuous in flight. The nest, a bulky open cup of grass, twigs and rootlets carelessly arranged in a bush or dense tree, may hold three to six pale blue-green eggs, spotted with brown. Both parents prepare the nest and show great courage in defense of their home against such enemies as snakes, which eat both eggs and young.

Mockingbirds have a very pleasant and delightfully varied song of their own, and are capable of miming man-made sounds. In distinguishing the singing of the common Mimidae, the mockingbird repeats each phrase several times in succession before taking up another air; the thrasher (*q.v.*) usually repeats once; and the catbird (*q.v.*) does not repeat.

In parts of South America mockingbirds are prized as cage birds. Some species have been introduced into Hawaii. The long isolated

MOCKINGBIRD (MIMUS POLYGLOTTOS)

Galapagos mockingbirds, which have longer legs and longer bills than the mainland species, have been given generic rank as *Nesomimus*. *See* also SONGBIRD.

**MOCK ORANGE,** the name given to species of *Philadelphus*, especially to those with highly fragrant flowers, and also to the Missouri gourd or calabazilla (*Cucurbita foetidissima*) of the southwestern U.S. *See* CUCURBITACEAE; PHILADELPHUS.

**MODELS AND MODELMAKING.** The value of the model in various professions and industries, as well as its interest as a hobby, lies in its unique power to communicate the essential visual aspects of something planned or already existing. Thus since early times men have made models, at scales ranging from miniature to full size, as the most direct approach to exploring the special relationships of new constructions and of demonstrating the three-dimensional qualities of known ones. The Egyptians used realistic models of chattels in tombs to serve the deceased in the next world; in China similar tomb models became schematized into paper cutouts. Witches used models incorporating some fragment of the original in magic rites to effect good or evil. Renaissance artists used models to study the lighting and composition of elaborate groupings. Models of clothing and of architecture have been used from the 16th century on. Today modelmaking is a highly developed profession in the service of education, architecture, industry, the armed forces and other fields, as well as a hobby.

As an educational aid, the model has no peer in its ability to give the student an immediate grasp of certain kinds of material. The actions of opposing forces in the battle of Waterloo, the operation of moving parts in a reciprocating engine, the anatomical functions of the kidney system are examples of the myriad subjects which lend themselves to the medium of the model.

Science museums and exhibitions incorporate models into the presentation of various kinds of material. In natural history exhibits, for example, the habitat of fauna and flora can be recreated for thorough ecological study of environment by the observer. The methods of reproducing full-size landscape vignettes have been developed to a high degree of perfection. Material of vegetable nature is collected, from which molds and casts are made of plastic or other material with absolute fidelity. In these "habitat groups" the three-dimensional foreground is made to merge imperceptibly into a painted two-dimensional background.

In contrast to these models where complete faithfulness in all details is essential, schematic models may be desirable in certain instances where a principle is to be explained or a certain aspect is to be emphasized. For clarity in communicating an idea it is sometimes necessary to distort nature, select some of its elements and omit others and create new forms and colours. The initial stages in the design of exhibits are worked out by rough models for study purposes.

The materials and techniques employed in making scale models are unlimited. The success of the illusion depends to a great extent on the choice of material, according to the ability of its texture to suggest structures of a different size—for example, certain kinds of moss give a convincing suggestion of trees in foliage at a scale of 1:16. This is very useful for architects in rendering landscape for buildings that are being planned. The use of material designed for one purpose to convey the impression of another kind of material, seen at a different scale, is basic to modelmaking. It is part of the fascination for the one who makes the model (as well as a satisfactory illusion for the viewer) to discover a means of suggesting, for example, the cloud of insecticide being sprayed by an airplane.

Problems of architectural design can best be studied by means of models, since the element of three-dimensional space is vital in this field. The scope of the study may range from an entire city area to the interior of a single room; it may emphasize the outdoor space between buildings on a site, the flow of space from one room to another in one building or the colour scheme of an interior. Scale can be made immediately apparent by the use of human figures proportional to the project under consideration. The model can also be photographed and the illusion of full scale approximated by careful adjustment of lighting and background.

The plan for the redevelopment of downtown Philadelphia was implemented by a model showing the area as it then existed; the part representing the section of the area under consideration could be turned over mechanically to reveal the projected improvement of that area. A very successful use of models for publicity purposes was seen in the "Highway of Tomorrow" exhibit of the General Motors corporation at the New York World's fair in 1939–40. In this exhibit the visitor was carried on a belt of moving chairs through a landscape in which the highway of 1939 gradually evolved into the highway of the future.

Nearly all industries use models varying in scale and purpose,

the greatest value, however, derives from experimentation. Scale models of entire proposed factories are made to check location of machines, stock rooms and other features and to determine efficiency of production-line assembly. The early stages of the design of nearly all manufactured products require study of small-scale models. Full-size models are then made to refine the details of the finished design and to determine tooling requirements in the case of automobiles, refrigerators or other mass-produced items. Models of various scales are used in the fields of shipbuilding and aerodynamics. In the latter, the models are tested in wind tunnels at speeds greatly exceeding that of sound. This testing ensures perfection of design without risking human life and expensive equipment.

Industry has its own educational programs and uses cutaway or clear plastic models to demonstrate working relationships of machine parts and problems of assembly or disassembly. It is here that oversize models most often are used to demonstrate the workings of small mechanical parts, although magnified models are used also as display devices by watchmakers or other manufacturers of tiny, intricate artifacts.

Some unusual models have resulted from the study of water flow. One of the largest of these is a complete working model of the Mississippi river basin which is used by the U.S. government for demonstrations and experiments in flood and channel control. Another interesting model which served a valuable purpose in this field was a scaled-down section of the Suez canal, the function of which was to determine precisely what pressures the banks must withstand. Installed in a hydraulic laboratory in Grenoble, France, it was 210 ft. long and 20½ ft. wide. In it a self-propelled model of the hull of a tanker made hundreds of round trips until the erosion of the banks reached a maximum. As a result of these studies, an asphalt mattress, poured over a framework of steel and wire mesh, was designed to slide over the banks of the canal, thus saving in part the endless job of dredging.

Another model showing water flow has been made of the St. Lawrence seaway project. This is a 40-ft. working model of a cutaway section (complete with flowing water), and hydraulic engineers from countries all over the world are able to study from it the interior workings of such a complex operation.

For recreational and hobby purposes, models are constructed and used by children and adults. Generally these are airplanes, boats, railway trains and equipment, automobiles, steam engines or buildings and structures of all sorts. These models may be for display only, or they may be powered by steam or electricity, by motors using gasoline, diesel oil or compressed gases or by jet engines using liquid fuel or compressed gas. The development of plastics and injection molding made possible mass production of model kits which have a quality of fine detail not previously possible at such low cost. The motion-picture industry makes extensive use of scale-modeled sets in order to reduce the cost of photographing sea battles, panoramas or any long-range or altitude camera shots. The theatre uses models of stage settings as a means of testing workability cheaply.

In the armed forces during World War II and the Korean War, modelmaking was used extensively, scaled solid models of planes, ships, tanks and other vehicles being used for recognition training for gunners. Elaborate models were made for tactical purposes, and in several cases scale models were made of entire areas under attack. These models were complete even to the shipping in the harbours and all shore installations, and they were used to ensure co-ordination in joint operations. Models of terrain or manufacturing areas were used to ensure recognition by bombardiers in the various air forces. (G. R. RE.)

**MODENA,** a city in northern Italy, in the Emilia-Romagna region, capital of the province of Modena and seat of an archdiocese. Pop. (1961) 139,183 (commune); province 511,355. The city lies at the centre of the Po valley, between the Secchia and Panaro rivers, 30 km. (31 mi.) E.S.E. of Parma by rail. It is crossed obliquely by the great national road, the Via Emilia (originally a Roman highroad built by the consul M. Aemilius Lepidus in 187 B.C.), which connects Milan with Rimini.

The city's fortified walls, now converted to promenades, give it a pentagonal shape. Inside the walls are open spaces, public gardens and squares and many buildings of historic and artistic interest. Among them are the cathedral, begun in the Romanesque style in 1099 on the site of two former basilicas of the 4th and 8th centuries. Its sculptural decoration is celebrated and the interior contains paintings and sculptures by a number of Renaissance artists. The detached campanile (Torre Ghirlandina), one of the finest in northern Italy, was completed in 1319. Other churches include S. Agostino, called the Pantheon Estense (17th century), a sumptuous baroque edifice; S. Francesco (16th century); S. Giovanni Battista; and S. Pietro (1476), in most of which are preserved works by Antonio Begarelli in terra cotta, a medium for which Modena is particularly well known. The imposing ducal palace, now a military academy, was commissioned by Francis I and begun in 1634. The Palazzo dei Musei houses the municipal collections, of which the more important are the Galleria Estense, rich in paintings of the Renaissance, and the Biblioteca Estense, noted especially for its collection of illuminated manuscripts. The picture collection was given by Francis V in 1869; the library was founded by the Este family at Ferrara in 1393 and moved to Modena in 1598. Modena also has a university, founded in the 12th century. The Aedes Muratoriana, a characteristic Renaissance edifice, contains the tomb of the historian Lodovico Antonio Muratori and a museum.

The modern city, which includes residential and industrial areas, extends outward from the city walls. Among the more important industries are metalworks, cast iron and light alloy foundries, automobile works and factories producing car bodies, machine tools and agricultural machinery. Modena also has a notable cattle market and there are tanning and other leatherwork factories.

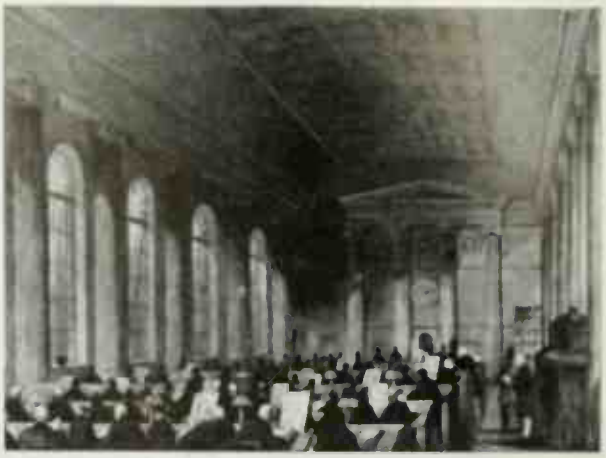
The ancient name of the city was Mutina; it was in the territory of the Boii, who were first subdued by Rome late in the 3rd century B.C., and was a place of some importance. The Roman town lay to the southeast of the modern one, its northwestern wall being marked by the Corso Umberto I. The ravages of Attila the Hun and Lombard attacks ruined it, but about the close of the 9th century it was restored. It later became the scene of violent conflicts between the Guelphs and Ghibellines until the 13th century, when it became a possession of the house of Este (*q.v.*), with whom its history is closely identified. The next to the last of the Este rulers, Francis IV, duke of Modena, was reactionary and despotic; his son, Francis V, who succeeded him in 1846, faced internal difficulties from the beginning and in 1859 the representatives of Modena declared their territory part of the kingdom of Italy. Their decision was confirmed by the plebiscite of 1860.

The province, covering an area of 2,690 sq km. (1,039 sq mi.), has a diversified economy which includes agricultural production, cattle breeding, food and clothing production and ceramic and brick factories. Among the urban centres are Vignola, 20 km. (12 mi.) S.E. of Modena, known for its fruit; Sassuolo, 16 km. (10 mi.) S.W., with ceramic and brick factories; and Carpi, 15 km. (9 mi.) N.W., with textile industries. Among the food products produced in the region are grapes from which wine is made, cheese, ham and sausage.

**MODERN ARCHITECTURE.** This article is concerned with architecture after 1800 and is divided into the following main sections:

I. Introduction
II. The 19th Century
  A. Background
  B. From 1800 to 1860
    1. Rationalism
    2. Classicism
    3. Romanticism
    4. Organicism
    5. Mechanism
    6. The Beaux-Arts
  C. From 1860 to 1885
    1. Ruskin's Influence
    2. Viollet-le-Duc
    3. New Forms
    4. H. H. Richardson
  D. From 1885 to 1900
    1. Art Nouveau
    2. The Chicago School

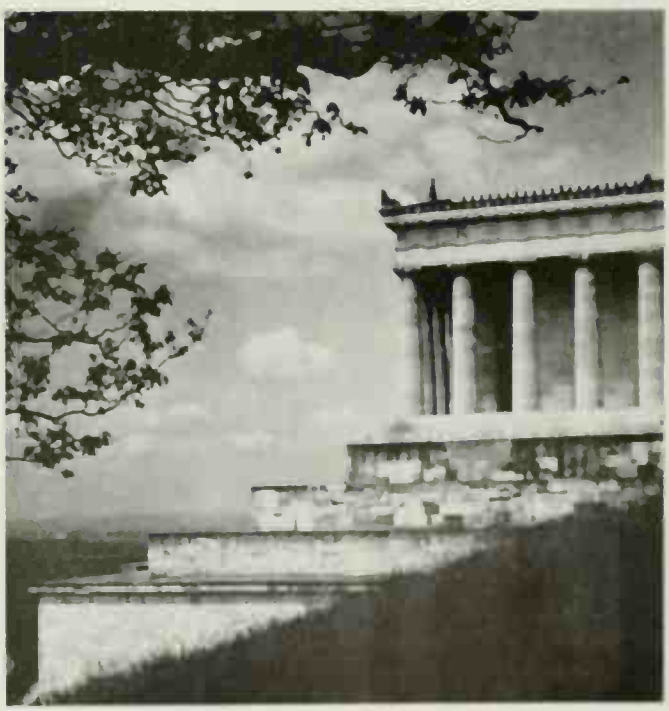
St. Nicholas church, Potsdam, Ger., 1826–49; by Karl F. Schinkel



Office of the Bank of England where £5 notes were sorted and examined; remodeled by Sir John Soane, 1788–1808

Drawing of the Reform club, London, built in 1837; Sir Charles Barry, architect

Old Kentucky capitol at Frankfort, 1827–30; by Gideon Shryock



"Valhalla" at Regensburg, Ger., 1830–47; by F. K. L. von Klenze

19TH CENTURY: RATIONALISM AND CLASSICISM

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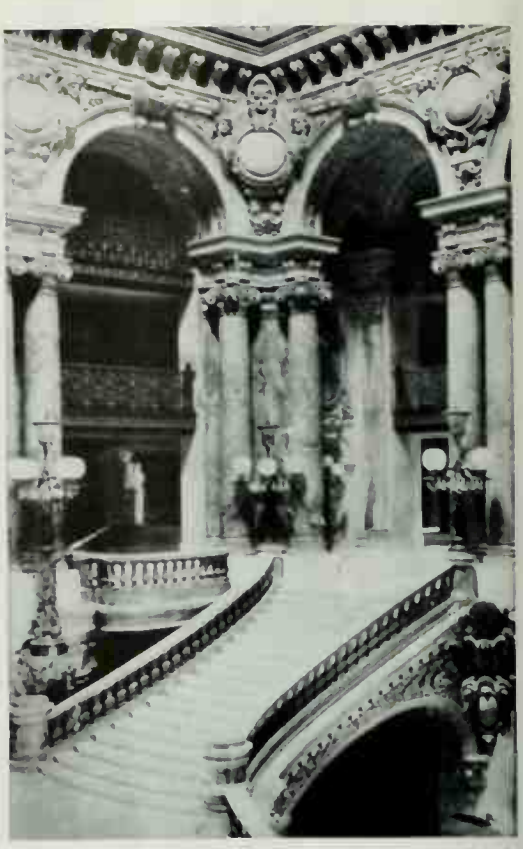
# MODERN ARCHITECTURE

North end of the Houses of Parliament, London; at left is the Clock tower ("Big Ben"). Sir Charles Barry and A. W. Pugin, 1837–57



Staircase of the Paris Opera by Charles Garnier, 1861–75

Reading room of the Bibliothèque Nationale, Paris, 1854–68, Henri Labrouste, architect

Entrance of St. Patrick's cathedral, New York city, by James Renwick, 1858–79

19TH CENTURY: ROMANTICISM AND THE BEAUX ARTS

[illegible]

The Albert memorial, London, 1863–72, by Sir George Gilbert Scott

University museum, Oxford, 1854–60, by Thomas Deane and Benjamin Woodward

National Academy of Design, New York city, 1862–65, by Peter Bonnett Wight

Crystal palace of the Great exhibition held in London in 1851, a timber, iron and plate glass building designed by Joseph Paxton

19TH CENTURY: VICTORIAN GOTHIC AND A NEW FORM

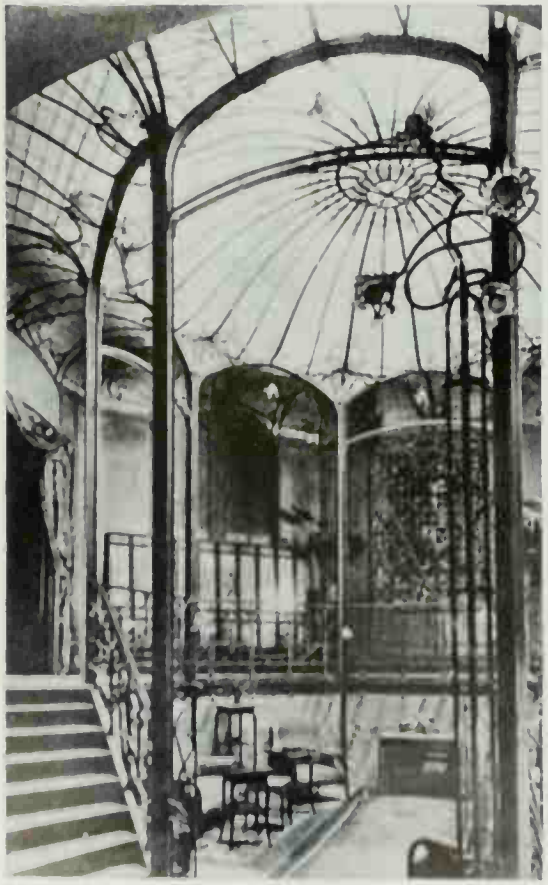
BY COURTESY OF (CENTRE RIGHT) NATIONAL ACADEMY OF DESIGN, PHILADELPHIA, (TOP LEFT) CENTRAL PRESS PHOTOS LTD., (TOP RIGHT) A. F. KERSTING, (BOTTOM) RADIO TIMES HULTON PICTURE LIBRARY

# MODERN ARCHITECTURE

Trinity church, Boston, Mass., 1872–77, in the Romanesque revival style of H. H. Richardson

Richardson's design for the Marshall Field & Company wholesale warehouse, Chicago, Ill., 1885–87

"The Breakers," Newport (R.I.) home of Cornelius Vanderbilt, designed by Richard Morris Hunt, 1892–95



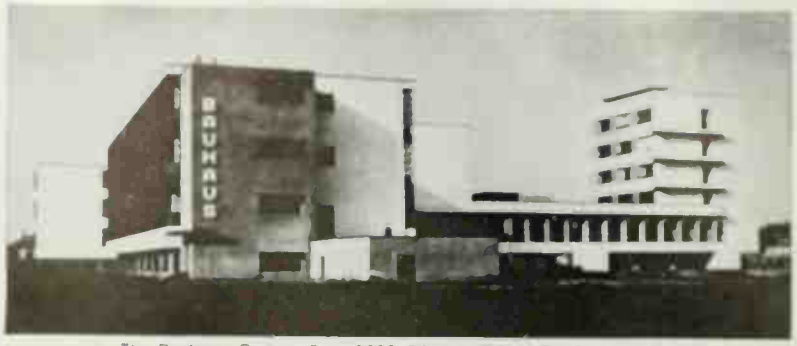
Interior of the house at 12 Rue de Turin, Brussels, Belg., by Victor Horta in the art nouveau manner of the 1890s

Wainwright building, St. Louis, Mo., 1890–91, one of the first skyscrapers; Louis Sullivan, architect

19TH CENTURY: THE END OF THE OLD AND BEGINNING OF THE NEW

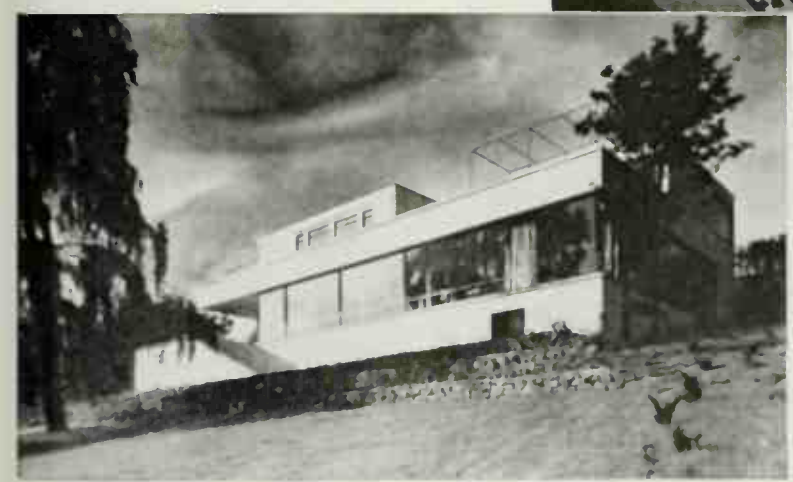
[illegible]

Villa Savoye, Poissy, France, 1928–30, by Le Corbusier (C. E. Jeanneret) and Pierre Jeanneret



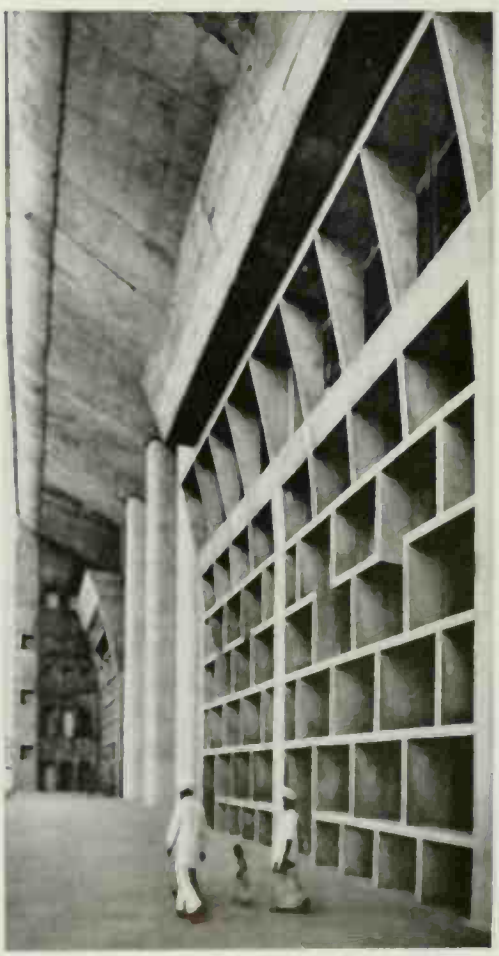

The Bauhaus, Dessau, Ger., 1925–26, by Walter Gropius, founder of the school which was a major centre of design until it was closed in 1933

Le Corbusier's model of the Voisin plan for a contemporary (1922) city of 3,000,000 persons



The Tugendhat house, Brno, Czech., 1930, by Ludwig Mies van der Rohe, Gropius' successor at the Bauhaus

Mies van der Rohe's German pavilion for the International exposition at Barcelona, Spain, in 1929



High Court of Justice, Chandigarh, India, one of several buildings by Le Corbusier for the Punjab capital, 1956

20TH CENTURY: LE CORBUSIER AND THE BAUHAUS GROUP

BY COURTESY OF (TOP RIGHT) WALTER GROPIUS; (CENTRE LEFT) MUSEUM OF MODERN ART, NEW YORK; AND MIES VAN DER ROHE; (BOTTOM LEFT) MIES VAN DER ROHE; PHOTOGRAPHS, (TOP LEFT, CENTRE RIGHT, BOTTOM RIGHT) JULIEN HERVÉ

# MODERN ARCHITECTURE

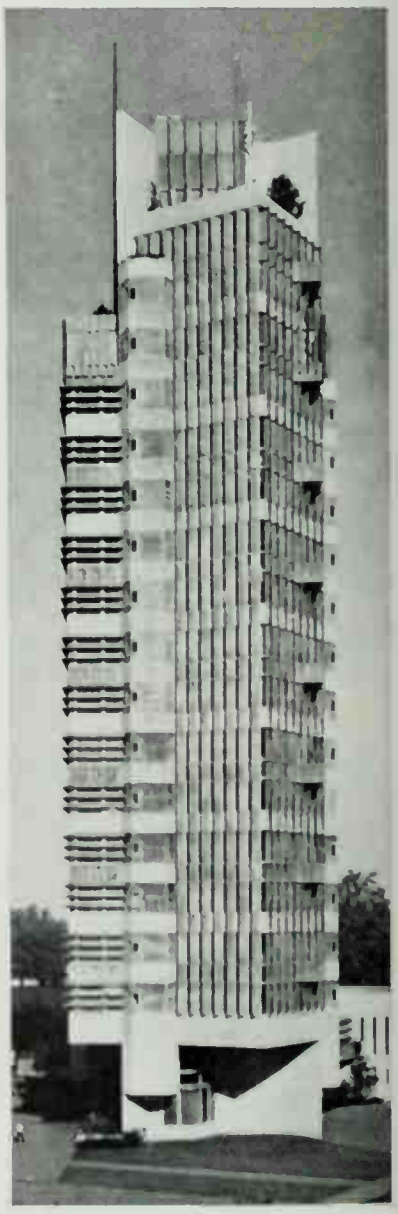
Robie House, Chicago, Ill., 1909, considered to be the finest example of Wright's "prairie" style

Guggenheim Museum of Non-Objective Art, New York city, Wright's last major building, completed the year he died, 1959

"Fallingwater," Bear Run, Pa., 1936–38, a house for Edgar Kaufmann in which Wright employed a bold use of cantilevers

Interior of the main workroom of the administration building of the Johnson Wax company, Racine, Wis., 1936–39

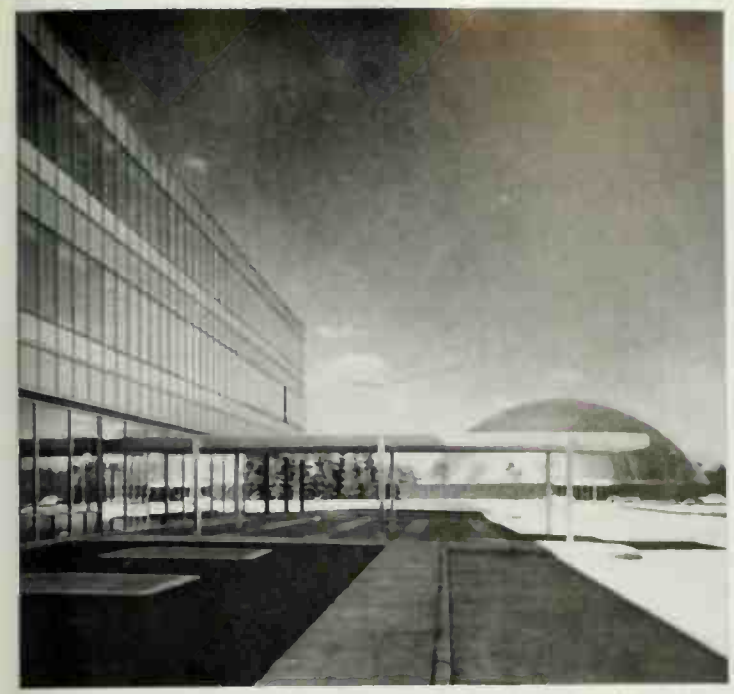
Taliesin West, Wright's home and studio near Phoenix, Ariz., begun in 1938



The Price Tower, Bartlesville, Okla., built in 1955–56, the completion of a design Wright had prepared 25 years earlier

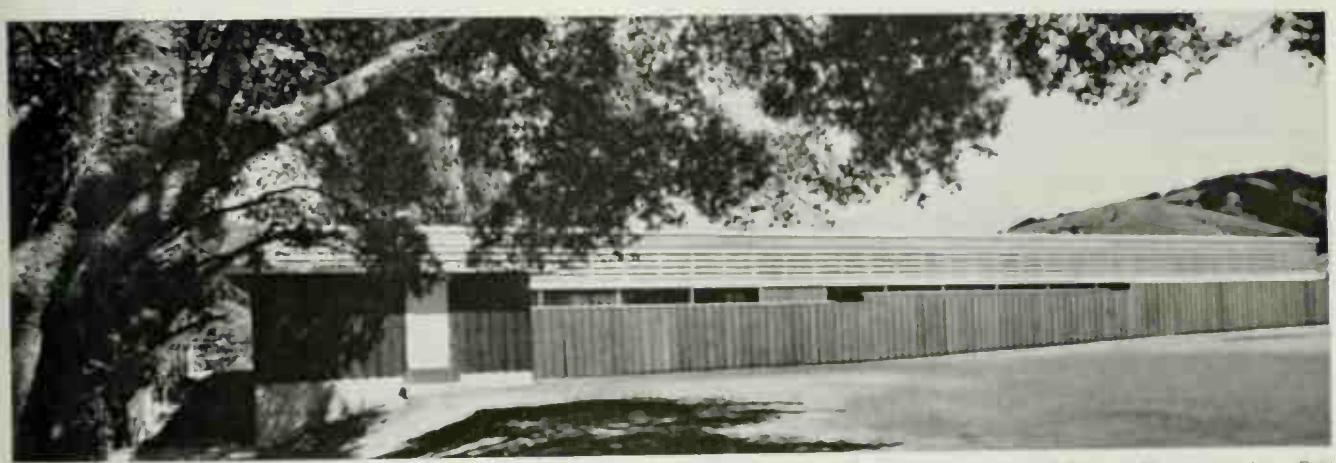
20TH CENTURY: FRANK LLOYD WRIGHT

BY COURTESY OF (TOP LEFT) ARCHITECTURAL FORUM; (CENTER) JOHNSON'S WAX; (BOTTOM RIGHT) JAY O. PRICE; PHOTOGRAPHS, (TOP LEFT) RICHARD NICKEL, (TOP RIGHT) A. DEVANEY FROM PUBLIC, (CENTER LEFT) HEDRICH BLESSING, (BOTTOM LEFT) P. E. GUERRERO



General Motors corporation Technical centre, Detroit, Mich.; by Eero Saarinen, 1955

Interior of roof of exposition hall at Turin, Italy, by Pier Luigi Nervi, 1950



Elementary school at Fairfax, Calif., by John Lyon Reid

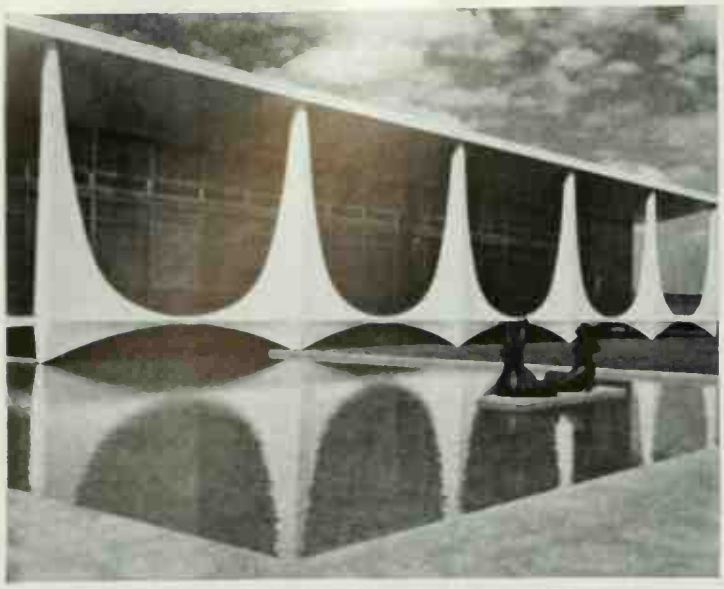
Court of the U.S. embassy at New Delhi, India, by Edward D. Stone, 1957–59

Royal Festival hall, London, by R. H. Matthew and J. L. Martin, opened in 1951

20TH CENTURY: INDUSTRIAL AND PUBLIC BUILDING DESIGNS

BY COURTESY OF (TOP LEFT) GENERAL MOTORS CORP.; PHOTO BY ERIK BUCHLER. (TOP RIGHT) PIER LUIGI NERVI; (CENTRE) JOHN LYON REID AND ASSOCIATES; (BOTTOM LEFT) EDWARD D. STONE, 1957. (BOTTOM RIGHT) PRESSED STEEL COMPANY LTD.

# MODERN ARCHITECTURE



Palace of the Dawn, residence of the president, Brasilia, Braz., dedicated 1960; Oscar Niemeyer, architect

Unusual roof design of the David S. Ingalls hockey rink, Yale university, New Haven, Conn., by Eero Saarinen, 1958

Lever house, glass, steel and aluminum skyscraper, New York city, by Skidmore, Owings & Merrill, 1952

Aluminum-sheathed tower, housing offices of the Aluminum Company of America, Pittsburgh, Pa., by Harrison & Abramovitz, 1954

Rectangular glass and steel house surrounding a brick cylinder; by Philip Johnson at New Canaan, Conn., 1949

Congress hall, Berlin, Ger., 1957, by Hugh Stubbins

## 20TH CENTURY: NEW SHAPES AND THE EXPLORATION OF MATERIALS

BY COURTESY OF (TOP RIGHT) YALE UNIVERSITY NEWS BUREAU; (CENTER RIGHT) PHILIP JOHNSON ASSOCIATES; PHOTO BY ALEXANDROS GARDNER; (BOTTOM LEFT) SKIDMORE, OWINGS & MERRILL; (BOTTOM RIGHT) GERMAN EMBASSY INFORMATION OFFICE; PHOTOGRAPH; (TOP LEFT) UNITED PRESS INTERNATIONAL

III. The 20th Century
A. From 1900 to 1930
1. Frank Lloyd Wright
2. Developments in Europe
3. Le Corbusier
4. Gropius
5. Mies van der Rohe
B. From 1930 to World War II
1. The Spread of Modern Styles
2. Residences by Wright
3. Other Works of the Period
4. Office Buildings
5. American Modernism
C. After World War II

## I. INTRODUCTION

Architecture after 1800 shared with earlier architectures three diverse requirements: to render good performance; to stand up and sustain loads; and to give aesthetic satisfaction. The buildings necessarily reflected the society in which they were created; they especially reflected the acquisition of technological control over natural power and the application of technology to problems of manufacture, distribution, transportation, communication, climate and physical comfort.

The greatest amount of energy was expended upon housing modern entrepreneurial management. The characteristic building types were the powerhouse or dam, the factory, the research laboratory, the administrative office building, the transportation terminal and the market. Architecture became the badge of commercial prestige, an advertisement of the new centres of power which sought in height, size and quality the architectural eminence accorded in the past to churches and places of political assembly.

Until about 1900 it was not clear that a new style of architecture would accompany the new institutions. Many architects and clients attempted to enshrine science and commerce, the new metropolis and its suburban fringe, within classical and medieval styles. Others subscribed to a cultural schism, allowing the factory and powerhouse to be bold, inartistic expressions of engineering while buildings at the top of the social hierarchy, the church and the college, were made to conform to Gothic, colonial or Roman antecedents.

Thus most 20th-century cities were cacophonies of architectural styles as clients and architects were guided by any of four contrasting ideas: formalism and romanticism, drawing upon classical and medieval precedents, respectively; mechanism, a hypothesis about nature extended to architecture; and organicism, a composite of romantic and mechanistic philosophies. The proponents of formalism, such as Charles Follen McKim, believed that beauty was obtained through the manipulation of cylinders, hemispheres and other simple geometric forms after Greek or Roman models. Arranged upon axes, these forms constituted impressive monumental buildings, Henry Bacon's Lincoln memorial in Washington, D.C. (dedicated 1922) being one example. John Ruskin and Ralph Adams Cram advocated romanticism. The complex spaces and structures of Gothic cathedrals were recreated in St. Thomas' church in New York city (1913) by Bertram Goodhue and in the University museum by Thomas Deane and Benjamin Woodward at Oxford, Eng. (*c.* 1858). The third idea, mechanism, the ancient philosophy of nature by which the universe was interpreted as a system of uniform laws governing inert masses, suggested an emphasis on structures and materials and on the efficient, economical adaptation of form to use. It gained support among such architects as Walter Gropius, who established the Bauhaus (*q.v.*) on principles compatible with those of science and industry. Still another point of view, organicism, was espoused by the great architect Louis Sullivan, who insisted that living organisms provide the formal, structural and adaptational principles of architecture. "Fallingwater," Bear Run, Pa., was designed by Sullivan's pupil Frank Lloyd Wright.

However suggestive for style, the four philosophies offered little basis for quality, which is a function of architectural design rather than style. Too few clients and architects realized that quality in architecture derives from a rhythmical arrangement of spaces and masses, which states a geometric theme in light and shade, expresses its purpose and executes that purpose well. The style may express a building's site, materials, use, structure, client, designer, interior spaces, era or social environment, but such expressions have nothing whatever to do with the utility (emotional as well as physical), stability or beauty of the result. Failure to understand the differences between style and composition contributed to the poor architecture of modern communities in instances such as those in which a Georgian, classical or Gothic style was chosen as being appropriate to a town, church, college or office building, however unsatisfactory the architectural result might be. (See ARCHITECTURE: *Expression.*)

Good modern designs might achieve unity through the use of interlocking, dynamically asymmetrical masses and spaces, as in the town hall at Hilversum, Neth. (1924), by W. M. Dudok or Ludwig Mies van der Rohe's German pavilion at Barcelona (1929), or by balancing similar voids or masses symmetrically with respect to an axis, as in the Galleria Vittorio Emanuele at Milan by Giuseppe Mengoni (1829–77) or the railroad station at Tours by Victor Laloux (1850–1937). The former arrangement characterized programmatic buildings, in which interior spaces were extruded to create salient, exterior masses, as in the Graduate centre at Harvard university (1950) by the Architects' Collaborative or Le Corbusier's Notre Dame du Haut at Ronchamp (1955).

The latter type of composition, sometimes called monumental, prevailed wherever regular geometric enclosures were practical, as in the intersecting barrel vaults of the Lambert-St. Louis (Mo.) air terminal (1950–56) by Minoru Yamasaki or the spherical triangle of the auditorium at the Massachusetts Institute of Technology (M.I.T.), Cambridge (1955) by Eero Saarinen. In each case, the successful building marked a graceful transition from the ground, terminated at the corners decisively, came to a forceful conclusion at its sky line and formed successful interior and exterior spaces with amenable transitions between them. Usually, a single spatial theme was varied rhythmically throughout the building, as in Frank Lloyd Wright's Johnson Wax company administration building at Racine, Wis. (1936–39), where the theme was a cylinder of space. Modern architecture must be judged on both its style—the building's expressive content, particularly as it reflects the people and institutions that built it—and its design—the organization of masses and spaces to achieve both a useful and an aesthetic result. Not all modern buildings were successful by either of these criteria, and only a few by both.

## II. THE 19TH CENTURY

### A. Background

The architectural theories that were ascendant during the 19th and 20th centuries were already operative during the 18th century. Formalist theories, derived from Renaissance ideas, were reflected in the works of Jacques François Blondel (1705–1774), in buildings like the Petit Trianon (1762–68) by J. A. Gabriel and in James Gibbs's St. Martin-in-the-Fields (1722–26). There were mechanists, such as Francis Hutcheson, Carlo Lodoli and the abbé Laugier. "Rationalist" architecture, exemplified by George Steuart's St. Chad's at Shrewsbury, Eng., Sir John Soane's Bank of England and C. N. Ledoux's plans for Chaux, an ideal village for France, was functional and programmatic in plan and classical in style. There were also utilitarian buildings; the factory at Soho, Eng., for instance, showed the intention of Matthew Boulton and James Watt to use iron and masonry economically in industrial buildings. Most evident were the romanticists. Archaeological investigations during the 1750s by R. Wood and J. Dawkins at Palmyra and Baalbek, by D. Leroy in Greece, by J. Stuart and N. Revett in Athens inspired a classical temple at Hagley, Eng., while C. L. Clérisseau's investigation of the Maison Carrée at Nîmes allowed Thomas Jefferson to reproduce the major features of that Roman building for the state capitol at Richmond, Va. The far east was the inspiration for a "pagoda" at Kew gardens. Marie Antoinette's peasantlike Petit Hameau at Versailles occasioned delight among the lovers of the rustic. Horace Walpole's Strawberry Hill expressed the enchantment with the Gothic that made Sir Walter Scott's works so popular. Scott himself built a

"Gothick" house at Abbotsford, Edinburgh, begun in 1812. *See* also BAROQUE AND POST-BAROQUE ARCHITECTURE.

B. FROM 1800 TO 1860

**1. Rationalism.**—Throughout western Europe and the eastern U.S. in 1800, remnants of Renaissance architectural forms survived until architects consciously revived them wholesale. Two clubs in London, the Reform (1837) by Sir Charles Barry and the Athenaeum (1829–30) by Decimus Burton, the latter a reflection of Baldassare Peruzzi's Palazzo Massimo at Rome, established the setting for the cultured English gentleman as the Renaissance *palazzo*. Dorchester house, London, by Lewis Vulliamy was a frank copy of the Villa Farnesina at Rome. The fashion also prevailed for churches, as in Arthur Gilman's Unitarian church on Arlington street, Boston, which was modeled upon Italian examples, and for department stores. In J. P. Gaynor's Tiffany store at New York city, the *palazzo* form, however much prestige it conveyed, was stretched into an absurdity.

Rationalist architects recognized the incongruity of Renaissance enclosures for modern institutions. One of the most interesting designers, Sir John Soane (1753–1837), in a series of buildings including the Bank of England (remodeled 1792–1823), the Dulwich Art gallery (1812), the stables at Chelsea hospital (1810) and his own house at Lincoln's Inn Fields (1812–14), created exterior masses out of interior spaces, achieved dramatic and unusual combinations of parallelepipeds and hemispheres and established innovative proportions. In Germany K. F. Schinkel (1781–1841), working in a variety of styles, attempted programmatic planning in his Royal theatre at Berlin (1818–21), St. Nicholas church at Potsdam, Altes museum at Berlin (1822–30) and "Project for a Department Store." His Academy of Architecture at Berlin (1831–35) was the most effective of his attempts to shed classical and medieval precedents.

In the U.S. rationalist architecture was introduced by the Frenchman J. J. Ramée, who designed buildings for Union college, Schenectady, N.Y., in 1813, and by the Englishman Benjamin Henry Latrobe (1764–1820), whose waterworks at Philadelphia (*c.* 1800) and Roman Catholic cathedral at Baltimore (*c.* 1820) perfectly reflected the desire for useful and theatrical spaces enveloped by classical forms. Such designers did not imitate classical precedents; Latrobe, for example, designed tobacco and corn orders for capitals in the senate rotunda at Washington. Native American architects soon caught the spirit; Charles Bulfinch (1763–1844) moved away from the academic design of his statehouse at Boston toward the rational composition of University hall at Harvard (1813–15), a direction later followed by Robert Mills (1781–1855) not only in his Washington monuments at Washington and Baltimore but in the Sansom Street Baptist church in Philadelphia (1808) and the jail at Charleston, S.C.

**2. Classicism.**—Latrobe attempted to dissuade amateur architects such as Thomas Jefferson from sacrificing utility for the sake of Greek and Roman details, but the classical revival swept many countries, sometimes leaving elegant legacies. Beginning about 1815, architecture and archaeology became more closely allied. H. W. Inwood and C. R. Cockerell increased the store of information about Greek architecture. Lord Elgin removed the Parthenon's pedimental sculptures and their deposit in the British museum in 1816 added to the then current interest in ancient Greece. This Hellenism became more fervid when, from 1821 to 1829, the wars of Greek independence inspired Englishmen such as Lord Byron and Americans such as Nicholas Biddle to become ardent supporters of the Greek cause. The classical theme was used at George Basevi's Fitzwilliam museum at Cambridge and Harvey Elmes's St. George's hall at Liverpool. Inwood's church of St. Pancras, London (1819–22), pedantically and eclectically repeated themes from the Athenian Tower of the Winds, Choragic monument of Lysicrates and Caryatid porch. The Edinburgh high school (1819, D. Hamilton) was the Thesenm (Hephaesteum) on the front of an academic building. Classical romanticism was in the architectural forefront in France also, where Napoleon's imperial aspirations left a monumental civic residue in the Arc du Carrousel, Paris (1806) by Charles Percier and Pierre Fontaine, and the church of the Madeleine, Paris (1806–42), by Pierre Vignon, which was intended to be a "temple of glory" for Napoleon's legionnaires. In Germany, meanwhile, under the influence of J. J. Winckelmann (1717–68), Goethe and Lessing, interest turned toward Greek archaeology. The architect F. K. L. von Klenze designed a "Valhalla," a Greek temple standing on an artificial hill at Regensburg in frank imitation of the Parthenon on the Acropolis. The Brandenburg gate at Berlin by K. G. Langhans (1733–1808), the Siegestor at Munich (1840) and the Aula at Göttingen established the precedent of antique settings for the gateways to cities and universities.

The U.S. succumbed to the charm of Greek and Roman architecture during the period from 1815 to 1860. Following his apostrophe to Roman Nîmes in the state capitol at Richmond (1785–92), Thomas Jefferson put his practical mind and elegant taste to the design of a university campus, the University of Virginia, Charlottesville (1817–25), where his plan for "an academical village" ensured privacy for students and professors and protection from inclement weather. It was dominated by the library rotunda, a copy of the Pantheon; and the pavilions, which punctuated the rhythms of low-lying dormitories in the lawns, imitated Roman and Palladian designs. Acceptance of Greek or Roman precedent in decorative details frequently required it in other matters, but in the hands of professional architects, Francis Costigan or Gideon Shryock for example, space was adeptly handled to achieve both utility and visual coherence, best exemplified by Shryock's state capitol at Frankfort, Ky., and in a building now recalled only by drawings, Bussière de Pouilly's St. Louis hotel at New Orleans (1836–40). Lesser designers graced the towns of Marietta, O., Ovid, N.Y., and Nantucket, Mass., with Greek and Roman temples, which in many cases remain the towns' finest embellishments. They offered no sound approach to an architecture for modern times, however, and failed to express modern ideas even in the Merchants' Exchange William Strickland erected in Philadelphia in 1834. Deluded by extraneous political symbolism, Americans housed state legislatures in classical ideograms, as at Columbus, O. (Henry Walter), New Haven, Conn. (1827, Ithiel Town), and Indianapolis, Ind. (1832–35, Town and Alexander Jackson Davis). Stephen Girard's express wishes for serviceable and simple buildings at the college he founded at Philadelphia were ignored by his trustee, Nicholas Biddle, who persuaded the architect, Thomas Ustick Walter, to make the main building (1833–47) a Greek temple with Corinthian columns; its rooms were poorly lighted, ventilated and reverberative. At its dedication Joseph Chandler spoke of its power to evoke classical grandeur and to inspire moral virtue. Greek houses, such as the one planned and owned by J. C. Stevens in New York city (1845), were sometimes ingeniously planned. Another amateur in New York, Philip Hone, noted in his diary that every departure from classical models seemed to him a departure from grace and beauty.

**3. Romanticism.**—In England, where Gothic construction still survived in rural regions, there was a conscious revival of medieval forms. Beginning with schools, colleges and churches, *e.g.*, St. Luke's, Chelsea (1820–24), by J. Savage, the fashion was stimulated by the Oxford movement and Camden Ecclesiological society and it received national approval when, from 1837 to 1857, the Houses of Parliament were rebuilt. The 97 designers who submitted drawings engaged in a battle of styles, Gothic versus classical. Gothic, which was thought to be more patriotically English, more manly and closer to nature, emerged triumphant. An academic, regular plan, preserving the old Westminster hall, enabled the architect, Sir Charles Barry (1795–1860), to fit the new quadrangles to the old hall, while the young designer Augustus Welby Pugin (1812–52), passionate advocate of Gothic architecture, ornamented the Gothic Revival elevations. At Ramsgate, Pugin designed the Gothic chapel of St. Augustine (1846) and, at Southwark, the cathedral of St. George. Equally active as a writer, he advocated Gothic, above all others, as a Christian architecture, a point of view he stressed in *Contrasts, or a Parallel Between the Architecture of the 15th and 19th Centuries* (1836) and *True Principles of Christian Architecture* (1841), in which his

basic, but highly debatable, assumption was that architecture that is aesthetically good nurtures a society that is ethically good.

Pugin gained some following on the continent. Frenchmen seldom accepted moral interpretations of medieval architecture and with a few exceptions, such as Chateaubriand's house at Châtenay (remodeled 1807) and the chapel of St. Louis at Dreux (begun 1816), they frowned on Gothic Revival. English influence was stronger in Germany, where the brothers Schlegel awakened interest in Gothic buildings. Cologne completed its medieval cathedral; and there were also new Romanesque buildings such as the Johanniskirche in Berlin (1835) by Schinkel, and picturesque Gothic castles, such as the Schloss at Neuschwanstein, Bavaria (1869–86), built for Louis II who, appropriately, invited Richard Wagner to visit him there after the "Ring" series was published.

Medievalism also flourished in the United States. Pugin gained an American following quickly, including the Episcopal bishop J. H. Hopkins, who wrote an appreciative essay about Gothic in 1838. Alonzo Potter, also a bishop, Henry Cleveland, professor of history at Harvard, and Andrew Jackson Downing, a landscape architect and architectural journalist, championed Gothic for use in churches, schools, public buildings and houses. The response was immediately favourable and James Renwick designed Gothic churches for New York's Episcopalians (Grace church, 1843–46) and Roman Catholics (St. Patrick's cathedral, 1858–79). Richard Upjohn (1802–78) matched Renwick's scholarship by erecting New York's Trinity church (1839–46) and surpassed his rival's range of expression with rustic rural churches employing board and batten construction. Gothic villas appeared in the countryside, often in picturesque compositions as in Upjohn's "Kingscote" at Newport, R.I. (1838), and in the villa for Charles Alger at Berkshire, Mass., designed by A. J. Davis (1803–92). Gothic church forms were used at colleges and universities, sometimes in a militaristic manner, as at the Virginia Military institute at Lexington (*c.* 1850) by Davis, or, more often, to suggest the affiliation between humanistic education and Protestant worship, as in New York university's main building (1836) and Yale's library (1842), both by Davis, and Harvard's Gore Hall library (1838), a clumsy version by Richard Bond of King's College chapel. Stretched still further, medieval forms served modern transportation, as in Thomas Tefft's design for Union depot at Providence, R.I. (1848).

The motivation behind this revival was to create a setting redolent of medieval piety and rich in moral associations. Literary associations and the fancied emotional nuances of simulated masonry vaults distracted attention from the true matrix of architectural experience, but they were beguiling.

Romantic clients and architects did not long remain content with classical or medieval reminiscence. There were also rich quarries in other historic and distant architectures. Memory sometimes slipped and an Islamic temple was built for Jews, as in J. K. Wilson's Plum street temple in Cincinnati, O. Egyptian obelisks appeared in Paris and Washington, cavetto cornices in Paris (Hôtel de Torcy, remodeled for Napoleon's stepson). Egyptian columns in New York (the Tombs, a prison, 1838, John Haviland), New Bedford, Mass. (the Pearl street railroad depot), and Cambridge, Mass. (the Mount Auburn cemetery gates). Early Christian basilicas were called to mind by the church of St. Vincent de Paul in Paris (1824–44) by J. I. Hittorff (1792–1867) and picturesque Italian villas appeared on the hills of England and the U.S. ("Prospect," Princeton, N.J., 1849, John Notman). Even more exotic were the Indian, Chinese, Japanese and Persian pleasure palaces, such as the Royal pavilion at Brighton, Eng. (1818–21), by John Nash and "Iranistan," P. T. Barnum's domed extravaganza at Bridgeport, Conn. (1848). Such eclecticism was encouraged by critical writing, which was best represented by A. J. Downing's *Landscape Gardening* (1841), *Cottage Residences* (1842) and *The Architecture of Country Houses* (1850).

**4. Organicism.**—Some persons proclaimed a day in which historical stage-sets would have no place. Perhaps the most cogent was Horatio Greenough (1805–52), a sculptor who recognized in the work of Schinkel and Latrobe the possibility of an architecture appropriate for modern institutions. It would provide useful spaces, light, air and protection from weather; its spaces would be defined by means of classical walls and columns, ornamented in ways relevant to modern society. Greenough was openly critical of Girard college's temple, saying it was "like seeing the Pitt diamond on an Indian squaw." Equally critical of the medieval towers and battlements on Renwick's Smithsonian institution in Washington, Greenough said, in a dramatic twist on the associationalist's argument, that they were expressive, admittedly, but of a politics and a religion that were foreign to those he believed America should have. He delighted in the structure of ships, bridges, hand tools and weapons, and his study of the anatomy of birds and plants led him to a far-reaching principle: form adapts to use. This organicism appeared in the writings of Ralph Waldo Emerson and the critics at Concord.

**5. Mechanism.**—A more mechanistic viewpoint emphasized the need for economical, utilitarian buildings. John Willis Griffiths, a naval architect, lectured in the eastern United States at mid-century about his revolutionary "extreme clipper ships," saying that strict adaptation of form to functional purpose was the only source of beauty and utility. His viewpoint reflected that of the industrialists who erected the Stanley mill in Stroud valley, Gloucestershire (1813), and the Allendale mills at Centerdale, R.I. (1822). Utilitarianism was the objective of engineers like Sir William Fairbairn, who was responsible for the mills at Saltaire, Eng. (1851–53). Perhaps the strongest proponents of utilitarianism were scientists, notably Joseph Henry, the U.S. physicist, Sir Francis Galton, the English physician, and Alfred Russel Wallace, the English biologist, who wanted functional laboratories, hospitals and museums, without wasteful expenditures on monumental galleries, staircases or vaults.

Characteristic of the serviceable, economical and flexible workrooms they wanted were the spaces in Harvard's Museum of Comparative Zoology, designed by the Swiss biologist Louis Agassiz in 1859. The rooms were excellent for displaying a typologically arranged exhibit of biological specimens, but the pile of brick was as ugly as if it had been tossed up by a prehistoric glacier. In rejecting all considerations of design as well as style, the mechanists accomplished an architectural result that was no more satisfactory than the eclectic chimeras of romantic fancy. Physical utility could not be ignored, but a building, to be architecture, had also to be an aesthetic expression of the great themes science and industry suggested.

**6. The Beaux-Arts.**—The dilemma was frequently avoided by architects of the academic tradition in France, particularly those from the École des Beaux-Arts in Paris. The most fruitful architectural school of the 19th century, it sought to furnish utility within handsome, classical buildings. Traditional elements, such as domes and columns, and traditional principles of composition, including geometric spaces balanced around axes, characterized the work of J. L. Duc and J. L. Pascal. A more radical part of the École group, led by Henri Labrouste (1801–75), attempted programmatic plans and nonarchaeological use of classical forms. Labrouste's Bibliothèque Ste. Geneviève (1843–50) and Bibliothèque Nationale (1854–68), both in Paris, were eminently successful, not only in the harmony of their spaces, but in the expression of programmatically arranged interiors and the introduction of useful devices such as iron stacks and cast-iron structure. More conservative designers, L. Visconti and H. Lefuel, for example, worked upon additions to the Louvre, in which they imitated earlier portions to achieve harmony (Louvre pavilion, 1852). Victor Baltard, however, in the church of St. Augustin (1860–68) and the Halles Centrales (1853), the central markets in Paris, used iron and glass in his programmatic arrangements of space. Baron Georges Haussmann directed Baltard and other architects in the design of the great boulevards of Paris: grand axes connected principal historic buildings and established prominent sites for monuments like the Arc de Triomphe de l'Etoile at the head of the Champs-Élysées by J. F. T. Chalgrin (1739–1811). Much of the present character of Paris remains a tribute

to Haussmann; although his despotic methods were seldom available to later city planners, the example of Paris long remained a model for modern urban patterns.

### C. From 1860 to 1885

Haussmann's example, following Labrouste's innovations, ended any search for ancient buildings that might be appropriated wholly to contain modern institutions. Museums, markets, office buildings and schools demanded new and complex plans and the best designers provided them, although they did not originate a compatible style. They attempted instead modern versions of classical and medieval styles. Perhaps the most exciting of the new sequences of space can be seen in a longitudinal section of the Opéra at Paris (begun 1861) by the Beaux-Arts architect Charles Garnier (1825–98); grand entrances, foyers, staircases, vestibules and boxes lead to a huge auditorium, which is separated from the office wing by a tall stage loft. Garnier's magnificent command of the sweeping spaces was equaled by his mastery of balance, punctuation and termination; the façade, a composition of stately rhythms and playful sculpture, provided a fitting entrance for Napoleon III.

**1. Ruskin's Influence.**—Nothing comparable appeared in the United States or England during the '60s and '70s. In these countries there was a continued insistence upon the literary appropriateness of Gothic sculptural details. The high priest of medieval sentiment at this time was John Ruskin (1819–1900), who preached the aesthetic and moral excellence of the doge's palace at Venice and the campanile at Florence and convinced young architects that medieval handicraft ways might change modern civilization. His *Seven Lamps of Architecture* (1849) and *Stones of Venice* (1851–53) inspired the architect Thomas Deane to essay polychromy and hand-carved ornamental capitals at the Engineering building for the University of Dublin (1851). With Benjamin Woodward, Deane designed the University Museum of Natural History at Oxford university (1854–60), where the brothers O'Shea were exhorted to carve decoration after the natural foliage of the region. Other Englishmen joined the medieval brotherhood. The most influential was William Morris (1834–96), a poet, novelist and artist, a great printer and a leading socialist (*see* Arts and Crafts Movement). He attempted to counteract the ugliness of much machine production by reviving the guilds and by espousing medieval principles, especially those regarding the expression of materials, structure and utility. Together with an architect, his friend Philip Webb, he created the Red house at Upton, Kent, in 1859, where brick, glass, shingles and interior spaces were expressed frankly and boldly. More ornate architecture was improvised on medieval themes by Alfred Waterhouse, William Butterfield and William Burges. Their versions of Gothic, called Victorian, are suggested by the St. Pancras station's Midland hotel (1865) and Albert memorial (1863–72), London, by Sir George Gilbert Scott (1811–78) and by George Edmund Street's New Law courts, London (1874–82). Occasionally, R. Norman Shaw turned out a well-composed version of Tudor Gothic in which massive blocks were chastely mounted to form a picturesque composition. But restraint in the use of ornate, flaccid and tortured forms was rare and the '70s and '80s gained a reputation as a period of notoriously bad taste.

In the U.S. some architects, clients and critics considered Victorian Gothic architecture to be a way of providing a colourful foil to the ugly urban and industrial scene. Ruskinian sentiment captured the hearts of a group in New York who founded the Association for the Promotion of Truth in Art. One of its members, Peter Bonnett Wight, designed the National Academy of Design (1862–65), in which capitals were carved by hand ("to give workmen opportunity to think," according to Wight). The building was a restudy of the doge's palace at Venice, and was meant to please Ruskin. Next, Wight moved his sculptors to New Haven, Conn., where they erected the Street School of the Fine Arts at Yale, another Ruskinian building. *The Crayon* and *The New Path*, periodicals promoting Ruskin's ideas, found favour with Charles Moore and Charles Eliot Norton in Cambridge, Mass., both friends of Ruskin, who was benignly moved by Norton's efforts to improve the architecture at Harvard university. Harvard's Memorial hall (1866–78), designed by W. R. Ware and Henry Van Brunt, was a major statement of Victorian Gothic environment. Such buildings were especially popular for educational institutions, such as Princeton university (Chancellor Green library, 1873, William A. Potter) and Trinity college (later Duke university, Durham, N.C.; quadrangle, 1876, Burges), as well as for museums of fine arts and concert halls in New York, Boston, Cincinnati and Chicago. Even courthouses and post offices tended to be Victorian Gothic while Potter was supervisory architect of the treasury. Some churches, notably the New Old South Congregational at Boston (1877, Cummings & Sears), revealed dramatic spaces, interesting structures and fascinating silhouettes, but the overtones of the architecture were literary and symbolic.

**2. Viollet-le-Duc.**—During the 1880s, architects and critics who became disenchanted with Ruskin's peevish moralism turned to a Frenchman, E. E. Viollet-le-Duc (1814–79), whose archaeological work on Notre Dame de Paris, Carcassonne and other medieval sites led him to respect Gothic architecture as a coherent structural system. His *Dictionnaire raisonné de l'architecture française*, published between 1854 and 1868, was an encyclopaedia of exact information, and his *Entretiens sur l'architecture*, published between 1860 and 1872, developed his general theory, which he formulated for lectures he delivered at the École des Beaux-Arts. Translated into English, the *Lectures* stimulated John W. Root and other Chicago architects to attempt what they called "rational architecture," which was based on frank expression of structure. Although Viollet-le-Duc himself was not a talented architect, as he demonstrated in the gross Gothic Revival church he built at St. Denis, his *Lectures* offered important information about the construction of modern iron skeletons enclosed by nonbearing masonry walls. Illustrations in his book indicated the possible uses of metal, which were exploited in an important building, the Menier chocolate works at Noisiel-sur-Marne (1871–72), by Jules Saulnier. Architects generally ignored Viollet-le-Duc's suggestions, but some did attempt more robust structures, such as Philadelphia's Provident Life and Trust Company building (1879) by Frank Furness and those in the same city by Wilson Eyre, Jr., whose medievalism was more whimsical.

**3. New Forms.**—Scientists continued to have little sympathy for medieval forms. In 1876 Thomas Huxley, the English biologist, advised the trustees of the new Johns Hopkins university at Baltimore not to allow funds to "fossilize into mere bricks and mortar" and to "hire an honest bricklayer" who should erect only useful structures. The physician John Shaw Billings designed the ward pavilions at the Johns Hopkins hospital, while professors of chemistry, biology and physics designed their own laboratories. The president, Daniel Coit Gilman, wanted modern, serviceable structures such as he saw in laboratories at German and English scientific institutes, for example, the chemistry laboratory at Manchester, Eng., which was a bald working machine designed by a professor of chemistry, H. E. Roscoe. Gilman criticized the expensive and unsatisfactory medieval piles at Trinity college and Edinburgh (George Gilbert Scott). His opinion was shared by Charles William Eliot, Harvard's president. A chemist, he had planned his own laboratory at M.I.T. and had high regard for buildings that were expandable, flexible and even expendable, since progress in science required frequent rebuilding. Critics like Clarence Cook now somersaulted from Ruskin's troupe to that of the scientists, whose aesthetic tastes were typified by Gilman's admiration for the precision, uniformity and economy of nature and of fine instruments and machines. Unfortunately, no architect could supply compatible buildings.

Had the scientists recognized it, there was an incipient new architecture that might have reconciled the differences between those who, wanting useful, economical buildings, settled for the commonplace work of bricklayers and mechanics and those who clung to medieval and classical forms to satisfy their craving for art. One could see the dichotomy even within a single building, as in London's St. Pancras station, where Scott's Gothic building stood alongside the iron and glass vaults of the train shed, without

any attempt at a resolution. The shed (1868) was designed by an engineer, W. H. Barlow. Metal arches hold a canopy of glass in a powerful, grand grasp of space. Engineers designed with new materials, exposing them and shaping them in accordance with function rather than a whim of historical taste. At most, architects used cast-iron columns and ribs to simulate traditional domes, as in Nash's Royal pavilion at Brighton, Sir Robert Smirke's British museum (1823–47) and Thomas Walter's dome on the United States Capitol (1851–65).

Builders who were less bound by history achieved new forms. In the Crystal palace at the Great exhibition held at London in 1851, a botanist, Joseph Paxton, employed timber, cast iron, wrought iron and glass in a ridge-and-furrow system he had developed for greenhouses at Chatsworth in 1837. Paxton was partly inspired by the organic structure of the Amazonian lily *Victoria regia*, which he successfully cultivated. The Crystal palace contained important innovations in mass production of standardized materials and rapid assembly of parts, but its chief architectural merit lay in its cadence of colossal spaces. French designers recognized its magic, and a series of buildings for universal exhibitions held at Paris in 1855, 1867 and 1878 showed its influence. In the Palais des Machines (1889) by Ferdinand Dutert and M. Contamin a series of three-hinged trussed arches sprang, from small points, across a huge space, 385 ft. long and 150 ft. high. The English historian James Fergusson happily concluded that the Crystal palace marked the beginning of a new architecture; an English critic, Thomas Harris, coined the name "Victorian" for 19th-century architecture and looked forward to an age of iron buildings. The most important emblem of the Paris exhibition of 1889 was the Eiffel tower (1887–89), designed by Alexandre G. Eiffel, an engineer, who had done outstanding work in the Paris exposition of 1878 and in steel structures like the trussed parabolic arches in the viaduct at Garabit, France (1880–84).

The new materials and forms were best introduced in the service of new architectural problems, such as railroad stations, which could not for long be contained within Renaissance palaces or Gothic guildhalls. As railroads became larger, they sought expressions of the fast and comfortable travel they offered; as they became chief gateways to cities, the stations acquired a distinctive, monumental character. The architectural progression can be followed: the motley, utilitarian Crown street station in Liverpool (1830) and Mount Clare station in Baltimore (1830) gave way to the Classical Revival Boston and Lowell "car house" at Lowell, Mass. (1835). New forms were sought in the arches, trusses and skylights of Sir William Tite's Nine Elms station at London (1837–38). The pagodalike towers on Henry Austin's Union station at New Haven, Conn. (1848–49), were a whimsical diversion, to be followed by Philip Hardwick's dignified Euston station, London (1839–40). All of this culminated in the Parisian Gare de l'Est (1847–52) by François Duquesnoy and Gare du Nord (1861–65) by Hittorf and F. L. Reynaud, London's King's Cross station (1851–52) by Lewis Cubitt, Berlin's Alexanderplatz Bahnhof (1880–85) by J. E. Jacobsthal, the St. Pancras at London and the station at Tours (1895–98) and Paris' Gare du Quai d'Orsay (1898–1900) by Laloux.

The emancipation of markets and stores was no less impressive. Designers erected iron and glass umbrellas such as Baltard's Halles. Members were admitted to the Coal Exchange in London (1846–49, J. B. Bunning) through a round, towered classical porch at the corner of two Renaissance palaces, to a magnificent rotunda hall, which was surrounded by three tiers of ornamental iron balconies and roofed by a lacelike dome of iron and glass. At Paris Eiffel, together with the architect L. A. Boileau, gave the retail shop a new and exciting setting in the Bon Marché (1876), where merchandise was displayed around the perimeters of skylighted, interior courts. The U.S. saw nothing comparable, but cast-iron columns and arches, appearing during the '50s, were used in commercial buildings like the Harper Brothers building at New York by John B. Corlies and James Bogardus (1849) and the *Baltimore Sun's* Iron building by R. G. Hatfield. Stores were given cast-iron faces, as in the pioneering Stewart's department store (later Wanamaker's) in New York city (1859–62) by John Kellum. Iron was frequently intended to simulate stone, and it was admired for its economy of maintenance. The material offered such neglected qualities as precision, standardization and efficient strength, however, which Van Brunt hoped would be recognized architecturally.

Unfortunately, the architects' society restricted their adventures into innovative spatial composition. The train shed was hidden behind the classical or Gothic waiting room; the skylight was thrust out of sight, as at the Bon Marché. Bold engineering was permitted in a bridge or warehouse, but time-honoured cultural institutions demanded an appropriate, traditional expression. In Germany the eclectic Renaissance architecture of Gottfried Semper (1803–79) and Alfred Messel (1853–1909) was dominant. There might be some simplification of form, as in the late work of England's Shaw or the studio (1888) of C. F. A. Voysey (1857–1941) at Bedford Park, London, and Voysey's house for Canon Grane at Shackleford, Surrey (1897). Amsterdam's Bourse (1898–1903) by H. P. Berlage (1856–1934) showed strong bold forms but there were still the traditional ones, as in the town hall at Copenhagen by Martin Nyrop (1849–1921), and little innovation was attempted in structure or materials.

**4. H. H. Richardson.**—Perhaps the architect's position during the '80s was best illustrated by the career of the American Henry Hobson Richardson (1838–86). A gentleman from a fine southern family, he graduated from Harvard, then attended the École des Beaux-Arts in Paris. Returning to New York and going later to Boston, he cast aside his weak Victorian Gothic and Napoleon III pavilions and won national acclaim for the bold and heavy masses of his Trinity church at Boston (1872–77) in which Romanesque motifs from Arles and Salamanca embellish a cruciform auditorium intended for the great preacher Phillips Brooks. The Sherman house at Newport, R.I. (1874–76), recalled Richardson's earlier mélange of styles, but it also hinted at an elimination of complications. He found his stride in his designs for small public libraries at Medford, North Easton and Quincy, Mass., and for small suburban stations along the Boston and Albany railroad tracks.

Like all great designers, Richardson recognized the need for the monumental, even subordinating utility to achieve a unified result, as in the handsomely proportioned Sever hall at Harvard (1878–80). He could be rustic, as in the gate lodge for the Ames estate at North Easton; he was adept in revealing the nature of wood shingles, brick, terra cotta and stone, as in his houses at Cambridge, St. Louis and Chicago; and he also mastered dynamic, programmatic compositions with strong silhouettes, realized in gargantuan stone, as in his Allegheny county courthouse and jail at Pittsburgh (1884–86). His short career ended while his Marshall Field wholesale warehouse (1885–87) was being erected at Chicago. The importance of this warehouse lay in its art. Its masonry arches, which were on a scale compatible with 19th-century commercial and industrial power, stated in light and shadow a theme that was terminated at the corners, phrased in a quieter way above and concluded by a cornice. The warehouse gave later architects in Chicago their first glimpse of how stone might spring to life in the service of industry, and its lesson, usually with more emphasis on the Romanesque Revival style than on the great composition, spread to Kansas City (Van Brunt & Howe), New York city (Potter & Robertson), Boston (Shepley, Rutan & Coolidge) and Minneapolis (L. S. Buffington).

### D. From 1885 to 1900

Still another attempt to instill modern vigour into traditional architecture was made by classicists, especially those who were centred around the École des Beaux-Arts. French students underwent a rigorous training, clearly defined in *Éléments et théorie d'architecture* (c. 1900) by Julien Guadet, a professor at the École. In their best work, such as the Grand Palais and Petit Palais in Paris (1897–1900) by Charles Girault, the French Beaux-Arts architects employed iron, steel and glass in combination with masonry; they organized plans and spaces for clear circulation, monumental vistas and expression of use and they were inventive in elevations and ornamental detail while preserving classical principles of composition. Germany, Russia, England and Italy fol-

lowed the French lead, as in Mengoni's Galleria Vittorio Emanuele at Milan (*c.* 1865). Americans also attended the École, beginning with Richard Morris Hunt (1827–95), and, although Richardson abandoned classicism for the Romanesque style, most Beaux-Arts graduates followed the style that was dominant at Paris. At its worst, the Beaux-Arts influence resulted in atrocious decoration, wasteful plans, inefficient structures and monuments that had little to say about their times. About 1875 inferior architects, such as A. D. Mullet, were in control of the design of most public buildings, and the Old Post Office in New York city, the State Department building in Washington and the city hall at Philadelphia show a reckless display of classical detail unchecked by the knowledge good Beaux-Arts designers invariably brought to their work. The commendable work of Hunt, such as the "Breakers" at Newport (1893–95) and the "Biltmore" at Asheville, N.C. (1890–95), and the more meritorious designs of the French critic at M.I.T., Constant Désiré Despradelle, as in his Berkeley building, Boston, could not prevent the Beaux-Arts from acquiring a bad reputation. Even after it lost its vigour, however, its best exponents were enviably skilled in planning, drawing and monumental composition.

Departures from classicism were numerous during the '80s and '90s. In England and the United States, Gothicists like Sir Giles Gilbert Scott (Liverpool cathedral) and Ralph Adams Cram (1863–1942; West Point Military academy and the cathedral of St. John the Divine, New York city) essayed modern versions of Gothic architecture, which became especially popular for colleges, churches and schools that claimed English cultural heritages. Bertram Goodhue (1869–1924), a talented designer in Cram's firm, gave the Gothic Revival St. Thomas' church in New York city convincing elements. A patron of Christian-humanistic education, Andrew Fleming West hired Cram to design the graduate college at Princeton (1913) because he wanted a setting similar to the medieval quadrangles of Oxford and Cambridge.

**1. Art Nouveau.**—Such departures from classicism failed to satisfy men who wanted a totally new architecture. *Art nouveau* (*q.v.*) was the general title for a highly varied movement toward modernism that had international representation. In France bizarre forms appeared in the iron, masonry and concrete structures of Hector Guimard (Humbert des Romans and Métro stations, Paris, *c.* 1900) and Anatole de Baudot (St. Jean l'Evangéliste, Montmartre, 1894–1904). Georges Seurat's "Sunday Afternoon on the Isle of Grande Jatte" begun 1884 had an architectural counterpart in the Dufayel store's interiors at Paris. In Belgium there were Baron Victor Horta's floral, tendrilous ornament at his house at 12 Rue de Turin, Brussels (1893), and an exposition of fine spaces and undulating enclosure in his Maison du Peuple in Brussels (completed 1897). In the U.S. *art nouveau* arrived with Louis Comfort Tiffany; in Italy furniture by A. Charpentier and C. Bugatti was exhibited an international exposition; in Scotland A. H. Mackmurdo and Charles Rennie Mackintosh expressed the new movement in buildings like Mackintosh's art school at Glasgow (1898–99). Even in Spain a representative belatedly developed in Antonio Gaudí (1852–1926), whose sculptural, fungus-like apartment house, Casa Milá, belied the structural experiments and spatial drama of his "Parc Güell" and the enigmatic church of the Holy Family, all at Barcelona. Like other *art nouveau* work, Gaudí's buildings were amazingly personal, gaining their effect through bizarre form and ornament and showing no way past the tangle of competing styles.

**2. The Chicago School.**—What was needed was a major endeavour in regard to the most important new type of building of the modern age, the large office building. The office building was made necessary by the concentration of markets, banks, railroad terminals and warehouses in small sections of growing cities, and it pushed skyward as a result of the attempt to get maximum income from expensive urban properties, the desire for the commercial prestige of tall emblems and the need of businesses for mutual proximity in the days before rapid electronic communication. The safe, fast elevator removed the major prejudice against height. Designed by traditionalist architects, the tall buildings stretched masonry construction to its limits; they frequently resembled towers comprised of smaller buildings stacked one on another, as in Hunt's Tribune building at New York (1874). The structural problem was solved at Chicago in 1884–85, when an engineer, William Le Baron Jenney, developed a metal skeleton of cast-iron columns, sheathed in masonry, and wrought-iron beams, carrying the masonry walls and windows at each floor level. Technically innovative, the building retained masonry side walls, and its elevations were disunified and inept.

Inspired by Viollet-le-Duc's rationalism, Chicago architects sought a better aesthetic expression of the metal frame, but even the talented John W. Root (1850–91), working with Daniel Burnham, failed to achieve it in the Ashland block (completed 1892), and lesser designers, such as William Holabird and Martin Roche in their Tacoma building (1887–88), also missed their chance. Even the great Louis Sullivan (1856–1924) was not successful in his early buildings such as the Ryerson (1884); covering them with gross, somewhat *art nouveau* ornament, he first accentuated the vertical columns and then the horizontal beams, in a covert admission of failure. At his best, as in his Auditorium theatre and hotel (1886–90), Sullivan treaded Richardson's path toward unified Romanesque forms. The Marshall Field warehouse showed Sullivan the way toward a theme for the skyscraper, which he first stated with assurance in the Wainwright building at St. Louis (1890). Brick piers mark each steel column and half module to create a rhythm of tall narrow bays punctuated by recessed spandrels, terminating at the roofline. It was a major, if lonely, triumph for the Beaux-Arts composition Sullivan learned at Paris. But one successful building hardly constituted a new national style. In spite of his eulogy to Whitman's nationalism, his paeans to Darwin's principles of organic growth and his protestations about a new architecture, Sullivan willingly joined other Chicagoans in helping the New York architects, Hunt and Charles Follen McKim (1847–1909), plan the World's Columbian exposition at Chicago in 1893.

A dazzling spectacle of monumental, classical architecture, the fair's midway caught the fancy of Americans who saw in its great axes, lagoons, sculpture, white buildings and large plazas an answer to the dreary urban environment of their home towns. Similar schemes were supported in their cities; some of them were designed by the fair's principal planner, Daniel Burnham, who brought the "great white city" to Cleveland, Washington, New York and San Francisco. The civic spaces of the Place de la Concorde at Paris and the squares at Nancy were emulated. There were gardens and fountains that dimly reflected those at Versailles, and their grandeur sometimes prompted a later generation to disapprove of them as symbols of callous indifference to the social and economic causes of the metropolitan cancer. Still, the best parts of many U.S. cities are as spacious as they are because of the city beautiful movement. Its most popular architect was McKim, whose Public library in Boston's Copley square (1888–95) made a dignified classical counterpart to Richardson's Trinity church. His plan for Columbia university (1895) carried the classical Beaux-Arts image into educational architecture, and for Rhode Island's government he built a classical state capitol at Providence (1895–1902). McKim provided Pierpont Morgan with an exquisite library in New York city (1906) and adapted the baths of Caracalla for the Pennsylvania railroad station there (1906–10). All of these were reliable buildings, grand in conception and competent in detail. Similar buildings appeared in many lands, perhaps because they were so universalized, dependable and unoriginal; often they were the marks of imperialism, as in the case of those built by the French in north Africa, the English in China and India and the Americans in the Philippines.

The ferment in Chicago was neither halted nor marred by classicism's transcontinental popularity. Burnham's firm went on to produce Chicago's Reliance building (1890–95), an excellent office building with logically ordered spaces enclosed by faceted walls of glass and a steel skeleton covered by terra-cotta panels. Sullivan found his best expression of the skyscraper in Buffalo's Prudential building (1894–1905) and developed the theory for it in an essay published in *Lippincott's Magazine* (1896). That theory received even more dramatic expression in the Schlesinger-Mayer store (later Carson Pirie Scott) in Chicago (1899–1904), in which the towered corner marked the climax of the logic of the steel frame

and the entrance was made inviting with rich, naturalistic ornament. At the very end of the 19th century the important emblem of modern commerce thus received an appropriate form: its structure was made of steel, its spaces were planned efficiently, its elevations were expressive of the skeleton and its scale was marked by the fenestration and ornament. Such designs offered clients an opportunity to build well in a style that expressed its time.

## III. THE 20TH CENTURY

### A. From 1900 to 1930

The channels opened by 19th-century engineers like Eiffel, theorists like Morris and movements like *art nouveau* and the Chicago school enabled architects to move quickly toward a refined new architecture for the 20th century. In general, modernism revealed two main tendencies: a strong insistence upon mechanical functionalism, which resulted in a machine aesthetic for architecture; and an organic point of view, which emphasized architectural themes derived from landscape, function and materials. Unfortunately, neither point of view gained more than sporadic allegiance. Most buildings, in an age when only a small percentage were actually designed by architects, were still in 19th-century historical styles. The locus for creative architecture in the U.S. remained the middle west. Californians such as the brothers Greene and the Gills struck occasional regional and modern notes in the west; Bernard Maybeck (1862–1957) ran an eclectic course. Roman in his Palace of the Fine Arts at San Francisco (1915), Gothic and romantic in his First Church of Christ Scientist at Berkeley (1910–12) and somewhat freer in his houses. The Chicago school was more seminal for modern architecture and its members, such as William G. Purcell and G. G. Elmslie, fanned outward. William Drummond moved to the area south of Chicago. Louis Sullivan was called to Grinnell and Cedar Rapids, Ia., and to Owatonna, Minn., to design banks.

**1. Frank Lloyd Wright.**—The greatest of all the Chicago architects was Frank Lloyd Wright (1869–1959). His "prairie architecture" expressed its site, region, structure and materials and avoided all historical reminiscences; beginning with its plan and a distinctive spatial theme, each building burgeoned to its exterior sculptural form. Starting from Richardson's rustic, shingle houses and making free use of Beaux-Arts composition during the '80s and '90s, while he was in Sullivan's office, Wright developed his "prairie house" for the Winslows at River Forest, Ill. (1895), made it more elaborate in the Coonley house at Riverside, Ill. (1908), and, ultimately, realized in it the flowing volumes of space defined by sculptural masses and horizontal planes, of his Robie house at Chicago (1909). Meanwhile, he scored a triumph with his administration building for the Larkin company at Buffalo in 1904, which grouped offices around a central skylighted court, sealed them hermetically against their smoky environs and offered amenities in circulation, air conditioning, fire protection and plumbing. In its blocky fire towers, sequences of piers and recessed spandrels were coupled together in a composition that foretold the handsome industrial architecture of the future.

Reactionaries saw little merit in Wright's work. Critics such as Russell Sturgis thought it was at best rational but awkward and praised instead Burnham's Flatiron building and Napoleon Le Brun's Metropolitan Tower, the distorted classicism of which still pleased New York's clients. Ironically, technological progress negated the Chicago school's successes in the rational expression of the steel frame. Artificial lighting, ventilation and communication compensated for the lack of an efficient plan or large, functional windows. Freed from strict accountability to practicality and logic, the skyscraper architect could dress the skeletal frame any way he or his client chose. A distinctive dress was an advertisement, and the Woolworth company, recognizing this, commissioned Cass Gilbert in 1913 to design a Gothic tower for them in New York city; its flamboyant summit was illuminated at night as a 24-hour advertisement.

**2. Developments in Europe.**—In England and the Netherlands, too, there were conservatives. In London the Beaux-Arts-Georgian War Office at Whitehall was completed in 1907, and Liverpool paid its respects to medieval times with the cathedral begun in 1903. There were also presages of change in the works of the Englishman Voysey and the Netherlands' Berlage. Berlage visited Wright and returned to show younger architects, such as Dudok, the way to handle brick simply in buildings that had regional character.

Germany and Austria moved more quickly and radically. A German architect, Theodor Fischer, inspired by Schinkel's precedent, attempted innovations, with only slight Romanesque and classical references, in his Garnisonkirche at Ulm (1905–11), and Otto Wagner, an Austrian, combined academic geometry with *art nouveau* decoration in his railroad station at Vienna (1894–97), which was followed by his simpler chapel for the cemetery of a sanatorium near Vienna (1904–07). Wagner's pupils broke free of his classicism and formed the Secessionists. The group included Joseph Olbrich (1867–1908), who joined the art colony at Darmstadt, Ger., where his houses and exhibition gallery of about 1905 were boxlike, severe buildings. Joseph Hoffmann left Wagner to found the Wiener Werkstätte, an arts and crafts movement; his best work, the Stoclet house at Brussels (1911), was a Cubist, asymmetrical composition in which white planes were defined at the edges by gilt lines. The Austrian Adolf Loos (1870–1933) opposed the use of any ornament and was determined to obtain quality in compositions of bald, functional blocks. Peter Behrens, having had contact with Olbrich at Darmstadt and with Hoffmann at Vienna, was in 1907 appointed engineer in charge of the German electrical trust (A.E.G.), for which he designed a turbine factory (1909) at Berlin, a direct expression of industry.

Behrens strongly affected three great architects who worked in his office: Walter Gropius, Le Corbusier (Charles Edouard Jeanneret) and Ludwig Mies van der Rohe. Gropius' Werkbund exposition building at the Cologne exhibition (1914) was a model factory building in which vigorous forms were enclosed by masonry and glass; its effect was gained by its use of steel frames, its strong silhouette and the logic of its plan. There were no historical influences, nor were there any expressions of local landscape, traditions or materials. The building was mechanistic; its beauty derived from the adaption of form to purpose.

A less rigorous modernism appeared in Scandinavia, particularly where, as in Sweden, handcrafts survived in furniture and building construction. Regional and national traditions kept history alive, and new architecture seldom revealed the doctrinaire avoidance of precedent or the blind adoration of the machine that harshened German contributions. The charm of Ragnar Östberg's town hall at Stockholm, a programmatic composition, lay in its cloistered spaces, brick walls and ornamental decoration, as well as in its picturesque towers, minarets and colonnades, all of which were simplified versions of earlier themes in Swedish building. Somewhat similar works, though more influenced by Mackintosh, appeared in Finland, as in Eliel Saarinen's railroad station at Helsinki (1910–14), which utilized traditional masonry in strong simple forms and showed the Scandinavians' aversion to anything as mechanistic as Gropius' factories.

France remained ambivalent. Guimard and De Baudot had essayed idiosyncratic versions of *art nouveau*, and other designers followed Henry van de Velde, a Belgian, who after 1895 stimulated a vogue for *art nouveau* in the minor arts which occasionally manifested itself in buildings, such as the house at 4 Avenue Jena, Paris. The dominant tradition, however, stemmed from the Beaux-Arts. Even the Théâtre des Champs Élysées (1911–13) by Van de Velde and Auguste Perret (1874–1954) was an academic composition, though its ferroconcrete frame sheltered three separate auditoriums and a store.

On his own, Perret achieved a frank exposition of reinforced concrete skeletons and developed spaces within temporary partitions, as at his apartment house on the Rue Franklin, Paris, which in 1902 and 1903 marked a major advance from the Beaux-Arts tradition. Still the École's Grand Prix went to traditional designs, such as that awarded for an Institut de France in 1921, a symmetrical, classical scheme. One winner, however, Tony Garnier (1869–1948), caught the modern currents in materials, structure and composition when he evolved his masterful plan for a *cité industrielle* (1901–04), published in 1917, in which reinforced

concrete was to be used to create a city of modern buildings. With insight, Garnier developed a comprehensive scheme for residential neighbourhoods, transportation terminals, schools and industrial centres, and his plan became a major and influential scheme for a modern metropolis. Garnier received no mandate to build such a city, but his pavilion for Lyons at the International Exposition of Decorative Arts at Paris (1925) and his town hall at Boulogne-Billancourt (*c.* 1935) recalled the promise he had shown, though they were not so innovative and masterful as might have been expected.

For about 15 years after World War I advocates of Expressionism achieved modern, personal, highly sculptural forms (*e.g.*, Eric Mendelsohn in his factories and Einstein tower at Potsdam). Rudolf Schwarz, D. Bohm and O. Bartning made important modern churches; but there was a return to more restraint in religious architecture as in Notre Dame de Le Raincy by Perret (1922–23).

Paris became the stronghold of the advocates of a new vision of space. Cubism, which Georges Braque and Pablo Picasso developed in 1908 from suggestions in Paul Cezanne's paintings and in primitive African sculpture. Forms were dismembered into their faceted components; angular forms, interpenetrated planes, transparencies and diverse impressions were recorded as though seen simultaneously. Soon, reflections of Cubism appeared in architecture. Interior spaces were defined by thin, discontinuous planes and glass walls; supports were reduced to slender metal columns, machine finished and without ornamentation; and Cubistic voids and masses were arranged programmatically in asymmetric compositions.

Membership in the movement was international. In the Netherlands, Piet Mondrian and Theo van Doesburg began their magazine, *de Stijl*, in 1917. Doesburg's work for the Bauhaus art school at Weimar, Ger., brought his influence to bear upon Gropius and Mies, whose plans for houses sometimes bore a marked similarity to Doesburg's Cubistic paintings. Meanwhile, the Dutch architect J. J. P. Oud collaborated with Doesburg for a time and vigorously proclaimed the new style in houses he built at Rotterdam (after 1918), Hook of Holland (1924–27) and Stuttgart (1927). Cubism, like any other style, might have faltered and fallen into a merely decorative cliché, as at the Paris exposition of 1925, but three great architects prevented its demise.

**3. Le Corbusier.**—The Swiss-French architect Le Corbusier gave the new architecture a firm foundation by writing the strong theoretical statement, *Vers une architecture*, published in 1923. It revealed a world of new forms—not classical capitals and Gothic arches but ships, turbines, grain elevators, airplanes and machine products, which Le Corbusier said, were indexes to 20th-century imagination. His love of machines being combined with a belief in communal authority as the best means of accomplishing social reform, Le Corbusier directed his attention toward the problems of housing and urban patterns. An architectural attack, using standardized building components and mass production, was required. His sociological and formal ideas appeared in a Cubist project for Domino housing (1916), and his aesthetic preferences led him after World War I to develop an extreme version of Cubist painting he and Amédée Ozenfant called Purism. Returning to architecture in 1921, he designed a villa at Vaucresson (1922), whose abstract planes and strip windows revealed his desire to "arrive at the house machine . . . standardized houses with standardized furniture." In 1922 he also brought forth his project for a skyscraper city of 3,000,000 people in which tall office and apartment buildings would stand in broad open plazas and parks with the Cubist spaces between them defined by low row housing.

Much of his works thereafter—his Voisin city plan, his Pavillon de L'Esprit Nouveau at the Paris exposition of 1925, his exhibit of workers' apartments at the Werkbund exposition at Stuttgart (1927) and his influential but unexecuted submittal to the League of Nations competition—were footnotes to that dream of a new city. The villa, "Les Terrasses," at Garches (1927) was a lively play of spatial parallelepipeds ruled by horizontal planes, but his style seemed to culminate in the most famous of his houses, the Villa Savoye at Poissy (1928–30). The building's principal block was raised one story above the ground on *pilotis* (heavy, reinforced-concrete columns), floors were cantilevered to permit long strip windows and space was molded plastically and made to flow horizontally, vertically and diagonally until, on the topmost terrace, the whole composition ended in a cadenza of rounded, terminating spaces. Gaining greater facility in manipulating flowing spaces, Le Corbusier designed the dormitory for Swiss students at the Cité Universitaire (1930–32) in Paris. This was a major public building, and it suggested that an exciting new architecture might soon serve education.

**4. Gropius.**—In Germany Gropius moved in a more mechanistic direction. After completing his model factory at Cologne in 1914, he succeeded Van de Velde as director of the ducal Arts and Crafts school at Weimar in 1919. Later called the Bauhaus (*q.v.*), it became the most important centre of modern design until the Nazis closed it in 1933. While he was at Weimar, Gropius developed a firm philosophy about architecture and education, which he announced in 1923. The aim of the visual arts, he said, is to create a complete, homogeneous physical environment in which all the arts have their place. Architects, sculptors, furniture makers and painters must learn practical crafts and obtain knowledge of tools, materials and form; they must become acquainted with the machine and attempt to use it in solving the social problems of an industrial society. At the Bauhaus, aesthetic investigations into space, colour, construction and elementary form were flavoured by Cubism and Constructivism. Moving the school to Dessau in 1925, Gropius designed the pioneering new Bauhaus (1925–26) in which steel frames and glass walls provided workshops within severely Cubistic buildings. Gropius assembled a staff of modern teachers, including Laszlo Moholy-Nagy, Wassily Kandinsky, Paul Klee, Marcel Breuer and Adolf Meyer, whose projects, such as the 116 standardized units at the experimental housing at Dessau-Theorten (1926–28), bore a highly machined, depersonalized appearance.

**5. Mies van der Rohe.**—Gropius was succeeded at the Bauhaus in 1930 by Mies, whose training as a mason was supplemented by the engineering experience he gained in the office of Behrens (1908–11). Influenced by Doesburg's *de Stijl*, Mies's natural elegance and precise orderliness soon revealed themselves in projects for a brick country house and a glazed, cantilevered concrete-slab office building (1920–22). He directed the Weissenhofsiedlung at Stuttgart (1927), contributing the design for an apartment house. Such practical problems failed to show his talent, which was not fully known until he designed the German pavilion for the International exposition at Barcelona in 1929. The continuous spaces partitioned with thin marble planes and chromed steel columns drew international applause. His Tugendhat house at Brno, Czech. (1930), along with Le Corbusier's Villa Savoye, epitomized the modern domestic setting at its best.

### B. From 1930 to World War II

**1. The Spread of Modern Styles.**—After 1930 the modern movement spread through Europe. In Switzerland Robert Maillart's experiments with reinforced concrete attained great grace in his Salginatobel bridge (1930) and Cement hall at Zürich (1939). Finland's Alvar Aalto won a competition for the library at Viipuri (now Vyborg, U.S.S.R.) in 1927 with a building of glass walls, flat roof and round skylights (completed 1934; now destroyed); but he retained a sympathy for wood and picturesque planning, which were evident in his house at Mairea (1938–39), the factory and housing at Sunila (1937–39), his building at the New York World's fair (1939) and M.I.T.'s Baker dormitory. Aalto and other Scandinavians gained a following among those whom severe German modernism repelled. Sweden's Sven Markelius and Gunnar Asplund (crematorium, Forest cemetery, Stockholm, 1938–40) and Denmark's Kay Fisker, C. F. Möller and Arne Jacobsen also brought regional character into their modern work. In the Netherlands J. A. Brinkman and L. C. van der Vlugt, at the Van Nelle tobacco factory in Rotterdam (1929–30), aimed at more mechanistic, universal form. In England, German refugees, alone or with English designers, inaugurated a radical modernism that culminated during the '50s in school architecture and the Royal Festival hall, London (opened 1951, R. H. Matthew and J. L. Martin).

As regards industrial architecture, notable successes were achieved in the clothing factory at Congleton, Cheshire (1948), by Rudolf Frankel and the rubber factory at Brynmawr, south Wales (1951), by the Architects' Co-operative Partnership. In housing, the Churchill Gardens at Pimlico, London (1952), by Philip Powell and Hidalgo Moya and the Lawn flats at Harlow New Town, Essex (1951), by Frederick Gibberd, were notable contributions.

Russia in the period after the Revolution at first encouraged modern art and several architects, notably Bruno Taut, looked to the new government for a sociological program. V. Tatlin's project for a monument to the third international (1920) was a machine in which the various sections (comprising legislative houses and offices) would rotate within an exposed steel armature. A workers' club in Moscow (1929) had a plan resembling half a gear, and the Ministry of Central Economic Planning (1928–32), designed by Le Corbusier, was a glass-filled slab. By the time it was completed, the building was subjected to official disfavour, as Stalin's government adopted classical monuments, such as B. M. Iofan's winning design for the Palace of the Soviets (1931), which was intended to pile classical colonnades to a height of 1,365 ft. and have a colossal statue of Lenin at its summit. With its gigantic Corinthian columns, the building for the central committee of the Communist party at Kiev (1937) showed an overbearing scale and wasteful pomposity. There were also evidences of regionalism where folk motifs appeared, as in the tentlike pavilion of Uzbekistan at the Moscow exposition of 1939. After World War II the classical, stepped skyscraper was the form used for Moscow university, which Russian architects admired for its amenities. There were evidences of simplification and mechanization of form in the Russian pavilion at the Brussels exposition of 1958, which showed a modified and more economical classicism. (*See* also RUSSIAN ARCHITECTURE: *The Soviet Period.*)

Mexico and South America broke their bonds to French, Spanish and Portuguese academic design during the '30s. Le Corbusier's influence became strong in Brazil, where Oscar Niemeyer and other architects designed the Corbusier-inspired Ministry of Education and Public Health at Rio de Janeiro (1937–42). Lucio Costa, Félix Candela and Niemeyer were the vanguard of modernism; whole communities, as at Caracas, São Paulo, the University of Mexico and Brasilia during the '50s, were rebuilt. In Mexico there was avid support for modern design in buildings such as the Presidente Juárez housing at Mexico City (1950) by Mario Pani and Salvador Ortega. In Colombia, after World War II, enormous strides were made in thin-shelled reinforced-concrete construction. In Brazil dramatic complexes were erected from concrete (*e.g.*, the school and gymnasium at Pedregulho housing, Rio de Janeiro, 1953, Affonso Eduardo Reidy).

Until about 1935 leading architects and architectural schools in the United States tended to ignore modernism. Industry showed some inclination to respect function, materials and engineering, as was evident in Joseph Leland's glazed, skeletal buildings for the Pressed Steel company at Worcester, Mass. (1930). The National Cash Register, United States Shoe Machinery, National Biscuit, Sears, Roebuck and various automobile companies, such as Ford, sponsored functional architecture. Occasionally a traditional architect produced an innovation such as Willis Polk's Halldie building at San Francisco. With the aid of Ernest Wilby, the engineering firm of Albert Kahn created a work of architectural merit in Detroit's Continental Motors factory of about 1918.

**2. Residences by Wright.**—During most of this period, America's foremost architectural genius, Frank Lloyd Wright, was ignored by all except a select following. The single figure who gave international distinction to American 20th-century architecture was for the most part neglected by major universities, church organizations and industries. His architecture remained the cherished property of personal clients, such as Aline Barnsdall for whom Wright designed the "Hollyhock house" at Hollywood, Calif. (1917–20). His *Autobiography* recorded his frustrations in gaining acceptance for organic architecture. The first edition summarized the chief features of that architecture: a reduction of the number of rooms to a minimum and the definition of them by point supports; the close association of buildings to their sites by means of extended and emphasized planes parallel to the ground; the free flow of space, unencumbered by boxlike enclosures; harmony of all openings with each other and with human scale; the exploitation of the nature of a material, both in its surface manifestations and its structure; the incorporation of mechanical equipment and furniture as organic parts of structure; and the elimination of applied decoration. There were also four new properties: transparency, which was obtained through the use of glass; density or plasticity of mass, achieved through the use of steel in tension as in reinforced concrete; naturalism, or the expression of materials; and integration, in which all ornamental features were natural by-products of manufacture and assembly.

The Millard house at Pasadena, Calif. (1923), exemplified many of these principles; its concrete-block walls were cast with decorative patterns. Taliesin East, Wright's house at Spring Green, Wis., went through a series of major rebuildings (1911, 1914, 1915 and 1925), and each fitted the site beautifully; local stone, gabled roofs and outdoor gardens reflected the themes of the countryside. A period of withdrawal at Taliesin afforded Wright several years of intensive reflection, from which he emerged with fabulous drawings for the Doheny ranch in California (1923), a skyscraper for the National Life Insurance company at Chicago (1924–25) and St. Mark's Tower, New York city (1929). The last was to have been an 18-story apartment house comprising a concrete stem from which four arms branched outward to form the side walls of apartments cantilevered from the stem to an exterior glass wall. Unexecuted, like most of Wright's most exciting projects, St. Mark's Tower testified to his revolutionary thinking about skyscraper architecture. His ideas gained a wide hearing in 1931 when he published the Kahn lectures he delivered at Princeton in 1930. In keeping with the needs of the United States during the depression, Wright turned his attention to the low-cost house, designing a "Usonian house" for Herbert Jacobs at Madison, Wis. (1937) and a quadruple house, "the sun houses," at Ardmore, Pa. (1939). These exemplified the residences he intended for his ideal communities, such as rural, decentralized Broadacre City (1936), which was Wright's answer to European schemes for skyscraper cities.

At about the same time, Wright sketched four masterpieces: "Fallingwater" (1936–35), the daringly cantilevered week-end house of Edgar Kaufmann; the administration building of the Johnson Wax company, in which brick cylinders and planes develop a series of echoing spaces, culminating in the forest of graceful "mushroom" columns in the main hall; the Johnson house at Racine (1937), aptly called "Wingspread"; and Taliesin West at Paradise Valley, near Phoenix, Ariz. (begun 1938), where rough, angular walls and roofs echo the desert valley and surrounding mountains. With increasing sensitivity to local terrain and native forms and materials, Wright stated more complex spatial and structural themes than European modernists who seldom attempted either extreme programmatic plans or organic adaptation of form to a particular environment. Eventually, Wright himself developed a more universal geometry, as he revealed in the sculptural Guggenheim Museum of Non-Objective Art at New York city (1955–59).

**3. Other Works of the Period.**—In terms of volume, Wright's work was inconsequential. During prosperous days, commissions for country clubs and splendid estates were given to more eclectic architects. Henry Ford entertained the idea of asking Wright to design his house, but ultimately went elsewhere. With the aid of technology, Spanish estates were built on the shores of Florida, French farmhouses in Philadelphia, Georgian and colonial homes in New England and pueblos in the southwest. Georgia revived its ante-bellum architecture, and Santa Barbara, Calif., which was destroyed by an earthquake in 1925, was quickly rebuilt as a Spanish mission. The Georgian Revival style threatened to supplant regionalism as architects worked with one eye on the "White Pine Series of Architectural Monographs." Gothic was nearly universal for churches; often archaeological, as in Cram's Swedenborgian Cathedral at Bryn Athyn, Pa. (1913–28), it was only occasionally creative, as in Goodhue's St. Bartholomew's, New York city, and H. Van Buren Magonigle's First Plymouth Congregational, Lincoln, Neb. University architecture invariably failed to

reflect forward-looking educational practices; Harvard's business school was housed in Georgian Revival buildings (1925), and Yale erected Gothic quadrangles for its residential colleges (begun 1929). M.I.T. moved to a new "Roman" campus in 1916, and at the universities of Colorado and California tales were invented to justify "regional" buildings. Expositions flaunted eclectic designs, usually Roman, as at the Panama-Pacific, San Francisco (1915), or regional, as was intended by the Spanish at San Diego, Calif. (1915); but modern could also be superficial, as proved by the Century of Progress exhibition at Chicago (1933–34). An illustration of the taste of the period is the Chinese temple incongruously erected as a teahouse on the Belmont estate, Newport, in 1916.

The traditionalists also produced some memorable things in their final hour. John Russell Pope's version of the Mausoleum at Halicarnassus which he built as the Temple of the Scottish Rite at Washington in 1916 and Louis Bourgeois' Bahai temple on the shore of Lake Michigan near Chicago were not defensible by 20th-century architectural standards. Critics like Jacques Greber, Werner Hegemann and Elbert Peets, however, found much that classical taste could admire: the New York Public Library, the Cleveland Museum of Art, the University Club at New York city and the Rockefeller estate at Pocantico Hills, N.Y. Architectural schools continued to put students through a Beaux-Arts curriculum. No school considered itself complete unless it had a French patron; one of them, Pennsylvania's Paul Cret, designed superb classical buildings, such as the Pan American Union building at Washington (1908–10), the Public Library at Indianapolis (dedicated 1917) and the Institute of Arts at Detroit (1927). Many architects achieved perfection of form, as in Bacon's Lincoln memorial at Washington, and even where there was more bombast than was suitable, as in Gilbert's Supreme Court building at Washington (1935) or his Public Library at Detroit (1921), the work was seldom ugly, and its durable materials, rational plans and extravagant spaciousness suited the public need for dignity and grandeur. Only an occasional designer showed an aptitude for originality without flagrantly violating tradition, and of those who did, Magonigle in his Liberty memorial at Kansas City, Mo. (1928), and Goodhue in the capitol in Lincoln, Neb. (begun 1922), and National Academy of Sciences at Washington (1924) showed, along with Cret, a time-honoured way to create an architecture for the 20th century.

**4. Office Buildings.**—The emblem of business, the office building, continued to suffer from demands for unique, distinctive towers. Harvey Wiley Corbett, a New York architect, admitted that publicity was the ruling motivation. Sometimes a business with nation-wide suboffices developed a corporate iconography; Sears Roebuck, Bell Telephone, Howard Johnson and the various competing gasoline companies were recognizable instantly. The Gothic skyscraper, popularized by Gilbert's Woolworth building, was used in Corbett's Bush Terminal building at New York city (1917) and Raymond Hood's winning entry to the *Chicago Tribune* competition (1922). Some buildings gained attention through their classical ornament (Le Brun's Metropolitan Tower); others, such as Charles Platt's Hanna building and Leader News building in Cleveland (*c.* 1922), were Renaissance palaces. About 1920 some architects developed simple cubical forms, and the stepped ziggurat was popularized by renderers, notably Hugh Ferriss, and artists like Georgia O'Keefe, John Marin and Charles Sheeler. This soaring and jagged form received legal support from the New York zoning law of 1916 and economic justification from the fact that, in order to obtain rentable, peripheral office space in the upper floors where the banks of elevators diminished, whole increments of office space had to be omitted. These cubical envelopes were not without ornament at their crests, as in Hood's American Radiator building in New York city (1924–25), suitably described as "one huge cinder incandescent at the top." Such decoration might be chic, as in New York city's Barclay-Vesey or Telephone building, where Ralph Walker recreated the gay interiors of the Paris exposition of 1925. In San Francisco, Miller, Pflueger & Cantin used Chinese ornament to enliven their Telephone building (1926). Paradoxically, one archaeological find led to simpler buildings when, about 1930, Mayan pyramids inspired Timothy Pflueger in his work on the 250 Sutter building in San Francisco. Cliff like blocks arose in Chicago, the Daily News and Palmolive buildings (1929) being the best examples; New York city acquired a straightforward expression of tall vertical piers and setback cubical masses in the Daily News building (1930) by the versatile Hood, who had run the course from Gothic to modern form. Philadelphia's bank and office building of the Pennsylvania Savings Fund society (1931) by George Howe and William Lescaze, a Swiss architect, gave the skyscraper its first thoroughly 20th-century form, and Hood, again, produced a counterpart in New York city, the McGraw Hill building (1932). Few of these, including the Empire State building (1929–31), did anything to solve urban density and transportation problems; indeed they intensified them. Rockefeller centre, however, begun in 1931, was, with its space for pedestrians within a complex of slablike skyscrapers, outstanding and too seldom copied.

**5. American Modernism.**—As the example of Rockefeller centre indicates, there was a move toward simple form, which was presaged by the architecture of the TVA. European modernism gained a firm following in the United States as some of its best practitioners emigrated there. Eliel Saarinen, who won second prize in the *Chicago Tribune* competition, gained the acclaim of Sullivan and other architects and settled at Bloomfield Hills, Mich., where he established a school of architecture at the Cranbrook academy. He designed its new buildings, gradually freeing himself from historical reminiscences. He remained sensitive to the role of art in architecture, best revealed by his use of Carl Milles' sculpture. Together with his son, Eero, Saarinen designed the Kleinhans Music hall at Buffalo (1940–41). Richard Neutra, after a visit in 1923, established a practice in California, recalled by the Lovell house at Los Angeles (1929). An exhibit of modern architecture in the Museum of Modern Art, New York city, in 1932, recorded in the book *International Exhibition: Modern Architecture* by Henry Russell Hitchcock, familiarized Americans with the international style. After 1933, as modernists fled Russia, Germany and Italy, the United States received Gropius, Breuer and Mies. Gropius was brought to Harvard by the newly appointed dean of the architectural school, Joseph Hudnut, and established an educational focus recalling the Bauhaus. In association with Breuer, Gropius introduced modern houses to Lincoln, Mass., and formed a group, the Architects' Collaborative, whose members designed the thoroughly modern Harvard Graduate centre. Mies became director of architecture at the Illinois Institute of Technology, Chicago, in 1938 and designed its new campus.

Not all the immigrants remained in the U.S. Aalto, whose work first appeared on the American scene in the Finnish pavilion at the New York World's fair and again in Baker dormitory, returned to Finland. The European who might have contributed most was Le Corbusier. The United Nations buildings at New York city, for which he was a member of a ten-man commission headed by New York architect Wallace Harrison, is a token of the new forms he might have suggested for U.S. cities. His plan for rebuilding St Dié (1945) was the inspiration for many city-planning proposals made after mid-century.

Beginning with private houses by Hood, Lescaze, Edward Stone, Neutra, Gropius and Breuer during the '30s, American modernism came to be used for all types of buildings and gradually supplanted sentimental historicism. Programmatic school architecture accompanied progressive education; Perkins & Will, the Saarinens, John Lyon Reid, Donald Barthelme, the Architects' Collaborative and many others made attractive pavilion, "finger," campus and "cluster" plans. In church architecture, Pietro Belluschi won converts to modernism with his brick and wood churches in Oregon and Boston; Eliel Saarinen's churches at Columbus, Ind., and Minneapolis were incomparable.

### C. After World War II

After World War II, big industry turned to modern architects for distinctive emblems of quality. The Connecticut General Life Insurance company hired one of the largest and best modern firms, Skidmore, Owings & Merrill, to design their new decentralized headquarters outside Hartford, Conn. (1955–57). Lever Brothers

turned to the same firm for New York's Lever house (1952), in which the parklike plaza, glazed curtain walls and thin aluminum mullions realized the dreams of Mies and others in the 1920s of freestanding crystalline shafts. The General Motors corporation's Technical centre at Detroit was compared with Versailles in its extent, grandeur and rigorous conformity to an aesthetic the Mies-like forms of Eero Saarinen. The tower for the Aluminum Company of America at Pittsburgh advertised its own product (Harrison & Abramovitz, 1954). Skidmore, Owings & Merrill also designed the Inland Steel building in Chicago in 1955. Perhaps the most chaste of all was the Seagram building at New York city, an elegant prism of bronzed skeleton and amber-lighted offices, designed by two of the purest architects, Mies and Philip Johnson. Wright alone avoided the rectilinear geometry. In 1955–59 he saw his Price Tower rise at Bartlesville, Okla., a richly faceted concrete and copper fulfillment of the St. Mark's Tower he designed more than 25 years earlier.

About 1952 there was a significant shift within modernism from what had come to be called "functionalism" toward a monumental formalism. Presaged by Wright's work at the Johnson Wax company, there was increasing interest in the convolutions of highly plastic, sculptural masses and spaces. Wright's Guggenheim museum was a manifestation of it. Those who had focused their attention on the rectilinear portions of Le Corbusier's Villa Savoye and apartment house (Unité d'Habitation) at Marseilles tended to ignore the plastic sculpture on the roofs of those buildings; to such people, Le Corbusier's building at Chandigarh, India (begun 1950), and the cavernous space in the lyrical Notre Dame du Haut seemed to be sports. Pier Luigi Nervi in Italy gave structural integrity to the complex curves and intricate geometry of reinforced-concrete structures, such as Bologna's tobacco factory (1949), Orbetello's hangar's (begun 1938) and Turin's exposition hall (1950). The Mexican Candela, the Spaniard Eduardo Torroja and the American Frederick Severud followed his lead. Essentially, each attempted to create an umbrella roof whose interior space could be subdivided as required. Mies constructed rectilinear versions of such a space in Crown hall at I.I.T. (1956) and in his Farnsworth house at Plano, Ill. (1952), while Johnson allowed a single functional unit, the brick cylinder utility stack, to protrude from the precise glass house he built for himself at New Canaan, Conn.

Other designers used curvilinear structural geometry, best indicated by Matthew Nowicki's Stock pavilion at Raleigh, N.C., in which two tilted parabolic arches, supported by columns, and a stretched-skin roof enclose a colossal space devoid of interior supports. In 1949 Nowicki challenged Sullivan's precept, form follows function, with another, form follows form, a dictum that freed architecture from programmatic expression. The mechanistically functional Harvard Graduate centre, in spite of its superior site planning, seemed a thing of the past when, in 1955, Eero Saarinen completed a spherical triangle for M.I.T.'s Kresge auditorium. Stone's U.S. pavilion at the Brussels fair, Hugh Stubbins' Congress hall at Berlin (1957) and the new terminals at the Idlewild International airport, New York (1958–59), were outstanding examples of the monumental, single-form buildings designed by leading architects. In their search for unique silhouettes, some designers invented bizarre geometric shapes, such as those in Eero Saarinen's hockey rink at Yale (1958) and Harrison & Abramovitz' Presbyterian church at Stamford, Conn. (1958). A much more difficult task, that of unifying a modern programmatic building within an old setting, was undertaken by Paul Rudolph in the Art centre at Wellesley college, Wellesley, Mass. (1957–59), but such an approach appeared infrequently; international competitions for the opera house at Sidney, Austr. (1957), and a government centre at Toronto, Ont. (1958), were won by the exponents of monumental design. These posed problems in structural engineering and in scale, but many architects, such as Yamasaki in the McGregor building for Detroit's Wayne university (1958), attempted to make structure become decorative, while the decorative screen, as used by Stone at the U.S. embassy in New Delhi (1957–59), offered a device for wrapping programmatic interiors within a rich pattern of sculptural walls.

Having created buildings that deserved a place in the history of architecture, the modern architect and city planner awaited a mandate to give shape to the modern social unit, the metropolitan-suburban-rural community. All its components were available and tested: Mies's 850–860 Lake Shore drive, Chicago, suggested what the apartment houses might be; 100 Memorial drive at Cambridge, Mass., by Brown, Rapson, de Mars, *et al.*, and Le Corbusier's Marseilles block showed other versions. Britain's festival and the Brussels fair suggested new kinds of civic and cultural buildings, while Victor Gruen's shopping centres at Minneapolis and Detroit provided humane retail cores for pedestrians. The competitions for the opera house at Sidney and the government centre at Toronto elicited monumental public buildings. Lewis Mumford and Sigfried Giedion described how the modern city should be shaped. Le Corbusier, Eliel Saarinen, José Luis Sert, Wright, Nowicki and City Planners drew clear proposals. Louis Kahn's Mill Creek project in Philadelphia, Boston's Back Bay centre by Belluschi, Gropius and others, the British "New Towns," the reconstructed sections of Rotterdam and Brasília showed what should have been clear by 1940: that modern architecture is a means of creating the environment needed in cities and towns.

*See* also articles on the different types of architecture, such as EDUCATIONAL ARCHITECTURE; RESIDENTIAL ARCHITECTURE; etc.; biographies of the leading architects; and references under "Modern Architecture" in the Index.

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**MODERN ART,** a term used to describe outstanding developments in western art since the end of the 19th century. It embraces a wide variety of movements, theories and attitudes whose modernity resides in a common tendency to repudiate past precedents and conventions. Although cumulatively modern art has been revolutionary, it has reflected a contemporaneous and wholesale reorientation of thought and human values.

Nineteenth-century art, no longer in service to church, court or community, had lost its *raison d'être* together with its spirit of collective endeavour, and artists were confronted with the need for new standards and justifications. Also, since the Renaissance painters had devoted their skills to problems of representation and although Impressionism (q.v.) seemed a triumphant vindication, its achievement disclosed that complete submission to the subject conceded nothing either to personal interpretation or to formal qualities of design. Modern painting began as a reaction to the aims and methods of Impressionism. Subsequent developments contained from the decisive influence of Paul Cézanne, Vincent Van Gogh and Paul Gauguin. Cézanne painted the permanent underlying structure of nature; his conception of form as the indispensable element was echoed in Cubism, was discernable in Futurism (q.v.) and found its ultimate expression in abstract art. Van Gogh recorded his highly charged feelings in the presence of nature; the compelling example of his emotional approach was strongly apparent in Expressionism (q.v.). Gauguin used visual themes as the basis of a decorative symbolism; Fauvism (q.v.) derived largely from his exploitation of colour and his deliberate use of shape and contour in design.

In the first quarter of the 20th century, eager, widespread investigations were made into new aesthetic experiences. The art

forms of every age and civilization were studied. Ceaseless experiments were made with media and treatments capable of expressing new concepts. The brilliant colours of Fauvism were extinguished by Cubism. Cubist forces, derived partly from Negro art but mainly from a close analysis of spatial relations and the qualities of different surfaces and materials, exercised a decisive influence on the development of abstract painting and sculpture. A throng of movements represented every shade of emphasis from a moderate desire for change to a violent intention to destroy.

Architecture was in similar confusion. *Art nouveau* attempted to break an enslaving continuity of historical mannerisms, but the application of yet another style solved no architectural problems. An important formative period between the wars, dominated by Le Corbusier (Charles Édouard Jeanneret), by Frank Lloyd Wright and his "organic architecture" and by Walter Gropius and the Bauhaus (*q.v.*), culminated in a drastic, calculated simplification. Ornament was stripped away ruthlessly to reveal the functional structure, newly informed with a refined sense of proportion and rhythm and expressed in new materials and techniques. (*See* also MODERN ARCHITECTURE: *The 20th Century.*)

This development mirrored a modern inclination to purge art of all ambiguities which might conceal its nature or hinder spontaneity of expression. The tendency was exemplified by modern music's anti-Romantic aversion to literary associations, by modern poetry's avoidance of insistent sentiment and rejection of sustained clarity of thought and, in both arts, by the dismantling of the scaffolding of stereotyped forms. Painting, undergoing a similar distillation, became an end in itself, not the imitation of anything else. The artist, solely preoccupied with the discovery and expression of his own personality, painted with the intention of recording his own responses. The door of the objective world was closed, but the inner world of the imagination, even the underworld of the subconscious, offered infinite possibilities for exploration. The deliberate explicitness of Surrealism and later the involuntary techniques of Abstract Expressionism were typical of these investigations. Form and colour, no longer representational, were the elements either of an expression or of a construction. In the next short step, the subject was rejected. Abstract art emerged, and its persistent ubiquity, particularly in its later development as Action Painting, tends to confirm it as the characteristic expression of the modern movement.

The evolution of abstract painting corresponded to architecture's reversion to first principles, but, while modern architecture found some coherence, modern painting continued to be the reflection of unfettered individualism; in its energetic, teeming creativeness, eloquent and significant expressions mingle with those that were obscure, impatient or tentative. Modern art is the sum of its greatest exponents, a record of such outstanding individual artists as Wassily Kandinsky, Henri Matisse, Piet Mondrian, Paul Klee, Pablo Picasso and Jackson Pollock.

*See* also biographies of artists mentioned and references under "Modern Art" in the Index.

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**MODERNISM, ROMAN CATHOLIC.** Modernism was a European intellectual movement of the last decade of the 19th and first decade of the 20th century which sought to reinterpret traditional Catholic teaching in the light of 19th-century philosophical, historical and psychological theories. "Modernism" as a technical term of Roman Catholic theology first appeared in the ecclesiastical journal *Ami du clergé* (1898) and quickly gained currency in French and German theological periodicals; it was first used in an official, public, church document in the collective Christmas pastoral letter of the bishops of north Italy in 1905. The term refers both to the intellectual movement and to a loosely knit body of propositions or theses advocated by members of the movement who are called modernists.

On Nov. 18, 1893, Pope Leo XIII, responding to the initial surge of interest in critical biblical studies based upon scientific linguistics and archaeological discoveries, issued the encyclical *Providentissimus Deus* which outlined the norms and attitudes Roman Catholics should adopt in critical exegesis and historical criticism of the Bible. It reaffirmed in clear terms the church's traditional belief in the Bible's inspiration (that the sacred books were written by the inspiration of the Holy Spirit and have God for their author *Spiritu Sancto inspirante conscripti Deum habent auctorem*) and inerrancy. Alfred Firmin Loisy (*q.v.*), French Catholic priest, biblical scholar and teacher at the Institut Catholique in Paris, on expressing disagreement with the encyclical in his periodical *L'Enseignement biblique* was dismissed by church authorities from his teaching post.

Loisy's disagreement with the pope's principles was shared by a group of European intellectuals, among them Baron Friedrich von Hügel and George Tyrrell (*qq.v.*) in England and Giovanni Semeria in Italy. They were dissatisfied with Catholic apologetics, which they thought ignored scientific history and relied too much on metaphysics. They believed that scholastic metaphysics when employed in theology turned the revelation into a narrow-minded dogmatism devoid of religious value. Loisy maintained that humanity possessed an intuitive sense which was ever in the process of evolving less anthropomorphic notions about God. He identified religion and this active evolution of humanity. Faith was the experience of man's beliefs about God and not an intellectual assent to God's revealed Word. The Bible recorded successive stages of this human evolution. It was not inspired by God and not inerrant. Credal formulas were true only for the age that composed them. Each creed and each religion represented a certain level in humanity's development. Catholicism was the highest stage yet reached by humanity, but unless it "opened" its dogmatic structure to the data of scientific history and modern psychology it would be superseded by another religion welling up from man's intuitive sense of the divine. These theories of Loisy were what the periodical *Ami du clergé* called modernism.

In 1901 the conservative theologian Julien Fontaine published a harsh and alarming book, *Les Infiltrations kantiennes et protestantes et le clergé français*, in which he accused the distinguished church historian Pierre Batiffol and the *Revue d'histoire et de littérature religieuses* of advocating principles condemned by *Providentissimus Deus*. Batiffol indignantly answered Fontaine, and two world-renowned scholars, Eugène Portalié and Marie Joseph Lagrange, joined in his defense. The Fontaine incident set a pattern for the orthodox reaction to modernism: Batiffol was not a modernist, but the *Revue d'histoire* had compromised its orthodoxy by printing articles by real modernists; Fontaine's attack on the *Revue* was justified, but his assault on Batiffol was not. Fontaine's successors employed his style of accusation, which confused rather than clarified issues and won sympathy for real modernists in quarters where they and their ideas were unacceptable.

In Nov. 1902 appeared Loisy's *L'Évangile et l'Église*, in which, using the pen name A. Firmin, he advanced his thesis that the burden of Jesus' message was the imminent arrival of an eschatological Kingdom and that when the Kingdom failed to materialize his disciples reinterpreted his teaching and founded the church—contradicting orthodox teaching that Christ founded the church; furthermore, Jesus revealed no real truths about God but gave his fellow men religious symbols to inspire every age. Tyrrell developed the meaning of religious symbolism that same year in *Religion as a Factor of Life*, published under a pseudonym, in which he clarified Loisy's theory by declaring that the symbols are speculatively false but practically true and that knowledge of them is gained not from the teaching of the church but from a religious, personal intuition. For Tyrrell the most important symbol was the resurrection, which signified that "the divine personality of Jesus cannot die"; so great an impact had Jesus made on humanity's intuitive sense of the divine that all future religion must incorporate his ideals. As a literal fact Christ did not rise from the

dead; yet, properly understood, a truly religious man must believe in the resurrection since it is a datum of humanity's intuitive sense of the divine. On Jan. 17, 1903, François Cardinal Richard of Paris condemned Loisy's *L'Évangile et l'Église* without mentioning Tyrrell's book.

Loisy bided his time until Tyrrell, using another pseudonym, published, later in 1903, *The Church and the Future*, in which he declared that the church was not infallible and that her dogmas were not definitive statements of immutable truths but attempts approximating intellectualization of religious symbols such as the resurrection. Once this had appeared, and was not condemned, Loisy, in Oct. 1903, published his *Autour d'un petit livre*, which sought to defend *L'Évangile et l'Église* by restating Tyrrell's position on the mutability of dogma and by putting the source of dogma not in divine revelation but in perfectible human consciousness.

At the request of Cardinal Richard, two theologians, Georges Letourneau and Pierre Bouvier, made a list of 33 propositions based on Loisy's work which the cardinal sent to Rome. There a special commission, consisting of Cardinals Mariano Rampolla, Andrea Steinhuber and J. C. Vives y Luto, with the Franciscan theologian David Fleming as secretary, was set up to look into the writings of Loisy and Tyrrell and appraise the whole modernist movement. On Dec. 16, 1903, Loisy's works were condemned at Rome and proscribed for all Catholics.

In 1904 Tyrrell published anonymously his *Letter to a Professor of Anthropology*, which, along with his earlier writings, was translated into Italian by P. Giacosa and Romolo Murri. The translation won enthusiastic reviews in the *Revista storico-critica delle scienze teologiche*, whose editor, Ernesto Buonaiuti, was an active modernist. He was also a warm supporter of D. Battaini, who was campaigning strongly against the church's regulations on clerical celibacy. Murri, Buonaiuti and Battaini popularized Loisy's ideas throughout Italy. On April 16, 1905, Edouard Le Roy published in *La Quinzaine* a closely reasoned article supporting Loisy's and Tyrrell's ideas on the nature of religious dogma, and this too was publicized in Italy by Buonaiuti. At Christmas 1905 the bishops of north Italy issued a joint pastoral letter condemning modernism and denouncing the work of Buonaiuti, Murri and Battaini. In the weeks that followed, Tyrrell was proved to be the author of the *Letter to a Professor of Anthropology*, and he was dismissed from the Jesuit order on Feb. 1, 1906.

Once Pope Pius X, successor of Leo XIII, had received the report of the commission set up to study modernism, he issued to the Italian bishops, on July 28, 1906, the encyclical *Pieni l'animo*, supporting the action of Cardinal Richard against Loisy and the stand of the north Italian bishops against modernism. He then appointed a new commission of scholars—Louis Billot, Umberto Benigni and Pie de Langogne—to draft a major encyclical on the subject of modernism. On April 17, 1907, in an address before the cardinals, he stigmatized modernism as "not a heresy, but the summation and essence of every heresy." On July 3, 1907, the Holy Office issued the decree *Lamentabili* condemning 65 propositions, on the subjects of the church, revelation, Christ and the sacraments, advanced by the modernists. And finally, on Sept. 8, 1907, was promulgated the encyclical *Pascendi*, which summarizes and rejects modernist teaching, traces the causes of the movement and suggests remedies that the church should use in extirpating it. *Pascendi* declares modernism to be an agnosticism which makes religious truth dependent on emotion and castigates it as a species of intellectual despair brought about by an ignorance of philosophy.

The means taken to enforce the condemnation of modernism included tightening of censorship of articles in theological journals and books dealing with Catholic dogma; scholastic philosophy and theology were to be taught in the seminaries by professors chosen with care and specially trained; furthermore, a special commission, composed of Cardinals Rampolla, Désiré Mercier and Pietro Maffi, was to be established to enforce these prescriptions (this, however, was never done).

On Nov. 18, 1907, Pius X confirmed the decree *Lamentabili* and the encyclical *Pascendi* and urged immediate compliance with his strict censorship regulations. These regulations, however, were based on the traditional canon law, which was as yet uncodified and consequently ambiguous and unclear. To ensure enforcement, Benigni organized, through his personal contacts with theologians, a non-official group of censors who would report to him in Rome those thought to be teaching condemned doctrine. This group, known as Integralists (or *Sodalitium Pianum*), though their zeal was commendable, often used methods similar to those employed by Fontaine in the Batiffol affair of 1901 and hindered rather than helped the combating of modernism. On June 29, 1908, Pius X publicly admitted that modernism was a dead issue, but at the urging of Benigni he issued on Sept. 1, 1910, *Sacrorum antistitum*, a *motu proprio* which prescribed that all teachers in seminaries and clerics before their ordination take an oath denouncing modernism and supporting *Lamentabili* and *Pascendi*.

For modernism as opposed to traditionalism in the Anglican Church, *see* ENGLAND, CHURCH OF: *Liberalism or Modernism*; for modernism in the Protestant use of the term, *see* LIBERALISM, THEOLOGICAL. *See also* references under "Modernism, Roman Catholic" in the Index.

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(H. J. Ry.)

**MODERN SCHOOL (GREAT BRITAIN)**, a secondary school providing a combination of general and practical education, which may include a foreign language, for boys and girls above the age of 11 not selected for grammar (academic) or technical schools. Some modern schools offer an extended, or fifth-year, course. *See* EDUCATION, HISTORY OF: SECONDARY EDUCATION.

**MODERSOHN-BECKER** (or BECKER-MODERSOHN), **PAULA** (1876–1907), German artist and a leader in the modern movement, was born on Feb. 8, 1876, in Dresden. As a pupil of Fritz Mackensen she became a member of the circle formed by the Worpsweder school, an artists' colony near Bremen. Between 1900 and 1906 she spent four periods of study in Paris, finding artistic inspiration in the Gauguin circle and the "Nabis" group. She soon transmuted this influence into a form of her own, however. She increasingly freed herself from the lyrically tinged naturalism of her early Worpsweder years and became, after Cézanne, Van Gogh, Gauguin and E. Munch, one of the founders of 20th-century painting. In her posed and figure compositions, her still lifes, portraits and self-portraits, she helped to a great extent to develop the expressive form language of modern painting several years before the Fauve and Brücke groups. In spite of her early death on Nov. 20, 1907, she left an extensive volume of work of about 400 paintings and more than 1,000 drawings.

*See* G. Pauli, *Paula Modersohn-Becker* (1919).

(Ge. B.)

**MODES, MUSICAL.** The word mode (from Latin *modus*, "manner," "measure," "mood") has two meanings in music: (1) the ways of ordering the notes of a scale according to the intervals they form with the tonic note, thus providing a theoretical framework for melodic music. In this sense, the term is generally used in reference to the modes defined by the Roman Catholic Church for the classification of plainsong (q.v.), or plain chant, but it also includes the modern major and minor scales, as well as modes found in ancient and oriental music and in folk music the world over. (2) A way of ordering long and short notes so as to form metrical (rhythmical) patterns used chiefly in the 13th century. This article discusses the first meaning.

*The "Church" Modes*

| Name | Greek name wrongly applied | Authentic | Plagal | Notes | Finalis | Tenor |
|---|---|---|---|---|---|---|
| Protus authenticus | Dorian | I | | D E F G A B C D | D | A |
| Protus plagalis | Hypodorian | | II | A B C D E F G A | D | F |
| Deuterus authenticus | Phrygian | III | | E F G A B C D E | E | C |
| Deuterus plagalis | Hypophrygian | | IV | B C D E F G A B | E | A |
| Tritus authenticus | Lydian | V | | F G A B C D E F | F | C |
| Tritus plagalis | Hypolydian | | VI | C D E F G A B C | F | A |
| Tetrardus authenticus | Mixolydian | VII | | G A B C D E F G | G | D |
| Tetrardus plagalis | Hypomixolydian | | VIII | D E F G A B C D | G | C |
| | The Additions of Glareanus | | | | | |
| | Aeolian | IX | | A B C D E F G A | A | E |
| | Hypoaeolian | | X | E F G A B C D E | A | C |
| | Ionian | XI | | C D E F G A B C | C | G |
| | Hypoionian | | XII | G A B C D E F G | C | E |

**The Medieval Modes.**—The modes in Europe owe something of their structure and terminology to the octave species (*harmoniai*) of ancient Greece, which early influenced the Christian church. But because of medieval Europe's own musical instincts and certain differences among her musicians in the interpretation of Greek music theory, European modal theory went its own way (*see* GREEK MUSIC [ANCIENT]).

St. Ambrose, bishop of Milan (*c.* 340–397), was the first to organize the melodies of the church in four modes (*protus*, *deuterus*, *tritus*, *tetrardus*, corrupt forms of the Greek words for first, second, third and fourth; that is I, III, V and VII of the table). Each of these consists of: (i) an octave scale comprised of tones and semitones in different orders; (ii) a keynote, to which all the intervals of this scale are referable, called *finalis* since a melody written in such a mode ends on this note; (iii) a *tenor*, so-called as it was the holding note on or around which most of the recitation occurred. The tenor is normally, though not always, an interval of a fifth above the *finalis*, a feature that divides the mode into two conjunct segments: (1) a lower pentachord (series of five notes forming the interval of a fifth), and (2) an upper tetrachord (series of four notes forming the interval of a fourth). These four modes came to be called authentic (original). The Greek names applied to them, as to all other medieval modes (*see* table) are, through a medieval error, quite different from those referring to Greek modes of comparable structure.

Subsequently, Pope Gregory (*c.* 540–604) provided more variety by introducing four new modes, or rather a new form of each of the four original modes of Ambrose. These new forms (II, IV, VI and VIII in the table) each kept the same *finalis* as their parent modes but occupied a lower range of the voice. Thus the original lower segment (pentachord) was retained, the original upper segment (tetrachord) being transposed an octave lower, *i.e.*, it was placed below the pentachord instead of, as formerly, above it. The *finalis* now occupied the middle of the scale, and the scale ran from the authentic tenor to its octave. But in order to avoid the reciting note being at the extreme ends of the scale the tenors were given new places as shown. These new modes were called plagal (from Greek *plagios*, "oblique") and their adopted Greek names were given the prefix *hypo-* ("below"), in reference to their compass being lower than that of the authentic modes. A mode of more extended compass, *i.e.*, including both authentic and plagal notes, is called a mixed mode.

By the end of the 8th century, a considerable time after Pope Gregory's redaction of the original corpus of melodies, this system of eight modes, known as the *oktoechos*, became the basis for classifying the melodies of plainchant. Many of the chants are indeed thus adequately classified, though others do not conform to the modes under whose appellation they appear, while others again have been deliberately modified to conform more closely. The system has, however, always remained the official basis of church music, and its modes are usually called "church modes" or "ecclesiastical modes," though they were also the principal basis for the works of composers generally until about 1500 and are found in folk music.

The next enrichment of modal theory was due to the Swiss monk Glareanus (Henry of Glarus, 1488–1563). Recognizing that each of the seven notes of the scale could form the *finalis* of a mode, Glareanus described, in his *Dodecachordon* (1547), three further pairs of modes, on the notes A, B and C. The authentic mode on B (Locrian) and its plagal derivative (Hypolocrian) he rejected since they had no true pentachord or tetrachord but possessed only the imperfect fourth F–B, called *diabolus in musica*. But the mode on *finalis* A (Aeolian, with its plagal derivative Hypoaeolian) and the mode on *finalis* C (Ionian, with its derivative Hypoionian) he admitted (IX, X, XI and XII in the table), thereby completing the set of twelve modes underlying melodic music.

The Aeolian and Ionian modes, virtually the modern minor and major scales (the *finalis* now being called tonic, and the tenor becoming dominant), had been rejected by the medieval church, the Ionian being called *modus lascivus* because of its popularity in secular music, in which it is found from the 11th century at latest. But of all the modes, it lent itself most to the harmonic feeling which was awakening in Europe, though it was not officially recognized by the church until the 16th century. Meanwhile, the efforts of musicians to avoid the tritone interval explains not only why the tenors of modes III and VIII settled on C rather than (by analogy with other modes) on B but also why altered notes gradually crept in, first B♭, later F♯, then E♭, C♯ and G♯, to create a system called *musica ficta*, in which these accidentals, although often not written, were executed by the performers according to certain rules. This practice, used especially at cadences, also modified the modes in the direction of the modern major and minor scales.

**The Modes Since 1600.**—From 1600 to 1900, the major and minor "scales," *i.e.*, virtually the Ionian and the Aeolian modes in their authentic forms, came to be used exclusively. For the major and minor scales are no less modes than the medieval structures. They are to be distinguished from keys, which are a device for transposing a given mode. A given mode can indeed be taken in any key. All major keys are modally identical (*i.e.*, their notes always have the same relation to the tonic), the difference between one major key and another being in the pitch of the tonic. Similarly, all the different modes can be transposed so as to start from the same key note; thus following the notes of the piano from C to C, the Lydian has F♯, the Ionian is all on the white keys, the Mixolydian has B♭, the Dorian B♭ and E♭, the Aeolian B♭, E♭ and A♭ and the Phrygian B♭, E♭, A♭ and D♭.

In modern times, the minor mode has three forms (*see* also

SCALE: *Diatonic Scale*). Two of these are for melodic purposes: descending (cf. mode IX, Aeolian); and ascending, where the upper tetrachord is major, viz., A B C D E F♯ G♯ A. In the third form, the harmonic minor, the upper tetrachord is, in the Greek sense, a chromatic genus, viz., A B C D E F G♯ A; that is, its tetrachord has two intervals of a semitone and one interval of a minor third, as opposed to the diatonic genus which, in its patterns of tones and semitones, characterizes all the other western modes.

During the period of the greatest popularity of the major and minor modes, *i.e.*, that of "classical music," the church modes, still kept for plainchant, tended to disappear in other music. Though the traditional material used by J. S. Bach is sometimes modal, his treatment of it is rarely so. After his time, modal thinking is exceptional, though rare instances occur in Beethoven's A minor Quartet, in which the slow movement has a Lydian theme, and in Bruckner's Symphony No. 6, in which the finale has a Phrygian theme. But a freer use of the modes was again found around the beginning of the 20th century as a result of the awakening interest in folk music and in plainchant, and of the tendency to use archaisms. The interest in folk music also reintroduced the modes of the anhemitonic (*i.e.*, without semitones) pentatonic scale.

**Ancient and Oriental Modal Systems.**—Toward the middle of the 20th century the western world became aware of living modal systems in the music of the Orient and of some of the systems used in antiquity. These systems are different from those of the west in many ways. The differences concern the range of notes (octave in Byzantine and Roman chant and in Indian classical music; tetrachord in Persia, as in ancient Greece); the direction of the modal scale (descending in ancient Greece, ascending in the west; both directions in India); the size of the intervals (diatonic only in Europe; often finer shades of interval in the east); and the number of focal notes which may be added to the dominant. Yet despite these differences, all these systems are related through their fundamental principle, namely, the relationship of each note to a permanent and immovable tonic and hence to each other. This tonic may be sounded only occasionally, and only in the melody, as the western *finalis* or tonic; or it may be permanently (or intermittently) sounded as a reference note throughout a performance, like the Indian *chhandozati sruti*, Byzantine *ison* and the bagpipe drone. Even European sacred music made considerable use of drones until at least the 12th century. The constantly sounding tonic lends the melody notes a far more certain expression than they have when left without a continuous point of reference.

The modal systems of music (ancient Egyptian and Mesopotamian, Greek, Jewish, Indian, Persian and Arab; Byzantine and Roman Christian; European till *c.* 1600) are different in principle from systems employing transposition (with a measure of modulation). The latter systems, based not on the division of a string (and its octave unit) but on the cycle of fifths (as in the music of Pythagorean Greece, China, and Europe since *c.* 1600), favour the development of harmony, though this is, strictly speaking, incompatible with a full modal system. The two systems, the divisive (modal) and the cyclic (transposing), were first confused by the later Greeks; the confusion continued in Europe, though European harmony first developed within the western modal system.

**Modal Ethos.**—The essence of mode lies in its mood. Indeed, the eight medieval western modes have been described as being respectively: I, grave; II, sad; III, mystical; IV, harmonious; V, joyful; VI, devout; VII, angelic; VIII, perfect. Here is an echo of the Greek concept of *ethos* or moral effect of modes. Some ancient peoples still traditionally regard music as, in its own language, reflecting the pattern of the universe or of divine nature. They regard *phenomena* (things apparent to the senses) as ideally reflecting *noumena* (principles lying behind all appearances)—Plato's *mimesis*—and in this view a mode of music, properly so-called, is part of a larger mode running through all existence. *Modus* also means measure, that is, the precise measure of a modal note in relation to its tonic, which indeed goes hand-in-hand with mode's particular expression (mood) and manner. This measure can be expressed as a ratio of string lengths or (in modern times) of vibration frequencies. Hence the number correspondence and number symbolism inevitably connected with *ethos*. Tribute is paid to the ancient beliefs about modal *ethos* in the myths which have come down—myths telling of marvelous music which can create and destroy, kill and cure, music which can influence and indeed control man's every mood. *See also* MUSIC IS ANCIENT CIVILIZATIONS.

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**MODICA,** a town of Ragusa province in Sicily, Italy, is situated at the confluence of two mountain torrents, the site of the Siculi town of Motyca, 72 km. (45 mi.) S.W. of Syracuse by road. Pop. (1961) 44,030 (commune). That Modica was once a wealthy city is shown by the church of Sta. Maria di Gesù with its adjacent cloister, the portal and rose window of the church of the Carmine; the De Leva portal and Arab-Norman chapel of the church of Sta. Maria di Bethlemme; and the massive baroque church of S. Giorgio in the upper town. About 9 km. (5½ mi.) from Modica is the famous Cava d'Ispica, enriched with thousands of natural grottoes, which were used for habitation and as tombs from before the 14th century B.C. The town is on the railway from Syracuse to Ragusa and Agrigento. Agriculture is important and there is also light industry and traditional local crafts. One of the oldest cities of Sicily, Modica was an impregnable Bronze Age (and perhaps Stone Age) fortress. The capital of a fief from the 12th to the 17th centuries, its counts rivaled in power and wealth the viceroys of Sicily. It was almost entirely destroyed by the earthquake of Jan. 11, 1693 and devastated by flood in 1902. (G. M.-Sc.)

**MODIGLIANI, AMEDEO** (1884–1920), Italian painter and sculptor and a leading figure among the Parisian artists of his day, was born of a Jewish family at Leghorn on July 12, 1884. Modigliani studied at the academies of Venice and Florence, his early admiration for Italian Renaissance painting—especially Sienese—was to last him all his life. In 1900 he left Italy and settled in Paris, first in Montmartre and subsequently in Montparnasse, where he remained until his premature death on Jan. 24, 1920. After 1915 his health had slowly deteriorated, in spite of the devoted care of his wife Jeanne Hebuterne and his friend and dealer Leopold Zborowski. Addiction to drugs and alcohol certainly hastened his end. His wife leaped from a window a few days after his death, killing herself and an unborn child.

The first paintings done by Modigliani in Paris (*e.g.*, "L'Amazone" of 1908) show the influence of Henri de Toulouse-Lautrec and of Picasso's early work. Very soon, however, he turned to Cézanne, as can be clearly seen from "Le Violoncelliste" and "Le Mendiant de Livourne" (both 1909). Between 1910 and 1914 Modigliani seems almost to have abandoned painting for sculpture. His drawings had attracted the attention of Constantin Brancusi, who encouraged him to carve heads and figures in stone. Several heads were shown at the Salon d'Automne in 1912; their elongations and simplifications reflect the influence of African art.

Late in 1914 financial difficulties forced Modigliani to begin painting again. The impact of Cubism may be seen in portraits such as that of Beatrice Hastings (Barnes foundation, Merion, Pa.), the English poetess with whom he lived from 1914 to 1916. However it was not Cubism but the characteristics of Modigliani's sculptured heads—long necks and noses, simplified features and long oval faces—that soon pervaded his painting. These mannerisms are first noticeable in the oil portraits that he made between 1915 and 1917 of many leading figures of Montparnasse artistic life. During the last three years of his life Modigliani painted mainly nudes and portraits of women.

Modigliani was a superb natural draftsman, as his many drawings bear witness. As a painter his style was a tight, linear one;

unlike his Cubist and Fauvist contemporaries in Paris, he was little concerned with analysis of form or with the expressive qualities of colour. He might indeed have remained a sculptor had not his development been interrupted in 1914. Like most sculptors he was almost exclusively interested in the human figure; he painted no still life and only three landscapes. Modigliani's men and women and children are presented very directly, usually seen half-length or head alone against a simple background. Their most remarkable aspect is the entirely personal atmosphere with which they are invested: a kind of mute sympathy between artist and sitter that implicates the spectator and helps to account for Modigliani's enormous popularity.

BY COURTESY OF MR. AND MRS. HENRY PEARLMAN

"JEAN COCTEAU" BY AMEDEO MODIGLIANI, 1917. IN THE HENRY PEARLMAN COLLECTION, NEW YORK

*See* Arthur Pfannstiel, *Modigliani et son Oeuvre* (1956). (A. Bs.)

**MODJESKA, HELENA** (HELENA MODRZEJEWSKA, née OPID) (1840–1909), Polish-U.S. actress, whose repertory included several Shakespearean roles and a variety of emotional parts in modern drama. The daughter of a musician, Michael Opido, she was born at Cracow, Pol., on Oct. 12, 1840. After her marriage, to a Pole, Gustav Modrzejewski, she joined a company of strolling players. In 1868 she married Count Bozenta Chlapowski, a Polish politician and critic, and began to act at Warsaw, where she remained for a number of years. Her chief tragic roles were Ophelia, Juliet, Desdemona, Queen Anne in *Richard III*, Louisa Miller, Maria Stuart, Schiller's Princess Eboli, Marion Delorme, Victor Hugo's Tisbé and Juljusz Slowacki's Mazeppa. In comedy her favourite roles were Beatrice in *Much Ado About Nothing*, and Donna Diana in the Polish translation of an old Spanish play of that name. Mme Modjeska also played in modern pieces by Gabriel Legouvé, Dumas (father and son), Guillaume Augier, Alfred de Musset, Octave Feuillet and Victorien Sardou. In 1876 she went with her husband to California, where they settled on a ranch. This enterprise was a failure, and Mme Modjeska returned to the stage. She appeared in San Francisco in 1877, in an English version of *Adrienne Lecouvreur*. She continued to act principally in the United States, but was also seen from time to time in London and elsewhere in the United Kingdom. Mme Modjeska died on April 9, 1909, near Los Angeles, Calif.

*See* M. Collins, *The Story of Helena Modjeska* (1883) and (autobiographical) *Memories and Impressions* (1910).

**MODJESKI, RALPH** (1861–1940), U.S. engineer, gained recognition for his distinguished work as a designer and builder of bridges. He was born at Cracow, Poland, Jan. 27, 1861, the son of the actress Helena Modjeska. He graduated from the École des Ponts et Chaussées, Paris, with high honours, and then settled in the United States. From 1892, he practised as consulting bridge engineer at Chicago, Ill. Among his best-known bridges are the government bridge over the Mississippi at Rock Island; the McKinley bridge at St. Louis; bridges over the Mississippi at Thebes (Ill.) and at Memphis (Tenn.); the Northern Pacific bridge over the Missouri at Bismarck (N.D.); and bridges over the Columbia and Willamette rivers in Oregon. Modjeski was a member of the Quebec Bridge commission, and consulting engineer for the Ohio river bridge at Metropolis (Ill.) for the Chicago, Burlington and Quincy railroad, and the Thames river bridge at New Haven (Conn.) for the New York, New Haven and Hartford railroad. He was chosen chief engineer and chairman of the board of engineers of the Philadelphia-Camden bridge over the Delaware river, which, on its completion in 1926, was the longest suspension bridge in the world.

Modjeski was appointed chief engineer of the Huey P. Long bridge over the Mississippi at New Orleans, and served as chairman of the board of consulting engineers for the Trans-Bay bridge at San Francisco, completed in 1936. He died in Los Angeles on June 26, 1940.

**MODOC,** a North American Indian tribe that formerly ranged between Klamath lake, Oregon, and Clear lake, California. In speech and custom there was little distinction between them and the Lutuamian-speaking Klamath, their near neighbours to the north. In 1864 the two tribes agreed to relinquish most of their territory and take up residence on a reservation around Upper Klamath lake. However, an insurgent band of Modocs under the leadership of Kintpuash, a subchief known to the whites as Captain Jack, bolted the reservation in 1870, and efforts to induce their return precipitated the Modoc war of 1872–73. About 80 warriors and their families retreated to the bad lands in the vicinity of the Lava Beds National monument, where they were able to resist dislodgment. Following the treacherous murder of Gen. E. R. S. Canby, who headed a peace commission in April 1873, the war was prosecuted more vigorously. Captain Jack surrendered and was hanged in October of the same year. His followers were removed to Oklahoma. In the 1960s less than 30 Modoc were reported from Oklahoma; others were sharing lands with the Klamath and Snake in Oregon with a combined population of less than 1,200.

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(H. G. Bt.; X.)

**MODULATION,** a musical term signifying the transition in diatonic harmony from one key to another achieved by the use of chords common to both keys. In the harmonic technique of the 18th-century sonata form, modulation determines the breadth and range of expression of a movement, allowing developments of themes on different tonal planes. At the end of the 19th century it became identified with chromaticism. There are three main methods of modulation in classical harmony: diatonic, in which a pivot chord is common to two tonalities; chromatic, in which a note or notes in the pivot chord require alteration by a semitone; and enharmonic, in which the notes of the pivot chord assume different names (*e.g.*, the chord C♯ E♯ G♯ changed enharmonically to D♭ F A♭). Modulation may be transitory, as a means of giving depth to thematic development, or it may be structural. The latter type is a principal consideration in the design of a musical form. *See* also HARMONY: *Tonality, Time Scale, Movement and Modulation;* CHROMATICISM; ENHARMONIC.

**MODULATION (ELECTRONIC),** the process by which some characteristic or characteristics of one wave (the carrier) are caused to vary in accordance with the instantaneous amplitude or frequency of another wave (the signal).

Speech provides a familiar example in which the mouth varies or modulates a sound stream to produce recognizable words. The mere production of a steady tone conveys no intelligence unless the tone is interrupted, such as by turning it off and on in accordance with some prearranged code. This type of modulation is synonymous with that used in the familiar dot-dash telegraphic code.

In radio or the audio portion of television, the transmission of a steady signal by the transmitter tells nothing except that the station is or is not operating. Speech, music and other wave forms can be transmitted by a refinement of the modulation scheme described for telegraphic code, such as causing the amplitude or frequency of the transmitted wave to vary in direct proportion to the frequency of a sound or picture signal. If the amplitude is varied, the process is called amplitude modulation (AM); if the frequency is varied, frequency modulation (FM).

Because of unsatisfactory antenna radiation at low frequencies and the desirability of operating on many frequency levels to allow simultaneous transmission of many programs without interference, as well as the presence of filtering problems, it is necessary to use a high-frequency carrier and to modulate it with a low-frequency signal. The high frequency carrying the modulation is commonly termed the R.F. (radio frequency) carrier.

In addition to the AM and FM schemes already mentioned, phase modulation and pulse modulation are also used, the latter finding application in radar and other tracking devices. *See* also RADIO; RADIO RECEIVER. (A. L. Sv.)

**MODULE,** in architecture, is an arbitrary unit adopted to regulate the dimensions, proportions or construction of the parts of a building. A number of modules, based on the diameter of a column, were used in determining the proportions of the order (*q.v.*) in classical architecture. In Japanese architecture, room sizes were determined by combinations of 3-ft. by 6-ft. rice mats called *tatami*.

In modern architecture, design modules may be used to spread the proportioning and dimensioning of plans. The metre has proved useful for this purpose; Frank Lloyd Wright used a 4-ft. rectilinear or diagonal grid; and Le Corbusier developed and widely published an additive proportioning system named by him the *Modulor*. Other modules reflect repetitive building elements such as the standard office size or the hospital bed unit.

In addition to these applications in space planning, modules may also serve as the basis for co-ordinating the dimensions of the various materials and pieces of equipment to be assembled in the course of constructing a building. The purpose is to assure that all of the elements will go together without wasteful cutting and fitting at the building site, and to lower costs by permitting the quantity production and distribution of modular products with the assurance that they may be incorporated into any building plan.

An increasing amount of attention has been devoted to this subject since the development in the 1930s of the Bemis 4-in. cubical module (10 cm. in Europe), and progress has been made in stimulating the manufacture of modular building products. In the 1950s an effort was made to combine into a single "number pattern" several of these modular systems to offer the designer a larger range of approved dimensions in the critically important first few feet and to reduce the cost to the manufacturer of converting to modular products. Most architects and producers of building materials continued, however, to use modules based on their own special needs and interests, without co-ordination.

*See* also GOLDEN SECTION.

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**MOE, JØRGEN ENGRETSEN:** *see* ASBJØRNSEN, PETER CHRISTEN.

**MOERAN, ERNEST JOHN** (1894–1950), English composer born at Heston and Isleworth, Middlesex, on Dec. 31, 1894, whose "pastoral" idiom resembles that of Frederick Delius and John Ireland, though it displays less harmonic sophistication. He was much influenced by folk song and made arrangements of tunes that he collected, chiefly in Norfolk and Suffolk. His individuality is best seen in his many solo and choral songs, which include settings of Shakespeare, Robert Herrick, A. E. Housman, James Joyce and Seumas O'Sullivan. He was also successful in the larger forms. Among his more ambitiously designed works are the Symphony (1937), concertos for violin and cello, and several chamber works. Although limited in emotional range and variety of thematic invention, his larger works are accomplished in form and well sustained. He died near Kenmare, County Kerry, Republic of Ireland, on Dec. 1, 1950.

*See* J. A. Westrup, "E. J. Moeran," in *British Music of Our Time*, ed. by A. L. Bacharach (1946). (CO. MA.)

**MOERIS, LAKE OF,** an ancient lake which once occupied a large area of the Fayyum depression in the Fayyum province of Egypt; it is now represented by the much shrunken Birkat Qarun. The researches of archaeologists and geologists on the desert margin of the depression have done much to elucidate the history of the lake and the problem of its extent and level in ancient times. It would appear that in early Paleolithic times water stood about 120 ft. above sea level and probably filled the depression. In the Mousterian period, the level stood rather lower, at 105 ft.; during the Late Paleolithic it fell slowly and then, c. 10,000 B.C., more rapidly to about 15 ft. below sea level, perhaps because free connection with the Nile was temporarily cut off. Early in the Neolithic period the lake rose once more, and then gradually subsided, remaining at times long enough at one level to allow the formation of beaches which can still be seen. On the slowly shrinking shores, Neolithic fisher folk made their homes. They were succeeded by villagers of the early dynastic age. It was not until the Middle Kingdom, c. 1950 B.C., that action was taken by the Pharaohs to stop the gradual silting of the channel that connects the lake with the Nile through the Hawara gap. It may have been Amenemhet I who widened and deepened the channel, setting the lake once more in hydraulic equilibrium with the river; the lake, then 55 ft. above sea level, served both as a flood escape and as a reservoir to increase the supply of water for cultivation after the flood had subsided. About 450 B.C. Herodotus visited the lake. He described it as being 3,600 furlongs in circumference and 50 fathoms deep; he assumed that it was artificial and was told that it had been dug by King Moeris at least 900 years before. He described two colossal statues, the bases of which, bearing an inscription of Amenemhet III, were found by Flinders Petrie at Biahmu.

Large land reclamation schemes were carried out by the Ptolemies in the Fayyum. Lake Moeris was partially drained by Ptolemy II Philadelphus by means of a barrage to restrict the entry of Nile water, and the rich soil (approximately 450 sq.mi. [1,200 sq.km.]) thus laid bare was irrigated by canals and subjected to intensive cultivation. The population grew rapidly and towns sprang up, among them Soknopaiou Nesos, Karanis, Bacchias, Dionysias, Euhemeria, Philoteris and Theadelphia. The ancient Crocodilopolis, or Shedet, seat of the worship of Sobek the crocodile god, became Arsinoe, the capital of the Arsinoite nome. The excavation of sites around the lake has yielded a rich harvest of papyri of Hellenistic and Roman date.

The province continued to flourish during the first two centuries of Roman rule, but thereafter declined. The *Kitab Ta'rikh al-Fayum* of Abu Osman al-Nabulsi, written in A.D. 1245 when he was governor of the Fayyum, deplores the decrease of its waters. The Birkat Qarun today is very shallow and covers only 50 sq.mi.

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**MOERS** (MÖRS), a town of Germany in the *Land* (state) of North Rhine-Westphalia, which after partition of the nation following World War II became part of the Federal Republic of Germany. Pop. (1961) 46,650. It lies 7 km. (4½ mi.) W. of Duisburg near the Rhine and is served by the Duisburg-Cleves and Oberhausen-Krefeld railways. The site of the Roman Asciburgium (located in the Asberg quarter), Moers was first mentioned in the 12th century and developed as a medieval flax market around the castle of the counts of Moers (now a museum). A charter was granted by King Albert about 1300. In 1600 the town became the property of Maurice of Nassau, prince of Orange, who fortified it. The county passed to Prussia in 1702 and the fortifications were razed by Frederick the Great in 1763. The old part of the town is surrounded in part by a 3-km.-long outer fortification wall with a moat and star-shaped dam and has some narrow crooked streets and half-timbered houses. Moers became important industrially after 1900 when it grew as the centre of the Lower Rhenish mining industry. Marketing activities focus on the town centre. On the outskirts many industrial concerns have been set up. Manufactures include machinery, heating equipment, cement, blankets and tents. There are colleges of mining technology and agriculture, and the Gymnasium Adolfinum continues the tradition of the Protestant college founded in 1582.

**MOESIA,** the Roman province (later two provinces) immediately south of the lower Danube, bounded to the west by the Drinus (Drina) river and to the south by the Haemus (Balkan) range. The many tribes of this region (the Moesi proper were Thracians inhabiting present-day Serbia) had frequent encounters with the Romans before they were subdued by M. Crassus (grandson of the triumvir) in 30–28 B.C., bringing the frontier of the empire to the Danube. The newly conquered region was at first part of the province of Macedonia, then (perhaps about A.D. 4) it was detached as a military district under a consular commander; only in A.D. 15 was it made a regular stipendiary province. In the latter year, though still retaining its identity, it was grouped again with

Macedonia and Achaea, an arrangement that lasted till 44. During his Dacian wars (*c.* 86) Domitian divided the province into Moesia Superior west of the Ciabrus (Tsibritsa) river and Moesia Inferior from there to the Black sea. After Trajan's annexation of Dacia (106), Upper Moesia was extended north of the Danube to include most of the Banat, and Lower Moesia acquired large tracts of Moldavia and Walachia. When Dacia was abandoned *c.* 270 its inhabitants were largely transferred to Moesia, and the provinces were called Dacia Mediterranea and Dacia Ripensis. The garrison was gradually increased. Under Tiberius there were only two legions; one more was added after the annexation of Thrace (*q.v.*); Vespasian probably added a fourth; and after the division the two provinces together were garrisoned by five.

Moesia included the Greek cities near the Danube mouths, such as Istrus, Tomi (Constanţa) and Mesembria (Nesebur). In the 1st century it was not always easy for the Romans to defend them, especially under Domitian, when a wall to the south of them was built from Rasova on the Danube to Constanta; but at most periods they continued to be exceedingly prosperous, not least because surplus corn from the Black sea area could always find a market in the Roman empire. The other principal cities of Moesia grew out of the legionary camps along the Danube, from Singidunum (Belgrade) to Troesmis in the Dobruja. There too there was a strong Greek element, since the Moesian legions in the 1st century drew many recruits from the Greek-speaking provinces. In the interior agriculture and fruit-growing flourished, and there was mineral wealth in the Balkan range. The country suffered heavily from barbarian invasions from the mid-3rd century onward, but it was held for the Eastern Roman empire until the 7th century.

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(G. E. F. C.)

**MOFFAT, ROBERT** (1795–1883), pioneer missionary and father-in-law of David Livingstone, was born at Ormiston, East Lothian, on Dec. 21, 1795, and sent to South Africa by the London Missionary society in 1816, with little formal training for the work of a missionary. The first seven years of his work were much distracted by the unsettled state of the country; but in 1824 he was settled at Kuruman, southeast of the Kalahari desert, which was to be his home for 49 years. Moffat traveled widely, and made the acquaintance of many tribes. He acquired a profound knowledge of the Tswana language, into which he translated the Gospel of St. Luke (1830). Up till that time the mission had made little progress, but thenceforward the number of converts increased steadily. By 1857 Moffat had translated the whole Bible. He also introduced the Africans to better methods of agriculture and irrigation and in every way raised their standards of living and conduct, though his methods were perhaps unduly patriarchal. On his first meeting with Livingstone in 1840 Moffat detected his fine qualities and encouraged him to come to Africa, but wisely directed his attention northward "where no missionary had ever been." After the death of his wife Mary, who had shared 50 years of his missionary work, Moffat lived in retirement in England for the last 13 years of his life, and died at Leigh, Kent, on Aug. 9, 1883.

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(S. C. N.)

**MOFFAT,** a small burgh in Upper Annandale, Dumfries, Scot., situated on the Annan river, 21 mi. N.N.E. of Dumfries by road. Pop. (1961) 1,917. Moffat was famous for its sulfur and saline waters in the middle of the 18th century, and is now a vacation and angling resort. The spa lies 1½ mi. N.E. of the town, and there are also springs at Hartfell (3½ mi. N.) and Garpol (2 mi. S.W.). At Moffat house, which is now a hotel, James Macpherson published "Ossianic Fragments."

Dumcrieff house, outside the town, a former seat of Lord Rollo, was the home of J. L. McAdam, the road builder.

**MOFFATT, JAMES** (1870–1944), eminent Scottish scholar and author of one of the best-known translations of the Bible in modern idiom, was born on July 4, 1870, at Glasgow, and educated there at the academy, the university and the Free Church college. He was ordained in 1896 and, after pastorates in the ministry of the United Free Church of Scotland, was Yates professor of Greek and New Testament exegesis at Mansfield college, Oxford (1911–15), professor of church history at the United Free Church college, Glasgow (1915–27), and then Washburn professor of church history at the Union Theological seminary, New York (1927–39), where he died on June 27, 1944.

Though most of Moffatt's teaching was done in the field of church history, to which he contributed a translation of A. von Harnack's *Expansion of Christianity* (1904–08) and his own *First Five Centuries of the Church* (1938), it was as a biblical scholar that he won his great reputation. Besides commentaries on Thessalonians, Hebrews and Revelation, he wrote *Introduction to the Literature of the New Testament* (1911), which after several revisions is still a standard work. Out of a total of about 40, the other most significant books are perhaps *The Theology of the Gospels* (1912), *The Approach to the New Testament* (1921), *Love in the New Testament* (1929) and *Grace in the New Testament* (1931).

But Moffatt will be remembered chiefly for his translation of the Bible. Though often criticized as unduly colloquial, it has for that very reason admirably captured the flavour of much of the New Testament (published 1913), while many parts of the Old Testament translation (published 1924), such as the Book of Job and the great prophetic passages, have high literary merit. Moffatt edited a popular series of New Testament commentaries based on his own translation, and was himself responsible for the volumes on I Corinthians (1938) and the Catholic Epistles (1928).

(G. H. C. M.)

**MOFFAT TUNNEL,** begun in 1923 and completed in 1928, is 6.1 mi. long and pierces the continental divide 50 mi. W. of Denver, Colo., at an elevation of about 9,200 ft. above sea level. The 16 by 24 ft. tunnel, which provides for a single-track, standard-gauge railroad, was driven parallel with and 75 ft. to the north of an 8 by 8 ft. water tunnel with which it is connected at about 1,500-ft. intervals by crosscuts. *See* TUNNEL.

**MOGADISHU** (MAQDISHU; Italian MOGADISCIO), principal port and capital of the Somali Republic (*q.v.*), lies 2° N. of the equator on the Indian ocean coast of northeast Africa. Pop. (1961 est.) 99,762, mainly Somali, but including also immigrant Asians and Europeans. It was one of the earliest Arab settlements on the east African coast, its origins going back at least to the 10th century. Many old Muslim buildings and mosques have been preserved, which blend harmoniously with modern architecture. The Garesa palace, built by the sultan of Zanzibar in the 19th century, houses a museum and library. The republic's national assembly sits in an impressive centrally located building. There is a new university institute, and on the outskirts a large modern hospital. The airport is served by international services.

(I. M. L.)

**MOGADOR** (officially ESSAOUIRA), a seaport on the Atlantic coast of Morocco, chief town of a *cercle* (administrative subdivision) of the same name, in the province of Marrakech, about midway between Safi and Agadir. Pop. (1960), city, 26,392; *cercle*, 323,385. The town stands from 10 to 20 ft. above high water on a projecting ridge of calcareous sandstone. In certain states of wind and sea it is turned almost into an island, and a sea wall protects the road to Safi. On the land side stretch miles of sand dunes studded with broom, and beyond, the argan forests, distinctive of southern Morocco. Approached from this side the city bursts on the view like a mirage between sky and sea. The harbour is well sheltered from all winds except the southwest, but escape is difficult with the wind from that quarter, as the channel between the town and Mogador Island is narrow and hazardous. Mogador has a fish-processing industry, tanning and palm-fibre working.

The earlier hypothesis of a Phoenician settlement at Mogador has been confirmed by archaeological excavations which brought to light numerous Carthaginian traces. A place called Mogador,

a corruption of the Berber name Amogdul, is marked in the 1351 portolan chart in the Laurentian library at Florence, and the map in Jodocus Hondius' 17th-century *Atlas minor* shows the island of Mogador, *I Domegador* (the Portuguese had a fortress there from 1506 to 1510); but the origin of the present town is much more recent. Mogador was founded by Sultan Sidi Mohammed ben Abdallah in 1765, built to the plan of a French engineer and fortified in the style of Vauban. It was at first settled by an important Jewish colony, which for long had relations with England. In 1844 the citadel was bombarded by the French. Mogador was temporarily occupied by U.S. troops in Nov. 1942. After independence the official name of the town became Essaouira ("the little fortress"), a name it had previously held locally. (A. AM.)

**MOGILA, PETER** (1596–1646), Orthodox metropolitan of Kiev, author of the *Orthodox Confession of the Catholic and Apostolic Eastern Church*, belonged to a noble Moldavian family. He studied in Poland and possibly in the west, although no evidence exists for an alleged stay at the Sorbonne in Paris. In 1626 he took his monastic vows at the famous Kievan Pecherskaya Lavra and was appointed abbot in 1627. In 1633 he was elected metropolitan of Kiev. He made great efforts to improve the education of his clergy and laity at a time when both Roman Catholic and Protestant missionaries were very active among the Orthodox population of Poland and the Ukraine. In 1633 he transformed the theological college of the monastery into an academy which became the source of the theological revival in the whole Russian church; its influence was felt until the end of the 19th century. Theology in Kiev was taught according to the methods of western scholasticism and accepted many of the teachings of St. Thomas Aquinas. Mogila is known as the promoter of the *Orthodox Confession*, drawn up at the request of Abbot Kosslowski of Kiev, approved at a provincial synod in 1640 and accepted by the patriarchs of Constantinople, Jerusalem, Alexandria and Antioch in 1642–43 and by the Synod of Jerusalem (*q.v.*) in 1672. In spite of this recognition the *Orthodox Confession* has remained an object of controversy among Orthodox theologians, several of whom criticize it for its Latin spirit. Mogila died at Kiev on Dec. 22, 1646. *See* also CATECHISM: *Orthodox*.

*See* P. Schaff, *Creeds of Christendom*, vol. i, pp. 58–61 (1877), and vol. ii, pp. 275–400 (1889); A. Malvy and M. Viller, *La Confession Orthodoxe de Pierre Moghila*, in *Orientalia Christiana Périodica*, vol. x (1928). (AL. S.)

**MOGILEV,** an *oblast* (established 1938) of the Belorussian Soviet Socialist Republic, U.S.S.R., lies in the middle Dnieper lowland, covering an area of 11,081 sq mi. Pop. (1959) 1,166,081. It forms a level plain, sloping gently southward from the loess-covered morainic hills of the Orsha and Smolensk-Moscow uplands in the north. Drainage is by the Dnieper, which bisects the *oblast* from north to south, and its tributaries. Soils are mostly podsolized clay loams, but sands are common. The natural vegetation is mixed forest of pine, spruce, oak and birch and more than one-quarter of the land is forested. Swamps cover nearly one-fifth of the area. Of the 1959 population 31% were urban, living in 13 towns and 10 urban districts. The largest are Mogilev (121,712), the administrative centre, Bobruisk (97,530), Krichev (19,028) and Osipovichi (15,777). Industry, chiefly engineering and timber processing, is largely concentrated in Mogilev and Bobruisk, but food processing, sawmilling and linen weaving are widespread. Flax growing and cattle rearing, especially dairying, are the main branches of agriculture. (R. A. F.)

**MOGILEV** (MOHILEV), town and *oblast* centre of the Belorussian Soviet Socialist Republic, U.S.S.R., stands on both banks of the Dnieper 110 mi. E. of Minsk. Pop. (1959) 121,712. It is an important industrial focus, producing metal pipes, building and lifting machinery, artificial fibres, leather goods, bricks, beer, wine and foodstuffs. Railways link the town to Minsk, Vitebsk, Bryansk and Gomel, and there are regular passenger and cargo services on the Dnieper. There is a reference to a fortress (1267) around which Mogilev probably developed. It is first mentioned as a town in 1526, when it belonged to Lithuania–Poland. Four churches of the 16th–17th centuries have survived. Russia acquired Mogilev in 1772 by the first partition of Poland but, although a seat of a *gubernuya* (as a province was called until the Revolution), it remained unimportant until the coming of the railway in 1904. Occupied by the Germans in World War II, the town was gravely damaged and its population fell from 113,000 to 10,000. (R. A. F.)

**MOGOK,** formerly a small district of Burma including the famous ruby-mining area. As the importance of the ruby mines waned the area was attached first to Katha district, and later to Shwebo. The washing of superficial gravels and sands for rubies, spinels and other precious stones was carried on from early times. By tradition women were free to do this work but not men. Large-scale working was long the monopoly of the Burma Ruby Mines Ltd., a British company, but synthetic rubies ruined the market for the real stones and after many vicissitudes the company ceased operations in 1927. The system adopted was to excavate large open pits from which the ruby-bearing earth was removed and washed by machinery. The rubies were traced to their bed rock site near the junction of gneissic and calcareous rocks and some attempt was made to work the parent rock but the stones proved inferior to those naturally weathered out. There is still panning of superficial deposits by local workers. Mogok is situated high on the Shan plateau and, reached by motor road from Thabeikkyin on the Irrawaddy, serves to some extent as a hill station.

(L. D. S.)

**MOGOLLON.** The Mogollon culture was one of three ancient major Indian cultures of the southwestern United States region and is significant because it reveals the little-known formative stages through which all civilizations pass. The area once occupied by the Mogollon Indians lies in east central and southeastern Arizona and west central and southwestern New Mexico. Much of this country is mountainous, in contrast with the high plateau country occupied by the Anasazi Indians and the low desert area occupied by the ancient Hohokam Indians.

The Mogollon culture developed from a relatively simple one, the Cochise, a culture which is characterized as a food-gathering rather than a hunting complex, for nuts, roots and edible plants were collected and formed the principal part of the Cochise food pattern, although a few animals were hunted for food. Primitive stone tools such as milling stones, mortars, pestles, choppers and scrapers were made and used. The Cochise did not develop pottery, houses or agriculture.

At some time between 4000 and 2000 B.C. corn or maize was introduced into the southwest, probably from Mexico. Soon after this, beans and squash made their appearance. After the introduction of these plants, more food was available, permitting a larger population and more leisure. Men had time to develop new arts, skills and inventions. For example, in the course of a few centuries, pottery and houses appeared. The houses were built below ground level and are called pit houses. Thus to the basic Cochise culture traits such as easily recognizable types of stone tools were added brown or red pottery, pit houses, corn, beans and squash and many other traits.

The term "Mogollon" signifies the addition of these later traits to the older, basic Cochise culture.

**First Period, 300 B.C.–A.D. 500.**—The first true Mogollon period in which are found pottery, houses, corn, beans, squash and new types of stone tools, dates from about 300 B.C. to about A.D. 500. During that period, the people began to accumulate possessions and therefore had interests to protect—homes, crops, food warehouses and other personal possessions. A feeling of gregariousness seems to have overcome simplicism, and the people increasingly banded together in groups or villages. Villages were not necessarily well laid out; each householder built more or less where he pleased, but within the vaguely defined village limits. Each pit house, however, conformed to a uniform pattern. This pattern demanded that the houses be round and partly below ground and that the food be stored in pits below the floors; also that the houses be supplied with a tunnel side entrance facing east. Often the villages were situated on high, narrow, defensible mesas. Each house was probably occupied by several families related by blood or marriage.

The Mogollon Indians of the early period probably had religious convictions and dogmas and carried on sacred rites in specially built, large pit houses, called kivas.

The Mogollon civilization, therefore, at its inception (about 300 B.C.), may be described as undeveloped but developing, rural and somewhat isolated, although limited contacts with other groups may be conjectured. The Mogollon people of that time, crude and primitive in many ways, had already overcome many obstacles on their uphill journey toward civilization.

**Second Period, c. A.D. 500–900.**—The next major period constitutes a span of about 400 years (*c.* A.D. 500–900), when slow but progressive changes occurred. Apparently fear of enemies had disappeared, for larger villages were built near streams or springs rather than on mesas. Round pit houses were replaced by smaller, rectangular buildings. These homes probably housed only the mother, father and offspring. Cooking was done in fire pits within the house, and food was stored on the floor in basketry and pottery containers. New and more efficient stone tools were adopted, and the spear was replaced by the more accurate and potent bow and arrow. During that period religious services were probably held both in the home and in the kivas. Great advancement took place in the arts as reflected in pottery, basketry, sandals and textiles.

Shortly after the year 500 the Mogollon potters began to decorate their pottery. The first designs were executed with red paint on a brown background. The designs became so complex and were so competently executed that they have been praised by modern ceramists. Basketry and sandals were better woven, and cotton cloth bearing woven designs in colour came into being.

Thus advances were made in the arts, architecture, handicrafts and domestic economy, and the population increased.

**Third Period, c. A.D. 900–1250.**—The third and last period began about A.D. 900 or 950 and ended about A.D. 1250. Profound changes occurred: pit houses were replaced by surface apartment houses from one to three stories in height, with masonry walls; the red-on-brown ware was supplanted by a pottery decorated with black paint on a white background. These traits plus some others were probably introduced to the area by Pueblo Indian migrants whose homeland was in northern New Mexico (*see* PUEBLO INDIANS). There is ample evidence that these newcomers lived peacefully with the older inhabitants of the area in the same villages. Although there was a peaceful penetration by other peoples and some new ideas were introduced, many of the older Mogollon traits continued to flourish. This was, therefore, an early example of cultural intermixture (acculturation).

Finally, about 1250, the Mogollon culture, which had flourished for about 4,000 years (including the early Cochise manifestation as well as the later hybrid), came to an end in the original homeland. The houses and villages were abandoned and the people gradually straggled off—perhaps northward or westward—to make new homes. Various reasons for this exodus have been advanced—war, pestilence, soil exhaustion, change of climate; by the 1960s, however, none of these hypotheses had gained wide acceptance.

*See also* INDIAN, NORTH AMERICAN; NORTH AMERICA: *Prehistory and Archaeology*.

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**MOGUL,** or MUGHAL, the Arabic and Persian form of the word Mongol. It is inaccurately used to describe the dynasty of emperors of India founded by Babur (*q.v.*) in A.D. 1526. On the male side Babur reckoned his descent from Timur, who was a Barlas Turk; through his mother he was descended from Jagatai, the second son of the Mongol ruler Genghis Khan. It is therefore more correct to refer to the Mogul empire in India as a Timurid or Turki empire.

*See* INDIA-PAKISTAN, SUBCONTINENT OF: *History; see* also references under "Mogul" in the Index. (C. C. D.)

**MOHAIR,** the main specialty hair fibre, forms the long lustrous coat or covering of the Angora goat which originated in Asia Minor. World production of mohair is approximately 50,000,000 lb. annually, with Turkey and the United States supplying approximately 40% each and South Africa the rest. The goat owes its name to the province of Angora in Turkey, where it has been cultivated for thousands of years.

Until the early part of the 19th century it was limited to that country, and the best mohair continues to come from the regions around the cities of Afyonkarahisar, Eskisehir, Ankara and Beypazar. In 1836 Angora goats were first imported into South Africa and are raised primarily in the Karoo region of the Eastern Cape Province. The United States mohair industry was started in 1849 and had its greatest development in the range areas, particularly in Texas and New Mexico.

The colour of most Angoras is white; dark or coloured fibres are undesirable. The production of mohair per goat ranges from 3½ to 7 lb. annually. Much of the mohair is taken off in two clips per year; the length of the fibre ranges from 4 to 6 in. for a half year's growth and from 8 to 12 in. for a full year's growth. The size of the fibre is comparable to that of coarse wool; the finest kid mohair has an average diameter of 25 microns and the adult hair averages between 30 to 40 microns. (Wool fibres range from 10 to 70 microns.) In its microscopic structure the mohair fibre is similar to wool. The epidermal scales are only faintly visible and hardly overlap. The number of scales per 100 microns is 5, as compared to 10 to 11 in fine wools. This scale formation is the cause of the smooth handle of the fibre as well as the high lustre.

Mohair is mainly used as an apparel fibre, being very popular in men's summer suitings in numerous combinations with other fibres and in women's wear coatings such as velours, fleeces and boucles and worsteds. Because of its lustre and because it dyes brilliantly and retains colour well, mohair fibre serves admirably for nets, laces and drapery materials and produces many novel effects in decorative trimmings for coats, hats and shoes. Long-fibre mohair is also used extensively for theatrical wigs and switches. (W. v. B.)

**MOHAMMED** (more correctly, MUHAMMAD) (*c.* 570–632), founder of Islam (*q.v.*), the Muslim religion, was born in Mecca. According to Arab terminology referring to the genealogy or clan, the full form of his name is ABULQASIM MOHAMMED IBN 'ABDULLAH IBN 'ABD AL-MUTTALIB IBN HASHIM.

**Significance of His Personality.**—Few men have exercised so deep and lasting an influence as Mohammed: a religious influence, first and foremost, since the teaching handed down by Mohammed remains a living faith and a doctrine observed by nearly one-seventh of the world's population; a historical influence too, since, in less than 20 years, the movement he started had shaken two great powers, the Byzantine empire and the Sassanid empire in Persia, founding a new civilization, a political and social influence as well, since Islam as preached by Mohammed is both a religion and a system for the organization of the community. Moreover, after the death of Mohammed a whole system of traditional teaching was developed, presenting his behaviour in the various circumstances of life as a model for the faithful, so that the influence of Mohammed's personality was reflected in the everyday conduct and outlook of succeeding generations of Muslims (*see* HADITH).

But though it is impossible to overestimate Mohammed's historical importance, it is necessary, in a quite different sense, to emphasize the fact that his position in the actual doctrine of Islam—at least in its orthodox form—is a comparatively modest one. For one of the basic tenets of Islam is that the Koran (*q.v.*) is a divine revelation of which Mohammed was simply the vehicle. Therefore, according to the strict doctrine, Mohammed has no supernatural quality. "I am not an innovator among the apostles. I am only following what has been revealed to me and I give sin-

cere warnings" (Koran xlvi, 9). But Mohammed is not the author of the Koran; any orthodox Muslim would regard such a suggestion as blasphemous. That is why the Muslims reject the term "Mohammedanism" by which the west often designates their religion. They themselves prefer to call it Islam, meaning "confident submission" (to God).

It was not long, however, before hagiography took over and began to idealize Mohammed's life. In a different way, since the 19th century, the liberal and modernizing reformers of Islam, wishing to humanize their religion and guard against what they considered to be the excessive predominance of its metaphysical or legalistic aspects, have strongly individualized the figure of Mohammed, conferring upon him, even to the risk of sentimentality, a theological position not recognized by orthodoxy. Western critics, however, have sometimes gone too far in the opposite direction. The information derived from historical sources, which deal chiefly with the last 20 years of his life, and the researches of modern scholars suggest a figure rather many-sided but utterly genuine. One of the most remarkable aspects of his biography is, in fact, this often moving contrast between the extent of his achievement and the real humanity of his character.

**Sources for His Life.**—Shortly after Mohammed's death Muslims started to write his life (*sira*), often in an idealized form. The earliest of these biographies have not survived; the chief traditional one, *Kitab sirat Rasul Allah*, by Ibn Hisham, is based on the earlier *sira* by Ibn Ishaq. Most later Islamic historians rely on this work, but the *Kitab al-Maghazi* by al-Waqidi and the *Kitab al-Tabaqat al-Kabir* of Ibn Sa'd are also important. All date from the 8th–9th centuries.

The most important historical source, however, for Mohammed's life is the Koran itself, giving the very words that he uttered as a revelation and that were collected in his lifetime. The final text was established as early as *c.* 650 and has not been altered since. The *hadith*, reporting the sayings of Mohammed in various circumstances as told by "chains of authorities" and collected by traditionists, are less reliable, as a number of them have been interpolated in the course of history; those that have earned the greatest regard are by al-Bukhari and Muslim ibn al-Hajjaj, both of the 9th century.

Reference to Arabia in contemporary non-Arabian chronicles is disappointingly rare. Inscriptions and written sources relating to the period have been little studied, but there are allusions, sometimes revealing, in contemporary poetry.

**His Youth.**—The posthumous son of 'Abdullah, a member of the prominent Meccan family of Hashem (Hashim), a subdivision of the Qoraish (Koreish) clan, Mohammed lost his mother when he was six years old. The orphan was taken care of first by his grandfather, 'Abd al-Muttalib, and later by his paternal uncle, Abu Talib. But the Hashemites had suffered serious reverses of fortune, so that their influence had declined. Entrusted to a Bedouin nurse, Halima, the child Mohammed must then have spent his early years in poverty as a shepherd boy, living the existence of the nomads in the mountainous regions near Mecca. Later he accompanied some of the caravans, first probably those of his uncle Abu Talib, which the Meccan tradesmen organized regularly, northward into Syria or south toward Yemen. In his trading expeditions he showed himself both successful and honest, qualities that caused a widow, Khadija, to entrust him with the management of her business affairs. At the age of 25 Mohammed married Khadija, and the marriage, which lasted until her death 20 years later, was a particularly happy one. Many years older than her husband, she was his truest confidant, the first to believe in him and the first convert to Islam.

Thus, until the age of about 40, when he started preaching, Mohammed lived a peaceful life and attained relative prosperity. Indeed, in a town racked by commercial speculations, in a world where every Arab had taken part in some armed fighting, the life of Mohammed might have appeared unusually quiet and uneventful. In a climate where men grow old early, he was already past the age of adventure and ambition. Suddenly, his whole existence changed; a new phase of his life began.

**Mohammed Begins to Preach.**—About the year 610 Mohammed had formed the habit of withdrawing periodically into the mountains near Mecca to meditate and pray. One night on Mt. Hira, according to the tradition, he had an overwhelming spiritual experience; the word of God was revealed to him by the archangel Gabriel. Mohammed himself related that he heard an imperious voice and that a luminous being grasped him by the throat and commanded him to repeat the sacred words. At first, he tried to flee; Khadija later described his doubts, his self-questioning as to the genuineness of his message, his dread of resembling the visionary poets to be seen in the markets at Mecca with their pretense of being possessed. Then came a period of inner emptiness when "the revelation was silent," and his distress was even greater. Finally he was again seized by the conviction that he had a message to convey. His hesitation ceased, and around 613 he began his preaching. This took the form of a rhythmical recitative packed with exhortations and vivid comparisons. In content it was a fervent and reiterated proclamation of the all-powerfulness of the one God, Creator of the universe, who would summon all his creatures into his presence for judgment on the day of resurrection. But this God of justice was a God of mercy too. He had filled the earth with the signs of his glory and grace. Every man was morally responsible to him for the conduct of his own life. Every man must respond to the divine love and blessings by faith, prayer and charity. Mohammed did not preach this as a new doctrine. He declared that his teachings formed part of the prophetic tradition. He constantly reminded his listeners of the apostles of monotheism, such as Abraham, Moses and Jesus, who had been sent in earlier times with the same message. Their "reminders" and "warnings," as the Koran calls them, were now being repeated, in Arabic, owing to the revelation made to Mohammed.

**Reaction at Mecca.**—There was no immediate opposition. During the first few years, indeed, Mohammed spoke only to a small, intimate group of his family and friends. The hostile reaction of Mecca arose gradually as he began preaching to a wider circle and was probably due in great part to economic considerations. For it is a mistake to suppose, as was done for a long time, that Islam originated among nomads of the desert. Islam took shape in a town, a town characterized by an avid interest in trade and finance. Mecca stood in a rocky valley with no agricultural resources, and all its profits came from trading. The temple had become a place of profitable pilgrimages, accompanied by fairs and markets. A mercantile republic had thus grown up—an oligarchy governed by a council which included the richest traders.

Mohammed's preaching was a frontal attack on this system. Opposition to him at first took the form of mockery and interminable polemics. Then came persecution, which developed to such an extent that in 615 he advised the most vulnerable of his followers to take refuge in the Christian land of Ethiopia. Membership of the Hashemite clan, which had so far afforded some protection to Mohammed in his immediate entourage, was no longer effective. Matrimonial or commercial relations with the clan were forbidden. With these political trials came personal sorrows. In 619, "the year of mourning," both Khadija and Abu Talib died. Mohammed then began to seek refuge outside Mecca. Help came from Yathrib, which after its hospitality to Mohammed was renamed "Madinat an Nabi," the city of the Prophet, Medina.

**The Medina Period.**—Unlike Mecca, Yathrib was not a trading centre but an oasis, where an agricultural community lived by cultivating date palms. Two hostile tribes, the Aws and the Khazraj, were vying for precedence. The population also included three Jewish tribes. Tension between the two parties had reached a pitch where it seemed that only arbitration by someone unconnected with the conflicting clans could dispel it. Mohammed, as the head of a community whose principle was to transcend tribal divisions, was fitted to be the arbiter. Moreover, the presence of considerable Jewish settlements at Yathrib might have encouraged the Prophet to hope that his monotheistic doctrines would find a better reception there.

The first negotiations, conducted in secret, culminated in 622 in an agreement known as the pact of Aqaba, by which the new disciples took an oath of fidelity. In small groups the Muslims began to settle at Yathrib. The Meccans, alarmed, decided to

strike at the leader. They plotted to assassinate Mohammed, who was still in Mecca almost alone. But he managed to escape during the night and, after hiding for a time on Mt. Thaur, reached Yathrib on Sept. 24. Thus began the hegira (*q.v.*) or emigration. The Muslims reckon their era from this year, starting July 16, 622. In that year Islam found its form, asserting itself not only as a religion but also as an organized community.

The date also marks a turning point in the life of Mohammed. The preacher now became a politician and a ruler and before long a military leader as well. The text of a charter that forms the first constitution of Islam has been preserved. It shows remarkable political insight. Thus, one of the first measures was to integrate the refugees from Mecca with the original population of Medina. For this purpose, Mohammed instituted legal bonds of brotherhood between each immigrant and one of the Ansar ("assistants," "helpers"), as the hosts at Medina were now called. So religious unity did not prevent recourse to the already existing Arab custom of brotherhood. The two principles reinforced each other.

Mohammed also set himself to win over the Jews, assuring them of freedom to practise their religion and even including certain of their rites in Islam (such as the custom of turning toward Jerusalem when praying) as a witness to the fundamental unity and permanence of monotheism. In return, the Jews were to accept the new civil authority and contribute to military expenses. These political and economic restrictions appeared irksome to the Jews, who had enjoyed a favourable situation in Yathrib. They also refused to acknowledge Mohammed as a prophet and opposed to him their own biblical writings. Relations became strained. Less than two years after the hegira, Mecca (the sanctuary of the Black Stone) took the place of Jerusalem as the direction in which to pray. Simultaneously the doctrine of original monotheism gained strength—of a monotheism older than Judaism or Christianity, symbolized by Abraham and the temple at Mecca with Islam as its authentic representative.

**Military Campaigns.**—If Mecca was to be the centre of Islam, the exile at Medina could be regarded only as a temporary necessity. Moreover, the Meccans, who controlled the trade of Arabia, were bringing economic pressure to bear on the refugees and their hosts. The *émigrés*, who had lost all their property, were beginning to feel the pinch of poverty. The war began gradually, in the Bedouin manner, with a succession of raids and skirmishes. Reprisals and counterreprisals intensified. The losses on both sides were comparatively slight. But success or failure had far-reaching psychological repercussions on the tribes, which were highly sensitive to gain or loss in prestige. The first considerable victory was won by the Muslims at Badr, in the spring of 624. Despite their inferior numbers, the Muslims' dash carried the day. But the Meccans were bent on avenging their dead and reasserting their impaired authority. A year after Badr, an army of 3,000 men advanced upon Medina. The Muslims made an ill-judged sortie and were defeated at Ohod, largely through lack of discipline. Mohammed himself was wounded.

However, the Meccans were incapable of following up their victory. Not until March 627, when they had persuaded a number of Bedouin tribes to join their cause, did they bring a strong force against Medina again. Mohammed then resorted to tactics which were unfamiliar to the Arabs, accustomed to brief, isolated raids. Avoiding the mistake made at Ohod, he did not sally out to meet the enemy in the usual way but had a ditch dug around Medina. The Meccan horsemen were disconcerted and bored. The coalition started breaking up. Bad weather added to the discouragement of the besieging force, and it finally dispersed.

**Pact of Hudaibiya and Return to Mecca.**—The "battle of the ditch" had restored the initiative to Mohammed. He used it, however, chiefly as a means to negotiation. The opposing forces were now more equally matched and the Meccans were tired of a war that was damaging their trade. They were further appeased by Mohammed's declared intention of not merely respecting the traditional pilgrimage but making it one of the basic rites of the new religion. After various overtures, including the resumption of trade between the two cities, Mohammed secured a truce to enable himself and his companions to undertake their pilgrimage. They set out on their peaceful march, but as they drew near the city their way was barred by an armed group. The Muslims stopped and camped at Hudaibiya, where a Meccan delegation came to parley. As a result of these negotiations Mohammed agreed to three conditions: the Muslims would return to Medina without visiting the temple at Mecca and would return the following year for a visit not to exceed three days; Meccans who emigrated to Medina would be extradited on request; and there would be a ten-years' truce during which each party should be free to cross the other's territory and remain neutral in the event of either's becoming involved in war with a third party.

This agreement, known as the pact of Hudaibiya, made concessions that many of Mohammed's companions found exaggerated and that gave rise to violent criticism. But it proved successful. It obliged the Meccans to give official recognition to a group of fugitives they had despised and to accept them as entitled to conduct negotiations with the chief city of Arabia. It also gave Mohammed time to establish his position at Medina once and for all.

The agreed pilgrimage, which took place in 629, found Mecca almost deserted, for the inhabitants had withdrawn to the neighbouring hills. Once their pious purpose had been fulfilled, the Muslims departed, as required by the treaty. This display of strength combined with moderation impressed the Meccans. The time was ripe for a solution. An opportunity arose when a quarrel flared up between two tribes and Mecca unwisely gave its support to one of them, thus breaking the pact of neutrality. At once, in Jan. 630, the Muslims were ordered to advance on Mecca. The city capitulated almost without a blow and nearly all the inhabitants accepted Islam. Thus the patience, the risks accepted, the restraint imposed on followers throughout the preceding years of negotiations at last bore fruit.

The same moderation prevailed in the hour of victory. Mohammed made a ceremonial entry into the temple and ordered all the idols to be overthrown and the building to be converted from a pagan shrine into a Muslim sanctuary. But apart from this symbolic act he was careful not to offend the population. By a general amnesty and other evidence of liberality, Mohammed succeeded, indeed, in gaining the lasting support of his former enemies.

**Relations With Judaism and Christianity.**—Established in its spiritual capital, Islam gradually took shape as a religion distinct from Judaism and Christianity. True, the Prophet's preaching had always stressed the essential unity of the monotheistic creeds, which is proclaimed in many verses of the Koran: "God has ordained for you the religion he commended unto Noah and which we have revealed to thee and we commended unto Abraham and Moses and Jesus" (xlii, 13). And to the "people of the Scriptures" or "book" the Muslims are told to say "We have faith in that which has been revealed to us and in that which has been revealed unto you. Our God and your God are one, and unto him we are resigned" (xxix, 46). But from the early days at Medina, despite all appeals to the Torah and to the name of Moses, the Jews had shown themselves reserved. Reluctant to change their manner of life, they were more inclined to favour the Meccans. However, they proved unable to unite against Mohammed, so that in the intervals of his campaigning outside Medina he was able to crush their sporadic moves within the city. Several of their groups were banished. After the pact of Hudaibiya had given him security from the Meccans, he struck his most severe blow, capturing (628) the important oasis settlement of Khaibar, populated entirely by Jews.

Relations with the Christians remained more satisfactory. The Koran declares that "Those who are most disposed to friendship with the faithful [*i.e.*, the Muslims] are they who call themselves Christians; this is because they have priests and monks, and because they are free from pride" (v, 85). While the community was struggling to survive and organize itself, it did not have to take account of the Christians, who were few at Mecca and Medina. But, as Islam spread and contacts with Christian communities developed, differences of doctrine were shown to be so fundamental and profound as to make a division inevitable in the long run. This became manifest, for instance, in 631 during the episode known as the Najran meeting. Theological discussions

with a deputation from Najran, a fertile valley in Yemen, inhabited by one of the largest Christian communities in Arabia, broke down over the dogma of the incarnation of Christ. Despite this failure, however, Mohammed had part of the mosque set aside for the Christians to perform their rites.

**Government From Mecca; the Last Years.**—The period 630–631 was not only that of various embassies sent to Mohammed. It was also marked by military expeditions, with which the Muslim state initiated its expansion. Around 630–631, Mohammed's authority was firmly established and the unification of the Arabian peninsula proceeded steadily. Mohammed thereupon reorganized his administration. Almsgiving was transformed into a government tax at fixed rates. Religious connections had now been permanently substituted for the system of clans and tribes. Paganism was outlawed. The Muslim community was based on the principle of equality and governed entirely by the koranic law. The verses of the Koran dating from this period are no longer cast in the breathless rhythm of the Meccan phase. Their style is calmer and they deal chiefly with the structure of society. The former social system had been particularly unfavourable to women; the new laws entitled them, for example, to own property and to inherit it. The husband's obligations were defined for the first time, and the legal maximum number of wives was reduced to four.

In considering the status of women in Islam, it is only fair to remember the position they had previously occupied in Arabia. Western critics have often reproached Mohammed for his own polygamy. Here again we should bear in mind the life led by the Arab tribal chiefs. As long as Khadija was alive, Mohammed remained unswervingly faithful to her. Among his later wives there were two of whom he seems to have been especially fond—'A'isha (*q.v.*), his favourite, whom he married as a very young girl, after the battle of Badr, and Zainab. Their personalities were not without influence on the life of the community. Only Mohammed's female offspring, all by his first marriage, survived. One of his daughters, Fatima (*q.v.*), married 'Ali (*q.v.*), Mohammed's first cousin and one of his earliest converts. There were two children of this marriage, Hasan and Husain (*q.v.*). If matters had been settled by right of birth, these should have succeeded to the Prophet's position. But the elective system was adopted, and the dispute over the succession caused the first and only major schism in Islam's history.

As early as the pilgrimage of 631, Mohammed had designated one of his earliest companions, Abu Bakr (*q.v.*), to preside over the ceremonies. In the following year Mohammed himself led the pilgrimage. He had by then begun to feel the effects of the malady to which he later succumbed, and this ceremony, known as the "farewell pilgrimage," served as a final recapitulation, a collective scrutiny of his lifework by both himself and the community. Tradition has preserved the moving terms of this farewell. In his last sermon he urged his followers not to split up after his death, affirmed yet again the unity of God and the brotherhood of the faithful, enjoined the community to watch over the rights of women and proclaimed the abolition of blood feuds and of usury. Then he returned to Medina and died there on June 8, 632. Tradition says that Abu Bakr, the newly elected *khalifah* (caliph, successor), said to the sorrowing faithful: "If you are worshipers of Mohammed, know that he is dead. If you are worshipers of God, know that God is living and does not die." Thus Mohammed's life ended as his preaching had begun, in the absolute devotion, amounting to self-effacement, of the man to the mission.

Mohammed's biographers have tended to make a sharp division between his two periods of activity—as the prophet and preacher of Mecca and as the politician and lawgiver of Medina. Critics of the 20th century, however, tend to modify this distinction, which seems to have no psychological or historical justification. The balance, the composure and the grasp of possibilities so often displayed by Mohammed at Medina would be unaccountable if the apostle of Mecca were no more than a passionate being in the throes of inspiration. Inspired he was, but he had foresight too. Yet the inner tension that set him to preaching never really subsided. There is ample evidence that Mohammed's main influence was not through any doctrinaire theological teaching but through stimulating leadership and a moral ascendancy over those who came within his range. His own stimulus throughout his career came from religion. His life derived its unity from faith.

*See* ISLAM; HASHEMITES; for the history of the spread of Islam, *see* CALIPHATE; *see* also references under "Mohammed" in the Index.

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**MOHAMMED V** (SIDI MOHAMMED BEN YUSUF) (1909–1961), sultan of Morocco from 1927 to 1957 and king from 1957 to his death, fifth ruler of the Filali (*q.v.*) dynasty to bear the name Mohammed, was born at Fès (Fez) on Aug. 10, 1909, the third son of Sultan Mulay Yusuf. On his father's death in 1927, the 18-year-old prince was chosen by the French authorities as sultan in preference to his two elder brothers. Within ten years his intelligence, capacity for work and diplomatic skill had marked him out as the outstanding personality in the country. Though conditions did not permit his governing, he set himself to encourage popular education, giving the example by providing excellent French as well as Arabic instruction for his children. During World War II Mohammed V continued to co-operate after the collapse of France, but refused to sanction the introduction of Vichy anti-Jewish legislation or to follow Gen. Auguste Nogues in 1942 in organizing resistance to the Allied landings. He was encouraged by personal contact with western leaders, and when, in 1944, the Istiqlal party put forward a demand for independence he let his sympathy for the nationalists appear. The next landmark was his visit to Tangier in 1947. In his speech in the international city he ignored France but stressed the affinities of Morocco with the eastern Arab states. The French government thereupon appointed Gen. Alphonse Juin as resident general, with authority to apply strong measures. In 1951 the latter, unable to impose his will on the sultan, mobilized the Berber tribesmen against him, but failed to extort more than a partial disavowal of the Istiqlal. Two years later, the new resident general, Gen. Augustin Guillaume, adopting a similar policy, deported the sultan first to Corsica, then to Madagascar. An elderly nonentity was appointed to succeed him. The result was a great increase in the deposed ruler's popularity, an outbreak of terrorism and, finally, fighting in the Rif.

In 1955 the French government yielded and the sultan made a triumphal return. Henceforth, he had the responsibility of ruling, as well as reigning over, a country faced with great political, economic and social problems. Consistently moderate, he directed his people toward a distant goal of constitutional government, while seeking to maintain good relations with the west. In 1957 he changed his style from sultan to king, and later secured the recognition of his eldest son, Prince Maulay Hassan, as his successor. He died very suddenly at Rabat on Feb. 26, 1961. *See* also MOROCCO: *History*. (N. BA.)

**MOHAMMED I** (d. 1421), Ottoman sultan of Turkey from 1413 to 1421, was the youngest son of Bayazid I. After the battle of Ankara in 1402, Timur (*q.v.*), victorious over the Ottomans, restored to their lands the Turkish begs of Asia Minor whom Bayazid I had evicted. He also left the Ottoman territories in a state of dismemberment. Of the sons of Bayazid I, Mohammed was ruling at Amasya, Isa at Bursa and Suleiman in Rumelia (Rumeli), *i.e.*, the Balkan lands under Ottoman control. Mohammed seized Bursa not long after 1403 and then became engaged

in a conflict with Suleiman. He sent to Rumelia his brother Musa, who defeated Suleiman in 1410, but, attempting to rule alone in Rumelia, was himself crushed by Mohammed in 1413 at Camurlu in Serbia. The events of the years 1402–13 demonstrated that the idea of an Ottoman state in Rumelia distinct and separate from the Muslim territories in Asia Minor, which Suleiman and Musa had striven to realize, was not viable. Mohammed, during his brief reign as sultan, re-established Ottoman control over much of western Asia Minor. He overcame a great religious revolt which broke out there in 1416 under Sheikh Badr al-Din and also had to face a new threat from a pretender who claimed to be his brother Mustafa, missing since the battle of Ankara in 1402. Mohammed died at Edirne in 1421.

*See* P. Wittek, "De la Défaite d'Ankara à la prise de Constantinople," *Revue des études Islamiques* (1938). (V. J. P.)

**MOHAMMED II** (1432–1481), Ottoman sultan of Turkey from 1451 to 1481, known as Fatih ("the conqueror"), was born at Edirne, Turk., on March 30, 1432. He had been called to the throne in 1444 when his father, Murad II, went into temporary retirement at Manisa (Magnesia) in western Asia Minor. Sultan Murad, in view of the fact that grave problems then confronted the Ottoman state and under pressure from the great dignitaries of the Porte, was soon, however, to reassume control of Ottoman affairs. Mohammed became sultan once more on the death of his father in 1451. He strove throughout his reign to realize one main purpose: the consolidation of the Ottoman state. Constantinople fell to him in 1453. (*See* ISTANBUL: *History*.) Mohammed repaired the walls, erected new public buildings and repopulated the town with groups of Muslims, Christians and Jews drawn from the provinces of the empire. He thus began the long process that was to transform Constantinople into Istanbul, a proud capital reflecting in itself the rich and varied character of the Ottoman state.

Consolidation was also the aim of the numerous campaigns that Mohammed carried out in the course of his reign. All that was left of an independent Serbia became in 1459 the Ottoman frontier province of Semendria (Smederevo) over against the Hungarian fortress of Belgrade, which the sultan had attempted to capture, but without success, in 1456. Bosnia was overrun in 1463–64; most of the Bosnian nobles then embraced Islam and had henceforward a great role as warriors of the Muslim faith engaged in constant warfare against the neighbouring Christian lands. Athens and almost all the Morea came under Ottoman rule in 1458–60. Sultan Mohammed fought a long war with Venice during 1463–79, as a result of which the Ottomans acquired Negroponte in 1470 and strengthened their position on the Adriatic shore through the conquest of Croia (Krugë) and of Scutari in 1478–79.

Mohammed also made an end of the Genoese imperium in the area of the Black sea. Amastris and Sinope (Sinop), centres of Genoese trade, together with the Greek state of Trebizond (Trabzon), yielded to the sultan in 1461. The Ottoman fleet, in 1475, seized Kaffa (Feodosiya), a Genoese emporium in the Crimea. At the same time the khan of the Krim Tatars became a vassal of the sultan. Meanwhile, in 1466, Karaman, a Turkish emirate in Asia Minor long hostile toward the Ottomans, was at last absorbed into the territories of the sultan. An attempt, made in 1480, to capture the island of Rhodes from the Knights of St. John of Jerusalem ended, however, in failure.

Mohammed II was a patron of the arts and of learning. His law code (Qanun-name) defined some of the basic institutions and usages of the Ottoman state. The sultan died at Tekfur Cayiri, near Gebze, on May 3, 1481, on the eve of a new campaign in the east. *See* also TURKEY: *History*.

*See* F. C. Babinger, *Mehmed der Eroberer und Seine Zeit* (1953). (V. J. P.)

**MOHAMMED III** (1566–1603), Ottoman sultan of Turkey from 1595 to 1603, was born at Manisa in the summer of 1566. Throughout his reign a bitter conflict was in progress with Austria. An Ottoman attempt to regain control of the lower Danube met with disaster in 1595. The same year saw, in addition, the Christian capture of Gran (Esztergom), the northernmost bulwark of Ottoman power in Hungary. Sultan Mohammed himself shared in the campaign of 1596, which led to the Ottoman conquest of Erlau (Eger) and to a severe defeat of the Christians at the battle of Mezö-Keresztes. There followed a stubborn war of sieges, in the course of which the Ottomans took the great fortress of Kanizsa in 1600. The last years of the reign witnessed the outbreak of serious revolts in Asia Minor and also the beginning of a new war with Persia. Mohammed III died at Istanbul on Dec. 22, 1603. *See* also TURKEY: *History*.

*See* J. von Hammer-Purgstall, *Histoire de l'empire Ottoman*, Fr. trans. by J. J. Hellert, vol. 7 and 8 (1837). (V. J. P.)

**MOHAMMED IV** (1642–1693), surnamed Avji ("huntsman"), Ottoman sultan of Turkey from 1648 to 1687, was born in Istanbul on Jan. 2, 1642. He succeeded his father Ibrahim I on Aug. 8, 1648, at the age of six, being the only Ottoman prince left alive. Until 1656 power was in the hands of harem factions; from that year onward it rested with a series of grand viziers, beginning with the two great Koprulus. The sultan was not devoid of spirit; he took part in several campaigns, notably those of 1663 and 1672, against Austria and Poland, respectively. He preferred, however, to devote his energies to hunting. No minister ever succeeded in curbing his enormous expenditure on this occupation. The disastrous defeat of the Turks at Mohacs in Hungary (1687) cost Mohammed his throne. Deposed in November of the same year by a revolt of the army supported by the ulemas, he spent the last three years of his life in retirement at Adrianople (Edirne), where he died on Jan. 7, 1693. (G. L. L.; E. Z. K.)

**MOHAMMED V** (1844–1918), Ottoman sultan of Turkey from 1909 to 1918, known as Reshid, was born on Nov. 3, 1844, at Topkapi. He was the son of Sultan Abdul-Mejid and a younger brother of Abdul-Hamid II. He became sultan when Abdul-Hamid was forced to abdicate in 1909. All his life he lived under close supervision at the palace. He was kind and gentle but very simple and weak. Although he did not have the ability to govern in difficult times, he never acted with cruelty. During the nine years of his reign he obeyed the wishes of the Committee of Union and Progress, went on a tour of Thrace at their suggestion and visited Albania, trying to convince the rebels there to give up their struggle. His reign is marked by the absolute rule of the Committee of Union and Progress and by the final downfall of the Ottoman empire. He is credited with having been opposed to the pro-German policy of Enver Pasha but if so, he was unable to take any effective measures against it. Having already seen in his short reign the loss to the Ottoman empire of much of the Balkans and Tripoli, he lived through the defeat of Turkey in World War I and died at Yildiz on July 2, 1918. *See* also TURKEY: *History*. (M. P. P.)

**MOHAMMED VI** (1861–1926), known as Vahid-ed-Din, 36th and last of the Ottoman sultans of Turkey (1918–22), was born on Jan. 14, 1861. He became sultan in 1918, at the age of 57, on the death of his brother Mohammed V. All his life he had lived as a prisoner in the palace. He had the cunning but not the intelligence of his elder brother Abdul-Hamid II. During his four-year reign as sultan, the intrigues he indulged in for his personal safety earned him the nickname of the "black sultan." He accepted the treaty of Sèvres (1920) and did his best to suppress the nationalist forces which were fighting for Turkish independence. Finally on Nov. 17, 1922, after the defeat of the Greeks by the nationalist forces, he escaped on a British warship. Later he tried unsuccessfully to set himself up as caliph in the Hejaz. He died at San Remo, Italy, on May 16, 1926. *See* also TURKEY: *History*. (M. P. P.)

**MOHAMMED** OF GHOR OR GHORI (MU'IZZ UD-DIN MOHAMMED IBN SAM) (d. 1206), Ghorid conqueror of the north Indian plain. Mohammed Ghori was the half nephew of Qutb ud-Din and the nephew of Saif ud-Din Suri, the slaying of whom by Bahram Shah of Ghazni in 1149 was revenged by the burning of Ghazni by 'Ala ud-Din Jahansuz in 1151. Subsequent to the latter's death, Ghiyath ud-Din, elder brother of Mohammed, acquired power at Firuz Kuh east of Herat in the region of Ghor (*c.* 1162). Mohammed Ghori always remained his loyal subordinate. Thus Mohammed expelled the Ghuzz-Turkoman nomads from Ghazni in 1173 and came as required to his brother's assistance in his

contest with Khwarizm for the lordship of Khurasan. After Ghiyath ud-Din's death in 1202, the rivalry between the two powers came to a head with Mohammed's direct attack in 1204 on the Khwarizmian capital Gurganj and his repulse and defeat at Andhkhud. In Hindustan, Mohammed enjoyed greater success, capturing Multan and Uch in 1175, annexing the Ghaznavid rump principality of Lahore in 1186 and winning the important battles of Tara'in (1192) and Chandwar (1194). He mostly left the rounding out of his Indian conquests to Qutb ud-Din Aibak (*q.v.*). Mohammed Ghori was assassinated on March 15, 1206, at Damyak on the Indus, according to some by Hindu Khokars, according to others by Isma'ilis. Within ten years of his death, Ghor was in the hands of the Khwarizmshah and only his Indian conquests remained. The career of Mohammed Ghori, no outstanding general or statesman, emphasizes the weakness at the end of the 12th century of the Rajput principalities of northern India against a military power in possession of the "Afghan" highlands and of a bridgehead, in the shape of Ghaznavid Lahore, across the Indus. *See* also GHOR.

*See* A. B. M. Habibullah, *The Foundation of Muslim Rule in India*, rev. ed. (1961); W. Barthold, *Turkestan Down to the Mongol Invasion*, 2nd ed. (1928, reprinted 1958). (P. H.)

**MOHAMMED AHMED** (called THE MAHDI; in full MOHAMMED AHMED IBN AL-SAYYID ABDULLAH) (1844–1885), founder of the mahdist movement in the Sudan, was born on Labab Island, Dongola district, Sudan, on Aug. 12, 1844, of a family that claimed descent from the Prophet. His father, a boatbuilder, later brought his family to settle at Karari near Khartoum. Mohammed Ahmed early revealed an aptitude for religious studies and, after frequenting teachers in the Gezira and at Berber, he sought the ascetic life in a religious confraternity. In 1861 he entered the Sammaniyya order but became disappointed at the worldly life of its local head, who, when the young man reproved him, expelled him from his lodge of the order. He then professed allegiance to a rival Sammani leader, and in course of time gathered his own disciples at a hermitage which he had made for himself at Aba Island on the White Nile. During 1880–81 consciousness of his divine election came upon him. In March 1881 he disclosed his mission to his adherents, and on June 29 he publicly assumed the title of the expected Mahdi, calling for the purification of Islam and the destruction of unbelievers, among whom he stigmatized the Turco-Egyptian government. He appointed four caliphs to be the living successors of the four earliest caliphs in Muslim history. Three responded: 'Abdullahi ibn Mohammed (the Khalifa 'Abdullahi), 'Ali ibn Mohammed Hilu and Mohammed Sharif ibn Hamid. The fourth, Mohammed al-Mahdi ibn al-Sanusi, head of the Senusi order at Jaghbub (Giarabub), ignored the invitation.

After a fracas at Aba with troops sent to arrest him, the Mahdi led his followers to Jabal Qadir in the Nuba mountains. There, on Dec. 9, 1881, and on May 30, 1882, he destroyed two Egyptian armies; then, descending from the hills, he laid siege to Bara and El Obeid. Bara capitulated on Jan. 6, 1883; El Obeid, after a hard siege, on Jan. 19. An Egyptian army under Gen. William Hicks advancing from the White Nile to recapture El Obeid was overwhelmed at Shaykan on Nov. 5, 1883. This spectacular victory isolated the garrisons of Darfur and the Bahr El Ghazal, and enormously increased the Mahdi's prestige. By this time Khartoum was in danger. Maj. Gen. C. G. Gordon (*q.v.*) reached the capital on Feb. 18, 1884. He had written to the Mahdi offering him the sultanship of Kordofan, but the offer was contemptuously declined. In early September the mahdist vanguard approached the suburbs; the Mahdi with reinforcements arrived on Oct. 23 and set up his headquarters at Abu Sa'd on the White Nile near the city. Khartoum fell on Jan. 26, 1885, and on Jan. 30, when the massacre of the citizens was over, the Mahdi made a triumphal entry and led the Friday prayers in the town mosque. He died in Omdurman on June 22, 1885, probably of typhus, and was buried under the dome which is a prominent feature of the town. Omdurman, the Mahdi's military headquarters, then became the capital of a new state that stretched from Nubia to the equatorial regions and from Darfur to the Red sea, the structure of which was a conscious copy of the polity of primitive Islam. The Mahdi referred to himself as the "successor to the apostle of God," *i.e.*, successor to the Prophet (*see* MAHDI), and directed the movement by proclamations, warnings and directives covering the entire field of theology, law, sociology and economics. The mahdist movement, which is still a powerful force in the Sudan, continues under the leadership of the Mahdi's descendants.

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(R. L. HA.)

**MOHAMMED ALI** (1769–1849), also known as Mohammed Ali Pasha, Ottoman viceroy (vali) of Egypt from 1805 to 1848 and founder of the dynasty that ruled Egypt until 1952. His origin has been much disputed. Most European writers, on the strength of his association with Albanian troops, have concluded that he was himself an Albanian. According to the family tradition his ancestors were Turks from Arapkir in Anatolia who afterward settled in Konya. From there his grandfather emigrated to Kavalla on the Aegean coast of Macedonia where the future viceroy was born (1769). He was one of 17 children of Ibrahim Agha, head of the local town watchmen. Here he married a wife who gave him five of his numerous children. As a young man he entered the tobacco trade, an occupation which, by bringing him into contact with the sharpest wits among the Greek and European commercial communities, introduced him to a wider world than was normally open to a Turk, and probably explains his ability to understand and live on easy terms with non-Muslims.

When in 1798 Bonaparte with a French army landed in Egypt, Mohammed Ali accompanied a contingent of Macedonian Albanians that was sent with an Ottoman expeditionary force to resist the invaders. On disembarking at Abukir (Abu Qir) the Ottomans were driven back to the sea and Mohammed Ali narrowly escaped from drowning. He survived the defeat and by 1801 had risen to be one of the two officers commanding Albanian formations in Egypt. After the departure of the French in that year Egypt relapsed into anarchy. By the judicious use of force and intrigue, about which he was reluctant to speak in after years, he systematically disposed of his Ottoman and Mameluke rivals for power. In 1805 he won the support of the citizens of Cairo against the undisciplined troops of the governor general, Ahmad Khurshid Pasha, the future imperial grand vizier, who was compelled to relinquish the citadel to Mohammed Ali. The Ottoman government attempted to lure Mohammed Ali from Egypt by offering him, on May 10, 1805, the grade of vizier and the governorship of Jidda. The new vizier announced to the people his elevation to the exalted grade but concealed from them his appointment to Jidda. Three days later the inhabitants publicly acclaimed him as their ruler and repudiated Khurshid. Finally Istanbul, bowing to reality, issued a firman, which arrived in Cairo on July 19, appointing him vali of Egypt in Khurshid's place. On March 23, 1806, Mohammed Ali received a firman of confirmation.

The new vali then embarked upon his long and distinguished term of office. In 1807 he was able to demonstrate his loyalty to Sultan Selim III, who was then at war with Britain, by twice defeating British forces that were supporting a Mameluke faction in the delta. Having delivered Egypt from attack he next set about the elimination of the Mamelukes, his last enemies within the country. In 1808 he persuaded many of the Mameluke beys to settle in and round Cairo where he could supervise their movements. Some refused to give up their armed retainers and were potentially dangerous. These were subdued in a series of small engagements. At this stage Mohammed Ali prepared their complete destruction. Some 300 beys were invited to the citadel to a ceremony of investiture of his son Tusun who was to lead an Egyptian army against the Wahhabi rebels in Arabia. The celebration was held March 1, 1811. No sooner had the guests arrived within the walls of the citadel than the gates were shut and a murderous fire was opened on them, and all but one were killed.

Tusun's campaign, undertaken at the request of Sultan Mahmud II, opened with defeat in 1811 and partial victory in 1812 when the holy places were liberated from the puritanical yoke of the Wahhabis. Mohammed Ali made a tour of inspection in the Hejaz, reorganized the Egyptian forces and replaced the sharif of Mecca whom he suspected of sympathizing with the enemy. In 1814 he took the field after visiting Mecca and gaining the pilgrim's title of *al-hajj*. Tusun proved his incapacity and on his death was succeeded in command by Mohammed Ali's eldest son Ibrahim (*see* IBRAHIM PASHA) who began his military career by breaking the power of the Wahhabi movement by a hard campaign in 1816–18.

In 1820–21 came the Egyptian penetration of the Sudan when two armies sent by Mohammed Ali occupied Sennar and central Kordofan. The commander of the army of Sennar was his third son, Ismail. In Oct. 1822 the killing of Ismail by an aggrieved Sudanese chief at Shendi was the signal for a desperate Sudanese revolt against the Egyptian conquerors. On hearing of his son's death Mohammed Ali vented his rage upon the commander of the region, urging him to massacre all the tribes within range, but, recovering himself, wisely allowed the local authorities to deal with the revolt in their own way.

Mohammed Ali did not regard the Greek insurrection in the Morea (1821–27) as involving the Greek colony in Egypt, which he treated with kindness even while his son Ibrahim was fighting their compatriots on the Greek mainland. Nor was he permanently embittered when the kingdom of the Hellenes was set up (1833). The consul general in Egypt of the new kingdom was his old friend, Michael Tossitza. But when all his services to the Ottoman sultan in Arabia and Greece were countered by what he conceived to be the sultan's ingratitude, he went to the length of declaring war against his imperial master. At the end of 1831 an Egyptian army under Ibrahim Pasha invaded Syria. A succession of victories over the demoralized Ottoman army, which was still in the difficult process of transition from oriental to western organization and training, brought the Egyptian outposts to within 100 mi. of Istanbul. For eight years the Egyptian frontier stood on the crests of the Taurus mountains and the Euphrates, and Syria was united to Egypt as it had been before the Ottoman conquest of 1517. But in 1840 the European powers intervened to protect the sultan who had rashly attacked the Egyptians and had been decisively beaten at Nizib in the preceding June. By virtue of firmans issued on Feb. 13 and June 1, 1841, Mohammed Ali surrendered Crete, Syria and Adana which reverted to the direct control of the Porte, while in compensation the sultan granted Mohammed Ali the hereditary rule of Egypt.

The exacting years of the Egyptian adventure in Syria left the viceroy physically exhausted though mentally serene. He was now an old man. In 1846 he visited Istanbul and made a nostalgic excursion to his native Kavalla where he founded a school. By 1848 senility overtook him. Ibrahim, who had been in virtual control of the administration since 1847, received a firman appointing him to his father's post but the son died on Nov. 10, 1848, leaving the viceroyalty to his nephew Abbas I. Mohammed Ali lingered on until Aug. 2, 1849, when he died at Alexandria.

Mohammed Ali's reputation has been much exposed to the variable winds of historical opinion. In Egypt at various times he has been hailed as a forerunner of Arab nationalism and condemned as a ruthless exploiter of the peasants. Though Lord Palmerston's distrust of him amounted almost to an obsession, European observers in general saw in him a reformer after their own hearts. The French patronized him with justice as a brilliant pupil, for his new Egypt had been built largely by French experts. The new-model army and navy were the work mainly of French instructors. Among the British commercial community he had a good name for straight dealing, and Sir John Bowring, when on a commercial mission for the British government in 1839, reported with critical approval on the Egyptian economy.

His land policy was nevertheless condemned as unjust from the standpoint of western conceptions of legality. For he seized the lands which had belonged to the Mamelukes, and between 1808 and 1814 appropriated most of the remaining land on the ground of neglect by the former owners. This vast act of confiscation injured only the small landowning class; it in no way affected the peasants who continued in their agelong poverty. The land thus acquired was put to better use. Mohammed Ali claimed to have installed 38,000 water wheels in Egypt and several more thousand in the Sudan, cleared derelict irrigation canals and dug new ones. The cultivable area of Egypt was thus increased by at least 100,000 acres. He maintained a state trading monopoly in Egypt and the Sudan which was bitterly criticized by European traders whose own profits were consequently diminished.

France and Britain had maintained consuls in Egypt before the arrival of the French, but it was not until after 1815 that the expanding European community at Alexandria and the growing strategic and economic importance of Egypt led every European state of consequence and the United States to post consuls in the country. Their correspondence gives a lively picture of the viceroy and of the efforts of the consuls to impress, cajole or threaten him. His supple mind was able to detect the underlying purpose behind the euphemistic verbiage of consular approaches. He too had mastered the euphemistic technique: to the British he was a paragon of antislave-trade virtue, to the Sardinians a liberal, to the Porte humble. The most revealing guide to his character is in his portraiture: the stocky figure, inclined in old age to obesity, the commanding face and, above all, the piercing eyes. *See* also EGYPT: *History;* and references under "Mohammed Ali" in the Index.

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**MOHAMMEDANISM:** *see* ISLAM. For Mohammedan art, architecture and law, *see* ISLAMIC ARCHITECTURE; ISLAMIC ART; ISLAMIC LAW.

**MOHAMMED REZA PAHLAVI** (1919– ), shah of Iran from 1941, the eldest son of Reza Shah Pahlavi (*q.v.*), was born in Teheran on Oct. 26, 1919. On finishing his preliminary studies in Teheran in 1931, he went to Switzerland to complete his education. Returning to Teheran in 1935 he entered the Officers' Training college there and later obtained a commission in the army. He has always shown a liking for natural science, literature and languages. He is fond of sport and of flying and is a fully qualified pilot.

On March 15, 1939, he married the sister of King Faruk I of Egypt, Princess Fawzieh, by whom he had a daughter, the princess Shahnaz; this marriage was dissolved in 1948. Succeeding to the throne on his father's abdication on Sept. 16, 1941, the new shah began his reign under difficult conditions, with British and Soviet troops (and later those of the United States) in virtual occupation of large areas in the north and southwest of the country.

After the war, the Allied troops were withdrawn and conditions gradually returned to normal. In 1951 the shah married Soraya Esfandiary Bakhtiari. After the appointment of Mohammed Mossadegh (*q.v.*) as prime minister in April 1951 strained relations developed between him and the shah. In Aug. 1953 a military *coup d'état* organized by Gen. Fazlullah Zahedi while the shah was in Europe resulted in the overthrow of Mossadegh and the return of the shah to Iran.

Mohammed Reza Shah has always endeavoured to rule as a constitutional monarch. His achievements in the fields of education, communications, land ownership, social welfare and public health have been far-reaching and of great value. In Dec. 1959, his union with Queen Soraya having been dissolved, he married Farah Diba, the daughter of Sohrab Diba, an Iranian army captain. A crown prince, named Reza after his grandfather, was born in Teheran on Oct. 31, 1960. *See* also PERSIAN HISTORY.

*See* Mohammed Reza Shah Pahlavi, *Mission for My Country* (1961). (L. Lo.)

**MOHAMMED SHAH** (1702–1748), Mogul emperor of India from 1719 to 1748, the son of Jahan Shah, fourth son of Bahadur Shah I, was born at Ghazni on Aug. 7, 1702. He was made emperor in 1719 by the powerful Sayyid brothers 'Abdullah and Husain 'Ali who had killed the emperor Farrukhsiyar. In 1720 a successful assassination plot against Husain 'Ali by Turani and Irani nobles and the defeat of 'Abdullah at the battle of Hasanpur freed Mohammed Shah from Sayyid tutelage. Nevertheless, he failed to obtain loyal and disinterested service after Nizam ul-Mulk Asaf Jah, appointed *wazir*, had left court in disgust in 1724. While Mohammed Shah went through the outward motions of kingship, the provinces steadily slipped out of imperial control: Sa'adat Khan made himself practically independent in Oudh, the Afghan Rohillas made themselves masters of Rohilkhand; Bengal merely remitted an annual tribute to Delhi, the Marathas under the *peshwa* Baji Rao made themselves lords of Gujarat, Malwa and Bundelkhand, and, in 1737, raided the suburbs of Delhi. Taking advantage of Mogul neglect of the northwest frontier areas, in 1739 Nadir Shah of Persia invaded India, routed the Moguls at Karnal, occupied Delhi and massacred the inhabitants. He returned laden with the Peacock throne and vast booty. The only event to cheer the last years of Mohammed Shah's reign was the defeat of the Afghan, Ahmad Shah Durrani, at Sirhind in March 1748. Mohammed Shah died in Delhi on April 16, 1748.

*See* INDIA-PAKISTAN, SUBCONTINENT OF: *History*.

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**MOHAMMED TUGHLUQ** (c. 1290–1351), sultan of Delhi from 1325 to 1351, was born c. 1290, the son of Ghiyath ud-Din Tughluq. Attaining prominence as superintendent of the royal stables under Sultan Qutb ud-Din Mubarak Shah Khalji (1316–20), Mohammed Tughluq was a prime mover in Ghiyath ud-Din's rising (1320) against Khusrau Khan Barwari, Qutb ud-Din's murderer. During his father's reign Mohammed Tughluq headed Delhi forces against Warangal in the Deccan.

Mohammed Tughluq's reign is a watershed in the history of the Delhi sultanate. In 1325 Delhi exercised a hegemony, however slight, over the greater part of the subcontinent; in 1351 it had lost all authority south of the Narmada, after nearly two decades of sporadic revolt against the sultan's rule. Contemporary writers explained Mohammed Tughluq's failures in the light of their own religious beliefs (the sultan appears to have offended important religious personages) or of their own political interests, but modern studies refuse to accept their rhetoric at its face value. Probably the sultan's greatest mistake was to make Daulatabad (*q.v.*) a second capital (1327) and to encourage a Muslim elite to settle in the Deccan with the consequence that local resources soon matched local temptations to throw off the control of distant Delhi. Ma'bar (Madura) was lost to rebels in 1334–35, Gulbarga in 1339, Warangal in 1345–46 and Daulatabad in 1347. In northern India the sultan's resources had suffered from a famine in the doab in 1335 and from a disastrous loss of troops in an expedition in the Kumaon-Gahrwal region (c. 1338). Mohammed died on March 20, 1351, while hunting rebels in Sind.

*See* INDIA-PAKISTAN, SUBCONTINENT OF: *History*.

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**MOHAVE** (MOJAVE), a Yuman (*q.v.*) tribe on the lower Colorado river near Needles, Calif. National unity prevailed among the small clusters of dwellings scattered along the periodically inundated bottom lands where crops were grown. Half the vegetal food was derived from mesquite beans and other wild plants. Fishing was considerable, hunting minor. Houses were low, gable-roofed, rectangular structures covered with brush and sand. Men commonly wore only a breechclout, women a full petticoat—both garments being made of woven willow bark. Clay vessels of fair quality were prevalent, basketry was minimal. The Mohave were exceptional in this region as travelers.

Warfare was frequent, undertaken with enthusiasm and often sanguinary. Combat was formalized, the massed company being led by champions. A cylindrical club wielded with an upward smashing blow was the favoured weapon. Their patrilineal exogamous clans were not localized and served largely to provide a bond of fellowship. A unique feature was the use of the meaningless clan name for women alone, who might also be particularized by nicknames. These clan names had totemic reference to animals and plants (*see* TOTEMISM).

Great significance was attached to stylized dreams, which were considered the source of all special powers. In dreams a man projected himself back to the world's beginning, experienced all happenings of the myths and was endowed with ability to cure, hunt, fight, etc. Public ceremonial took the form of singing a cycle of dreamed songs which recited a myth, ordinarily the narrative of a journey. Some cycles consisted of hundreds of songs.

By the 1960s the 18th-century population of about 3,000 had decreased two-thirds.

*See* A. L. Kroeber, *Handbook of the Indians of California* (1925); G. Devereux, "Dream Learning and Individual Ritual Differences in Mohave Shamanism," *Amer. Anthrop.*, vol. 59 (1957); *Mohave Ethnopsychiatry and Suicide* (1961). (L. Sr.)

**MOHAVE DESERT:** *see* MOJAVE DESERT.

**MOHAWK,** the easternmost tribe of the Iroquois confederacy, occupied three villages west of Schenectady, N.Y., beyond Schoharie creek on the south side of the valley of their name. The location and removal of these settlements in historic times links them with Laurentian peoples whom Jacques Cartier encountered between Quebec and Montreal in the 16th century. Their place names—Ticonderoga, Saratoga, Canajoharie, Oneonta—dot the waterways of their tribal territory from Canada to Pennsylvania. On the west were the related Oneida (*q.v.*).

The deep-seated fear and hatred of the Iroquois among descendants of neighbouring Algonkian tribes stems from wars of displacement going back to protohistoric times. The general trend of Mohawk "castles," so called for fortified hilltops situated back from the river, to open townsites on the river plain reflects an enhanced military position at the expense of the Mahican. The trade at Albany in axes, guns and kettles implemented a superior native organization. Traditionally, their leader Hiawatha was the first to accept the principles preached by the prophet of peace Dekanawida, who founded the Iroquois league. The Mohawk had nine representatives in the league, three from each of their village bands of the Turtle, Wolf and Bear, inhabiting 180 houses and comprising over 800 families, or approximately 2,500 people.

After contact with Europeans, their population decreased rapidly. Substantial losses resulted from defections to the Christian settlements on the St. Lawrence river, principally at Caughnawaga; these converts (the "praying Indians of Quebec") espoused the French cause, raided Deerfield for captives and guided expeditions against their erstwhile brothers of the league. The resident Mohawks, "fastening a chain" and "planting a tree of peace" at Albany, tortured the Jesuits, accepted Dutch Reformed ministers and sent three of their young men to London with Peter Schuyler to the court of Queen Anne, requesting military assistance and Anglican missionaries. Their affairs during the mid-18th century were guided by Sir William Johnson (*q.v.*); during the American Revolution they remained loyal to their pro-British leader Joseph Brant (*q.v.*) and followed him to Canada, where they have descendants at the Bay of Quinte and Six Nations reserve at Brantford, Ont. Their total number in the 1960s was about 5,000. A few are successful farmers, but the Laurentian Mohawks are workers in structural steel, having a passion for dangerous occupations. *See* also IROQUOIS.

*See* J. Mitchell, *Mohawks in High Steel* (1956). (W. N. F.)

**MOHINDERGARH,** a town and district in Punjab, India. The town, headquarters of the district, lies 64 mi. S.W. of Delhi on the Delhi-Bikaner railway. Pop. (1961) 9,071. It was founded by Mahdud Khan during the reign of the Mogul emperor Babur. A fort built by the Marathas in the 17th century was renamed in 1861 by Maharaja Narinder Singh after his son, Mohinder Singh. The town is known for embroidered footwear.

MOHINDERGARH DISTRICT (area, 1,313 sq.mi.; 1961 pop. 547,

850), a semiarid tract with stony and sandy ridges on the south, was constituted from exclaves of the former princely states of Jind, Patiala and Nabha. A government college at Narnaul (23,950) is affiliated to Punjab university. There is a cement factory at Dadri (13,839). The Sirsa branch of the Western Jumna (Yamuna) canal provides irrigation. Wheat, gram and millets are the main crops. (S. S. Bh.)

**MOHL, HUGO VON** (1805–1872), German botanist, famous for his recognition of the true nature of cells, was born at Stuttgart on April 8, 1805, and took his degree in medicine at Tübingen in 1828. He then studied for several years at Munich. In 1835 he became professor of botany at Tübingen, retaining that post until his death there on April 1, 1872. Mohl was concerned chiefly with the structure of the higher forms, including both gross anatomy and minute histology. He gave currency to the word "protoplasm," first used by J. E. Purkinje; he recognized under the name of "primordial utricle" the protoplasmic lining of the vacuolated cell and first described the behaviour of the protoplasm in cell division; he observed cell division in the alga *Conferva glomerata*.

Mohl also held the view, later generally adopted, of growth of cell wall by apposition. He was the first to explain the true nature of pits, and he showed the cellular origin of vessels and of fibrous cells. His early investigations on the structure of palms, cycads and tree ferns laid the foundation for all later knowledge of this subject; so also did his work on the quillworts, *Isoetes* (1840). Mohl's later anatomical work was chiefly on the stems of dicotyledons and gymnosperms. He was extremely skilful with the microscope and polished and set his own lenses. Mohl's most notable papers were republished in *Vermischte Schriften* (1845); his *Die Vegetabilische Zelle* appeared in 1851 (Eng. trans., 1852).

**MOHL, JULIUS VON** (1800–1876), German orientalist known for his edition of the Persian national epic *Shah-Nama*, was born at Stuttgart on Oct. 25, 1800. Having studied theology at Tübingen, he abandoned the idea of entering the Lutheran ministry and in 1823 went to Paris, at that time, under Silvestre de Sacy, the great European centre of oriental studies. In 1826 he was charged by the French government with the preparation of an edition of the *Shah-Nama* ("Book of Kings"), which became his lifework. The first volume appeared in 1838; the seventh and last was left unfinished at his death, being completed by Barbier de Meynard. In 1844 he was nominated to the academy of inscriptions and in 1847 became professor of Persian at the Collège de France. He served for many years as secretary and then as president of the Société Asiatique. His annual reports on oriental science from 1840 to 1867, collected after his death under the title *Vingt-sept ans d'histoire des études orientales* (1879), are an admirable history of the progress of eastern learning during these years. He died in Paris on Jan. 3, 1876.

His wife, Mary (1793–1883), had passed a great part of her early life in Paris, where she was a close friend of Mme Récamier (*q.v.*). For nearly 40 years her house was one of the most popular intellectual centres in Paris.

**MÖHLER, JOHANN ADAM** (1796–1838), German Roman Catholic church historian, renowned as the "theologian of church unity," was born at Igersheim, Württemberg, on May 6, 1796. Ordained to the priesthood in 1819, he taught church history in the Roman Catholic faculty of the University of Tübingen from 1826 to 1835 and then, until his death, on April 12, 1838, at the University of Munich.

Outstanding among his half-dozen books is *Symbolik* (on the creeds), first published in 1832 (Eng. trans. by J. B. Robertson, 1843). In this work, as in his earlier volume *Die Einheit in der Kirche* ("Unity in the Church," 1825), Möhler argued that man's journey to God could be made only in the church founded by Christ. His longing for church unity induced him to engage in discussion with Protestant scholars of his day so as to find a basis for mutual understanding which, he hoped, would eventually lead to acknowledgment that the church must be undivided. His unflagging efforts on behalf of Christian reunion have made him a theologian of increasing importance and influence in the ecumenical movement of the 20th century.

*See* Gustav Voss, "Johann Adam Möhler and the Development of Dogma," *Theological Studies*, vol. 4, pp. 420–444 (1943); Serge Bolshakoff, *The Doctrine of the Unity of the Church in the Works of Khomyakov and Moehler* (1946). (C. V.)

**MOHOLY-NAGY, LASZLO** (Ladislaus) (1895–1946), Hungarian painter, photographer and art teacher, was born at Bacsbarsod, Hung., July 20, 1895. He studied law in Budapest, joined the poetry circle of Endre Ady and published woodcuts of Cubist influence in the avant-garde journal *Ma*. He went to Berlin in 1921 to realize his vision of a nonrepresentational art consisting of pure visual fundamentals: colour, texture, light and equilibrium of forms. In 1923 he headed the metal workshop of the Bauhaus school and edited the *Bauhausbook* series. During his Bauhaus years (1923–29) he evolved the two contributions for which he is known.

As painter and photographer he worked predominantly with light. His "photograms" were composed directly on the film and his "light modulators" (oil paintings on transparent or polished surfaces) included mobile light effects. As an educator, Moholy-Nagy evolved a widely accepted curriculum developing natural visual gifts instead of specialized skills in the student. His dictum was: "Everybody is talented." Fine arts training was abolished in favour of "designing the whole man." In 1937 he organized in Chicago, Ill., the New Bauhaus (later the Institute of Design), the first American school based on the Bauhaus program. He died Nov. 24, 1946, in Chicago.

*See* also Painting: *Bauhaus Group*.

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**MOHR, CHRISTIAN OTTO** (1835–1918), German engineer whose most important work was the development of methods of calculating stresses and deformations in frameworks, girders and arches. He was born at Wesselburen on Oct. 8, 1835, and entered Hanover polytechnic at the age of 16. After completing his schooling he worked as a structural engineer on railways in Hanover and later in Oldenburg. In 1867 Mohr became professor of engineering mechanics at the Stuttgart Polytechnic, where he achieved a high reputation as a lecturer. In 1873 he moved to the Dresden polytechnic, where he taught until 1900. After his retirement from teaching he continued his scientific work at his home near Dresden until his death on Oct. 2, 1918.

Mohr devised many graphical methods of solving engineering problems. One of these, the Mohr stress circle, which represents the state of stress at a point in a material, is well known to engineering students. His theory of failure of materials has received much attention but is of limited application. Altogether, he published about 40 papers as well as his collected works. (B. S. O.)

**MOHR, KARL FRIEDRICH** (1806–1879), German chemist, designer of laboratory apparatus and one of the originators of the doctrine of the conservation of energy, was born at Coblenz on Nov. 4, 1806, the son of a chemist. He studied under L. Gmelin and, after five years at Heidelberg, Berlin and Bonn, returned to Coblenz to assist his father. He gave up business in 1857, and devoted himself to research work until 1863 when he returned to the university at Bonn, where he became a professor in 1867. He died there on Sept. 28, 1879.

Mohr was the leading scientific pharmacist of his time in Germany; he was the author of many improvements in analytical processes. He invented the pinchcock, the cork borer, Mohr's balance for the determination of specific gravities and other pieces of apparatus. His methods of volumetric analysis were expounded in his *Lehrbuch der chemischanalytischen Titrirmethode* (1855). His *Geschichte der Erde* (1866) also obtained a wide circulation. In a paper "Über die Natur der Wärme," in the *Zeitschrift für Physik* (1837), he gave one of the earliest general statements of the doctrine of the conservation of energy.

**MOHS' SCALE.** One of several ways of determining the hardness (designated H) of a mineral is by testing its resistance to scratching or abrasion. This test is performed by observing if the smooth surface of a mineral of unknown hardness is scratched by a sharp edge or point of a series of minerals or other substance

whose hardnesses are known. Rapid mineral identification is greatly facilitated whenever the approximate hardness is easily determinable.

A series of ten minerals (all common except the last, diamond) has been devised, as an arbitrary scale of reference, against whose hardnesses the relative hardness of any other species may be checked. This scale of species, arranged in order of increasing relative hardness, is:

| | |
|---|---|
| 1. Talc | 6. Feldspar |
| 2. Gypsum | 7. Quartz |
| 3. Calcite | 8. Topaz |
| 4. Fluorite | 9. Corundum |
| 5. Apatite | 10. Diamond |

Thus if a mineral is scratched by feldspar but not by apatite, its H = 5.5. It is known as the Mohs' scale of hardness after its originator Friedrich Mohs (1773–1839), German mineralogist, who first revealed it in 1812.

In the determination procedure it is necessary to observe whether the known species is harder and is actually producing a groove, or whether it is softer and is itself being abraded by the unknown to leave a removable mark. If the unknown species is fine grained, friable or pulverulent, the scratch test may only loosen grains from the aggregate without testing the individual mineral surfaces; thus certain textures or aggregate forms may hinder or prevent a true hardness determination.

As supplements to the mineral scale there usually are added: fingernail, 2+; copper penny, about 3; pocketknife blade, 5+; ordinary window glass, 5.5; and steel file, 6.5. (E. W. Hu.)

**MOIETY,** as commonly used in social anthropology, a type of dual division of a society based on descent groups. The clans of a tribe may be paired into two opposing moieties for such purposes as the maintenance of marriage rules, organization of war parties and participation in games and ceremonies. *See* DUAL ORGANIZATION.

**MOIRÉ,** a textile fabric with a distinctive watered pattern visible because of the varying angles at which rays of light are reflected from the design areas that have been pressured into the fabric. Although a ribbed weave is more conducive to a moiré effect, similar effects can be obtained with other fabrics of similar texture, more popularly those produced from silk, rayon, acetate and mercerized cotton.

Various finishing methods may be used. In the earlier method the material was first dampened and then folded with the face side inward and with the two selvages running together side by side. The cloth was then put under considerable pressure for several hours. This gave a lasting watered effect but the folds produce objectionable creases and the process is no longer used in the United States. In the more modern method the design is pressed into the fabric by means of engraved rollers. Effects similar to moiré can be obtained by overprinting in a shade of the same colour and also by weaving a pattern of a watered design.

Watered fabrics date from the middle ages in Europe and from a much earlier period in the orient. One of the popular early watered fabrics was made of mohair. The French term for a watered mohair became *la moiré ondée;* the word for watered, *ondée,* was gradually omitted and the term moiré used to mean any type of watered fabric. (G. R. Co.)

**MOISSAN, HENRI** (1852–1907), French chemist, winner of the 1906 Nobel prize in chemistry for his isolation of the element fluorine and development of the Moissan electric furnace, was born at Paris on Sept. 28, 1852. He was educated in Edmond Frémy's laboratory at the Musée d'Histoire Naturelle and attended lectures by H. E. Sainte-Claire Deville and Henri Debray. He received his doctoral degree in 1885 with a thesis on the cyanogen series. In 1879 he was appointed to a junior post in the Agronomic institute, Paris, and was subsequently professor of toxicology (1886) and of inorganic chemistry (1889) at the school of pharmacy and of inorganic chemistry (1900) at the Sorbonne. He was awarded the Lacase prize in 1887. He died in Paris on Feb. 20, 1907. Moissan often said, "Fluorine has shortened my life ten years."

Moissan's first research was on a biological problem and dealt with the interchange of oxygen and carbon dioxide in leaves, but he soon went over to inorganic chemistry. His early work in this field was on the oxides of the iron group metals, and of chromium; he also made a careful study of the chromous salts. In 1884 he turned to the study of fluorine and prepared several new compounds, including phosphorus and organic derivatives. In 1885 he found that potassium fluoride could be dissolved in certain proportions in liquid hydrofluoric acid to give a solution which conducted electrolytically and which remained liquid at low temperatures. A year later by electrolyzing this solution in a platinum tube using platinum-iridium electrodes he obtained for the first time the highly active fluorine gas. He made a full study of the properties of the gas and of its combinations with other elements.

In 1892 Moissan developed the electric arc furnace as a means of obtaining high temperatures for experimental work. By its aid he prepared many new compounds, especially carbides, silicides and borides, and melted and volatilized substances which had previously been regarded as infusible. His claim to have prepared tiny artificial diamonds (*see* GEM, *Synthetic Gems*) by cooling rapidly a solution of carbon in molten iron was not confirmed. He discovered the abrasive carborundum (silicon carbide) but this method was not suitable for commercial production. He studied the chemistry of the carbides and the action of water on them, and was led by the results to suggest that petroleum formation may be caused by a similar process occurring in the earth. Moissan also prepared the hydrides of calcium, sodium and potassium, finding them to be nonconductors of electricity.

He was one of the best scientific lecturers in Paris. He was a skilled experimenter and insisted that his laboratory be immaculate. Even a few drops of water on the floor brought a rebuke.

Moissan's published works include *Le Four électrique* (1897) and *Le Fluor et ses composés* (1900), besides numerous papers. A *Traité de chimie minérale* (five volumes) was published under his direction in 1904–06.

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**MOISSI, ALEXANDER** (1879–1935), Austrian actor, was born on April 2, 1879, at Trieste on the Adriatic sea. His father was Albanian, his mother Italian. While taking voice lessons in Vienna, Moissi had the opportunity (frequently as a supernumerary) to study the acting technique of Josef Kainz, the star of the Imperial Burgtheater, whom he was to emulate first in Prague, then at Max Reinhardt's Deutsches Theater and Kammerspiele in Berlin. During World War I, Moissi was interned in Switzerland. After his release in 1917 he became associated once again with Reinhardt's enterprises in Berlin and Vienna.

In 1920, when the Salzburg festival was initiated, he was the first Jedermann in Hugo von Hofmannsthal's version of the old morality play. But his greatest parts remained Fedja in Leo Tolstoi's *The Living Corpse,* Oswald in Henrik Ibsen's *Ghosts,* Hamlet, Oedipus and Montezuma in Gerhart Hauptmann's *Der weisse Heiland*—roles in which the neuroses of a melancholiac could be expressed in terms of vocal lyricism.

Moissi died in Vienna on March 22, 1935. (A. M. N.)

**MOJAVE DESERT,** an arid region of eastern California, United States, lying north of the San Gabriel-San Bernardino mountains and extending from the southern Sierra Nevadas to the Colorado river valley, south of latitude 36°. Southeastward it merges into the Yuma desert (*q.v.*). The area has typical mountain-and-basin topography; steep rugged mountains rise abruptly above broad basins floored smoothly with sand and gravel and draining to central salt flats.

Summer days are hot (maximums over 100° F.); winters have warm days (50°–60° F.) and cold nights (17°–30° F.). Frosts are common in winter and snow occasionally falls. Annual rainfall averages less than five inches.

In the basins, vegetation consists of widely-spaced low shrubs, especially creosote bush and burroweed. Cacti occur sparingly on south-facing rocky slopes. Higher areas have thicker brush and

some stands of weird Joshua trees (*Yucca brevifolia*). The highest mountain ranges have open woodlands of piñon and juniper.

The northern portion is grazed by cattle. Various chemicals are extracted from the salt flats and there is some mining. The southwestern part, adjacent to Los Angeles, is undergoing rapid urban and recreational development. (R. F. Lx.)

**MOJI:** *see* Kita-Kyushu.

**MOKP'O,** a port and city at the southwestern tip of Korea, became a thriving commercial seaport after its opening to foreign trade in 1897. The deep harbour is well sheltered by peninsulas and islands. Rail lines connect Mokp'o to the inland areas and make the port a major commercial centre of southwest Korea.

The industries of the city are rice milling, cotton ginning, brewing, fish processing and vegetable oil milling. Pop. (1960) 129,667. (S. McC.)

**MOLASSES** is the syrup remaining from the crystallization of sugar from cane or beet juice (*see* Sugar). It is separated from sugar by centrifuging and contains impurities present in the cane or beets. Cane molasses contains about 14% invert sugar as compared with about 1% in beet molasses. Final or blackstrap molasses has had all of the sugar removed from it that can practically be separated by ordinary crystallization. Edible grades of molasses, called treacle in Great Britain, are higher in sugar and are usually partially decolorized; their flavour is sweeter and milder.

Until 1948 the principal use for molasses was fermentation to produce industrial ethyl alcohol and rum. Production of alcohol from ethylene decreased the market for fermentation alcohol and caused a lowering in the price of molasses, which made it more attractive as a feed for farm animals, thereafter its principal market. The addition of urea and other nonprotein nitrogen to molasses enables the microorganisms in the rumens of cattle and other ruminants to synthesize their own protein from these sources. The animals digest the bacteria and protozoa. (H. B. Hs.)

**MOLAY, JACQUES DE** (*c.* 1243–1314), last grand master of the Knights Templars, who notably failed in leadership when the order was attacked, was born at Molay (Jura). He entered the order in 1265, fought in Syria and after 1291 was at Cyprus. He was elected grand master in about 1298. Summoned to France (1306 or 1307) by Pope Clement V to discuss a new crusade and the amalgamation of the Templars with the Hospitallers, Molay opposed any union and asked the pope to investigate accusations made against his order. On Oct. 13, 1307, all the Templars in France, including Molay, were arrested and interrogated by command of Philip IV. On Oct. 24, 1307, Molay agreed that on admission to the order he had denied Christ, but he rejected a charge of sodomy. He wrote to Templars throughout France, enjoining confession, but when the pope sent his own delegates to conduct the inquiries, Molay and many of his subjects retracted their statements, saying they had been exacted by torture. In Nov. 1309 and in March 1310 Molay appealed for a personal judgment by the pope. But Clement formally suppressed the order in Nov. 1312, and on March 18 or 19, 1314, a commission of three cardinals condemned Molay and other dignitaries of the order to perpetual imprisonment. On hearing this sentence they again retracted their statements and were burned as relapsed heretics by Philip IV's officers the same afternoon. *See* also Templars.

*See* E. Besson, *Étude sur Jacques de Molay* (1877); G. Lizerand, "Les Dépositions de Jacques de Molay," *Le Moyen Âge*, 2nd series, vol. xvii (1913).

**MOLD** (Yr Wyddgrug), a market town, urban district and the county town of Flintshire, Wales, is the natural centre of the fertile Alun (Alyn) valley and lies 11 mi. W. of Chester by road. Pop. (1961) 6,857. The town's wide High street, crowded with open stalls on market days, rises to the noble Perpendicular church of St. Mary. Above this is Bailey Hill, an impressive motte and double bailey castle, in shape resembling a figure 8. It was probably built by Robert de Montault, shortly after the conquest of the Alun valley by the Normans in the reign of William II (Rufus). Henry III rebuilt the castle, but hardly any trace of stonework survives. In the 200 years of war between the Welsh and Normans the castle changed ownership many times and the small town which grew up nearby was frequently burned and pillaged.

The famous Mold corslet, a gold ceremonial cape, was discovered in a large Late Bronze Age barrow at Bryn yr Ellyllion (hill of goblins) in 1833 and is now in the British museum, London. It is believed that the site was on or near an important gold route from Ireland to Wessex and the continent. Mold was the centre of a lead- and coal-mining district, the last colliery having been closed in the mid-20th century. Daniel Owen (1836–95), the 19th-century Welsh novelist, was born and worked as a tailor in Mold; his statue ornaments the County Hall field. The town's industries include the making of agricultural machinery. Quarrying and agriculture are the main sources of employment in the district. Mold is also a tourist centre.

Maes Garmon, 1 mi. W. of Mold, has an obelisk raised in the 18th century, claiming that the site, Germanus' field, is the battlefield where the Britons under St. Germanus won the Alleluia victory over the Saxons and Picts, a story found in Bede. (M. B.-Ev.)

**MOLDAVIA** (Rum. Moldova; Turkish Bogdan), one of the two Danubian principalities from which Rumania was constituted in the 19th century. It emerged as an independent state in the middle of the 14th century, under its voivode or prince Bogdan. At its greatest extent, when it included Bessarabia, it was bounded on the north and the northeast by the Dniester river; on the south by the Black sea, Dobruja and Walachia; and on the west by Transylvania. Having long been subjected to pressures from Poland and from Hungary, Moldavia finally became a vassal of Turkey in the 16th century, by which time the Bessarabian coastal area had already been detached from it. The Russo-Turkish treaty of Kuchuk Kainarji (1774) improved the principality's status, but Bukovina, the northwesternmost area, was annexed by Austria. All Bessarabia was taken by Russia under the treaty of Bucharest (1812), but the southernmost part was restored to Moldavia by the treaty of Paris (1856). The union of Moldavia with Walachia (Nov. 9, 1859) paved the way for an independent Rumania. *See* Rumania: *History;* Moldavian Soviet Socialist Republic.

**MOLDAVIAN SOVIET SOCIALIST REPUBLIC** (Moldavskaya S.S.R. or Moldavia) is the smallest of the 15 constituent republics of the U.S.S.R., covering 13,012 sq mi. It lies in the extreme southwest, between Rumania on its southwest and the Ukrainian S.S.R., which surrounds it to north, northeast and southeast.

The republic occupies the basins of the middle Dniester and Prut. The Dniester, which forms the boundary with the Ukraine in the north, flows through northeastern Moldavia, while the Prut forms the whole length of frontier with Rumania. Between the relatively narrow flood plains along the rivers are the hills of the Bessarabian upland (Bessarabskaya Vozvyshennost), which are greatly cut up by the deep, narrow valleys of the tributaries of the Dniester and Prut. The upland can be divided into subregions: the Khotin upland of the northwest, the Northern Hilly plain around Beltsy, the Dniester uplands running parallel to the river, the Kodry uplands of the centre, the Southern Hilly plain and the Baimakliya heights in the extreme south. The highest point of Moldavia, 1,409 ft., is located in the Kodry.

The climate of Moldavia is one of the mildest in the U.S.S.R., with winter conditions much modified by the passage of depressions across the Black sea. In January average temperatures range from −3° C. (27° F.) in the south to −5° (23°) in the north. Thaws are frequent throughout the winter. July temperatures also vary from north to south, between 20° (68°) and 23° (73°). Rainfall is 22 in. a year in the north to 12–16 in. in the south, with a spring-summer maximum.

The northern part of Moldavia is part of the forest-steppe zone, the south belongs to the steppe. Soils, although displaying considerable local variation, are mostly related to the chernozem group. Very little of the natural feather grass steppe vegetation has survived, and the forest areas too have been ruthlessly cleared for agriculture, until only 6% of the area of the republic remains forest-covered. The surviving forests are mainly deciduous, with many west European species.

**History.**—Moldavia, or Bessarabia (the name often given to the Dniester-Prut interfluve), has a long and stormy history. Part of Scythia (*q.v.*) in the first millennium B.C., it later came marginally under the control of the Roman empire as part of Dacia (*q.v.*). Lying on the great routeway into Europe it was invaded by successive waves of barbarians, and the area knew many masters. Gradually, under varying influences, the Vlach or Walachian nationality developed. Part of the area came under Kievan Russia in the 10–12th centuries A.D., and passed later to the Galician princes. From 1240 to the 14th century Moldavia was vassal to the Tatars but, after a brief period under Hungary, in 1359 an independent princedom was achieved under the voivode Bogdan. His successor, Stephen the Great (who reigned as prince from 1457 to 1504), successfully resisted the growing power of Turkey, but on his death Moldavia fell under the Turkish yoke. For the next 300 years it was a strongly fortified border region of Turkey and was fought over in many Russo-Turkish campaigns. After the 1792 treaty of Jassy small areas in present-day eastern Moldavia were ceded to Russia, but by the 1812 treaty of Bucharest all Moldavia as far as the Prut passed to Russia. Thereafter considerable Russian colonization took place and in 40 years the population was quadrupled.

In 1918, after the Revolution, Moldavia voted for union with Rumania. The boundary lay along the Dniester, on the eastern bank of which the Moldavian Autonomous S.S.R. was formed in 1924. In 1940 Rumania ceded Bessarabia to the U.S.S.R. and the area was added to the Autonomous S.S.R. to form the Moldavian S.S.R. A year later the German onslaught overran Moldavia, and occupation by Rumanian troops lasted until the spring of 1944. (*See* also BESSARABIA; MOLDAVIA.)

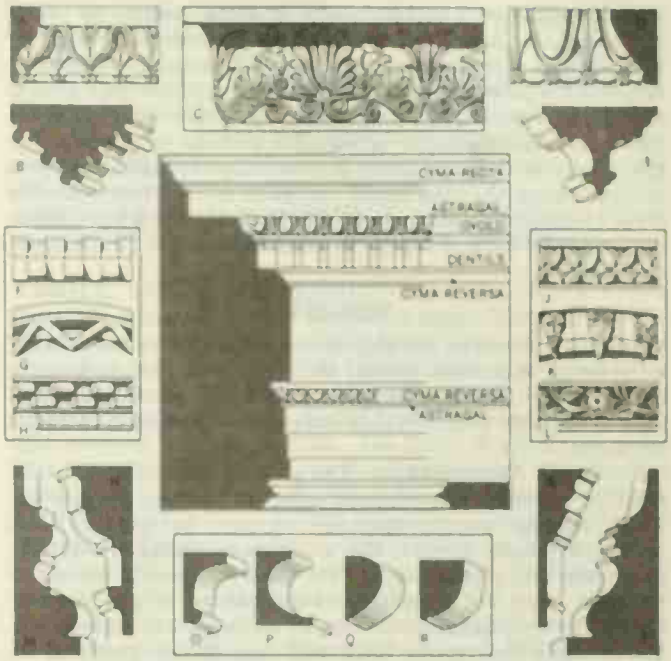
**Population and Administration.**—The 1959 census enumerated 2,884,477 people in Moldavia. Of these 1,887,000 (65.4%) were Moldavians, 421,000 (14.6%) were Ukrainians and 293,000 (10.2%) Russians. Other nationality groups were the Turkic-speaking Gagauzy 96,000 (3.3%), Jews 95,000 (3.3%) and Bulgars 62,000 (2.1%), with a few Greeks and gypsies. The Moldavians are Walachian in origin, related to the Rumanians. Their language shows strong Latin and Slavic influences. The urban population of 642,244 represents only 22.3% of the total. There are 17 towns and 21 urban districts, but the only one of size is the capital, Kishinev (*q.v.*), with 216,005 inhabitants. Beltsy has 67,114 people, but of the other important towns, Tiraspol, Bendery, Rybnitsa and Soroki, none reaches 50,000 inhabitants. The suitability for agriculture of the good soils and mild climate has given rise to a dense rural population. The overall density of 222 persons per square mile is the highest of all the union republics. Living standards and the provision of social services are steadily improving, although in these respects Moldavia tends to be one of the more backward republics.

The supreme soviet, elected in 1959, consists of 281 deputies including 104 women. The Moldavian Academy of Sciences was established in 1961 at Kishinev, and there are more than 40 research institutes and 800 medical centres in the republic.

**Economy.**—Moldavia is often regarded as the garden of the U.S.S.R. Vineyards and orchards are extensive, especially along the Dniester and in the Kodry uplands. Moldavian wines are highly rated in the Soviet Union. Fruits grown include apples, pears, plums, apricots, peaches, cherries, quinces, strawberries and walnuts. Grains, especially wheat and maize (corn), are the main field crops. Sunflowers, soybeans, sugar beet and tobacco are important industrial crops. Melons and potatoes are widely grown. Livestock husbandry, chiefly sheep and goats, is not well developed. Beekeeping is widespread and in the southeast there are mulberry plantations for silkworms. Industry is chiefly concerned with processing agricultural products (wine making, distilling, brewing, jam making, canning, flour milling, etc.), and is carried on widely in small-scale undertakings. Timber is cut in the Kodry, in the centre of the republic, for crate making. Engineering is important at Kishinev and Beltsy. (R. A. F.)

**MOLDAVITE:** *see* TEKTITE.

**MOLDING,** in architecture and the decorative arts, is a transitional or terminal element usually appearing horizontally in a cornice, architrave or capital, or curved in an arch. A molding is a modeled surface, most frequently a band and approximately continuous, with a constant profile or one with rhythmically repeated elements. Moldings doubtlessly originated in prehistoric building, where they served specific structural functions. As monumental architecture developed, moldings were gradually translated from wood or other ephemeral materials into more permanent ones, most often stone. In this gradual transition moldings were retained as a matter of conservatism or taste; in stone they were elaborated and refined, contributing order and richness to a decorative system.




SOME TYPES OF MOLDING

(A) Greek cyma reversa with the water leaf; (C) Greek cyma recta with anthemions; (D) Greek ovolo with egg and dart; (I) classic entablature; (M, N) Roman base and capital; (S, T) Greek capital and base; (F) Byzantine dentil; (G, H, J, K) Romanesque; (B, L) English Gothic; (E) Elizabethan; (O) cavetto and torus; (P) scotia; (Q) torus; (R) ovolo

Although their original structural function was satisfied by other means, moldings were used in a manner that implied a structural logic. From this usage, best characterized in the orders of architecture of ancient Greece (*see* ORDER), it was possible later to develop theories for the correct form and employment of moldings, according to which several basic shapes were standardized in the vocabulary of architectural design.

## TYPES OF MOLDING

**Flat or Angular.**—(1) The facia, face or band is a continuous member with a flat surface, parallel to the surface it ornaments and either projecting from or slightly receding into it. (2) Fillet, listel or regula are terms for a relatively narrow band, usually projecting, commonly used to separate curved moldings or to finish them at top or bottom. (3) Bevel or chamfer molding is an inclined band, facia or fillet. (4) A splay is a large bevel.

**Single Curved.**—(1) The cavetto is a concave molding with a profile approximately a quarter-circle, quarter-ellipse or similar curve. (2) Scotia molding is similar to the cavetto, but has a deeper concavity partially receding beyond the face of the general surface which it ornaments. (3) A flute is a small groove of semicircular, segmental or similar section. (4) Ovolo, a convex molding, has a profile approximating a quarter-circle or quarter-ellipse. (5) Torus, a convex molding, approximates a semicircle or semiellipse. (6) Roll or bowtell molding is convex, approximating three-quarters of a circle. (7) An astragal is a small torus, often with fillet attached below. (8) Apophyge molding is a small exaggerated cavetto.

**Compound.**—(1) The cyma recta, a projecting molding, con-

sists essentially of a cavetto above an ovolo, forming in profile one continuous double curve, often used as a crowning member, in which case it is sometimes known as a cymatium. When used as a base the convex portion is uppermost. (2) The cyma reversa or ogee, a projecting molding essentially a reversed cyma recta with ovolo above cavetto, is used for a crown or a base. (3) Bird's beak or thumb molding is essentially similar to the cyma reversa, except that the upper convexity is separated from the lower concavity by a sharp edge. (4) Keel molding is a projection consisting of a roll molding with a small fillet attached at its outermost surface.

## HISTORY

The basic forms of molding developed largely in the classical architecture of ancient Greece, although there were some similarities in pre-Greek architecture. They persisted with modifications in the main stream of architectural development in the western world.

**Pre-Greek Architecture.**—The most conspicuous early use of moldings in architecture occurred in Egypt, probably by 3000 B.C. There, building having progressed from reeds and mud to stone, walls were usually crowned with a cornice consisting of a cavetto underlined with a small torus. The torus was usually painted to represent reeds tied together, and the cavetto with a series of vertical forms suggesting the tops of reeds used as walling. In Mesopotamia the typical brick wall construction produced an architecture in which moldings were practically absent.

Archaeological evidence has indicated that moldings appeared on Hittite columns and the arched portals of the Assyrians. In ancient Persia the shafts of columns were ornamented with flutes and the capitals with moldings of floral inspiration. In Aegean architecture the ovolo was used in the capitals of columns at Cnossus (*c.* 1500 B.C.) and Mycenae (*c.* 1200 B.C.) in much the same way as the echinus of the later Greek Doric column.

**Greek Architecture.**—The Doric was the first and simplest order of architecture developed by the Greeks; its essential elements having taken permanent form by the end of the 7th century B.C. In the Doric order, moldings still retained much of their original structural appearance, being restricted largely to a variety of facias and a cymatium in the cornice. Most attention was given to refining the bulging elliptical profile of the echinus (an ovolo) of the capital of the column, which by the 5th century B.C. had become almost a straight line.

The Ionic order was also fully developed, through the Ionians of Asia Minor, by the 5th century. There the angularity of the Doric yielded to the plastic surface; curved moldings predominated, adding sculptural richness to the total effect. And the curved moldings themselves were enhanced, especially in the Hellenistic period, by carving inspired from natural forms. Although the basic profiles remained, the moldings were given additional names descriptive of their decoration. Thus the simple tubular astragal became the bead and reel, consisting of elliptical beads separated by disklike reels. The ovolo became the egg and dart, consisting of ovoid solids framed with sharp ridges of similar curvature, separated from each other by vertical dart shapes. The cyma recta was adorned with the anthemion (a stylized honeysuckle or palmette) or the acanthus leaf. The cyma reversa was enriched by a repetition of leaf forms, tonguelike in appearance and separated by slender stems, usually called the leaf and tongue or tongue and dart molding. The torus was sometimes fluted, horizontally, or carved in guilloche, an intricate pattern of interlacing bands winding around circular buttons. The cavetto and scotia usually remained undecorated.

The moldings of the Corinthian order were similar to the Ionic; and in all three orders moldings were often painted. Furthermore, Greek molding profiles were characterized by a constantly changing radius of curvature and were usually quirked, having the convex (or concave) moldings brought sharply in (or out) at the top to emphasize shadow. Subtlety of profile and delicacy of carved detail were characteristic of Greek molding.

**Roman Architecture.**—Moldings in Roman architecture, based on modifications of the three Greek orders plus the Tuscan, were more vigorous and robust in appearance. Although the basic profiles and decorative systems were retained, the moldings suggested the work of the engineer more than the sculptor. The curves were often determined mechanically, and the standardized details revealed some quality of mass production. Nevertheless, the tendency was toward greater richness, and among new surface decorations were stylized fish scale or imbrications, spiral rope moldings, rows of flat vertical leaves and others.

**Early Christian and Byzantine Architecture.**—Classical forms in architecture persisted for several hundred years after the decay of Rome in the 4th century. In early Christian churches secondhand Roman moldings and other details were often used in combinations violating the strict canons of classical composition. Similar naïveté or decadence was especially apparent in the Syrian churches of the 5th and 6th centuries, where moldings were usually in the form of a large torus draped like a heavy ribbon, alternately horizontal and vertical, in one sinuous line, without regard for the original logical arrangement.

Likewise in Byzantine architecture, from the 6th century on, moldings were reduced to their simplest elements and used sparingly. The articulation of moldings on wall or entablature was less favoured than broad, smooth surfaces of rich inlaid materials. Moldings were often reduced to two-dimensional patterns; the molded entablature block over the column was simplified to an inverted truncated pyramid (the dosseret), with carving in low relief.

Basic Byzantine forms were perpetuated in the medieval architecture of Greek and Slavic lands. They persisted through the 16th century in Russia, where the principal molding was a large, bold torus ornamented with stylized animal and vegetable figures; the simple curvature of an arch was often interrupted by sharp angles with similar designs. In these derivative styles moldings assumed a purely decorative character.

**Islamic Architecture.**—Roman and Byzantine forms were adopted as the architecture of Islam, which lacked a national building tradition. Thus the variety in Muslim architecture depended on the pre-existing architecture of conquered provinces, and moldings were used according to local traditions. The most conspicuous instance was the revival and perpetuation of Byzantine architecture by the Ottoman Turks, from the 16th century on. In the eastern expansion of Islam, however, Persian influence predominated over Byzantine, and moldings were further reduced in favour of smooth decorated surfaces.

This development culminated in the 17th century in India, in such structures as the Taj Mahal at Agra, where small moldings appeared with considerable delicacy and originality. The Muslim architecture of India was little influenced by the earlier Indian style.

**India and the Far East.**—Although early architectural decoration in India was related in some degree to Greek prototypes, the Buddhist and Hindu artistic traditions were largely an independent development. The decorative system requires a vocabulary of its own, although it can be described approximately in classical terms. The molding forms most frequently used were similar to the facia, bevel, ovolo (inverted) and torus. Usually large in scale and frequently carved with natural leaf forms, they were characteristically composed in layers with sharp shadow lines, producing a stacked-up, sculptured effect. Similar compositions occurred in southeastern Asia.

In China and Japan the prevalent use of wood reduced the role of moldings to the decoration of masonry bases for walls and columns, where a simple torus was often undercut to produce a powerful line of shadow.

**Pre-Columbian Architecture.**—The architecture of America before Spanish conquest in the 16th century also requires descriptive terms of its own. However, the stone moldings most commonly appearing in Mayan, Toltec and Aztec art approximate the basic classical profiles. Base courses and cornices were often large sweeping bevels. Broad facias were used to frame panels of abstract geometrical sculpture or stylized animal forms. Similar decorative bands—sometimes horizontal, sometimes crenelated—provided the major articulation of large wall surfaces. Survivals

of this decorative tradition gave a strong indigenous stamp to later Spanish buildings.

**Romanesque Architecture.**—In western Europe basic Roman forms persisted into the 11th and 12th centuries, the Romanesque period. Through crudity of technique, moldings tended to be robust and simple, consisting chiefly of roll moldings on the edges of arches, and of cavettos and cyma reversas in cornices and in the capitals of columns. However, innovations and variations appeared in the regional schools of Romanesque architecture. In Tuscany and Provence the nearest approximation of antique classical forms obtained. In Lombardy moldings (often brick) were enriched with spirals and other geometrical forms reminiscent of barbarian jewelry.

In the Norman Romanesque of France and England the classical shapes were broken with zigzags and chevrons, or studded with little pyramids and birds' heads. There were such varieties as the billet molding, being a torus broken into small separated sections, and the rope or cable molding, a spirally carved molding that resembles a rope. Many of these details were originally accentuated in brilliant colours.

**Gothic Architecture.**—The old forms were further modified in the Gothic period, extending from the 13th through the 15th centuries. The new structural system based on the ribbed groin vault and pointed arch provided new opportunities for an integral decorative system. Keel moldings on arches and ribs became standard. The cyma, cavetto and torus were used in cornices and capitals, but with increasing exaggeration and originality in form, and often decorated with crockets. In the late, or flamboyant, Gothic of the continent there was the greatest variety of moldings, composed with alternations of sharply projecting members and deep shadows, often interpenetrating in complex tracery patterns, but with a general vertical emphasis.

In the early Gothic of England, especially the Decorated period, forms were more complicated, the moldings consisting of a combination of basic forms worked into one deeply undulating profile; while later, in the Perpendicular period, a general simplicity and flatness was common. Richness was provided by carvings of vine patterns, or repetitions of rosettes (or the Tudor rose), square blocks or heraldic insignia. In the late Gothic period, on the continent as in England, many forms of stone moldings were adapted to timber framing and wood paneling.

**Renaissance and Baroque Architecture.**—Roman classical forms were revived in Italy in the 15th century and soon transmitted to all western Europe. In the early Renaissance there were some compromises with vestiges of medieval forms; in the 16th century the strict rules of classical usage were well understood. However, by the late 16th century, especially in the work of Michelangelo, moldings were treated with a strong sense of sculptural plasticity and freedom in composition, which led to the inventiveness of the baroque. The qualities of the baroque depended on compositions in curving lines and receding surfaces, integrated with sculpture and colour. They attained their greatest richness in the Spanish churrigueresque style, especially in Mexico, and greatest delicacy in the decorative arts of the Louis XV style in France.

Reaction to the exuberance of the baroque came in the 18th century, from the prestige of official art academies, when the return to strict classical forms inevitably led to the imitative neoclassical style.

**The 19th and 20th Centuries.**—The romantically inspired neoclassical style of the 19th century initiated a general eclecticism, in which moldings appeared in classical, medieval, oriental or Renaissance style, or in combinations of them, not only in stone and brick, but in plaster, wood and cast iron.

Out of this stylistic confusion of the Victorian period came the search for new and appropriate forms, notably in the work of Louis Sullivan (U.S.). Moldings were once again inspired directly from nature, especially the nature of the building materials concerned, and used according to structural or functional logic. This provided a new aesthetic for modern architecture, in which classical or other historical moldings have disappeared. Modern moldings, whether in wood, masonry or metal, have generally acquired the simpler forms of functional structural elements and a correspondingly limited use.

In traditional carpentry, however, the basic classic profiles have survived as standard manufactured moldings with a descriptive vernacular nomenclature, including apron, base, beak, bed, bolection, chain, crown, dentil, drop, edge, flush, hip, neck, panel, paternoster, pellet, reeding, roll, scroll, shoe, thumb, tooth, wave and zigzag moldings.

*See* ORNAMENT, ARCHITECTURAL; CAPITAL; DOGTOOTH; JOINERY; *see* also references under "Molding" in the Index.

(E. A. C.)

**MOLÉ, LOUIS MATHIEU,** COMTE (1781–1855), French statesman, a monarchist who held office under Napoleon I, Louis XVIII and Louis Philippe, was born in Paris on Jan. 24, 1781, the son of Edouard François Molé de Champlâtreux, a president in the Paris *parlement*. His father was guillotined in 1794; but the young Molé, who had been taken to Switzerland and then to England, returned to France in 1796. His *Essais de morale et de politique* (1806), justifying monarchical government, won the approval of Napoleon, who made him auditor to the council of state in 1806, prefect at Dijon in 1807, councilor of state and director of bridges and highways, with the title of comte, in 1809 and minister of justice in 1813. A peer of France on Louis XVIII's second Restoration (1815), Molé was minister for the navy under the duc de Richelieu from 1817 to 1818. Subsequently he supported the liberal monarchist opposition to the comte de Villèle.

When the July revolution of 1830 had made Louis Philippe king, Molé was minister of foreign affairs from Aug. to Nov. 1830. In Sept. 1836, however, the king made him prime minister and minister of foreign affairs. Guizot's withdrawal from the cabinet made a new formation necessary (April 15, 1837), but the king retained Molé. The ministry strengthened France's hold on Algeria, achieved a satisfactory solution of the Belgian question and sought conciliation at home, but was increasingly attacked, even by the most convinced Orleanists, as the mouthpiece of the king's personal policy. When the electorate rejected this policy in March 1839, Molé resigned. When revolution broke out in 1848, Louis Philippe again asked Molé to form a ministry (Feb. 23), but this proved impracticable.

As deputy for the Gironde in the assemblies after the revolution, Molé was a member of the "party of order" and favoured Louis Napoleon's candidature for the presidency of the republic. On the *coup d'état* of Dec. 1851 he retired from public life. He died at Champlâtreux, Seine-et-Oise, on Nov. 23, 1855.

(JE. V.)

**MOLÉ, MATHIEU** (1584–1656), French magistrate venerated for probity in an age of timeserving and faction, was the son of Edouard Molé, who as *procureur-général* was conspicuous for loyalty to the crown during the Holy League's ascendancy in Paris. He became *procureur-général* himself in 1614. During Richelieu's ministry he protested against the government's arbitrary procedures and interceded forcefully for the abbé de St. Cyran (Jean Duvergier de Hauranne) on his arrest in 1638. Richelieu then commented with kindly irony on Molé's single-minded integrity and, in 1641, rewarded it by making him premier president of the Paris *parlement*. St. Cyran's release in 1643 was largely due to Molé, who, however, had no inclination to the abbé's doctrines.

As premier president, Molé was faced with crisis after crisis during the Fronde (*q.v.*), when his respect for the royal authority and his contempt for self-interested agitators conflicted tragically both with his determination to uphold the rights of the *parlement* and with his family's affection for the house of Condé. The graybeard Molé's sardonic courage in the face of hostile mobs caused the cardinal de Retz, politically an opponent of his, to describe him as one of the three most intrepid men of his time. Anne of Austria and Mazarin were often exasperated by his rectitude but saw his merit. On April 3, 1651, Anne made him keeper of the seals. Though the seals had to be withdrawn from him on April 13 (because the duc d'Orléans objected to the appointment), Molé received them back on Sept. 8, when Louis XIV had come of age. Having gone to join the king on his travels in Dec. 1651, he re-

sumed his functions as premier president at Pontoise and returned with the *parlement* to Paris in Oct. 1652, but resigned the premier presidency, as incompatible with his tenure of the seals, in April 1653. He died in Paris on Jan. 3, 1656. (J. G. R.-S.)

**MOLE,** in zoology, any member of the mammalian family Talpidae, order Insectivora, all of which are highly modified for burrowing; also, loosely, species of the insectivore family Chrysochloridae, the Cape golden moles. In a much wider sense the term is used for the Asiatic zokors, Mediterranean mole rats, African strand "moles" (all rodents) and the Australian pouched "moles" (marsupials).

The true moles, the talpids, may be distinguished from the closely related shrews by the presence of a complete bony arch (jugal or malar arch) beneath the eye, the arch being lacking in shrews. Typical species include the common European mole (*Talpa europaea*) and the North American eastern mole (*Scalopus aquaticus*). These animals both have a cylindrical body about six inches long and a one-inch tail. They are strictly burrowers and have powerful, laterally-placed, paddlelike forelimbs; minute eyes and inconspicuous ears; a pointed muzzle; and soft, short, erect, gray-to-black fur with a singularly velvetlike texture.

Moles construct elaborate two-level burrow systems in which they spend most of their lives. The deeper level is the dwelling area; the upper level consists of temporary feeding burrows. True moles favour moist friable soil and do not live in dry areas where the soil is hard packed. The mole "swims" through loose soil so close to the ground surface that the course of the burrow is indicated by up-heaved ridges. The diet consists mainly of earthworms, grubs, insects and other small animals. The mole is a voracious eater, and if deprived of food succumbs in about 12 hours; it normally eats one-third to two-thirds of its own weight daily. In *Talpa* and *Scalopus* the male and female live separately most of the time, coming together to mate in March; the four to six well-developed young are born about six weeks later, and in two months are of adult size.

Moles are sometimes regarded as nuisances because they occasionally eat plant bulbs and roots and disfigure lawns with their burrows and open "molehill" vents. They may be caught in specially made mole traps, or killed by fumigants or poisoned baits. They are not so noxious as usually regarded; they serve a useful purpose in aerating the soil and controlling potentially harmful soil insects, and are important fur-bearers in some areas. A number of mammals and rapacious birds that are not discouraged by the moles' strong, musky odour, prey on them. Most moles swim readily and seem not to object to partially flooded burrows.

In North America the eastern mole occurs over the United States as far west as eastern Wyoming; the western moles (*Scapanus latimanus* and others) occur along the west coast. The latter are larger than the eastern mole, measuring overall as much as nine inches. The tiny shrew-mole (*Neurotrichus gibbsii*) of the Pacific northwest prefers a forest habitat, unlike most of the larger moles. The hairy-tailed mole (*Parascalops breweri*), of the northeastern United States and nearby parts of Canada, is a social species. The curious star-nosed mole (*Condylura cristata*), with 22 fleshy, pink, sensitive appendages surrounding the nose, is an expert swimmer and often ventures from its burrow.

PHOTOGRAPH, LYNWOOD CHACE

STAR-NOSED MOLE (CONDYLURA CRISTATA) FOUND IN EASTERN CANADA AND NORTHEASTERN UNITED STATES

NORTH AMERICAN EASTERN MOLE (SCALOPUS AQUATICUS) AT ENTRANCE OF LOWER DWELLING BURROW

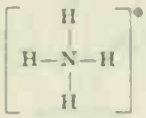
Among the number of aberrant talpid moles occurring in Asia are the eared moles of China and Japan (*Uropsilus*), the furry-snouted moles of Japan (*Dymecodon*), the club-tailed moles of southern Asia (*Euroscaptor*), the small Temminck's moles of eastern Asia (*Mogera*) and the Siberian musk moles (*Scaptochirus*). No true moles are found in South America, Africa or Australasia. *See* INSECTIVORE. (K. R. KN.)

**MOLE,** known in medicine as a pigmented nevus, is a skin blemish that either may be present at birth or may develop later in life. The yellow-brown to black colour of the mole is due to the presence of melanocytes, cells that form the pigment melanin. (*See* SKIN: *Skin in Man.*) Moles may be flat or raised, smooth or rough, hairy or hairless, large or small. In medicine they are classified into three types—intradermal, junctional and compound.

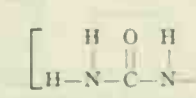
The intradermal or common moles occur in the dermis or corium. They seldom become malignant.

In junctional moles, the nevus cells are located at the junction of the epidermis and dermis. Highly malignant tumours called melanomas develop in rare instances from junctional moles, usually starting with a proliferation of melanocytes at the dermo-epidermal junction. Junctional nevi upon the palms, soles and genitalia may be forerunners of melanoma and usually should be removed as a prophylactic measure. Junctional moles occur more frequently in childhood than do the other two types but these usually mature and change to intradermal moles in adulthood. Junctional moles usually are hairless but become hairy as they change to the intradermal type. The third type of mole is the compound, which is a combination of intradermal and junctional types. Malignant melanomas may arise from the junctional portion of a compound mole. Clinical signs that suggest malignant change are growth of the mole, increased depth of pigmentation, a tendency to form scabs or to bleed, or the development of smaller satellite moles. Moles suspected of being malignant should be excised surgically. Almost every person has some moles, which are considered to be atavistic remnants of tactile sensory organs. Another type of nevus is the birthmark (*q.v.*). *See* SKIN, DISEASES OF. (G. C. AN.)

**MOLECULAR REARRANGEMENTS** are chemical processes which result in changes in the basic arrangements of bonds between atoms in molecules. A historically important example is the conversion of ammonium cyanate ($NH_4^+OCN^-$) to urea ($NH_2CONH_2$) which was discovered by F. Wöhler in 1828. Ammonium cyanate is an ionic substance, analogous to sodium chloride, comprised of a positive ammonium ion having four hydrogens attached by covalent bonds to nitrogen

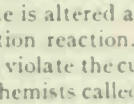


and a negative cyanate ion with oxygen and nitrogen attached to carbon in a linear fashion $[O{-}C{\equiv}N]^-$. When ammonium cyanate is heated, the ammonium ion adds to the carbon-nitrogen double bond of cyanate ion and affords urea, a nonionic substance with a very different arrangement of bonds between the several atoms



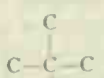
The ammonium cyanate–urea rearrangement is historically important as the first example of the conversion of a typical inorganic compound to a typical organic compound but is hardly representative of the types of molecular rearrangements of current interest.

Molecular rearrangements can be divided for practical purposes into two simple classes. In the first class are those rearrangements, such as the ammonium cyanate–urea conversion, which involve no change in molecular formula but only changes in arrangements of the chemical bonds between atoms. Since different chemical species with the same molecular formula are called isomers, this kind of rearrangement may be called isomerization—the conversion of one isomer to another. In the other class of rearrangements, the basic arrangement of the bonds between atoms in a molecule is altered as an adjunct to a substitution, elimination or addition reaction. Rearrangements of this latter type may be said to violate the customary working hypothesis of practicing organic chemists called the principle of minimum structural change. These concepts are well illustrated by specific examples from the classical researches of F. C. Whitmore on the reactions of neopentane and neopentyl derivatives. Neopentane has a central carbon atom bonded to four $CH_3$— or methyl groups, as they are commonly called.



neopentane

Substitution reactions are available for replacement of the hydrogens of the methyl groups of neopentane by a variety of different atoms or groups. The principle of minimum structural change suggests that such processes should not be accompanied by any change in the arrangement of carbon–carbon bonds in the neopentane skeleton.

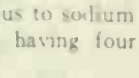


neopentane carbon skeleton

This is found to be true for many but not all substitution reactions. Thus, the following sequence of substitutions at one carbon of the neopentane molecule occurs without detectable rearrangement of the carbon skeleton.

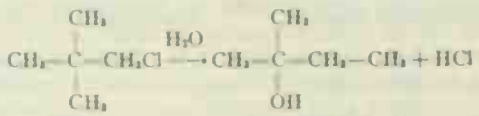
$$RCH_3 \rightarrow RCH_2Cl \rightarrow RCH_2MgCl \rightarrow RCH_2CO_2H \rightarrow RCH_2NH_2$$

(Here is abbreviated the $(CH_3)_3C$— part of neopentane to R, and $RCH_3$ is then neopentane.) However, other reactions and, particularly, all attempts to convert $RCH_2Cl$ or $RCH_2NH_2$ to $RCH_2OH$ give rearrangements of the neopentane skeleton and formation of substitution products of isopentane.



isopentane carbon skeleton

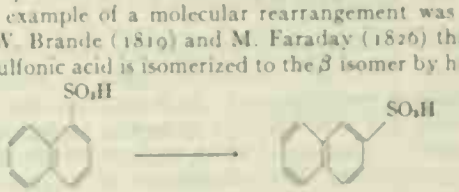
Thus,



Fortunately for the synthetic organic chemist, relatively few reactions result in carbon skeleton rearrangements so that it is usually possible to carry out a long sequence of transformations with reasonable assurance that the backbone of the molecule will remain unaltered. The neopentane system, however, is particularly prone to rearrange. This predilection for rearrangement can be used as a test for the general propensity of a given type of reaction to give rearrangement products according to whether or not rearrangement is observed with neopentyl derivatives. Cyclopropylcarbinyl derivatives, $(CH_2)_2CHCH_2X$, with X as the replaceable group, provide a still more sensitive test for possible rearranging substitutions since the carbon skeleton of such compounds is extraordinarily easily converted to that of the isomeric cyclobutyl derivatives $(CH_2)_3CHX$.

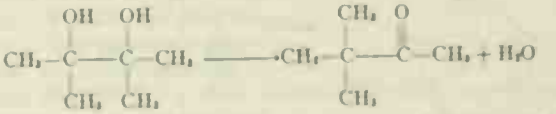
The classification of molecular rearrangements into isomerizations and rearranging substitution, elimination or addition reactions is one of practical convenience and can hardly be rigorous. Indeed, isomerization at some intermediate stage characterizes all substitution, elimination or addition reactions which result in a change in carbon skeleton. In practice, an over-all isomerization is usually easily recognized since the starting material and product have the same molecular formula but different physical and chemical properties. It is often much more difficult to establish that rearrangement has occurred in a substitution, elimination or addition reaction because there will be an over-all change in chemical composition, as well as a change in physical and chemical properties.

An early example of a molecular rearrangement was the discovery by W. Brande (1819) and M. Faraday (1826) that naphthalene-$\alpha$-sulfonic acid is isomerized to the $\beta$ isomer by heating

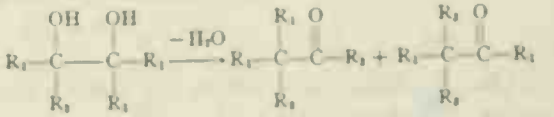


naphthalene-$\alpha$-sulfonic acid  naphthalene-$\beta$-sulfonic acid

An important general type of rearrangement was observed by R. Fittig (1860) when he found pinacol to be converted to pinacolone by elimination of water.



Much research has been done with symmetrically substituted pinacols to determine the relative "migration aptitudes" of various types of groups. Thus, for the reaction,



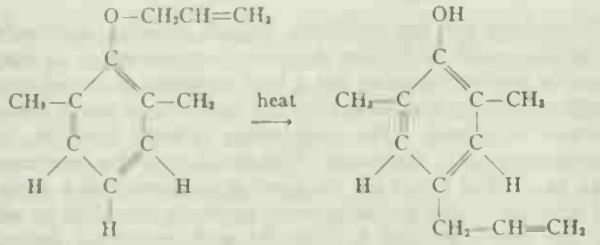
the ratio of the two possible products may be said to represent the ratio of the relative migration aptitudes of $R_1$ and $R_2$. Unfortunately ratios of migration aptitudes obtained in this way do not always carry over well to other types of rearrangement reactions.

The rearrangements discussed so far are all examples of "1,2-shifts" which can be written in the general form. R—A—B—X ⟶ X—A—B—R, where R and X are groups which exchange positions on the adjacent atoms, A—B. Many types of rearrangements are known involving shifts of groups between nonadjacent atoms. The facile isomerization of α-methylallyl bromide to γ-methylallyl bromide is an example of a 1,3-shift.

$$CH_2{-}CH(Br){-}CH{=}CH_2 \longrightarrow CH_3{-}CH{=}CH{-}CH_2{-}Br$$

α-methylallyl bromide — γ-methylallyl bromide

The *para*-Claisen rearrangement of 2,6-dimethylphenyl allyl ether is a 1,5-shift.



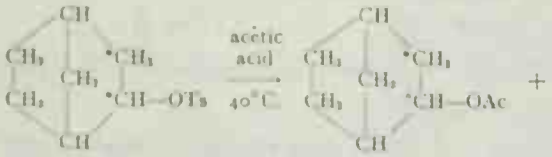

2,6-dimethylphenyl allyl ether — 2,6-dimethyl-4-allylphenol

The study of molecular rearrangements has been greatly facilitated by the use of isotopic atoms as tracers to find out which atom of a starting material becomes a particular atom of the product. For example, isotopically labeled carbon has been used to show that the Wolff rearrangement of α-diazoketones to carboxylic acids actually proceeds with a change in carbon skeleton. In this case, carbon atoms of mass 13 ($C^{13}$) were used to label the carbonyl (C=O) carbon atoms of phenyl diazomethyl ketone to distinguish them from the other ordinary $C^{12}$ carbon atoms in the molecule.

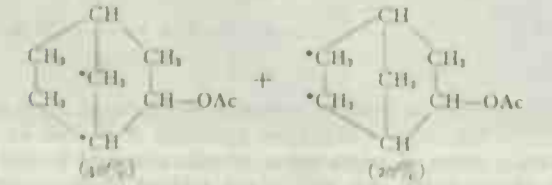
$$C_6H_5C^{*}{-}CHN_2 \xrightarrow[H_2O]{\text{heat}} C_6H_5{-}CH_2{-}C^{*}(=O){-}OH + N_2$$

$C^{13}$-labeled phenyl diazomethyl ketone
(C* indicates position of labeled atom)

The reaction product was found to have all of the $C^{13}$-label in the carboxyl (−$CO_2H$) carbon as would be expected for a carbon-skeleton rearrangement. In some cases, the use of isotopic tracers has revealed very extensive carbon-skeleton rearrangements in reactions of which might otherwise appear to be simple substitutions. The substitution of an acetoxy group (−OAc) for the *p*-toluenesulfonate group (−OTs) of carbon-labeled norbornyl *p*-toluenesulfonate affords a striking example of substantial carbon-skeleton rearrangement under exceptionally mild conditions.

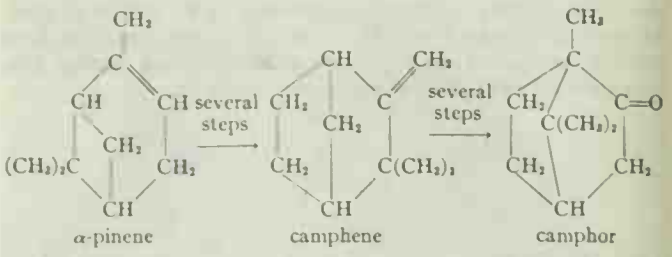



norbornyl *p*-toluenesulfonate — normal product (40%)



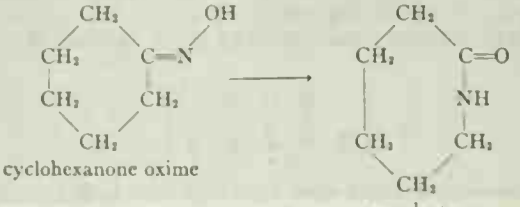

rearranged products (60%) (20%)

A number of molecular rearrangements are key steps in large-scale industrial syntheses. The conversion of α-pinene (derived from turpentine) to synthetic camphor by way of camphene involves a plethora of 1,2-shifts from carbon to carbon.



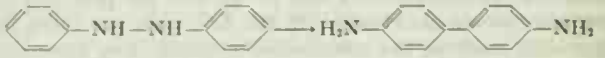

α-pinene — camphene — camphor

Rearrangement of cyclohexanone oxime to ε-caprolactam is a simple 1,2-shift from carbon to nitrogen. The product is easily convertible into a high polymer



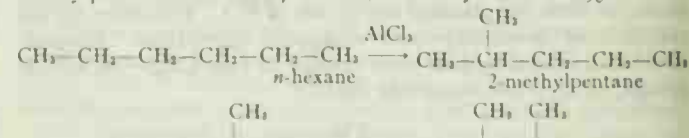
cyclohexanone oxime — ε-caprolactam

with nylonlike properties. Hydrazobenzene is isomerized by acid in a 1,10-rearrangement to benzidine which is a valuable dye intermediate.



hydrazobenzene — benzidine

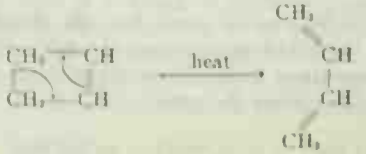
Rearrangement of straight-chain petroleum hydrocarbons to their branched-chain isomers is carried out on a large scale as a means of upgrading gasoline for use in high-compression engines. Branched-chain hydrocarbons have superior antiknock properties as compared with the corresponding straight-chain compounds. Thus, the isomerization of *n*-hexane with the aid of aluminum chloride to a mixture of 2- and 3-methylpentanes and 2,3-dimethylbutane gives a large increase in octane rating since *n*-hexane has an octane rating of only 26, whereas the methylpentanes are near 70 and 2,3-dimethylbutane is 93.



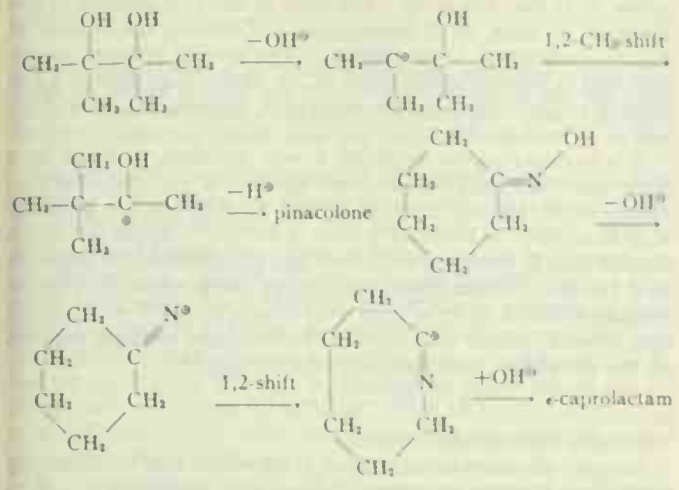

*n*-hexane — 2-methylpentane — 3-methylpentane — 2,3-dimethylbutane

Much progress has been made in the study of the mechanisms by which molecular rearrangements take place. No one mechanism or type of mechanism will suffice for the correlation of all rearrangements. This conclusion is in accord with the finding that rearrangements may be induced by agents as diverse as strong acids, strong bases, free-radical catalysts, heat and electromagnetic radiation. Key steps for several types, given below, illustrate the difficulty of producing any satisfactory single theory of rearrangements as often attempted in the past.

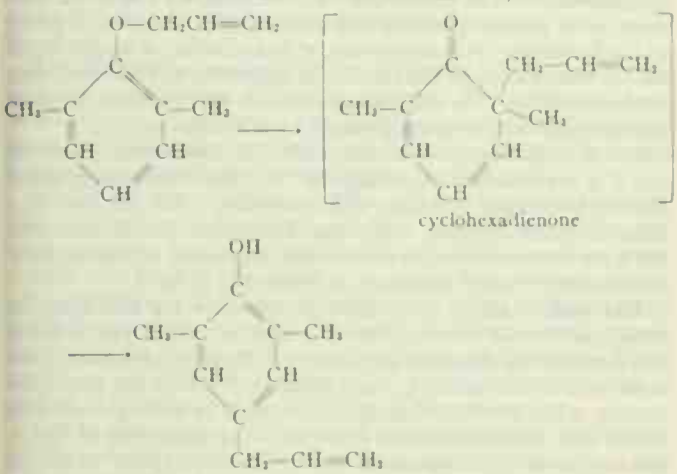
The conversion of naphthalene-α-sulfonic acid to the β isomer is a dissociation-resubstitution process with naphthalene and sulfuric acid as the intermediates. The thermal isomerization of cyclobutene to butadiene is a simple monomolecular process involving merely a rearrangement of the bonds in the molecule.



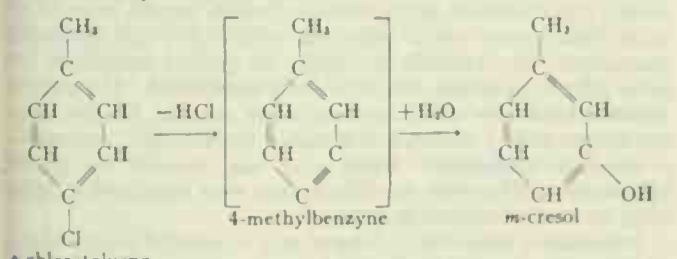
The pinacol–pinacolone and cyclohexanone oxime–caprolactam rearrangements involve loss of $OH^{\oplus}$ (with the aid of a strong acid) and 1,2-shifts of the resulting cationic species.




The *para*-Claisen rearrangement has been shown to proceed by way of an unstable cyclohexadienone intermediate so that the over-all 1,5-shift is the result of two successive 1,3-shifts.




The formation of *m*-cresol from the high-temperature alkaline hydrolysis of *p*-chlorotoluene is believed to be the result of an elimination-addition process with a "benzyne"-type substance as a transitory intermediate.

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**MOLECULAR SPECTRA.** Through a spectroscope, the light from the flames of many reacting gases (*e.g.*, the blue cone of a gas flame burning in air) appears as a discrete set (spectrum) of bright lines or bands, and not as a continuous band containing all wave lengths over a wide range. The simplest spectroscope consists of an entrance slit, a collimating lens to give parallel rays which fall on a prism, and a second lens to view the spectrum (see SPECTROSCOPY). Line spectra, made up of discrete lines of no obvious pattern, arise from free atoms, and band spectra derive from molecules of two or more atoms. The study of molecular spectra has done much to clarify molecular structure, and is important in physics, chemistry and such fields as astrophysics and thermodynamics.

Molecular spectra may be observed over a range of wave lengths from 1 cm. down to about $10^{-5}$ cm. or 1000 Angstrom units (A). For the long wave lengths, monochromatic radar pulses are passed through the gas in a tube (wave guide) and the power output is measured for different input frequencies; at an absorption-line frequency of the gas the power drops, since there some input is absorbed. In the infrared region ($10^{-2}$ to $10^{-4}$ cm.) continuous radiation is passed through a cell containing the gas. The radiation is then dispersed by a prism of rock salt (NaCl) or sylvite (KCl), or by a grating. Rotation of the prism or grating allows different wave lengths to fall on a detector that records the intensity of the radiation and so gives a picture of the absorption spectrum. For wave lengths less than about $10^{-4}$ cm. detection may be by photoelectric recorders (especially for quantitative measurements of intensity), but generally is by photographic plates. These integrate the energy falling on them, so that very weak sources may be studied, even the light of the night sky. Instruments are of two kinds: those of high light-gathering power but rather low resolution, for weak sources; and those of high resolving power. In this region lines differing in wave length by 2 parts in 1,000,000 may be resolved. Visible light ranges from about 7000 A in the red to about 4000 A in the violet. Spectra in the near ultraviolet from 4000 A to 2000 A present no special problem, except that below 3500 A ordinary glasses are poor transmitters, so that prisms and lenses are made of quartz, usable down to 1900 A. But the gelatin of photographic emulsion begins to absorb at 2300 A and atmospheric oxygen at 1800 A. Below 1900 A (in the Schumann region) special plates or detectors must be used and spectrographs must be free of air.

Down to wave lengths of about 12000 A, absorption spectra have so far been the most important. Below that, emission spectra are of equal interest; among sources studied are arcs, flames, electric discharges through gases and vapours, and celestial objects (*see* SPECTROSCOPY, ASTRONOMICAL).

Molecules exist in well-defined energy levels; spectral lines arise when a molecule jumps from one such level to another. The frequency $\nu$ (in $sec^{-1}$) of radiation emitted or absorbed in a jump from a state of energy $E_1$ to one of energy $E_2$ is given by $h\nu = E_1 - E_2$, where $h$ is Planck's constant.

A molecule has (1) energy of translational motion, with levels that lie close together and are unimportant in what follows; (2) rotational energy; (3) vibrational energy (the molecule can be considered as a system of atomic point masses linked by springs); (4) energy due to the arrangements and velocities of its electrons. Possible energy levels of the last three kinds are generally more and more separated, in the order given.

The rotational energy states of a simple diatomic molecule, such as hydrogen chloride (HCl) are given approximately by

$$E_{rot} = BJ(J+1)$$

$J$ is a quantum number, taking the values $J = 0, 1, 2, 3 \ldots$ and

$$B = h^2/8\pi^2\left(\frac{m_H + m_{Cl}}{m_H \cdot m_{Cl}}\right)r^2,$$ where

$m_H$, $m_{Cl}$ are the masses of the hydrogen and chlorine atoms re-

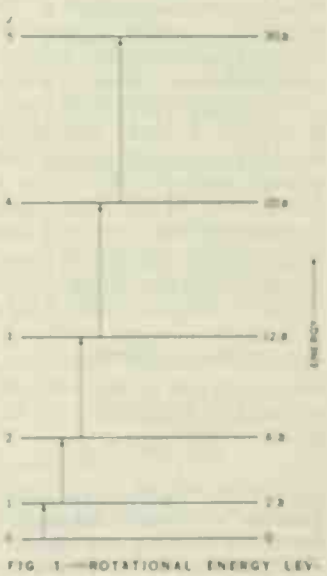

FIG. 1.—ROTATIONAL ENERGY LEVELS FOR A DIATOMIC MOLECULE. THE VERTICAL ARROWS REPRESENT TRANSITIONS THAT GIVE RISE TO THE ROTATIONAL SPECTRUM ILLUSTRATED IN FIG. 2

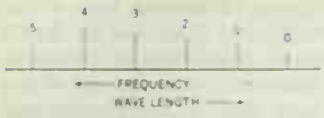


FIG. 2.—A PURE ROTATION SPECTRUM. THE NUMBERS ABOVE THE LINES REPRESENT THE VALUE OF $J$ FOR THE INITIAL STATE OF THE TRANSITION

spectively, and $r$ is the distance between them. Transitions between the energy levels, with absorption or emission of radiation, are limited to those in which $J$ changes by $\pm 1$, as in fig. 1, so that the rotation spectrum of such a molecule may be represented as in fig. 2: it consists of a series of lines, each separated by about $2B$ in energy from its neighbour. Spectra of this kind were first reported in 1927. The values of the moments of inertia for ordinary molecules are such that $B$, in frequency units, is commonly of the order of $10^{10}$ sec.$^{-1}$. Since the wave length $\lambda$ is related to the frequency $\nu$ by $c = \nu\lambda$, where $c$ is the velocity of light ($3 \times 10^{10}$ cm.sec.$^{-1}$), the wave length corresponding to $\nu = 10^{10}$ is about 3 cm. Apart from pioneer work at rather shorter wave lengths, no studies of the pure rotation spectra of molecules were possible until the development of radar techniques. These provide convenient sources of radiation at wave lengths corresponding to the energy jumps of molecules from one rotational state to another, and microwave spectroscopy became prominent from 1945 onward.

From the measured energy separation between two rotational levels and the values of the quantum number $J$, the value of the moment of inertia of the absorbing molecule can be found. Since frequencies may be measured with great precision in the microwave region, moments of inertia and, hence, interatomic distances in molecules (which are of the order of $1 \times 10^{-8}$ cm.) may be measured with high accuracy. Further, since the resolving power (the capacity to separate lines lying close together in the frequency scale) in microwave techniques may be high, it is possible to study fine details of rotational spectra arising, for example, from isotope effects, the interactions of electronic and nuclear motion, and the asymmetry of electrical charge in the absorbing molecules.

At shorter wave lengths, that is, higher energies, lie spectra which arise from simultaneous changes in rotational and vibrational energy ($\lambda = 10^{-2}$ to $10^{-4}$ cm.). Vibrations in molecules are often like those of the simple harmonic oscillator, for which the energy levels are

$$E_{v1b} = hc\omega(v + \tfrac{1}{2})$$

where $\omega$ is a characteristic frequency, here in cm.$^{-1}$ units, and $v$ is a quantum number, taking the values $v = 0, 1, 2 \ldots$. For a polyatomic molecule containing $N$ atoms, there will in general be $(3N - 6)$ such frequencies; for a diatomic molecule, there is only one frequency corresponding to vibration of the two atoms along their line of centres. In this case, the molecule has a single set of equidistant vibrational energy levels, neighbours being separated by $\omega$ cm.$^{-1}$. A transition between the rotational levels of two vibrational levels is called a vibration-rotation band. The structure of such a band is illustrated in fig. 3. The number of observable transitions is limited: commonly the rule is either $\Delta J = +1$, or $\Delta J = 0, \pm 1$.

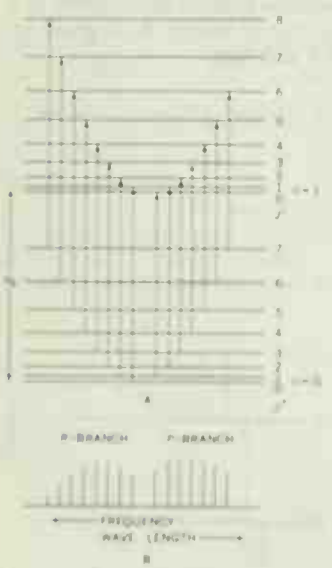


FIG. 3.—A VIBRATION-ROTATION BAND OF A DIATOMIC MOLECULE. THE ENERGY LEVELS AND TRANSITIONS (IN ABSORPTION) ARE ILLUSTRATED IN (A), AND THE APPEARANCE OF THE BAND IN (B). $\nu_0$ REPRESENTS THE DIFFERENCE IN ENERGY BETWEEN THE VIBRATIONAL LEVELS $v = 0$ AND $v = 1$

Consider an absorption band in which molecules initially in rotational states $J''$ in the vibrational level $v = 0$ absorb quanta of radiation and go into rotational states $J'$ in the vibrational level $v = 1$. A molecule in the level $J'' = 1$ may go either to $J' = 0$ or $J' = 2$, assuming the case $\Delta J = \pm 1$. The former transition gives rise to the line $P(1)$, the latter to $R(1)$, numbering according to the $J$-value of the lower level. Similarly the transition $(J' = 10) \leftarrow (J'' = 9)$ gives rise to the $R(9)$ line, and so on. The band in this case consists of two branches of lines, an $R$-branch and a $P$-branch, the former at higher, the latter at lower energies. The spacing between successive lines is approximately equal to $2B$, except that there is a line missing at the origin, for the separation between the lines $R(0)$ and $P(1)$ is about $4B$.

A vibration-rotation band of a real diatomic molecule is a little more complex than described above, for (1) the rotational energy levels are not those of a rigid rotator, but are given by $E_{rot}/hc = BJ(J+1) - DJ^2(J+1)^2 + \ldots$, where $D$, much smaller than $B$, expresses the centrifugal expansion of the molecule as it rotates; (2) the vibrational energy levels converge with increasing $v$, thus $E_{v1b}/hc = \omega_e(v + \frac{1}{2}) - x_e\omega_e(v + \frac{1}{2})^2 + \ldots$ where $x_e\omega_e$ is much smaller than $\omega_e$; (3) the rotational constant depends on the vibrational quantum number according to

$$B_v = B_e - \alpha(v + \tfrac{1}{2}) + \ldots$$

where $\alpha$ is much smaller than $B_e$.

In a real vibration-rotation band, these effects lead to decreasing separations between successive $R$ lines with increasing $J$, and to increasing separations between successive $P$ lines with increasing $J$. In such a band (as in fig. 3), the heights of the lines are roughly proportional to their intensities. The intensity of a spectral transition is in general given by the product of a constant, a power of the frequency ($\nu^1$ in absorption, $\nu^4$ in emission), a weight factor for the transition, and the number of molecules in the initial state of the transition. In thermal equilibrium, this number decreases exponentially with increasing energy by a Boltzmann term $e^{-E/kT}$, where $E$ is the energy (per molecule), $k$ is Boltzmann's constant, and $T$ is the absolute temperature in °K. Since the weight factor for the transitions increases with increasing $J$ for the lines in a vibration-rotation band, while the Boltzmann factor decreases, there are observed maxima of intensity, dependent on the temperature, in the $R$- and $P$-branches, as illustrated in fig. 3.

The weight factors for a diatomic molecule are zero both for pure rotation and vibration-rotation spectra, unless the molecule has electrical or magnetic asymmetry. Thus homonuclear molecules such as nitrogen ($N_2$) and chlorine ($Cl_2$) do not give these spectra, while heteronuclear molecules such as hydrogen chloride (HCl) and carbon monoxide (CO) do. The intensities of the vibration bands in absorption, $v' \leftarrow v''$, fall very rapidly in the sequence $1 \leftarrow 0$, $2 \leftarrow 0$, $3 \leftarrow 0 \ldots$.

Most of the information derived from the study of vibration spectra in the infrared region has been obtained from measurements of the position of the lines: these give the structural constants, particularly $B$, $D$, $\omega_e$ and $x_e\omega_e$, which in turn provide detailed information about molecular architecture and molecular mechanics. The absolute intensities of spectral transitions are more difficult to measure and less easily interpreted. But relative intensities are very useful in quantitative analysis, for the infrared spectrum of a molecule is a highly characteristic property—a molecular fingerprint. From what was formerly the special equipment of a few research laboratories were developed familiar tools of routine analysis in industry.

Information about the rotational and vibrational energy states of molecules may also be obtained from scattering effects. When light falls on atoms or molecules, the distribution of electrons around the nuclei may be somewhat changed and therefore some light is scattered. It is indeed the scattering of sunlight by the atmosphere that makes the sky blue, as Lord Rayleigh showed. This classical effect, explicable without quantum theory and now called Rayleigh scattering, occurs without change of wave length. Molecules may also show a much weaker, nonclassical scattering with change of wave length; this is the Raman effect (*q.v.*). It depends on how the polarizability varies during molecular rotation and vibration; since the intensities of the infrared spectra depend on different molecular properties (on the electric dipole moment) during rotation or vibration, the infrared and Raman effects are, in general, complementary.

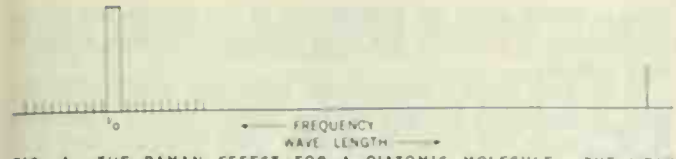


FIG. 4.—THE RAMAN EFFECT FOR A DIATOMIC MOLECULE. THE WEAK LINES ON EITHER SIDE OF THE EXCITING FREQUENCY $\nu_0$ ARE THE LINES OF THE PURE ROTATIONAL EFFECT. THE STRONGER "LINE" AT MUCH GREATER SEPARATION ARISES FROM THE VIBRATIONAL EFFECT

Suppose that the frequency of the monochromatic exciting radiation is $\nu_0$. Then the Raman effect produces scattered radiation of other frequencies, $\nu = \nu_0 \mp \Delta\nu$. Lines for which $\nu = \nu_0 - \Delta\nu$ are called Stokes lines; lines at higher frequencies than $\nu_0$ are anti-Stokes lines. The values of $\Delta\nu$ are characteristic of the scattering molecules. For a rigid rotating diatomic molecule of rotational constant $B$, the rotational Raman spectrum contains lines corresponding to the changes $\Delta J = 0$ or $+2$. For $\Delta J = 0$, $\nu = \nu_0$, but for $\Delta J = 2$, an $S$-branch is obtained on either side of the exciting line. $S(0)$ lies at $\nu_0 \pm 6B$, $S(1)$ at $\nu_0 \pm 10B$, $S(2)$ at $\nu_0 \pm 14B$ and so on. The formation and appearance of such a spectrum is illustrated in fig. 4.

At bigger separations $\Delta\nu$, the Raman spectrum of a diatomic molecule contains at least two further "lines." These are the piled up $Q$-branches ($\Delta J = 0$) of the vibrational effect; with long exposures, lines of the $S$-branches may also be seen. Neglecting this rotational structure, $\Delta\nu \sim \omega$, or, more exactly, $\Delta\nu = \omega_e - 2x_e\omega_e$.

Raman spectra—particularly the rotational effects—are of low intensity and therefore difficult to observe. The techniques were, however, greatly improved from 1955 onward, and the closely spaced rotational Raman spectra of molecules, even as heavy as benzene, were satisfactorily resolved by the late 1950s.

Finally, there are electronic spectra. If two atoms are far apart, their interaction is negligible; if they are brought sufficiently close together, the electron-electron and nucleus-nucleus interactions will lead to repulsion (*i.e.*, atoms are to some extent incompressible). At intermediate distances either the atoms interact to form a stable chemical bond, with a reduction in the potential energy; or the atoms repel each other at all distances. These two cases are illustrated in fig. 5, in which potential energy is plotted as a function of the interatomic separation.

Just as electrons may be arranged around the nuclei of atoms in different ways to give states of different electronic energy, so also with molecules, and electronic spectra arise by transitions between the rotational and vibrational states of two different electronic states of a molecule. Since such states are often quite widely separated in energy, the transitions occur at wave lengths between about $10^{-4}$ to $10^{-5}$ cm or 10000 to 1000 Å (1Å = $10^{-8}$ cm); this range includes visible light from violet at about 4000 Å to red at 7000 Å. Such a transition is called an electronic band system. For example, such a transition between two electronic states gives chlorine gas its green-yellow colour, iodine vapour its purple colour, and it is a transition in ozone that makes the earth habitable, by absorbing the sun's ultraviolet radiation at wave lengths below about 3000 Å.

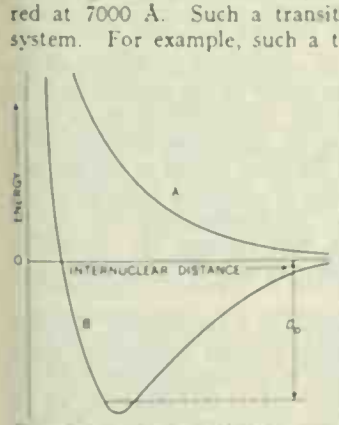


FIG. 5.—POTENTIAL ENERGY AND DISTANCE FUNCTIONS FOR DIATOMIC MOLECULES. (A) SHOWS THE FORMATION OF A STABLE MOLECULE, WITH DISSOCIATION ENERGY $D_0$. (B) SHOWS REPULSION. NO STABLE MOLECULE IS FORMED

The appearance of an electronic band system of a diatomic molecule depends upon the values of the constants $\omega''$, $\omega'$, $B''$, $B'$, the vibrational and rotational constants for lower ($''$) and upper ($'$) states. Selection rules (of the kind $\Delta J = \pm 1$ or 0) limit the number of rotational transitions, but the vibrational transitions depend upon the relative orientations of the potential energy curves for the upper and lower electronic states. Two possibilities are illustrated in fig. 6(A) and 6(B). Roughly, it can be said that electronic rearrangements are swift compared with nuclear motion, so that transitions which can be represented by vertical lines in potential energy diagrams are the most probable.

If the minima of the potential energies for upper and lower states happen to occur at about the same internuclear distance (fig. 6[A]) then it is found that most of the intensity of the system is concentrated into the rotational transitions associated with the changes in vibrational levels from $0 \leftrightarrow 0$, $1 \leftrightarrow 1$, $2 \leftrightarrow 2$ and so on. If, however, there is a big difference between the values of the internuclear distances at the minima, then the most probable vibrational transitions are from high $v'$ to low $v''$ and from low $v'$ to high $v''$, and the $0 \leftrightarrow 0$ band may be too weak to be observed. How closely the vertical lines are spaced depends on the rotational constants $B'$ and $B''$, which are in turn determined by the moments of inertia. Light molecules give bands of open structure; heavy ones, bands of structure sometimes irresolvably close. Because of interaction between electronic and nuclear motion, the expressions for energy levels are in some cases more complicated than the rigid rotator formulas; a band may thus have more than the two or three branches mentioned above. In some cases the positions of the vibrational energy levels of a particular electronic state may be followed to high values of the vibrational quantum number.

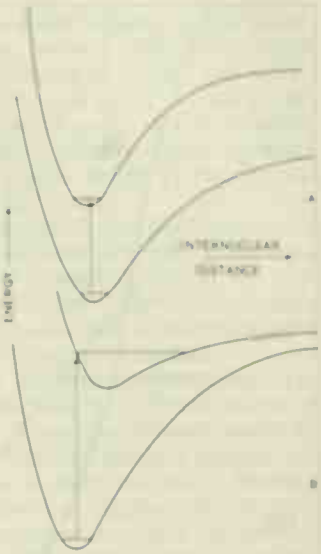


FIG. 6.—TRANSITIONS BETWEEN ELECTRONIC STATES OF DIATOMIC MOLECULES. IN (A) $R'_e = R''_e$; IN (B) $R'_e > R''_e$. VERTICAL ARROWS REPRESENT THE STRONGEST TRANSITIONS IN THE ABSORPTION SPECTRUM

The intervals between successive vibrational levels decrease with increasing value of $v$, and it may be possible to extrapolate to the point at which the interval becomes zero (*see* fig. 7). On the potential energy diagram, this corresponds to the limit for two noninteracting atoms at relatively large internuclear separation. The energy difference between the lowest vibrational level ($v = 0$) and the dissociation limit is called the dissociation energy, and represents the energy necessary to separate the two atoms in the normal state of a diatomic molecule to infinity. Thus, the energy required to break up the oxygen molecule ($O_2$) into two oxygen atoms, is about 120 Kcal/mole (1 mole = $6 \times 10^{23}$ molecules).

Atoms of identical nuclear charge and identical number of extranuclear electrons but differing nuclear mass are called isotopes. Thus naturally occurring oxygen ($O_2$) contains mostly atoms of relative mass 15.9994 atomic weight units ($O^{16}$) but also a small proportion of heavier atoms $O^{18}$, and a still smaller proportion of $O^{17}$ atoms. The spectra of two isotopic molecules such as those of oxygen-16 and oxygen-18 or $HCl^{35}$ and $HCl^{37}$ are not identical, for the heavier molecule has a bigger moment of inertia, and thus a smaller value of the rotational constant $B$ than the lighter one; furthermore, the characteristic vibration frequency for the heavier molecule will be less than that of the lighter one. Indeed, some isotopes were in fact first discovered by observations of their spectra, notably $O^{18}$. Such isotope effects help to clarify the spectra of polyatomic molecules.

At shorter wave lengths than can commonly be photographed in air (because of the strong absorption by oxygen) there lie spectra which, though similar to the electronic spectra, are more analogous to atomic spectra. In this region, a series of band systems converging to a high energy limit has been found for some molecules. These arise from the progressive excitation of an electron from the molecule; the convergence limit marks the point at which ionization occurs (the electron becoming detached). This may

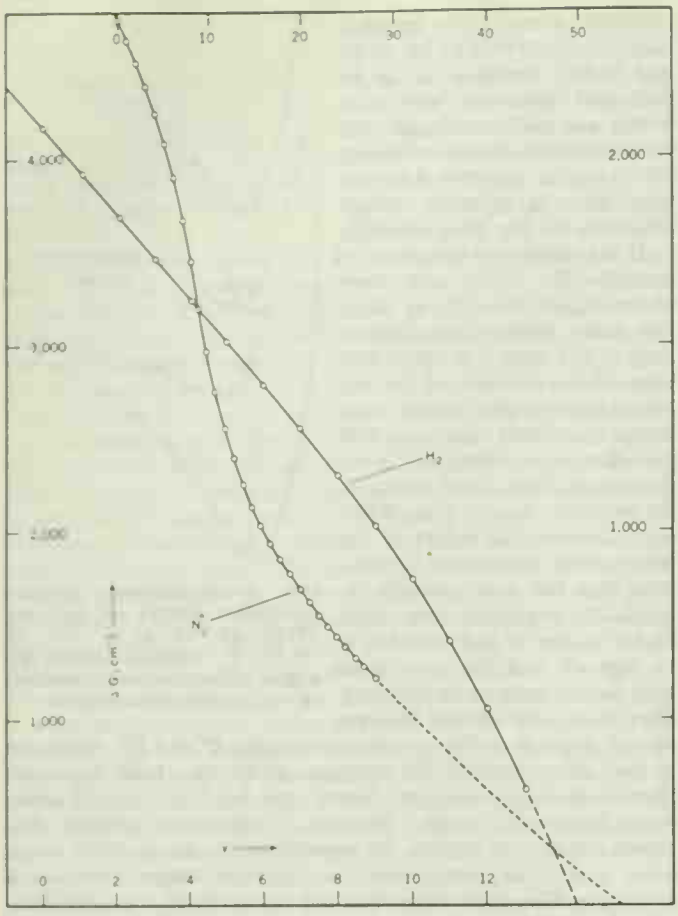


FIG. 7.—THE SEPARATIONS BETWEEN SUCCESSIVE VIBRATIONAL LEVELS PLOTTED AGAINST VIBRATIONAL QUANTUM NUMBER (1) FOR THE LOWEST ELECTRONIC STATE OF $H_2$ (LOWER AND LEFT SCALES), (2) FOR AN EXCITED STATE OF $N_2^+$ (UPPER AND RIGHT SCALES)

be written $MX \rightarrow MX^+ + e^-$. Such series are called Rydberg series.

A molecule has many different electronic states, some stable and some unstable (fig. 5). As in atomic spectra, not all possible transitions take place with measurable intensity, but a molecule may still have a large number of strong band systems. Some spectra, particularly in emission, are therefore greatly complicated by the overlapping of different systems.

Molecular spectroscopy helps to reveal molecular structure. For diatomic molecules, it indicates the size of the molecule (*i.e.*, the equilibrium internuclear distance), the characteristic vibration frequency $\omega_e$ and the energy of dissociation. For polyatomic molecules where, so far, the infrared, Raman and microwave spectra have been the most helpful (the electronic spectra of polyatomic molecules are generally very complex), in the simpler cases spectroscopy yields information about the equilibrium configuration of the molecule and about the ways in which the molecule can vibrate.

So far it has been assumed that the emitting or absorbing molecules are in the dilute, gaseous state. In going to a compressed gas and thence to the more concentrated liquid or solid states the spectra generally change, the fine structure arising from rotational changes is lost and evidence is obtained about the nature and extent of interactions between molecules.

Since the populations of molecules in different energy states are determined (in equilibrium) by their temperature, and since the intensities of spectral lines are proportional to their populations in the initial states of the quantum jumps, the measurement of relative intensities of lines may yield the temperature of the emitting molecules. Thus can be measured the temperatures of inaccessible sources, such as flames from rocket motors, the upper atmosphere (using the aurora) and stars. Most of what is known about the atmospheres of the planets and of the composition of the stars has been discovered through study of their spectra.

In the 19th century spectroscopic techniques were mainly applied to qualitative analysis through atomic spectra (following R. W. Bunsen and G. R. Kirchhoff). New elements were thus discovered, *e.g.*, cesium and thallium, and helium was identified in the sun. Little progress in molecular spectroscopy was made until a theory of the energy levels in molecules was formulated, particularly in the decade 1920–30. Intensive testing followed and confirmed the theory, which now became adequate to many problems concerning diatomic molecules.

The spectra of polyatomic molecules raise complex problems, and attracted increasing attention after 1945. Technical advances have made it possible to work out the molecular structure in some of the simpler cases. The properties of stable molecules have been found from a study of transitions between closely spaced energy levels produced by electric or magnetic fields, sometimes in molecular-beam experiments. For example, positions of hydrogen atoms in certain crystals, difficult to detect by X-ray diffraction, were located through nuclear magnetic resonance, from observed transitions between energy levels arising when nuclei with a magnetic moment are placed in a magnetic field.

Likewise, knowledge of unstable molecules was greatly advanced by the development of flash photolysis, in which products formed by rapid absorption of large numbers of quanta are examined spectroscopically at short-time intervals after the flash. Such studies are relevant to special problems of chemical reactivity in flames and combustion processes. Thus, the first definite information about the structure of the methyl radical was obtained from the flash photolysis of mercury dimethyl.

Indeed, experiment had outstripped theory by the 1960s. A quantitative theory of the structure of polyatomic molecules had yet to be found. *See* LASER; MASER.

*See* G. Herzberg, *Molecular Spectra and Molecular Structure*, vol. I of *Spectra of Diatomic Molecules* (1950); A. G. Gaydon, *Dissociation Energies and Spectra of Diatomic Molecules* (1950). (R. F. Bw.)

**MOLECULE.** The molecule may be defined, in chemistry and physics, as the smallest part of a substance that can exist free in the gaseous state while retaining the composition and chemical properties possessed by the gaseous material in bulk. From the chemical point of view, however, the foregoing definition is somewhat too restrictive, since many substances cannot be obtained in the gaseous state without partial or complete decomposition. If the concept of the molecule is to be retained for such substances, therefore, it must be generalized so that it has meaning with respect to states of matter other than the gaseous. One such generalization, which is widely adopted, is made possible by the fact that many, although not all, nonvolatile substances can be dissolved in inert solvents (*i.e.*, in solvents with which they do not react chemically). For example, many proteins are soluble in water.

The molecule of a substance can accordingly be defined as the smallest part of it that exists free either in the gaseous state or in dilute solution in an inert solvent. Ordinarily, in those cases in which a direct comparison can be made, the molecule of a given substance is found to be of the same weight in the gas and in solution; several significant types of exception exist, however, as will be mentioned again later. With substances that can be neither vaporized nor dissolved in inert solvents, the concept of the molecule loses most of its utility, as well as its meaning, and is not commonly employed.

The molecule also may be defined, in a superficially different but usually equivalent way, as either a single independent atom or an aggregate of atoms; the atoms in the aggregate are held together by relatively strong (valence) forces and therefore act as a unit. (Although, according to this definition, a molecule may consist of a single atom, as, for example, a molecule of helium or other rare gas, an unfortunate tendency has arisen in certain circles to limit the term molecule to aggregates of two or more atoms.) The relation between this definition and the preceding one can be clearly seen if it is realized that a pure substance in bulk consists

of a very large number of molecules, or aggregates of the type described, that (aside from possible variations in isotopic composition) are exactly alike and exert only relatively weak forces upon one another. Consequently, a division of a sample of the substance into progressively smaller parts produces no change in either composition or chemical properties until parts consisting of single molecules are reached. Further subdivision then leads to still smaller particles that usually differ from the original substance in composition and almost always differ from it in chemical properties because, in the last stages of the fragmentation, one or more strong valence bonds are necessarily ruptured (or, if the molecules in question consist of single atoms, these atoms themselves must be broken up).

**The Molecule in the Solid State.**—Since it has been found that atoms joined by strong valence bonds are always relatively close to one another in space, a method by which the concept of the molecule can be extended to the solid state is at once suggested. In solid naphthalene, for example, examination of the crystal structure has shown that the substance consists of identical aggregates, each composed of ten carbon and eight hydrogen atoms. In each aggregate, each atom is close to, and so must be relatively strongly bonded to, at least one other atom of the same aggregate; but no two atoms in different aggregates are comparably close to one another. Consequently, the aggregates can be regarded as identical with the individual molecules.

The molecular weight of naphthalene in the gaseous state and in solution has been measured by the procedures mentioned below; under these conditions likewise, the molecules consist of ten carbon and eight hydrogen atoms each.

Although many solid substances resemble naphthalene in that they consist of distinct molecules, the nature of many others is entirely different. Sodium chloride (common table salt) consists of sodium ions and chloride ions so arranged that each sodium ion is surrounded by six equidistant chloride ions, and each chloride ion is surrounded by six equidistant sodium ions. Hence, no distinct aggregate identifiable with a molecule of sodium chloride exists, unless each entire crystal be considered as a single molecule. Consequently, in sodium chloride, and in all other solids of similar type, the concept of the chemical molecule loses its significance. (*See* also CRYSTALLOGRAPHY; SOLID STATE PHYSICS: *Physical Properties of Solids.*)

**Molecular Sizes and Weights.**—The absolute sizes and weights of individual molecules cannot be determined by purely chemical methods; various other methods, however, have been successfully applied to the determination of both their linear dimensions and their weights. Thus, it has been shown that the lengths, or diameters, of most molecules lie between $10^{-5}$ and $10^{-7}$ cm., and that most molecules weigh between about $10^{-23}$ and $10^{-20}$ g. Some substances, such as the proteins, consist of much larger molecules, and a few consist of molecules large enough to be "seen" with the electron microscope. These are extreme cases, however; ordinarily molecules are much smaller. (*See* also PROTEINS; MICROSCOPE.)

More important chemically than the absolute weights of the individual molecules are their relative weights with respect to one another. For this purpose the weight of the hydrogen atom was originally adopted by convention as the unit in terms of which the weights of all other atoms and molecules were to be expressed. Thus, the atomic weight of hydrogen was by definition exactly 1.0000, that of oxygen was about 15.87, and so on. Subsequently, however, it was found more convenient to use, as the standard unit, one-sixteenth the weight of an oxygen atom, so that the atomic weights of hydrogen and oxygen became about 1.008 and exactly 16.0000, respectively. This second convention was replaced in 1961 by a system based on carbon-12, the principal isotope of carbon. In this system the atomic weights of hydrogen and oxygen are 1.00797 and 15.9994 respectively. (*See* ATOMIC WEIGHT.)

The weight of a molecule in terms of the foregoing conventional unit is called the molecular weight of the corresponding substance. It is numerically equal to the sum of the atomic weights of all the atoms that make up the molecule. Thus, since a molecule of oxygen contains two atoms of oxygen, the molecular weight of oxygen is 31.9988; since a molecule of water contains two atoms of hydrogen and one of oxygen, the molecular weight of water is about 18.015; and so on. If the molecular weight of a substance is M, then M grams of that substance is called a gram molecular weight, a gram molecule or, more briefly, a mole. Thus, a mole of oxygen weighs 31.9988 g; one of water weighs about 18.015 g; and so on.

It is a corollary of Amedeo Avogadro's law (*see* AVOGADRO'S CONSTANT) that the number of molecules in a mole is the same for all substances. This number (Avogadro's number or Avogadro's constant) is approximately $6.02456 \times 10^{23}$. The absolute weight of a single molecule of any substance is the weight of a mole of that substance divided by Avogadro's number.

**The Effect of Variations in Isotopic Composition.**—The discovery of isotopes established the fact that different atoms of an element may differ in weight. Therefore different molecules of a given substance may have different absolute weights and hence different molecular weights, if they are not of identical isotopic composition. From the practical chemical point of view, however, these ambiguities are unimportant, since the average atomic weight of each element is almost always found to be constant within the experimental error of measurement, regardless of the source of the element or of its state of combination. In all ordinary chemical experiments, the numbers of molecules involved are so enormous that only the average atomic and molecular weights are important. (*See* ISOTOPE: *Relationship of Chemical Atomic Weights to the Existence of Isotopes.*)

**The Determination of Molecular Weights.**—Several experimental methods have been devised for the determination of molecular weights. Of these, the most fundamental is based upon Avogadro's law, which states that equal volumes of any two gases at the same temperature and pressure contain the same number of molecules. This law, which is rigorously true only for perfect gases, is obeyed approximately by all gases and it becomes increasingly true as the pressure is decreased. Consequently, the ratio of the molecular weights of any two substances is approximately equal to the ratio of the measured weights of equal volumes of the gaseous substances at the same temperature and pressure; and the equality becomes more nearly exact as the pressure is lowered. Since the molecular weight of oxygen is by definition 31.9988, that of any other substance can be determined by comparison with oxygen. Thus, it has been found that one mole (31.9988 g.) of oxygen occupies 22.421 litres at 0° C. and 760 mm. pressure; consequently, the gram molecular weight of any other substance is seen to be equal to the weight of it in grams that would occupy 22.421 litres in the gaseous state at 0° and 760 mm. If the substance is not gaseous under these conditions, the required weight can often be calculated with the aid of the perfect gas laws from the measured density of the gas under any suitable experimental condition.

The molecular weights of substances that cannot be vaporized can often be determined in solution in an inert solvent since the lowering of the freezing point of any given solvent, the raising of its boiling point, the decrease of its vapour tension at any temperature and the osmotic pressure of the solution are all directly proportional to the number of solute molecules present in a given weight of solvent (*see* SOLUTIONS: *Thermodynamic Properties*). Consequently, the molecular weight of the solute must be inversely proportional to the magnitudes of the effects, of the types listed, produced by a given weight of it in a given weight of solvent. Since the value of the proportionality constant depends upon both the property studied and (ordinarily) the solvent used, but not upon the solute, it must be determined by comparison with some substance, the molecular weight of which has previously been determined in the gaseous state. Thus, it has been found that one mole of any solute dissolved in 1000 g. of water lowers the freezing point by 1.855° C. and raises the boiling point by 0.51° C.

As with the methods based directly upon Avogadro's law, these methods also give only approximately correct values of the molecular weights, but they become more nearly exact as the solu-

tions are made more dilute. (*See* ATOMIC WEIGHT: *Experimental Determination.*)

**Empirical and Molecular Formulas.**—The empirical formula of a substance is the simplest formula that describes its chemical composition. Thus, benzene contains 7.74% hydrogen and 92.26% carbon. Since the atomic weights of hydrogen and carbon are 1.00797 and 12.01115, respectively, and since these are in the ratio of 7.74 to 92.26, it follows that the numbers of hydrogen and carbon atoms in a molecule of benzene must be equal. The empirical formula of the substance is therefore CH.

The molecular formula of a substance describes not only the chemical composition but also the molecular weight of the substance. Thus, the molecular weight of benzene can be found by any of the above methods to be in the neighbourhood of 78, whereas the calculated weight corresponding to the unit CH is about 13.019. Evidently, therefore, the molecule of benzene must contain six such units, so that the molecular formula is $C_6H_6$. An alternative, but equivalent, definition of the molecular formula is that it is the formula that specifies the number of atoms of each element present in a single molecule of the substance in question.

**Association and Dissociation in Solution.**—As has already been mentioned, molecular weights measured in the gaseous state and in solution, although they are usually identical, may be different. Two distinct types of discrepancy are encountered; the molecular weight of a substance may be either greater or less in solution than in the gas. When it is greater, the substance is said to be associated in solution; when the weight is less, the substance is said to be dissociated. Association occurs commonly in nonpolar solvents like benzene when the molecules of the solute contain hydroxy groups (OH) or amino groups ($NH_2$). (*See* ASSOCIATION, CHEMICAL.) On the other hand, the most important type of dissociation is the electrolytic dissociation undergone by acids, bases and salts when dissolved in ionizing solvents like water.

It has been shown that, in aqueous solution, most salts and some acids and bases are almost completely dissociated into ions, but that a few salts and many acids and bases are only partially dissociated. Sodium chloride, for example, exists in aqueous solution almost entirely as a mixture of sodium ions ($Na^+$) and chloride ions ($Cl^-$); on the other hand, acetic acid exists mostly as undissociated molecules ($CH_3CO_2H$) and to only a small extent as hydrogen ions ($H^+$) and acetate ions ($CH_3CO_2^-$). If an attempt is made to measure the molecular weight of a substance in a solvent in which it is dissociated into ions, the numerical result of the experiment should correspond, ideally, to the average weight of the various ions and molecules present. Actually, however, the situation is complicated by the strong electrostatic interactions between the charged ions.

The result of these interactions is that, unless the concentration of the ions is extremely low, the effects of the solute upon the freezing point, etc., are appreciably smaller than those that would have been produced by an equal concentration of uncharged molecules. Consequently, the extent of dissociation appears to be less than it really is.

**The Determination of Very Large Molecular Weights.**—The determination of the molecular weight of a substance that has a very large molecular weight is relatively difficult. Such a substance (for example, a protein) is almost certainly nonvolatile, so the method based directly upon Avogadro's law is inapplicable. Moreover, the various methods that could be used for the determination of the molecular weight in solution are unsatisfactory, since the effects produced by the presence of the solute, being inversely proportional to its molecular weight, are very small and may be too small to be measured precisely, or even to be observed. For such substances, "minimum molecular weights," which can be obtained from analytical data, are frequently useful. Hemoglobin, the protein responsible for the red colour of blood, for example, contains about 0.335% iron. If each molecule of hemoglobin contains $n$ atoms of iron, the molecular weight of hemoglobin is easily shown to be about $16{,}700n$. Since $n$ cannot be less than one, the minimum molecular weight of the protein is therefore 16,700. Moreover, since $n$ must be an integer, the true molecular weight must be an integral multiple of 16,700. Such information is often of value in the determination of the true molecular weights.

The most generally useful methods for the determination of actual, as distinguished from minimum, molecular weights of large molecules involve the use of the ultracentrifuge. The principle underlying these methods is that when a solution of the substance is subjected to extremely great centrifugal forces the solute is forced measurably away from the centre if it is more dense than the solvent, or toward the centre if it is less dense than the solvent. The molecular weight of the solute can be calculated either from the rate of sedimentation or from the final distribution of solute after equilibrium has been reached. In this way, molecular weights of any magnitude, provided they are sufficiently large, can be determined. A more recent method, which, like the ultracentrifugal one, is restricted to the study of extremely large molecular weights, is based upon the scattering of light by solutions of the substances of interest. The principles of this method, however, are too technical to be discussed further here. If, by either of these methods, a rough value of the true molecular weight of any substance is obtained, a comparison with the minimum molecular weight often permits the derivation of a more precise value. Thus, since the molecular weight of hemoglobin, for example, must be of the form $16{,}700n$ (where $n$ is an integer), knowledge that the molecular weight lies between, say, 60,000 and 70,000 is sufficient to show that $n$ must be exactly equal to four, and that the molecular weight is approximately 66,800.

**Molecular Weights of Solids.**—If a substance is solid under ordinary conditions, and if analysis of its crystal structure shows that it consists of individual molecules, the molecular weight is, of course, simply the sum of the atomic weights of all the atoms contained in a single molecule. On the other hand, if analysis of the crystal structure shows that a given solid does not consist of individual molecules, then its molecular weight is an essentially meaningless concept. For such substances as these latter, one speaks instead of the formula weight; this is the weight corresponding to the empirical formula.

With sodium chloride, for example, the empirical formula is NaCl, even though no molecules consisting of one atom of sodium and one of chlorine are present in the solid. Consequently, since the atomic weights of sodium and chlorine are 22.9898 and 35.453, respectively, the formula weight of sodium chloride is 22.9898 + 35.453 = 58.4428. Speaking somewhat loosely, one frequently refers to 58.4428 g. of sodium chloride as constituting a mole of the substance.

*See* also CONFORMATIONAL ANALYSIS; ELEMENTS, CHEMICAL: *Molecules and Modifications;* MOLECULAR REARRANGEMENTS; MOLECULAR SPECTRA; DIPOLE MOMENTS; FREE RADICALS; CHEMISTRY: *Studies of Chemical Composition (1800–1900); Changes in Structural Concepts After 1895; Structural Chemistry; The Development of the Theory of Molecular Structure; Mechanisms of Organic Reactions.* *See* also references under "Molecule" in the Index. (G. W. WD.)

**MOLE RAT,** the name for two distinct kinds of old world rodents:

1. A group of blind burrowing rodents typified by the large gray *Spalax typhlus* of eastern Europe, western Asia and Egypt, which represents the family Spalacidae. These mole rats are characterized by the lack of a distinct neck; they have small or rudimentary ears and eyes, short limbs provided with powerful digging claws, and a rudimentary tail. They make burrows in sandy soil, and feed on bulbs and roots. The closely related bamboo rats (*Rhizomys*) from India and Burma and *Tachyoryctes* from East Africa differ by the absence of skin over the eyes, the presence of short ears and a short, sparsely-haired tail; they burrow among tall grass, or at the roots of trees.

2. Another group is the African family Bathyergidae, which contains several genera living south of the Sahara, one of which is almost naked. These very specialized burrowers rarely come to the surface. *See* RODENT.

**MOLESKIN,** a stout, heavy cotton fabric used for purposes in which a fabric capable of resisting rough usage is desirable. *See* FUSTIAN.

**MOLESWORTH, MARY LOUISA** (1839–1921), British writer of children's stories who has been called "the Jane Austen of the nursery," was born at Rotterdam, Neth., on May 29, 1839. She was the daughter of Charles Augustus Stewart, a Scottish merchant and shipper of Manchester, where she lived until her marriage in 1861 to Major Richard Molesworth. She settled in London in 1883 and died there on July 20, 1921.

Mrs. Molesworth began her literary career in 1870 with three-volume novels of little merit. *Tell Me a Story* (1875) and *Carrots: Just a Little Boy* (1876) set her suddenly among the leading writers for children, and *The Cuckoo Clock* (1877) made that position secure. She wrote many more stories: *Two Little Waifs* (1883), *Us* (1885), *Four Winds Farm* (1887), *The Children of the Castle* (1890), *Nurse Heatherdale's Story* (1891), *An Enchanted Garden* (1892), *The Carved Lions* (1895), *The House That Grew* (1900), *Peterkin* (1902), *The Story of a Year* (1910) and *Fairies Afield* (1911) are the most perfect examples of her rare gifts as storyteller and interpreter of childhood.

*See* Roger Lancelyn Green, *Mrs. Molesworth* (1961), with short-title bibliography. (R. L. GR.)

**MOLESWORTH, SIR WILLIAM,** BART. (1810–1855), English radical politician, son of the 7th baronet, was born on May 23, 1810, in London. After succeeding to baronetcy in 1823, he studied at Edinburgh, Cambridge, Offenbach, Rome and Naples. On the passing of the Reform act of 1832 he was returned to parliament for the eastern division of Cornwall. He made the acquaintance of George Grote and James Mill, and in April 1835 founded, in conjunction with John Roebuck, the *London Review*, as an organ of the "Philosophic Radicals." After the publication of two volumes he purchased the *Westminster Review*, and for some time the united magazines were edited by him and John Stuart Mill. He sat for Leeds from 1837 to 1841, and acquired considerable influence in the house of commons by his speeches and by his tact in presiding over the select committee on transportation. But his radicalism made little impression either on the house or on his constituency. From 1841 to 1845, when he had no seat in parliament, he devoted his leisure time to editing the works of Thomas Hobbes in Latin and English, a recreation that cost him no less than £6,000. He was returned for Southwark in 1845, and retained that seat until his death. On his return to parliament he devoted special attention to the condition of the colonies, and was the ardent champion of their self-government. Lord Aberdeen included him in the cabinet in Jan. 1853 as first commissioner of works, the chief work by which his name was brought into prominence at this time being the construction of the new Westminster bridge; he also was the first to open Kew Gardens on Sundays. Molesworth was made colonial secretary in July 1855 but before he had time to implement his views he died on Oct. 22, 1855, in London. (A. BRI.)

**MOLFETTA,** an Adriatic port and episcopal see in the Puglia region of Italy, in the province of Bari, 26 km. (16 mi.) W.N.W. of the city of Bari. Pop. (1961) 57,994 (commune). It dates from the middle ages and the medieval town is clearly distinguishable from the modern. The cathedral of S. Corrado, a national monument, is in the Romanesque style and dates from the 13th century. Molfetta is an important fishing port in the lower Adriatic; other industries are boatbuilding and the manufacture of foodstuffs, cement, chains and oil. Fish and vegetables are exported.

**MOLIÈRE** (1622–1673), often called the greatest of French writers, was born and died in the heart of Paris. The registers of St. Eustache show him to have been baptized as JEAN BAPTISTE POQUELIN on Jan. 15, 1622. His mother died when he was ten; his father, one of the appointed furnishers of the royal household, gave him a good education at the College de Clermont (the school which, as the Lycée Louis le Grand, was to train so many brilliant Frenchmen, including Voltaire) and clearly intended him to take over his royal appointment, but this the young man renounced in Jan. 1643, determined to break with tradition and seek a living on the stage. Within six months we have his signature to an act of association (June 30, 1643) with nine like-minded persons to produce and play comedy with a view to maintaining their company under the name of the Illustre Théâtre. His stage name, Molière, is first found in a document dated June 28, 1644. He was to give himself entirely to the theatre for 30 years and to die exhausted at the age of 51.

According to Tallemant des Réaux it was a successful actress, Madeleine Béjart, who persuaded Molière to take to the theatre, but her acting could not save the young company. Documents of 1645 show Molière twice in prison for debts on the building and properties. Existence in Paris with two well-established theatres already seemed financially impossible, so from the end of 1645, for the next 13 years, Molière and his friends sought to gain a living in the provinces. The Illustre Théâtre seems to have been soon dissolved, its survivors associating themselves with a certain Charles Dufresne, under the patronage of the 2nd duc d'Epernon (Bernard de La Valette) and for a time, until his conversion to austere piety, of the prince de Conti (Armand de Bourbon). No history of these years is possible; municipal registers and church records show the company emerging here and there. A letter from the intendant of Languedoc to the consuls of Albi in 1647 asks that they be paid dues and expenses. They were in Lyons intermittently from the end of 1652 to the summer of 1655 (when the poet Charles d'Assoucy comments on their good living and generosity) and again in 1657; they were at Montpellier in 1654 and 1655 and at Béziers in 1656. Clearly they had their ups as well as downs. The unchronicled years are of crucial importance to Molière's career, forming a rigorous apprenticeship to his later work as actor-manager, teaching him how to deal with colleagues, authors, audiences and authorities. His rapid success afterward in Paris, in the face of distinctly adverse conditions, is inexplicable without these years of training. To these years belong Molière's first two known plays: *L'Étourdi, ou le Contretemps*, performed at Lyons in 1655, and *Le Dépit amoureux*, performed at Béziers in 1656.

The turning point in his career was probably the afternoon of Oct. 24, 1658, when, in the guardroom of the Louvre on an improvised stage, the company acted Corneille's *Nicomède* before the king, Louis XIV, and followed it with what Molière described as one of those little entertainments which had won him some reputation and which he used to offer to provincial audiences. This was *Le Docteur amoureux*, which apparently brought the house down and secured the company's adoption by Monsieur (the king's brother Philippe, later duc d'Orléans). From this date onward the known facts about Molière almost exclusively concern his activity as actor-manager and author. Whereas earlier writers used to speculate at length on the details of Molière's personal life, all that need be given here is a brief summary of the principal events as an introduction to his work.

For two years after his success of Oct. 1658, Molière's company had the use of a hall in the Petit-Bourbon, a great house adjacent to the Louvre. There took place the first performances of *Les Précieuses ridicules* (Nov. 18, 1659) and of *Sganarelle, ou le Cocu imaginaire* (May 28, 1660). *Les Précieuses ridicules* (see below) was repeated many times in 1660. In the same year he took out a privilege to print the texts of his plays and resumed again his right to his father's appointment as furnisher to the king. In Jan. 1661, on the demolition of the Petit-Bourbon, the company moved to a hall in the Palais-Royal, where all Molière's future plays were to be staged except those which he was commanded to produce for royal galas or private patrons. His one tragedy, *Dom Garcie de Navarre, ou le prince jaloux* (Feb. 4, 1661), was a failure, but *L'École des maris* (June 24) was another success. *Les Fâcheux* (Aug. 17) was composed for an entertainment at Vaux.

On Feb. 20, 1662, Molière married Armande Béjart. It is not certain whether she was Madeleine's daughter, as contemporaries thought, or her sister, as the documents state. She bore Molière three children, but only one of them, his daughter, survived to maturity. Their married life was not happy, and the flirtations of Armande were made the subject of hostile pamphlets.

*L'École des femmes* (*see* below), first staged on Dec. 26, 1662, ran till Aug. 12, 1663, but caused considerable outcry, to which Molière replied in two more comedies, *La Critique de l'École de femmes* (June 1) and *L'Impromptu de Versailles* (at Versailles in October). In 1664 he produced *Le Mariage forcé* in the Louvre (Jan. 29) and, for a gala at Versailles, not only *La Princesse d'Élide* (May 8) but also the first version of *Tartufe* (May 12; *see* below). This great comedy provoked more opposition than any of his other works, and his next play, *Dom Juan, ou le festin de Pierre* (Feb. 15, 1665; *see* below), caused another scandal. In the following August, however, despite the attacks on Molière the king himself took over from Monsieur the patronage of the company, which was henceforth known as *la troupe du Roi*. On Sept. 13, 1665, at Versailles appeared *L'Amour médecin*, in which Molière began that satirizing of the medical profession which he was to make more pointed as ill-health from 1666 onward brought him more experience of doctors.

The year 1666 saw *Le Misanthrope* (June 4; *see* below), *Le Médecin malgré lui* (Aug. 6) and *Mélicerte* (Dec. 2). The last-named was composed for a series of winter entertainments at St. Germain, to which Molière subsequently added *La Pastorale comique* (Jan. 5, 1667) and *Le Sicilien, ou l'amour peintre* (Feb. 10). In the following months Molière was seriously ill, but he returned to the theatre in June. On Aug. 5, 1667, *Tartufe*, with the subtitle *L'Imposteur*, was shown publicly for the first time in Paris, but on the next day it was banned by order of the *président* Guillaume de Lamoignon. The archbishop of Paris, Hardouin de Péréfixe, reinforced this ban with ecclesiastical censure. This was the occasion of the defense of the play in a famous pamphlet *Lettre sur l'Imposteur*. In 1668, after producing *Amphitryon* at the Palais-Royal (Jan. 13) and *George Dandin* at Versailles (July 15), Molière on Sept. 9 at the Palais-Royal gave the first performance of *L'Avare* (*see* below). Early next year authorization was at last given for public performances of *Tartufe*, which began on Feb. 5, 1669. *Monsieur de Pourceaugnac* (Oct. 6, 1669) was written for the king's stay at Chambord, and *Les Amants magnifiques* (Feb. 4, 1670) for St. Germain. *Le Bourgeois gentilhomme* (*see* below) was first performed at Chambord on Oct. 14, 1670, and *Psyché*, a most spectacular production, in the Tuileries on Jan. 17, 1671 (it was subsequently transferred to the Palais-Royal). This was followed by *Les Fourberies de Scapin* at the Palais-Royal (May 24) and *La Comtesse d'Escarbagnas* (at St. Germain, Dec. 2, 1671). *Les Femmes savantes* (*see* below) was presented at the Palais-Royal on March 11, 1672.

In Aug. 1672 Molière fell ill again. On Feb. 10, 1673, he appeared in the first performance of his last play, *Le Malade imaginaire* (*see* below), at the Palais-Royal. During the fourth performance of it on Feb. 17, 1673, he was taken gravely ill on the stage. Carried back to his house in the rue de Richelieu, he died there in the same night. As he had not been given the sacraments or the opportunity of formally renouncing the actor's profession, he was buried without ceremony and after sunset on Feb. 21.

### THE MAN OF THE THEATRE

This great writer was not in the usual sense an author. He wrote little that could be then called literature or that was meant for publication: some poems, one in praise of his friend Pierre Mignard's decoration of the Val de Grâce, and a translation of Lucretius, unfinished and unpublished. His comedies were written for performance and were only published after the text of two of them had been pirated by Jean Ribou. Molière took out a "privilege" to publish in 1660 but made no use of it till 1662. He left seven of his plays unpublished, never issued any collected edition, never as far as is known read proofs or bothered with his text. It was as an actor that he wrote, for acting purposes. Comedies, in his view, were made only to be acted. This fact was forgotten in the 19th century, and it is to 20th-century actors such as Louis Jouvet, Charles Dullin and Jean Louis Barrault that we owe a new sense of his dramatic genius.

Competition, the fight for existence, was the keynote of Molière's whole career. His company had to share the hall of the Palais-Royal with the Italians. To keep his actors and his audiences, in face of the established theatres at the Hôtel de Bourgogne and the Marais, was an unremitting struggle. His fame was in the first place due to his winning the contest, as it were, singlehanded. He held his company together by his personality; he made up for lack of authors by writing more plays himself. The asperity of the struggle has been uncovered only by patient research. He could never sit back and enjoy leisure; his works could not be slowly elaborated or rewritten. He could be sure neither of his actors nor of his authors—Racine, whose first play, *La Thébaïde*, he had put on in 1664, transferred *Alexandre* in 1665 to the Hôtel de Bourgogne while Molière's company was actually performing it. He was constantly in trouble with the authorities: even *Les Précieuses ridicules* had to be taken off for a fortnight three weeks after the first production; *Dom Juan* ran for 15 performances only; *Tartufe* was held back for years. His life had the luck of the theatre: everything was uncertain, experimental. Certain plays brought him enormous successes, *L'École des femmes* in 1662, *Tartufe* at long last in 1669. Recruits to the company made up for desertions. He enjoyed royal favour less than has been said, and it was capricious. The pension promised to the company by Monsieur in 1658 was never paid; the court supported his lighter plays more than his greater works. It seems that he had practically lost the royal favour to Lully in his last years. The receipts of his company show great fluctuation. As they fell, we find him writing more. René Bray (see *Bibliography*) calculates that he wrote 31 of the 95 plays put on the stage by his players in the 14 years 1660–73. To meet the situation caused by his own illness, the seven weeks of mourning for Anne of Austria and the proscription of *Tartufe* and *Dom Juan*, he wrote five plays within the season of 1666–67, of which only one, *Le Médecin malgré lui*, was financially successful.

His own acting was at once his disappointment and his glory. He aspired to be a tragic actor and was not considered such by his contemporaries, partly because audiences then favoured the pompous style of strutting and chanting and roaring. He had rather the build, the elasticity, the india-rubber face of the born comedian. Though neither a great talker nor what is known as a merry man, he imitated gesture and speech irresistibly. He had the tireless energy of the actor, always ready to make a scene out of any incident, putting himself on the stage: he gave Harpagon his own cough, Alceste his own moods, and made a play out of his own green room. The characters of his greatest plays are very like the members of his company. It was quite in character that he died playing the part of the sick man that he actually was.

It cannot be that his acting genius has had no influence on his writing, since he wrote what he could most naturally act. He gave himself choleric parts, servants' parts, a henpecked husband, a foolish bourgeois, a superstitious old man who cursed "that fellow Molière": the comparison with Charlie Chaplin in our own day recurs constantly. His success, on stage and in writing scenes and composing parts, was due in part to this energy but also to another quality that one can only describe as intensity of dramatic vision. He seems to have been incapable of visualizing a situation without vivifying it, dramatizing it, forcing it to the limit of probability and often recklessly beyond. Here again actors have helped to recover an aspect of his genius that scholars had neglected, his theatrical violence. To think of his plays as arguments for a reasonable view of things is to miss their true vitality. He imagines characters so excited that their language becomes incoherent, their actions absurd. He seems always to have sacrificed plot to vivacity. This is natural if one remembers his medium and gifts. He who could get anything across was satisfied to get a scene across, no matter what rules of writing it defied. To think of him as the cool apostle of reason, like the *raisonneurs* of his plays, is a heresy that dies hard, but careful study of the milieu in which as a craftsman of the theatre Molière worked should make such a heresy impossible. The comedies are not sermons; any doctrine they may contain is incidental and not an attempt to improve or instruct. The ideas discussed do not belong so much to the author as to the public whom they were intended to please. Had we been able to ask their author what he thought of hypocrisy or atheism, he would

have marveled at the question and agreed with Lamoignon that the theatre was not the place to discuss such matters. Despite continued argument to the contrary, there is no documentary evidence that Molière ever tried to get his own views across in his plays, whether on marriage, or on the church, or on hell or on class distinctions. Strictly speaking, we do not know his views on these subjects. All we know is that he worked for the theatre and that he used to the full his gift, unique and amazing, of forcing the maximum of dramatic suggestion out of any scene or conversation that he imagined. If he has left us a vivid picture and a sympathetic picture of an atheist, that is because of his imagination, not because of his ideas. His picture of the earthy servingman is no less vivid and sympathetic. Scholars who have tried to make his plays prove things and convey lessons have made little sense of his work and have been blind to its inherent fantasy and imaginative power.

## NINE GREAT PLAYS

If (as would seem to be the case) the power of Molière's writing lies in its creative vigour of language and suggestion, the usual divisions of his work into comedy of manners, comedy of character and farce are not helpful. There is again no evidence that he set out in any given instance to write a certain sort of play. The evidence is rather that an occasion presented itself for him to animate figures around a skeleton theme. The work that emerged was always actable (it was meant to be); in fact it frequently left an indelible impression, one that audiences wished to see over and over again. This impression is given by the vigour and life of the words, not by the story or plot of the play. To recount Molière's plots is therefore to leave out the essentials of his plays. For purposes of information, however, it may be well to give some account of the content of his main plays.

**Les Précieuses ridicules (1659).**—This play, the first that Molière wrote for a Parisian audience, is in many ways typical of all that were to follow. Its origin has been shown to be polemic, within the coterie of the finance minister Nicolas Fouquet, of the most violent kind. Its satire was so personal that it had to be taken off for a fortnight; what we now read or see is a revised and generalized version. It is built on the theme of two provincial girls anxious at all costs to be in the fashion of Paris as established by the *Précieuses*, and their exposure by valets masquerading as their masters. The play does not obey the canons and rules laid down by contemporary theorists of drama. It has no discernible exposition or denouement; the unities do not arise. The entertainment is provided in a succession of scenes that enforce the comic contrast between desire for elegance without common sense on the one hand and plain downright presence of mind without any real culture on the other. The girls can risk fatuities like "voiturez-nous ici les commodités de la conversation" ("carriage us here the conveniences of conversation") while the valets grossly offer to show their wounds and are actually undressed on stage by their masters. The fun seems too obvious for comment, yet by the end we know in detail what an intelligent observer might have seen in the *Précieuses:* the affectation, in the name of culture and distinction, of thinking material things vulgar, of regarding marriage as something altogether shocking ("une chose tout à fait choquante") coupled with an entire lack of discernment that failed to distinguish between taste and valets' fooling.

**L'École des femmes (1662).**—Some good judges have considered *L'École des femmes* to be Molière's masterpiece, in the sense that he never came nearer to pure comedy. Based on *La Précaution inutile* (1657), Paul Scarron's adaptation of a Spanish story, the comedy shows how a man may be so exasperated by feminine coquetterie that he decides to marry a fool. Arnolphe is a pedant, who has thought out a complete scheme and "cooked up" a girl in a convent from the age of four, so that she shall be entirely untrained in the ways of the modern world. The gradual portrayal in Agnès of an awakening temperament, all the stronger for its naïveté and limitations, is one of the marvels of modern comedy. The crowning fantasy is to imagine the pedant falling in love himself, he who had dismissed "all that" as beneath him, and with the person whom he had done his best to make unlovable. He has to eat his words, and his elephantine gropings toward the language of love are his punishment and the spectators' delight. As we shall see, this play aroused much hostility, partly perhaps because men felt that here was an ebullience of comic power for which nothing could expect to be sacrosanct.

**Tartuffe (1664–69).**—When in Molière's own street a hypocrite seduced his landlady, Molière's friends must have felt uneasy about his notion of making a play on that theme, for fear of what the church and the authorities would say. Yet he did make just such a play, and it brought him more trouble and more notoriety than any other. *Tartuffe* was played (in a three-act version now lost) before the king at a Versailles gala in 1664. It seems reasonable to think that it portrayed a pious crook, Tartuffe, so firmly established in a bourgeois household that he can make the master, Orgon, promise him his daughter's hand and disinherit his son in Tartuffe's favour. This went near the bone, for lay directors of conscience were in fact placed in families to reprove and reform manners. The play showed the "holy" man's sensuality tempting him too far, into making love to his employer's wife. Caught in the act, he recovers by masterly self-reproach. Orgon, taken in completely by appearances, not only pardons him but urges him to see his wife as much as possible "pour faire enrager le monde" ("to infuriate people"). Molière must have seen a lot in this theme, for in the final version, as publicly performed in 1669, the play is lengthened to five acts and contains two seduction scenes, and the interest is transferred from the gullible bourgeois to the paradox in Tartuffe himself, outwardly an inhuman ascetic but actually a very human sensualist and glutton. It is difficult to think of a theme more likely to give offense in 17th-century Paris, yet the tenacity with which Molière stuck to his design is matched by the brilliance of dramatic execution. The play seems to exploit another case of the dichotomy discovered in *L'École des femmes*. Arnolphe came to grief because he trusted in wit and forgot instinct. Tartuffe seems to have been imagined on similar lines. It is a recurrent theme, for which Molière seemed to delight to invent new cases.

**Dom Juan, ou le festin de Pierre (1665).**—This play, meant to be a quick money raiser, was a costly failure that had only 15 performances before it was mysteriously removed and never either repeated or published by Molière. It is a priceless example of his art. Dom Juan thinks himself free from all obligation and believes neither in God nor hell nor doctors, nor in the sacredness of promises, yet as an aristocrat assumes that others will keep their obligations to him who acknowledges no obligation. His servant Sganarelle is his opposite in every point, earthy where he is lofty, timorous where he is scornful, superstitious where he is skeptical. They form the perfect French counterpart to Don Quixote and Sancho, yet the play had no success until modern actors showed its power.

**Le Misanthrope (1666).**—By contrast *Le Misanthrope* almost from the beginning was treated as a masterpiece by discerning critics, if not by the general public. It is a drawing-room comedy, constructed from the elements of Molière's own company, with himself in the role of Alceste, the hasty, well-meaning but blind critic of everybody else, the more irritating because he claims the highest motives, and Molière's wife as the flirt Célimène, who is equal to every occasion. The technique of structure is as simple as it is profound and poetic. After railing against humanity, Alceste has to face a fop and give an "honest" opinion on his poem; he is too good-natured to do so at first, then really speaks his mind, with disastrous results. He thinks he has a cast-iron case against Célimène but crumples up at once when it does not go his way. The marvel is that this brilliant pathological sketch of a doctrinaire is so appealing and his increasing moodiness so entertaining. He is always ready to see the mote in another's eye, regardless of the beam in his own, as ignorant of his real nature as Arnolphe, Tartuffe or Dom Juan.

**L'Avare (1668).**—Sooner or later it was inevitable that Molière would attempt a modern rendering of the ancient comic figure of the miser. *L'Avare* is in prose that reads as if the author had wished to turn it into verse; the stock situations are all renewed, and gradually a picture emerges of a man rendered inhuman by love of money. Harpagon's mania is imagined to the point of

cruelty, pathology and insanity, all in breath-taking scenes of great dramatic force. For those who think comedy must cause laughter the play is too stark. Goethe started a bad fashion by calling it tragic. Yet it would seem to be imagined in much the same way as *L'École des femmes* and the other plays often regarded as greater, involving as it does (in differing forms, of course) a basic separation between the forces of mind and intention, devoted to cruel and inhuman ends, and the underlying instincts and human nature, which is not so homogeneous nor so much a servant of the mind as the subject would have it be. In his distress Harpagon becomes human once more, but a pitiful specimen, quite different from what he thought himself to be. There is laughter in this comedy, but it is incidental; the basic comic suggestion is rather absurdity, incongruity, paradox.

**Le Bourgeois gentilhomme (1670).**—That the master's gaiety or imaginative powers were not yet exhausted is proved by *Le Bourgeois gentilhomme*, an apparent exposure of the contemporary desire of the *bourgeoisie* to compete in magnificence with the great nobility, yet perhaps the least dated of all the comedies. The imaginative power is shown in the fact that the comic figure who might have turned out an unpleasant sycophant and climber is in fact delightful, good-natured, fatuous yet naïve and genuine. His nature (which again he despises) gives us more pleasure than his follies which he thinks to be sensible. Molière seems to return here to the vein of comedy that he had exploited in *Les Précieuses ridicules* and in the farces, of imagining fatuity, not only in the bourgeois but in the masters, and pitting it against common sense in the wife and servant.

**Les Femmes savantes (1672).**—As if he recognized the value of such presentation, Molière renewed it 18 months later with *Les Femmes savantes*, which in lesser hands would have been, as some have thought it, a satire on bluestockings, but which becomes the most refreshing comedy with every appearance of the main character, a bourgeois more sensible than his wife but less forceful. The contrast is so delightful that we forget the less pleasant parts of the play and the fact that Trissotin is a cruel caricature of a respected living contemporary, the abbé Charles Cotin.

**Le Malade imaginaire (1673).**—Molière's last play is about a hypochondriac who fears death and doctors. As the fourth performance of it caused his hemorrhage and death, the irony of events has masked or made readers reluctant to probe the irony of the choice of subject. The power of suggestion is still present, in the author's delineation of servitude to jargon and professionalism, in his imagination of fatuity in young Diafoirus (a would-be doctor with some learning but no sense) and in the old but ever fresh opposition of youth and sense (Angélique and Béralde) to superstition and greed and charlatanry (Argan, Béline, Purgon).

## THE ESSENCE OF THE COMEDY

Few great authors can in their lifetime have given so much pleasure to so many people (that is, before the days of cheap editions) as did Molière. This consideration enables us to see in true perspective the hostility that his plays aroused, not only from professional rivals but from public authorities. The writer now acknowledged to be the greatest classical author of France was in his own day decried as impious and unhealthy. The printed attacks on him are almost all without merit; the plays put on the stage against him enjoyed favour only because of the play they were attacking. *Les Précieuses ridicules* provoked *Les Véritables Précieuses* of Antoine Baudeau de Somaize, *Sganarelle* provoked *La Cocue imaginaire* of François Donneau, and *L'École des femmes* raised such a chorus of discussion that Molière joined in with a dramatic reply in *La Critique de l'École des Femmes* and some months later with *L'Impromptu de Versailles*. Both these playlets of his make excellent points, discussing how much should be read into plays, praising the taste of the court and of the pit and breaking a lance for the new realism that demanded recognizable human types in plays rather than the heroic gallant figures of a previous generation. Dorante, in scene 6 of *La Critique*, states that "vous n'avez rien fait, si vous n'y faites reconnaître les gens de votre siècle . . . c'est une étrange entreprise que celle de faire rire les honnêtes gens" ("you haven't achieved anything in comedy unless you give recognizable portraits of contemporary types . . . making decent people laugh is a strange business"); and later in the same scene he makes his famous statement about the rules which some were anxious to impose on all writers for the stage: "Je voudrais bien savoir si la grande règle de toutes les règles n'est pas de plaire et si une pièce de théâtre qui a attrapé son but n'a pas suivi un bon chemin" ("I wonder if the golden rule is not to give pleasure and if a play that achieves its purpose has not been following the right track"). Now that most documents of the controversy over *L'École des femmes* are long since dead, *La Critique* stands as Molière's nearest approach to an exposition of his guiding principles. *L'Impromptu*, no less original an invention, gives not only a charming picture of the manager with his company but the only direct answer that Molière ever made to personal attacks: "Je leur abandonne de bon coeur mes ouvrages, ma figure, mes gestes, mes paroles, mon ton de voix et ma façon de réciter . . . Mais . . . ils me doivent faire la grâce de me laisser le reste . . . voilà toute la réponse qu'ils auront de moi" ("I gladly let them do what they like with my works, my appearance, my gestures, my words, my tone of voice and my way of reciting . . . But . . . they should be kind enough to leave me what remains. That is the only answer that they will get from me").

This restraint and lightness of touch now seem more remarkable than the violence of the attack on *L'École des femmes*, but that attack was a slight thing compared to the storm raised by *Tartufe* and *Dom Juan*. The official condemnations of *Tartufe* in 1665 and the even more savage pamphlets of Pierre Roullé, curé of St. Barthélemy, and B. A. sieur de Rochemont (probably a pseudonym) drew from the poet valuable statements concerning his art. On *Dom Juan* he made no public reply since it was never officially condemned. The documents in defense of *Tartufe* are two *placets* to the king, the preface to the first edition of the play in 1669 (all published under Molière's own name) and the famous *Lettre sur l'Imposteur* of 1667. The *placets* and the preface are aesthetically disappointing, since Molière was forced to fight on the ground chosen by his opponents and to admit that comedy must be didactic. There is no other evidence that Molière thought this, so it is not unfair to assume that he used the argument only when forced. The *Lettre* is much more important. It provides in a few pregnant lines the aesthetic basis, not only of *Tartufe* but of Molière's revolutionary conception of comedy:

> Le ridicule est la forme extérieure et sensible que la providence de la nature a attachée à tout ce qui est déraisonnable, pour nous en apercevoir et pour nous obliger à la fuir. Pour connaître ce ridicule il faut connaître la raison dont il signifie le défaut et voir en quoi elle consiste . . . la disconvenance est l'essence du ridicule . . . il s'ensuit que tout mensonge, déguisement, fourberie, dissimulation, toute apparence différente du fond, enfin toute contrariété entre actions qui procedent d'un même principe, est essentiellement ridicule. ("The ridiculous is the outward and visible form that nature's providence has fixed to all that is contrary to reason, in order to draw our attention to it and to make us avoid it. To appreciate it, we must appreciate that reasonable quality of which it suggests the lack and perceive what constitutes that quality . . . the essence of the ridiculous is incongruity . . . thence it follows that all lying, disguising, cheating, dissimulation, any outward show different from the underlying reality, in short any contradiction between actions arising from the same principle, is essentially ridiculous")

Here surely is the insight which enabled Molière to create something entirely new in comedy. Didactic comedy, satiric comedy, farce, all these were known before his time and none of them are his invention. But the comedy that is only incidentally funny and essentially rests on a constant double vision, of the right and the wrong together, of the normal and the abnormal, of the true and the specious, of the intelligent and the pedantic, this form of the comic is his invention and his glory.

Comedy depends, in Mme de Staël's view, on constant intrusion of the physical into the realm of intellect. Bergson preferred to describe it as the intrusion of the mechanical into the domain of the spontaneous. The mixing of registers, so to speak, which is suggested by both these definitions, is a constant feature of Molière's work that does not emerge in such thumbnail accounts of the chief plays as given above. The wit, the insight, the fun emerge as frequently in the light plays as in the more serious (Diderot

reminds us that a one-act farce is as complex a product of the imagination as *Le Misanthrope*). Characters are made to play a part, then forget it, speak out of turn, overplay their role, so that in all cases the spectator has the delicious suggestion of two registers mixed. Beaten into acting as a doctor, Sganarelle in *Le Médecin malgré lui* not only invents the right sort of jargon, he enjoys it and, to say something, utters inanities about Hippocrates. Overjoyed to find a patient ignorant of Latin so that he can utter further nonsense, he finally comes up to his famous howler of putting the heart on the right instead of the left. Interrupted by a mild protest, he has to keep up his role of scholar with the immortal "Nous avons changé tout cela." Harpagon in *L'Avare*, describing his miserable condition without his money is pathetic: "Mon esprit est trouble et j'ignore où je suis qui je suis et ce que je fais . . . c'en est fait, je n'en puis plus, je me meurs, je suis mort, je suis enterré" ("My mind is disturbed and I don't know where I am, who I am, what I'm doing . . . it's all over, I can stand no more, I'm dying, I'm dead, I'm buried"). His very violence has carried him beyond the rational into the absurd. This is not an accident but the sign of a powerful imagination on the part of the writer who seems untiring in creating cases of this kind. In the same part of the same play, an even more powerfully poetic suggestion comes through Harpagon's incoherence: "Je veux aller quérir la justice et faire donner la question à toute ma maison . . . si l'on ne me fait retrouver mon argent, je demanderai justice de la justice" ("I want to call the law in and have my whole household put to torture . . . if they don't restore my money, I will have the law on the law"). Does Alceste do any more than this in complaining "J'ai pour moi la justice et je perds mon procès" ("I have justice on my side and I lose my case")? What is here imagined? Surely the tendency to confuse social institutions with moral qualities, to think that if we have courts of justice it is scandalous that complete justice is not in our case given.

This insight into human behaviour so French and so inaccessible to others is near the centre of Molière's appeal to his own nation. When Voltaire described him as "le peintre de la France" he was not referring to realism but to French attitudes for which Molière has imagined an immense variety of incarnations. This may be what gives the French an almost "proprietary" interest in Molière: they appear to regard him as "their" author in a curiously possessive way and to feel at home with aspects of his work that others may tend to overlook. Three of these may best close this survey.

First of all is its formality. Molière's public were delighted by the realism and naturalness of his work precisely because they did not expect these things in literature as we do. Drama for them was formal and as far removed from ordinary speech as possible. Much of his work is in fact in verse. Apart from his acting and the provoking of laughter, his public wished to be "charmed" by spectacle, by a fusion of light and colour and movement in which music and dance were as important as speech. Modern productions that omit the *intermèdes* and ballets are far from the original effect. A similar sense of form is in all the comedies in the opposition of characters, the arrangement of scenes and speeches, the comic repartee carried to its conclusion in defiance of realism.

Psychology is now no longer regarded as a governing feature of Molière's work. To speak of him as having created comedy of character, wherein forms of social mania are studied, is an overemphasis of academic criticism. Is the psychology, even in the greater plays, so deep and sound? The French prefer to see them as creations of fantasy, an imaginative and poetic quality that vivifies ideas and attitudes only to drop them and pass on when a point has been taken. *Le Misanthrope* is not usually in France held to be a study of misanthropy or even a French equivalent of *Hamlet* but a subtly arranged chorus, so to speak, of voices and attitudes that illumine the attitude of the individual in society. The play charms by its successive evocation of this single and central theme. To speak your mind is easy when you are annoyed or detached or disapproving or when society has hurt you, and to be frank may be honourable and idealistic, it may equally well be egoistic and self-seeking and rude and spiteful. All centres round a concept; our inability to see ourselves or, as the charming Célimène puts it, "ce grand aveuglement où chacun est de soi." It is in this fantasy playing on the mystery of the self-centred character that Molière is, in the eyes of his own people, unsurpassed.

A third quality admired in France is a kind of intellectual penetration that distinguishes parts of a man from the whole man. Montaigne, to whose thought Molière owed much, has separated "acquired qualities," learning or politeness or professional competence, and "natural qualities," such as self-interest, humanity, animality, what we would often just call "human nature." Conversations in Molière seem designed as crucibles in which the shock of characters and interests makes social veneer peel off. How many dialogues in his plays start with politeness and end with open insults?

The final achievement of Molière's imagination may well be the double vision to which his comic genius led him—the simultaneous presentation of a quality and its opposite, the norm and the aberration, the scandal and the reaction, ingenuity and nature, scheme and reality, principle and practice. Dandin, in *George Dandin* (1668), may well be one of his greatest creations. If taken seriously, then he is a pathetic figure out of place in comedy. But there is never time to take him seriously and indeed for the French *he*, as something in flesh and blood, does not exist, as they see only his emphases, his judgements, his terribly human and typical blunders.

For many people a man is not comic who is so outwitted by a faithless wife as to make him want to drown himself. The French see not a man but a comic attitude, that of expecting that the world will help the honest, and of finding that it inexplicably hits him (or rather us) again and again. This is so, yet it is a scandal to our sense of order. "J'enrage d'avoir tort lorsque j'ai raison" ("It infuriates me to be wrong when I'm right"). The subject is trivial, the intellectual suggestiveness is limitless. A way has been found for comedy to embrace everything, things in the mind and outside it, thanks to the double vision that keeps the contrasting terms both present to the charmed spectator. Things that are not are evoked to illumine things that are. As the hearty Sosie in *Amphitryon* puts it "Cela choque le sens commun. Mais cela ne laisse pas d'être" ("That conflicts with common sense. But it is so, for all that").

*See also* references under "Molière" in the Index.

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(W. G. MR.)

**MOLINA, LUIS DE** (1535–1600), Spanish Jesuit theologian who worked out an original theory of the relationship between divine foreknowledge and human free will, was born into the lower nobility of Spain at Cuenca, Castile, in Sept. 1535. He became a Jesuit at Coimbra (1553), studied philosophy and theology there (1554–62) and at Évora (1562–63), taught philosophy at Coimbra (1563–67) and theology at Évora (1568–83), spent his last years

writing and died in Madrid on Oct. 12, 1600. His works include his celebrated *Concordia liberi arbitrii cum gratiae donis* (1588–89), *Commentaria in primam partem divi Thomae* (1592) and *De iure et iustitia*, six volumes (1593–1609).

Molinism has been a bone of contention between Dominicans (as Thomists) and Jesuits for over three centuries. Molina in his *Concordia* aimed at a unified and coherent conception of divine justice and mercy, foreknowledge and providence, predestination and reprobation, efficacious and sufficient grace, and human freedom. His originality lay in a reformulation of traditional views on divine knowledge to stress the component (called *scientia media*) regarding human choices that not only could but also would occur. The strength of his theory lies in its basic simplicity and coherence, its weakness in the possibility that the shift of attention to hypothetical future choices transposes issues without solving them. *See* MOLINISM.

BIBLIOGRAPHY.—Critical edition of *Concordia* by J. Rabeneck (1953); letters and excerpts ed. by F. Stegmüller, *Geschichte des Molinismus*, vol. i (1935); *see* also J. Rabeneck, "De vita et scriptis Ludovici Molina," *Archivum historicum societatis Iesu*, 19:75–145 (1950); F. Stegmüller, *Zur Literaturgeschichte der Philosophie und Theologie an den Universitäten Evora und Coimbra in XVI. Jahrhundert* (1931). (B. J. F. L.)

**MOLINE**, a city of Rock Island county, northwestern Illinois, U.S., just above the upper rapids of the Mississippi river 167 mi W by S of Chicago. The name was derived apparently from the Spanish word *molino*, meaning "mill." Swedish immigrants played an important part in the settlement of the town, laid out in 1843. John Deere, inventor of an improved steel plow, settled in Moline in 1847 and established a small shop there. With the advantages of a broad agricultural hinterland and exceptional transportation facilities, Moline, sometimes called "The Plow City," was by 1890 a centre of plow production. Farm implement manufacturing, a major industry, is a part of a large industrial complex whose products include heating and ventilating equipment, tools, clothing and furniture. Pop. (1960) 42,705; Davenport–Rock Island–Moline standard metropolitan statistical area (Scott county in Iowa and Rock Island and Henry counties in Illinois) 319,375. For comparative population figures *see* table in ILLINOIS: *Population*. (D. L. A.)

**MOLINET, JEAN** (1435–1507), French poet and chronicler, a leading figure among the Burgundian *rhétoriqueurs* (*see* FRENCH LITERATURE: *15th-Century Prose*), was born at Desvres in the Pas-de-Calais. After studies in Paris he entered (*c.* 1464) the service of Charles the Bold, duke of Burgundy, becoming secretary to Georges Chastellain, chronicler and court poet; on the latter's death he succeeded to this appointment, continuing to hold it from Mary of Burgundy and Philip the Handsome. His duties as chronicler took him far afield to the wars and on the journeys of the court. He died at Valenciennes, Aug. 23, 1507. His writings include a prose version of the *Roman de la Rose*, an *Art de Rhétorique* (1492), mysteries and religious poems, occasional verse and parodies. Molinet was essentially a man of the late middle ages, not of the Renaissance; an incomparable virtuoso with words, he prepared the way for Rabelais.

BIBLIOGRAPHY.—*Les Faicts et dictz de Jean Molinet*, ed. by N. Dupire, 3 vol. (1936–39); *L'Art de rhétorique de Jean Molinet*, ed. by E. Langlois (1890); N. Dupire, *Étude critique des manuscrits éditions des poésies de Jean Molinet* (1932) and *Jean Molinet, la vie, les oeuvres* (1932). (H. G. WH.)

**MOLINISM**, a Roman Catholic theological system which endeavours, by avoiding Pelagianism and the extremes of Augustinianism, to explain the action of divine grace on the human will. It takes its name from Luis de Molina (*q.v.*), whose *Concordia* (1588–89) is primarily concerned with the problem of reconciling grace and free will, while seeking to vindicate the doctrine of the Council of Trent that man's will remains free under the action of divine grace. The inherent difficulty of the problem was not lessened by the ambiguity and obscurity of Molina's style. Even before the *Concordia* was published, it was attacked by theologians who had got wind of its contents and wished to prevent its appearance. Indeed when it finally was published it contained an appendix, prepared by Molina, in answer to the principal objections raised against it. Spain soon rang with the controversy it aroused. Its chief, although by no means only, opponents were Thomist theologians of the Dominican order, especially Domingo Bañez.

Rome soon intervened and set up a special congregation to decide the dispute. The congregation during 1598–1607 held 85 sessions, 68 under Clement VIII and 17 under Paul V, listening to the debate between Jesuit and Dominican theologians. In the end it proved impossible to reach a decision. Both opinions were allowed, but the contending theologians were forbidden to censure each other. A somewhat developed Molinism is still taught in Jesuit and other Catholic schools, while the Thomistic system as developed by Bañez also has its adherents. The Jansenists sharply attacked Molinism.

*See* J. Pohle in *Catholic Encyclopedia*, vol. x, pp. 437–441 (1911); F. Stegmüller (ed.), *Geschichte des Molinismus*, vol. i (1935). (E. A. R.)

**MOLINOS, MIGUEL DE** (1628–1696), Spanish priest, proponent of an extreme Quietism, was born at Muniesa, Aragon, on June 29, 1628. He studied theology at the Jesuit Colegio de San Pablo, Valencia, where he was ordained priest in 1652. Sent to Rome in 1663, he soon became one of the city's most esteemed spiritual directors. There in 1675 he published his *Spiritual Guide*, a small handbook of the contemplative life that was an immediate sensation. Some attacked its doctrine and had their efforts put on the *Index Librorum Prohibitorum*, while those who defended it received ecclesiastical advancement. In 1685, when his influence with the people was at its zenith, his favour in ecclesiastical circles most marked and his friend Innocent XI was pope, Molinos was arrested by the papal police, tried and eventually sentenced to life imprisonment for heresy.

The occasion of this sudden reversal of opinion would appear to have been the discovery of his personal immorality, which in turn revealed what had previously remained hidden (perhaps even from himself): the antinomian implications of his doctrine (*see* ANTINOMIANISM). In the "Summation" of his trial he is found defending his own and his followers' sexual aberrations as sinless purifying acts, which, effected by the devil and passively permitted by the truly interior Christian, providentially deepen such a one's quiet repose in God. But as the doctrinal propositions, chiefly from his correspondence, were successively brought forward, his moral sense seems to have been jarred into life once more. He admitted that he had been wrong and offered no further defense. He died in prison at Rome on Dec. 28, 1696.

Ambiguities and misapprehensions long attended the historical evaluation of Molinos, chiefly because in the *Guide*, his only work generally known, doctrines which brought about his condemnation are not to be found; it evidences at most a speculative climate not unfavourable to their origin and development. *See* also QUIETISM.

BIBLIOGRAPHY.—The "Summation" is preserved in the Vallicellian Library, Rome (Ms. P 180). For the 283 propositions considered at the trial, see *Analecta Iuris Pontifici*, vol. x, cols. 570–594 (1868–69) and for the sentence of the Inquisition, vol. vi, cols. 1633–49 (1865); for the condemnation by Innocent XI, J. de Guibert, *Documenta Ecclesiastica*, pp. 269–288 (1931). Other relevant documentation is given in P. Dudon, *Le Quiétiste espagnole Michel Molinos* (1921). *See* also M. Petrocchi, *Il quietismo italiano del Seicento* (1948); R. A. Knox, *Enthusiasm*, pp. 295–318 (1950). An incomplete English version of the *Guide*, edited in 1906 by K. Littleton, is frequently reprinted. Molinos' letters are in the archives of the Holy Office. (E. O'B.)

**MØLLER, POUL MARTIN** (1794–1838), Danish author whose novel of student life heralded a new realistic approach and so marked an important stage in the history of Danish literature, was born near Nakskov on March 21, 1794. After taking a degree in divinity at Copenhagen, he began his literary career by translating Homer. To recover from a broken engagement, he went to China as a chaplain on a Danish ship (1819–21); the literary results were some journals, a number of *Strøtanker* ("Aphorisms"), nostalgic poems about Denmark and Copenhagen (*e.g.*, "Scener i Rosenborg Slotshave") and a witty parody of statistical-topographical descriptions, *Laegdsgaarden i Olsebymagle*. He had already shown gifts as a poet in both humorous and melancholy moods (*e.g.*, "Torbisten og Fluen" and "Aprilvise"), and as a prose-writer in *Eyvind Skaldaspiller*, a saga pastiche. After his return he earned his living by teaching classics, while studying philosophy

Møller first read his most famous work, *En dansk Students Eventyr*, a *novelle* originally planned as a historical novel in the manner of Sir Walter Scott but in its final (though fragmentary) form describing contemporary student life, to the students' union at Copenhagen in 1824. His own character is reflected in the three main characters: Curly Frits, the irresponsible idler; the pedantic Magister; and the antiromantic Bertel. *Blade af Dødens Dagbog* ("Leaves From Death's Diary"), a poetic fragment inspired by Byron, and other sketches such as his witty essay "Quindelighed," demonstrate both his mastery of style and his lack of energy to complete anything. Møller was lecturer in philosophy at Christiana (Oslo) university from 1826 to 1828, when he became professor, and from 1831 he held the chair of philosophy at Copenhagen, where he died on March 13, 1838. Among his students was Søren Kierkegaard (*q.v.*), who much admired him.

The most important of Møller's later works, apart from several philosophical essays, is the poem *Kunstneren mellem Oprørerne*, advocating the artist's freedom from political commitments. Møller's realistic approach to literature in a romantic age may be summed up in his aphorism: "All poetry that does not come from life is a lie."

BIBLIOGRAPHY.—*Efterladte Skrifter*, ed. by F. C. Olsen, 6 vol. (1855–56); *Udvalgte Skrifter*, ed. by V. Andersen, 2 vol. (1930); V. Andersen, *Poul Martin Møller, hans Liv og Skrifter* (1894). (E. L. Br.)

**MOLLET, GUY** (1905– ), French Socialist who served as premier of France in 1956–57, was born at Flers-del-l'Orne on Dec. 31, 1905. Orphaned during World War I he studied with the help of public grants, joined the Socialist party in 1921 and was teaching English at the Arras *lycée* when, in 1939, he was elected secretary of the Fédération de l'Enseignement, a Socialist teachers' trade union. After serving in the army and in the Resistance during World War II, he was elected mayor of Arras and deputy for Pas-de-Calais in 1945. He was minister of state in Leon Blum's Socialist cabinet (Dec. 1946–Jan. 1947).

As secretary-general of the Socialist party from Sept. 1946, Mollet strengthened the authority of the party machine over the parliamentary group. At first he opposed the party's participation in coalitions without the Communists, but by 1950 he supported it. He was minister of state dealing with the Council of Europe from July 1950 to July 1951. With Pierre Mendès-France he led the left-centre Republican front in the election of Jan. 1956 and was premier from then to May 21, 1957. His government—the longest of the fourth republic—failed to deal effectively with Algeria and was chiefly responsible for the Anglo-French intervention in the Israeli-Egyptian fighting in Oct.–Nov. 1956. He became minister of state under Pierre Pflimlin on May 13, 1958. Having helped to ensure that Gen. Charles de Gaulle's return to power was by constitutional means, he retained his post in De Gaulle's cabinet (June 1958–Jan. 1959). His support for De Gaulle was endorsed by the Socialist party in a stormy congress in Sept. 1958, when the party split. (P. W. C.)

**MOLLIEN, NICOLAS FRANÇOIS,** COMTE (1758–1850), one of Napoleon I's chief advisers on financial matters, was born at Rouen on Feb. 28, 1758. Having worked in the office of the farmers-general of the taxes from 1775, he joined the office controlling their activities in 1781; and it was he who drew up the contract of 1786 whereby their payments to the royal treasury were increased. During the Revolution he was appointed to Evreux to be director of domains for the *département* of Eure in 1791 but was dismissed in 1792 and was imprisoned for five months in 1794. Napoleon Bonaparte, however, made Mollien administrator of the sinking fund in Nov. 1799 and director general of it in July 1801. Under the empire, Mollien was minister of the public treasury from Jan. 1806 to April 1814 and during the Hundred Days in 1815; he reorganized its administration and introduced double-entry bookkeeping. Napoleon, who created him comte in 1808, frequently consulted him but did not always follow his advice. Even so, notwithstanding his own assertions in his *Mémoires*, Mollien did not criticize Napoleon's "continental system" or the sinking fund's purchase of government stocks in order to maintain their price artificially.

After the second Restoration, Mollien retired (July 1815). He refused the offer of the ministry of finance in 1818 but accepted a peerage. Subsequently he sponsored reports on financial questions in the chamber of peers. He published his *Mémoires d'un ministre du trésor public 1780–1815* in 1845 (new ed., 3 vol., 1898). Mollien died in Paris on April 20, 1850.

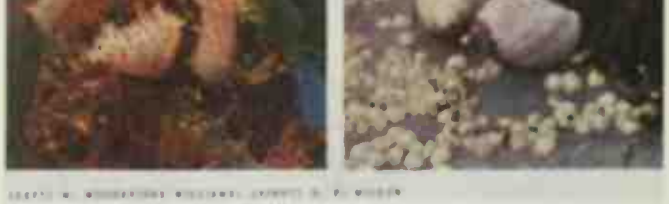
BIBLIOGRAPHY.—N. A. Salvandy, *Mollien* (1851); A. G. P. de Barante, *Études historiques et biographiques* (1857); L. de Lanzac de Laborie, *Paris sous Napoléon*, vol. vi (1910). (C. E. Dr.)

**MOLLUSK,** any member of the invertebrate phylum Mollusca, one of the largest and most important divisions of the animal kingdom. It includes such groups as the gastropods (snails, slugs), pelecypods or bivalves (clams, oysters, mussels), scaphopods (tooth or tusk shells), cephalopods (squids, octopuses, nautiluses) and amphineurans (including chitons). The phylum comprises six classes containing more than 100,000 living species and an even greater number of fossil forms. Mollusks range in size from snails little larger than a grain of sand to giant squids measuring more than 15 m. (60 ft.) from the tip of the extended arms to the end of the tail. Clams range from only a fraction of an ounce to more than 500 lb. (the giant clam, *Tridacna gigas*).

## GENERAL FEATURES

**Importance.**—Mollusks have always been of great interest and importance to man because of their use as food, as tools and utensils by primitive man and as ornaments, money or religious emblems. They are also important as intermediate hosts of trematode parasites that cause serious diseases in man, his domesticated animals and other vertebrates. Shipworms, which bore into wooden vessels or pilings, and bivalves, which foul the bottoms of ships and buoys, are of great concern to fishermen, shipping companies and navies of the world. Industries that use sea water in the cooling systems of plants are also concerned with mussels and other fouling mollusks; the free-swimming larval forms are carried into the intake tunnel with the circulating water and many settle out on the walls, where they become attached, grow rapidly and soon restrict the flow of water. The European fresh-water clam *Dreissena* may do a great deal of damage in clogging water systems. Millions of dollars have been spent annually to solve the problem of fouling mollusks and to develop and produce effective antifouling paints. Mollusks are important to the oil geologist and paleontologist as index fossils and are one of the organisms most often used in carbon dating. They are an aid to anthropologists in tracing the trade routes of primitive peoples who fed on the animals and used the shells as money. Shells are also of interest to collectors and are an important part of the tourist trade in some seaside areas. (*See* also SHELLS AND SHELL COLLECTING; CURRENCY, PRIMITIVE.)

**Habitat and Distribution.**—Mollusks are an extremely adaptable, hardy group of animals that have radiated into nearly all types of habitats—marine, land and fresh water. They range from the greatest depths of the ocean to the tops of high mountains in the tropics. They are found in deserts and tropical rain forests



GASTROPODA OF WIDELY DIVERGENT FORM AND HABITS. (LEFT) CLOWN SEA SLUGS (TRIOPHA CARPENTERI). THESE BRIGHTLY COLOURED SOFT BODIED NUDIBRANCHS LIVE IN TIDE POOLS AND FEED ON SEAWEED AND OTHER PLANTS. (RIGHT) TWO DOG WHELKS (NUCELLA LAPILLUS), BORDERED ABOVE BY MUSSELS (BIVALVIA) AND BELOW BY ACORN BARNACLES (OF AN ENTIRELY DIFFERENT CLASS, CRUSTACEA) ARE SHOWN COMPLETELY EXPOSED AT LOW TIDE. THESE SNAILS FEED ON BARNACLES, CLAMS AND OTHER SNAILS

and in nearly all fresh-water habitats. Land and fresh-water mollusks are more abundant in areas rich in limestone, the raw material for building their calcareous shells. Of the six classes, the Cephalopoda, with the most highly developed nervous, digestive and reproductive systems, are restricted to the marine habitat, probably by some factor in their physiology. The Amphineura and Scaphopoda are entirely marine. The Gastropoda are the most versatile; they are equally abundant in the sea, in fresh water and on land, the land forms having evolved a pulmonary cavity that allows them to breath air. The Pelecypoda are restricted to an aquatic habitat by their method of feeding and respiration, but they have been very successful in invading fresh water. Living Monoplacophora are known only from the great depths of the ocean, though the fossil record indicates that at one time they were abundant in the littoral zone.

Some mollusks are truly pelagic, living their entire lives as free-swimming organisms in the sea. The most important of these are the squids and the sea butterflies (slugs). The greatest abundance of marine forms occurs in the littoral zone, usually at or just below the low-tide line, where there is an abundance of food and the animals are not exposed to the air. Bivalves occurring in the intertidal zone are either deep burrowers that can retreat to the bottom of their burrows during low tide or can close their valves tightly to prevent drying while exposed. Snails living in the intertidal zone are usually forms that have an operculum or plug to close the aperture of the shell during exposure.

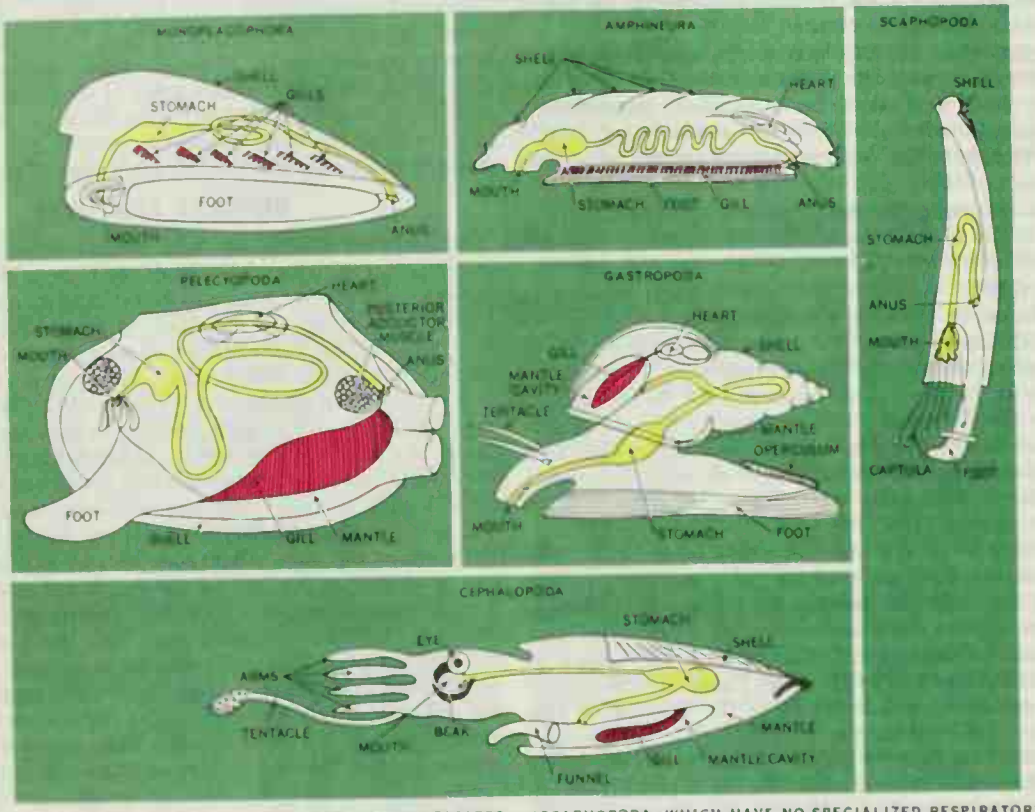



FIG. 1—BODY PLANS OF THE SIX CLASSES OF MOLLUSKS. RED INDICATES THE RESPIRATORY SYSTEM, YELLOW INDICATES THE DIGESTIVE TRACT (SCAPHOPODA, WHICH HAVE NO SPECIALIZED RESPIRATORY SYSTEM, RESPIRE DIRECTLY THROUGH THE FLESHY MANTLE)

MARINE SNAILS (GASTROPODA) THAT APPEAR TO BE TOO LARGE FOR THEIR SHELLS. (LEFT) MOON SNAIL (POLINICES LEWISII) AVERAGES MORE THAN 4 IN. LONG. THE FLESHY FOOT, WHICH "BULLDOZES" THROUGH SAND SEARCHING FOR FOOD, PRACTICALLY ENVELOPES THE GLOBULAR SHELL. (RIGHT) THIS GIANT KEYHOLE LIMPET (MEGATHURA CRENULATA), 7 IN. LONG, HAS A VELVETY BLACK MANTLE WHICH PARTLY COVERS ITS OVAL SHELL. HOLE AT CENTRE OF FULLY FORMED SHELL BEGINS AS A NOTCH IN THE SHELL OF THE IMMATURE LIMPET. AS THE LIMPET AGES, CALCAREOUS SHELL SUBSTANCE IS ADDED IN CONCENTRIC CIRCLES. A LIMPET'S FOOT IS LIKE A LIVING SUCTION CUP BY WHICH THE ANIMAL CAN CLING TENACIOUSLY TO A ROCK OR OTHER SMOOTH SURFACE, REPUTEDLY MORE TIGHTLY THAN ANY OTHER ANIMAL

They remain quiescent during low tide and resume feeding with the return of the sea. Few mollusks are found living in the intertidal zone in high latitudes because of the scouring action of winter ice. Those that are found are usually the young of forms with pelagic larval stages. The free-swimming young are carried in by currents in the early spring and grow throughout the summer, only to be destroyed by the winter ice. A few forms migrate to deep water with the coming of winter. Fresh-water mollusks living in cold temperate and subarctic regions generally burrow into the mud or move out into deeper water at the time of the fall overturn and the arrival of cold weather. They are generally rare or lacking in shallow, rapidly flowing streams in such areas; the turmoil that results from the breakup of the ice in the spring would crush their relatively delicate shells. During periods of drought fresh-water mollusks, both bivalves and gastropods, retreat with the dropping of the water in lakes and streams. In areas of extreme drought, as occur in Africa and Australia, these forms burrow into mud and remain quiescent for long periods until the return of the water. Land shells in high latitudes seek protection by burrowing into the ground with the coming of fall. In desert areas they may secrete themselves under rocks, bury themselves in the ground or fasten themselves to the trunks of trees or rocks by means of a limy mucus that they produce. Some land snails may estivate for several years under such conditions of drought; with the coming of rain they immediately become active, feeding voraciously and breeding.

## STRUCTURE AND FUNCTION

**Basic Body Plan.**—The word "mollusca" or "mollusk" comes from the Latin *molluscus*, meaning "soft," and refers to the soft body of the animal, which is generally enclosed in a protective shell. Until the discovery in the 1950s of *Neopilina galatheae*, a living species of Monoplacophora (*q.v.*), mollusks were also characterized as being unsegmented, but in this rare deep-sea group the organs such as gills, muscles and kidneys (nephridia) are serially arranged in pairs. In all other classes there is only a single pair of each organ and in some groups only one member of each organ is present. All mollusks have a mantle, a thin cape or covering that hangs over the dorsal surface of the body and that secretes the shell. Though a similar organ is also found in the phylum Brachiopoda (the lamp shells), it is quite different in structure from that of the mollusks, and the two lobes of the brachiopod mantle are dorsal and ventral rather than left and right as in the bivalve mollusks. In most mollusks the mantle cavity, the space between the mantle and the visceral mass and foot, contains the gills, but in the land mollusks this space is modified as a pulmonary cavity, which is supplied with numerous blood vessels and functions as a lung. The foot of the mollusks is typically a broad, flat, muscular organ, developed for creeping or plowing. In some forms, however, it is used as a swimming organ, and in the octopus and squid it is modified as tentacles used in securing prey. All appendages of mollusks are soft, lacking internal supporting structures, and they are never segmented.

Mollusks are bilaterally symmetrical, at least in the early stages of development, and in all classes except the gastropods the digestive tract is straight or curved, with the mouth at one end and the anus at the other. The snails are bilaterally symmetrical in the early larval stages, but as the shell develops, the soft parts become strongly displaced so that the mouth and anus are brought close together. Then the portion posterior to the head is twisted in 180° so that the anus comes to lie over the head and generally one of each of the paired organs is lost. The remaining organs are coiled to fit into a spirally coiled shell (*see* SNAIL).

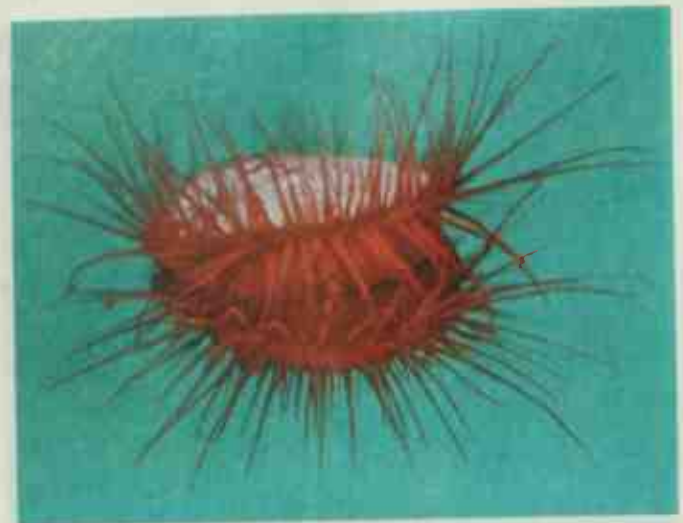
A radula, or rasping, tonguelike organ used in feeding, is present in the forward part of the mouth in all classes except the bivalves. The radula is a long, filelike protrusible chitinous ribbon on which are numerous transverse rows of teeth. By a slight upward sweeping motion of the radula the mollusk can rasp particles of food and carry them into the mouth.

The reproductive system may be relatively simple, as in the chitons, clams and some of the lower gastropods, or highly complicated, as in the land snails and the squids. The fertilized eggs

A COMMON SEA SLUG (HERMISSENDA CRASSICORNIS) OF THE AMERICAN PACIFIC COAST ATTACHING A SPIRAL RIBBON OF EGGS TO SEA GRASS. THE COLOURFUL FLESHY PLUMES SERVE AS RESPIRATORY ORGANS

in all groups except the cephalopods develop into a trochophore; in the scaphopods, pelecypods and gastropods the trochophore is followed by a second larval stage known as the veliger. Both these larval forms may be free swimming or passed within the egg capsule or protective gelatinous mass in which the eggs may be produced. Some land and fresh-water snails produce eggs with a calcareous shell that may be laid in the ground, attached to twigs or rocks, or may be held within the body of the parent until the young are fully developed and emerge as crawling snails. The trochophore is also found in other phyla including the Annelida (segmented worms), but the veliger stage occurs only in the Mollusca.

**Shell and Mantle.**—All mollusks have a mantle and most have a shell in the adult stage, though it may be reduced or internal. The shell and the mantle are so closely associated that in reality they are but a single organ; the mantle produces the shell. The mantle is a thin membranous fold of tissue covering the dorsal surface of the body like a tent, but in some forms, such as the tusk shells and many bivalves, the ventral margins are united to form a tube. Although the mantle secretes the shell, it is not attached to it except at a single point or a few points, depending on the group. In many of the gastropods the mantle is attached only in the region of the columella muscle and can move freely over the inner surface of the shell, allowing the animal to retreat well within for protection. In many bivalves the mantle is attached



(LEFT) MARINELAND OF FLORIDA; (RIGHT) RALPH BUCHSBAUM

SWIMMING CLAMS (BIVALVIA): (LEFT) FILE SHELL (LIMA SCABRA). SO-CALLED FROM THE RASPLIKE SURFACE OF ITS SHELLS. A DOUBLE FRINGE OF LONG SLENDER, RED SENSORY TENTACLES, EXTENDING FROM THE EDGE OF THE MANTLE, HIDES THE EYES. THE TENTACLES ARE CONTRACTILE BUT CANNOT BE COMPLETELY WITHDRAWN INTO THE SHELL; (RIGHT) QUEEN SCALLOP (CHLAMYS OPERCULARIS) DISPLAYS A ROW OF BLACK-PIGMENTED EYES ALTERNATING WITH DELICATE TENTACLES ALONG LOWER MANTLE WHEN MENACED. THE SCALLOP REVERSES ITS PATTERN OF SWIMMING AND PROCEEDS AT HIGH SPEED WITH HINGE IN ADVANCE, USUALLY OUTSWIMMING ITS ASSAILANT

to the shell along a line well in from the ventral margin of the shell, extending from the anterior to the posterior adductor muscles. This arrangement allows the clam to retract the edge of the mantle and close the valves.

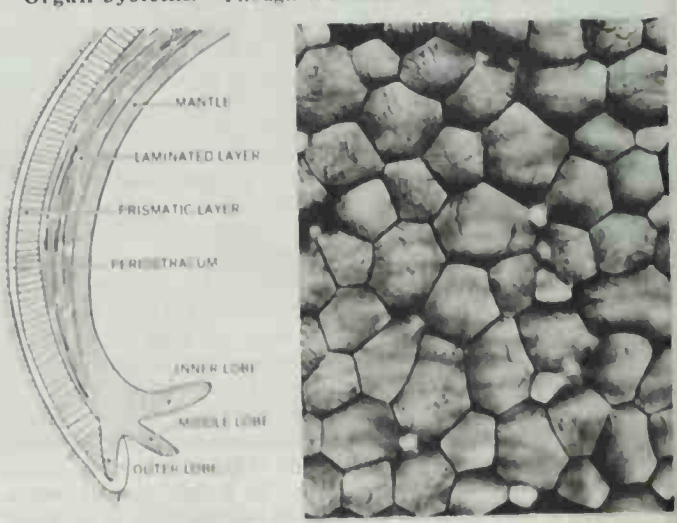
The outer edge of the mantle is generally muscular, and is typically composed of two or three lobes. The shell is composed of mineral salts, mainly calcium carbonate with traces of calcium phosphate and magnesium carbonate, which are laid down in a framework of conchiolin. The outer surface of the shell is generally covered by periostracum, an organic nitrogenous, chitinlike substance that may vary greatly in thickness and may be smooth, scaly or hairy. It is produced in a groove between the outer and middle lobes of the mantle edge and serves to protect the shell from acids in the environment. The outer lobe of the mantle edge secretes the prismatic layer, which lies beneath the periostracum. It is composed of crystals that are produced generally at right angles to the surface of the shell. The inner laminated layer is secreted by the entire surface of the mantle and is composed of overlapping plates of crystals that parallel the outer surface of the shell. This layer in the lower groups of bivalves and gastropods is usually nacreous, or pearly, and highly iridescent.

The shell increases in size by the addition of prismatic cells to the growing edge, the lip of gastropods or the ventral margin of bivalves. It increases in thickness by the addition of laminated layers to the inner surface of the shell. If the shell is injured in any way or if a foreign object becomes wedged between the mantle and the shell, a mollusk can quickly repair the damage by producing shelly material when the need arises; the breaks are repaired or the foreign object entombed by secretions from the mantle in a short time (*see* PEARL).

In the various groups of mollusks different layers of the shell predominate. In the majority of bivalves the laminated layer is very thick, but in the Pinnidae (the pen shells) the laminated layer is greatly reduced, both in area and thickness, and the shell is composed almost entirely of prismatic material. The large land snails of the genus *Paryphanta* of New Zealand have shells composed almost entirely of periostracum. This is also true of many small North American land and fresh-water snails, particularly those living in areas low in limestone. Some mollusks, such as the cowries and olive shells and those with internal shells, lack the periostracal layer, and in many groups this layer is very thin. Colour may be deposited in all three layers of the shell. Though the periostracum usually ranges from light yellow to blackish-brown, it may be more highly coloured in some land snails. The prismatic layer is colourful in many forms, and it is in this layer that all colour patterns are produced. The inner laminated layer, when coloured, is usually uniform or irregularly mottled. In the lower forms of gastropods and bivalves that have a pearly or nacreous laminated layer, additional iridescent colours result from the physical structure of the shell.

The mantle, in addition to secreting the shell, functions in many other ways. Its inner surface, particularly in bivalves, is lined with cilia that aid in creating water currents important in respiration and feeding. Some marine groups have a mantle outgrowth that functions as a gill, and in land shells the mantle cavity is well supplied with blood vessels and functions as a lung. The muscular inner lobe of the edge of the mantle (also called a velum) often controls the flow of water into the mantle cavity; in scallops it is highly developed and used in swimming. The middle lobe of the mantle edge in bivalves and many gastropods is sensory and is often supplied with fine tentacles and in scallops with bead-like mantle eyes. The mantle forms the siphons of bivalves and, depending on the number of lobes of the mantle involved, the siphons may or may not be covered with periostracum. Many gastropods have a long siphonal canal, an outgrowth of the mantle, which may be held well above the surface on which the snail is crawling.

**Organ Systems.**—Though the shells of the six classes of mol-




(RIGHT) BY COURTESY OF MOLLUSK DEPARTMENT, MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY

FIG. 2.—SHELL STRUCTURE. (LEFT) DIAGRAM OF PARTS OF A BIVALVE MANTLE AND SHELL; (RIGHT) CROSS SECTION OF PRISMATIC LAYER OF A PEN SHELL (PINNA CARNEA) SHOWING CRYSTALS AND CONCHIOLIN NETWORK

lusks vary a great deal, and there appears to be little in common between a chiton and a bivalve or between a gastropod and a squid, the anatomy of the soft parts is more basic, only a general account of which is given here.

*Respiratory and Circulatory Systems.*—Respiration in most marine groups is by means of gills that lie in the mantle cavity or in a groove between the mantle and the foot. The gills, composed of numerous connecting tubular filaments that may be strengthened by chitinous rods, are bathed by fresh, well-oxygenated water brought into the mantle cavity and directed by ciliary currents over the gills. The blood circulates through the tubes of the gill filaments, where the oxygen-carbon dioxide gas exchange takes place. In air-breathing land snails the mantle cavity is lined with a network of blood vessels. In all mollusks the entire body surface also functions in respiration; some, such as the scaphopods, breathe exclusively by this means.

The blood of mollusks is usually colourless, but the pigments hemoglobin and hemocyanin occur in some groups, particularly those adapted to water low in oxygen. The heart is well developed in all groups except the scaphopods and is usually composed of a muscular ventricle and one or two auricles enclosed in a pericardial cavity. The blood is carried from the ventricle of the heart through the anterior and posterior aortas to all parts of the body. It returns from the gills to the auricles. The system, however, is only partially closed, for in all classes except the cephalopods there are open blood sinuses among the organs. The kidneys generally open internally into the pericardial cavity and externally in the mantle cavity.

*Digestive System.*—This system is composed basically of a mouth with a radula in all classes except the bivalves; a short esophagus; a stomach that may be very complicated, particularly in the bivalves and some gastropods; and simple nonmuscular intestine. The liver is the most important digestive gland, but in many groups other digestive glands occur. A crystalline style is found in most bivalves and in a few gastropods, mollusks that feed on phytoplankton or larger aquatic plants. This structure is a gelatinous rod found in the forward part of the intestine or in a special style sac that opens into the stomach. The style extends into the stomach, where it is rotated by means of cilia against a style plate and is slowly worn away, releasing a digestive enzyme, amylase, for the digestion of starch. This slow, constant release of a digestive enzyme is a perfect adaptation for animals that feed constantly on plants. Carnivorous forms generally have less complicated stomachs and shorter intestines. Their digestive glands produce enzymes for the breakdown of proteins. The glands of the more omnivorous feeders may produce a variety of digestive enzymes. Digestion is mainly extracellular, but in some of the lower forms, in which particles of food may also be engulfed by amoeboid cells, digestion takes place intracellularly.

*Nervous System.*—The molluscan nervous system is relatively simple except in the cephalopods (*see* CEPHALOPODA). In the lower forms a nerve ring surrounds the esophagus, and joins the ganglia in the viscera and the foot by means of long nerve commissures. In the higher groups of gastropods the ganglia are all concentrated in the large circumesophageal ring, the nerves emanating from this to all parts of the body. The simple eyes of scallops are sensitive to changes in light intensity; most bivalves have tentacles and filaments on the mantle edge and siphons that are sensitive to touch. Many of the bivalves and gastropods have an additional organ, the osphradium, the function of which is not clearly understood but may be to detect changes in the condition of the water. True eyes are found only in the gastropods and the cephalopods. The eyes of snails are poor, being able to detect little more than changes in light intensity. Those of the squids are highly developed and perhaps as efficient as the eyes of man.

*Reproductive System.*—In the lower forms the sexes are separate and the gonads simple. In some cases eggs and sperm are ejected separately into the water and fertilization takes place externally, where the sperm are carried into the mantle cavity of the female by water currents fertilization is internal. Forms that have such haphazard means of fertilizing their eggs and that provide little or no protection for the developing young produce thousands or even millions of eggs. In the more highly developed marine and fresh-water prosobranch snails a male intromittent organ or penis is developed and the eggs are always fertilized internally. Such groups usually produce the eggs in a protective gelatinous mass, in egg capsules, or retain them within the body of the parent until development is nearly complete; a few groups are ovoviviparous. The pulmonate snails are all hermaphroditic, a single individual having a complete set of both male and female organs. They are capable of self-fertilization but under normal conditions cross-fertilization usually takes place. The system in the higher pulmonate groups is complicated by the addition of many accessory organs. In many gastropods and most cephalopods there is some form of courtship.

## CLASSIFICATION AND RELATIONSHIPS

Mollusks are grouped into six classes on the basis of the type of shell, the number and arrangement of the various organs, the type of foot, the method of feeding and the embryology.

The following taxonomic outline of the phylum Mollusca is one in general use:

Class Monoplacophora
" Amphineura
" Scaphopoda
" Bivalvia or Pelecypoda
" Gastropoda
" Cephalopoda

**Monoplacophora.**—These are bilaterally symmetrical mollusks having a simple cap-shaped shell with the apex central or pointed forward. The head region is poorly defined, lacking eyes and tentacles. The mouth, which has labial palps and a radula, is anterior; the anus is posterior and there is no flexure of the system. The gills, nephridia, muscles and reproductive organs are serially arranged in pairs. The foot is large and flat with a muscular rim. The heart is posterior. The sexes are separate. The developmental stages are unknown but there is probably only a trochophore. Only three living species of this class are known, from the great depths in the eastern Pacific. Fossil forms are known from the Cambrian to the Jurassic. (*See* MONOPLACOPHORA.)

**Amphineura.**—These are elongate, bilaterally symmetrical animals that lack shells or have a shell composed of eight transverse plates. The digestive tract is simple, having an anterior mouth and posterior anus, with no flexure or torsion. The head region is poorly developed, lacking eyes and tentacles, but a well-developed radula is usually present. There is no segmentation of the soft parts. The heart is posterior and dorsal. The sexes are separate. The eggs develop into a trochophore but there is no veliger stage.

CHITONS (*CRYPTOCHITON STELLERI*) AND TWO BLACK ABALONE (*HALIOTIS CRACHERODII*) SHARE ROCK IN INTERTIDAL ZONE. A CHITON MAY SPEND ITS ENTIRE LIFE ON ONE ROCK OR MAY RETURN TO THE SAME ROCK WHEN NOT FORAGING FOR ALGAE. LIKE CHITONS, BLACK ABALONE FEED ON MICROSCOPIC PLANTS (IN CONTRAST TO LARGER FARE TAKEN BY RED OR GREEN ABALONE)

Chitons are entirely marine, ranging from the intertidal zone to deep water; they are known from the Cambrian.

The class is divided into two subclasses (which are sometimes given class rank) on the presence or absence of a shell. The subclass Aplacophora contains wormlike animals in which the foot is rudimentary and the mantle covers most of the animal and is embedded with calcareous spicules. The radula is reduced or lacking. Aplacophorans usually are found in moderate depths. They may be free living, commensal or parasitic. None of this subclass is known as fossil. The second subclass, the Polyplacophora, the chitons or coat-of-mail shells, have the shell consisting of eight transverse plates surrounded by a girdle. The foot is large and muscular, extending nearly the length of the animal. They are known from the Upper Cambrian. (*See* AMPHINEURA.)

**Scaphopoda.**—Commonly known as tusk shells, elephant's tusks or tooth shells, these bilaterally symmetrical mollusks have the shell tubular, open at both ends, the smaller end being posterior. The mantle is united on the ventral margin to form a tube and is fastened to the shell at the posterior end. There is no true head; the mouth is at the end of a snoutlike projection and is surrounded by contractile and prehensile filaments called captacula, which are used for catching food. There are a well-developed radula and jaws. The digestive tract is simple and bow shaped. There are no gills and respiration is carried on over the entire surface of the body. The circulatory system is poorly developed, lacking definite blood vessels and a heart. The foot is variable but is usually pointed or boat-shaped. The sexes are separate. The eggs develop into trochophore and veliger larvae. Tusk shells are entirely marine, ranging from shallow to very deep water, usually living partially buried in the mud, though one species is known to cement itself to bottom detritus. Scaphopods are known from the Ordovician to the Recent period, though they are believed to have existed as early as the Cambrian. (*See* SCAPHOPODA.)

**Bivalvia.**—These mollusks, also known as Lamellibranchia or Pelecypoda, are commonly referred to as bivalves or clams. They are bilaterally symmetrical, having the shell composed of two valves hinged at the dorsal margin and usually held together by a ligament. The foot is usually hatchet-shaped, capable of considerable extension and developed for digging or plowing. The head region is poorly developed, lacking eyes, tentacles and radula, but having labial palps. Respiration is by means of gills and feeding by means of cilia and mucus. The sexes are generally separate; fertilization is external or takes place in the mantle cavity.

The eggs develop into trochophore and veliger larvae. There are marine and fresh-water forms. Restricted to an aquatic habitat by their method of feeding, bivalves may be found from the intertidal zone to great depths. They are abundant as fossils and are known as far back as the Cambrian. (*See* BIVALVE.)

**Gastropoda.**—Commonly known as snails, these are asymmetrical mollusks characterized by having a univalve shell (sometimes greatly reduced or lacking) that may be variously shaped but is usually spirally coiled. In the single case of the family Juliidae the shell is bivalve in the adult. The foot is usually developed as a creeping organ. The head region is well developed, having eyes and tentacles. The mouth has a radula and often jaws. Respiration is by means of gills, a pallial outgrowth or pulmonary cavity. Sexes may be separate or united. Fertilization is internal except in a very few lower forms, and an intromittent organ is present in the male in most species. The eggs develop into trochophore and veliger larvae, which may be free swimming, enclosed within a protective covering or retained within the body of the parent. Gastropods are known as far back as the Cambrian and the fossil record of the marine prosobranchs is very rich. (*See* SNAIL.)

**Cephalopoda.**—This class includes such well-known forms as octopuses, squids and nautiluses, the most highly developed of all invertebrate animals. They are bilaterally symmetrical. The head region is well developed, with the ganglia concentrated in a brain. The eyes are highly developed and efficient sense organs. The mouth is surrounded by tentacles and arms, modifications of the foot, and is provided with powerful beaks or jaws and a strong radula. The mantle in most forms is thick and muscular and surrounds the animal; the funnel in conjunction with the mantle controls the flow of water through the mantle cavity. The propulsive activity of the funnel and the fins are used in swimming. The shell is reduced and internal or lacking in all living forms except *Nautilus*. Respiration is by means of gills. The circulatory system is highly developed, with a complete, closed system in most forms. The sexes are separate and development is direct. There

LAND SNAILS. (LEFT) GARDEN SNAIL (CEPAEA HORTENSIS) WHICH, WHEN THREATENED, USES ITS SHELL FOR PROTECTION BY RETREATING COMPLETELY WITHIN. (RIGHT) GARDEN SLUG (LIMAX), WHICH INSTEAD SPITS MILKY MUCUS INTO THE PATH OF ONCOMING PREDATOR. MOST LAND SNAILS AND SLUGS HAVE WELL-DEVELOPED HEAD REGIONS WITH A PAIR OF RETRACTILE TENTACLES, EACH OF WHICH BEARS AN EYE AT ITS TIP. IF A TENTACLE IS CUT OFF, THE MOLLUSK CAN GROW ANOTHER ONE. FEEDING MAINLY ON VEGETATION AND LEAVING A TRAIL OF MUCUS WHEREVER THEY GO, LAND SNAILS AND SLUGS LIVE IN DIMLY LIGHTED, MOIST PLACES, COMING OUT TO FEED USUALLY AT NIGHT AND ON OVERCAST DAYS

MARINELAND OF FLORIDA

AMERICAN SQUID (LOLIGO PEALEI) FOUND IN SCHOOLS ALONG THE ATLANTIC COAST. THE ELONGATED BODY WITH HORIZONTAL MUSCULAR FINS ENABLES THIS SHELL-LESS MOLLUSK TO SWIM BACKWARD OR FORWARD OR TO TURN SHARPLY AT HIGH SPEEDS. THE TWO LONGER TENTACLES ARE USED FOR GRASPING PREY WHILE THE EIGHT SHORTER ONES TRANSFER FOOD TO THE MOUTH

is no trochophore or veliger stage. Cephalopods are entirely marine; they are found in all seas, from shallow water to profound depths. They are known from the Upper Cambrian. The Nautiloidea reached their greatest abundance in the Ordovician, there being only three living species of this subclass. The subclass Ammonoidea is completely extinct but was abundant in the Jurassic. The fossil record of the subclass Coleoidea is not so rich as that of the other subclasses but they are known from the Upper Mississippian. (*See* CEPHALOPODA.)

**Relationships.**—Mollusks may be related to the brachiopods; they share with them the mantle, the shell and the trochophore larval stage. With the phylum Annelida they are related on the basis of the trochophore larval stage and, with the discovery of *Neopilina*, serial arrangement of paired organs. The relationship of the mollusks to the segmented worms has been recognized for a very long time, and early scientists often classified them in the large general group Vermes (worms).

Many attempts have been made to relate the six classes of mollusks to one another. However, all classes go so far back in the fossil record, and that record is still so incomplete, that it is impossible to do more than theorize. In fact, the anatomy of the soft parts is so important in the classification of mollusks (and the soft parts, of course, are not preserved in fossils) that it may never be possible to answer some of the questions of relationship. It is generally believed that the chitons are closer to the Monoplacophora than to the other classes, but whether they were derived one from the other or from some common stock is not known. The scaphopods show certain characteristics, such as the radula, that relate them to the gastropods, but others, such as the foot and the veliger larval stage, appear closer to the pelecypods. The cephalopods are said to be more closely related to the gastropods than to other mollusks, but the embryology of the cephalopods is so totally different from that of all other classes that it seems difficult to believe there is any close relationship.

Mollusks are known to have existed as far back as the early Cambrian and all six classes were well differentiated by the Upper Cambrian. They have been highly successful and, except for the class Cephalopoda, are today more abundant than at any time in their long history of existence.

*See* related articles on various mollusks, as CLAM; CUTTLEFISH; MUSSEL; OYSTER; SNAIL; etc.; *see* also references under "Mollusk" in the Index.

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(R. D. T.)

**MOLLY MAGUIRES,** a term applied to certain men in the anthracite coal-producing counties of Schuylkill, Luzerne, Carbon and adjacent counties in Pennsylvania, who violated property rights of coal-mine operators and even committed murder during the years 1862 to 1876. In those areas there had been a large immigration of Irish workers. Foreign-born Welsh and Germans were also numerous. There were draft riots during the Civil War, and the area was divided by racial, religious and language barriers, anti-Catholicism and labour struggles. Radicalism born of Chartist, Marxist and former nationalist loyalties vied with trade-union organizational attempts and with the vigorous laissez-faire conduct of mine and railroad operators during times of coal price fluctuations to make the vicinity ripe for violence.

The Irish, a surplus labour force inexperienced in mining, were often embattered by arbitrary wage cuts, company stores, employment discrimination and blacklisting of independent spirits. Many joined the Workingmen's Benevolent association (an early union) in its pioneering efforts to win concessions from the Anthracite Board of Trade, the Mahanoy Valley and Locust Mountain Coal association and individual operators. Many Irish Catholics were members of the Ancient Order of Hibernians, a fraternal order with secret but entirely benevolent printed ritual.

As early as 1862 a newspaper account of coal-mine violence assigned blame to the "Molly Maguires," which in Ireland 20 years before had been an antilandlord agitational group. By the mid-1870s the mine operators and much of the public came to believe that sabotage and certain murders were the work of "Mollies" and that these were local Hibernian leaders, perhaps associated in an inner order, who were dedicated to violence. It appears that some Hibernian lodges in anthracite counties were then in the control of lawless men who found the "Molly" label a help in local politics and in engineering deeds of violence.

Franklin B. Gowen (1836–89), president of the Philadelphia and Reading Railroad and its Coal and Iron company, placed James McParlan, a member of the National Detective agency, among the Irish Catholics of the area in 1873. McParlan gained admission to the Hibernians and won the full confidence of local leaders, reporting daily to his employers. In 1876–77, in a series of sensational trials, McParlan testified on the inner workings of the local "Mollies." By 1880, 19 men were hanged and others imprisoned, and consequently the violent acts ceased and the society

was disbanded. Some injustices may have resulted, however, as guilt by association conquered the local mind, impressed overwhelmingly non-Irish juries and intimidated potential witnesses for the defense. Sir Arthur Conan Doyle made McParlan's exploit the subject of a dramatic story, *The Valley of Fear* (1915).

There is some justification for considering the Molly Maguire episode as an aspect of the labour struggles in the coal mines. Yet those convicted of violence were not orthodox trade-union leaders, and murders committed under "Molly" auspices often avenged personal grievances. Court convictions, publicity and more prosperous times apparently combined to bring the era of violence to a close.

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**MOLNÁR, FERENC** (1878–1952), Hungarian playwright and novelist, one of the Hungarian dramatists best-known outside his own country, was born in Budapest on Jan. 12, 1878. His early career was in journalism and during World War I he was a war correspondent. He moved to the United States in 1940 and died in New York on April 1, 1952.

Molnár published his first short stories at the age of 19, and achieved his first great success with the play *Az ördög* (1907; Eng. trans., *The Devil*, 1908), in which he showed himself an accomplished master of stagecraft and witty dialogue and an expert chronicler of the contemporary high society of Budapest. Many of his plays, *e.g.*, *Liliom* (1909; Eng. trans., 1921), *A hattyú* (1920; Eng. trans., *The Swan*, 1929), *A vörös malom* (1923; Eng. trans., *The Red Mill*, 1932), were successfully played abroad, particularly in Austria, Germany and the United States. Some of them were adapted for the screen. Unfortunately, most of these translations and adaptations give a distorted, commercialized picture of Molnár's gifts of characterization, and water down his bitter cynicism and biting irony.

Some of Molnár's short stories, *e.g.*, those published under the title *Muzsika* (1908), are masterpieces, concise and often deeply moving. They reveal Molnár's sympathy with the poor and the underdog, and his ability to see the social and human problems behind the glittering façade of society life. Although capable of making a correct diagnosis, Molnár was unwilling to advocate any cure. Often moved, but never shocked, he depicted the victory of evil, of egoism, of immorality, with a touch light enough to amuse his public. A fine playwright and short-story writer, Molnár was a weak novelist. Only *A Pál-utcai fiuk* (1907; Eng. trans., *The Paul Street Boys*, 1927) achieved a well-deserved success.

(Ds. Sr.)

**MOLOCH** (MOLECH), the name of the divinity to whom child sacrifices were offered in the later days of the Hebrew kingdom (*e.g.*, II Kings xxiii, 10). Since the consonants (*mlk*) are simply those of the common Hebrew word for "king" (*melek*), it is probable that the latter was the original form of the name; the form *molek* arises from combining these consonants with the vowels of *bosheth*, meaning "shame," a derogatory title frequently substituted by Old Testament editors in proper names containing the element "baal" (*q.v.*), as in Ish-bosheth (II Sam. ii, 8) for Eshbaal (I Chron. viii, 33).

In the present edition of the Hebrew text the reader is undoubtedly intended to regard Molech as a foreign deity who had been illegitimately given a place in Israel's worship as a result of the syncretistic policies of certain apostate kings. One passage of the Hebrew Bible (I Kings xi, 7) explicitly identifies Molech with Milcom, the god of the Ammonites (*cf.* verse 5), but this identification is not original (the Greek version having preserved a different text). The identification, though incorrect, is instructive, since the very fact that the Ammonite god had a name involving the consonants of the word for king (*mlk-m*) shows how natural it was for the ancient Semites to think in terms of the kingship of deity. Foreign gods, bearing names of good Mesopotamian types, compounded with *melek*, are also mentioned in II Kings xvii, 31—in connection, significantly, with child sacrifice. Evidence from Mari, on the middle Euphrates, shows that a god named *muluk* was worshiped there in the 19th century B.C. Despite this evidence that gods with names similar to Molech were known in neighbouring countries, and the knowledge that the worship of imported deities was at certain periods encouraged in Israel, it seems unlikely that Molech in the Old Testament is the name of a foreign god. The deity to whom child sacrifice was offered was Yahweh, the chief—and, for normative Hebrew religion, the only—god of the nation, honoured in this connection as "the King." So repulsive was this abnormal practice, largely confined to the apostatizing reigns of Ahaz (II Kings xvi, 3) and Manasseh (II Kings xxi, 6), that the later Hebrews transformed the divine title associated with it into the artificial name Molech, as though the sacrifices had indeed been offered to a foreign god.

An attempt by O. Eissfeldt to show that "Molech" was originally the technical name for a legitimate sacrificial offering (*molk*), later distorted into a proper name, has not met with general acceptance, although his evidence is deserving of further study. It is unlikely that child sacrifice was ever regarded, in historical times, as a normal part of Israelite religion (*see* Ps. cvi, 37; Isa. lvii, 4 *et seq.*; Jer. xxxii, 35; Ezek. xvi, 20; Mic. vi, 7 *et seq.*); its occasional appearance was due either to a recrudescence of ancient superstition in times of special peril or to foreign influence.

(R. C. De.)

**MOLOTOV, VYACHESLAV MIKHAILOVICH** (1890– ), Soviet Communist leader, of Russian nationality, who as prime minister (1930–41) and as foreign minister (1939–49 and 1953–56) became known for his dogmatic rigidity. He was born on March 9, 1890, in the village of Kukarka (now Sovetsk), in Vyatka province, of middle-class parents whose name was Skryabin. In 1902 he entered the secondary school in Kazan; and in 1906 he joined the Communist party and engaged in revolutionary activity among the students. For this he was arrested in 1909 and deported to the Vologda region. After his release in 1911, he went to St. Petersburg, studied at the Polytechnic institute there and became at the same time a full-time organizer for the Bolsheviks. In 1912 he helped found the newspaper *Pravda*. He was again arrested in 1915 in Moscow and deported to Manzurka in Irkutsk province. Escaping in 1916, he returned to Petrograd and entered the Russian committee of the party. After the Revolution of 1917, Molotov occupied several posts in the provincial organization of the Communist party, and in 1921 was made a member and secretary of the central committee and a candidate member of the Politburo. In Jan. 1926 he became a full member of the Politburo, a position that he retained until 1957. He became one of Stalin's closest and most self-effacing collaborators. In Dec. 1930 he was made chairman of the council of the people's commissars (prime minister); and for the next ten years he concerned himself mainly with internal affairs and the country's industrial expansion.

In May 1939 Molotov was made commissar of foreign affairs in succession to Maksim Litvinov. He was thus responsible for negotiating the nonaggression pact with Germany that led to the outbreak of World War II. In May 1941 Stalin became prime minister, with Molotov as his first deputy. But after the German invasion it was Molotov who first spoke to the Soviet people and called for resistance. Throughout the war he served as deputy chairman (to Stalin) of the state defense committee, which directed the war effort. He visited Great Britain and the United States in 1942 to lay the foundations of the alliance with the western powers. He attended all the major interallied wartime and postwar conferences and was principal Soviet representative to the United Nations. He earned a reputation for uncompromising hostility to the west and to any deviation from Stalinist policies. In March 1949 he gave up his post as foreign minister to Andrei Y. Vyshinski.

Molotov presided over the opening of the 19th party congress in 1952. On Stalin's death in March 1953, he remained a member of the party presidium (as the Politburo was then called) and a first deputy prime minister and became minister of foreign affairs once more. In the conflicts that developed over the succession to Stalin, he was regarded as one of Nikita S. Khrushchev's principal opponents. He ceased to be foreign minister in June 1956

and was given the relatively unimportant ministry of state control in Nov. 1956. At the central committee meeting in June 1957, at which the conflicts came to a head, Molotov was deprived of all his high positions. Of Khrushchev's opponents he alone was allowed to abstain from voting in self-condemnation and was given a post abroad as ambassador to Mongolia. In Sept. 1960 he was appointed permanent Soviet delegate to the International Atomic Energy agency in Vienna. Recalled in Nov. 1961, he stepped out of public view in Feb. 1962. In April 1964 a secretary of the C.P.S.U. said that Molotov had been "thrown out of our party" but gave no details. (D. Fp.)

**MOLTKE, ADAM GOTTLOB,** COUNT (1710–1792), favourite and influential adviser of the Danish king Frederick V, was born on Nov. 10 or 11, 1710, at Walkendorf in Mecklenburg. When he was still a child his father moved to Denmark, where two uncles were already established, one as equerry to Prince Charles (d. 1729), brother of Frederick IV. In 1722 a post was obtained for the young Moltke as page to the crown prince, afterward Christian VI. In 1730 he became a chamberlain (*kammerpage*) to the future Frederick V, then only seven years old. In 1743 Moltke became Frederick's *hofmarskal* (court marshal or master of the household), an office which he retained after Frederick's accession in 1746. Frederick made him a privy councilor in 1747 and gave him the estate of Bregentved. Moltke was created a landgrave in 1750.

Moltke's influence soon became so great that a foreign diplomat declared that he could make and unmake ministers at will. He opposed liberal projects for the emancipation of serfs; but as one of the largest landowners in Denmark he did service to agriculture by introducing scientific and technical improvements.

Frederick V died in Moltke's arms on Jan. 14, 1766. Dismissed from his most important offices by the new king, Christian VII, Moltke was recalled in 1767 to help with agrarian reform. Again dismissed on Dec. 10, 1770, he retired to Bregentved. He died there on Sept. 25, 1792. His interesting memoirs, written in German, were published in 1870.

*See* C. F. Wegener, "Grev Adam Gottlob Moltke's efterladte Mindeskrifter," *Historisk Tidsskrift*, series IV, vol. ii (1870–72); E. Holm, *Danmark-Norges Historie, 1720–1814*, vol. iii–v (1897–1906).

(F. Sk.)

**MOLTKE, ADAM WILHELM,** COUNT (1785–1864), Danish statesman, prime minister of the first government responsible to parliament in Denmark, was born at Einsiedelsborg in Fünen on Aug. 25, 1785, the son of the minister Joachim Godske Moltke and a grandson of Adam Gottlob Moltke. After completing his legal studies in 1805 he became assessor of the supreme court in 1809, a deputy at the *rentekammer* (exchequer) in 1812 and a member of the national debt commission in 1816. He succeeded his father as count of Bregentved in Oct. 1818. He became minister of finance in 1831 under Frederick VI (d. 1839) and president of the *rentekammer* in 1845 under Christian VIII (d. Jan. 1848). When Frederick VII renounced absolute rule in March 1848 and a representative government was set up, Moltke became prime minister. The mere fact that a distinguished statesman who had served the last two absolute kings of Denmark now voluntarily placed himself at the head of a ministry which included the most advanced of the National Liberals gave the new government prestige. It was this administration which introduced the constitution of June 5, 1849. Moltke was responsible for finance in the new government, but exchanged that portfolio for foreign affairs and Schleswig in Nov. 1848. He gave up these responsibilities in Aug. 1850 and resigned as prime minister on Jan. 27, 1852. Moltke was a member of the *landsting* (upper house) from 1849 to 1860, and was a member of the consultative *rigsraad* from 1854 to 1861. He died in Copenhagen on Feb. 15, 1864.

*See* N. Neergaard, *Under Junigrundloven*, 2 vol. (1892–1916); H. Jørgensen (ed.), *Statsrådets Forhandlinger 1848–1863*, 3 vol. (1954–58).

(F. Sk.)

**MOLTKE, HELMUTH JOHANNES LUDWIG VON** (1848–1916), German army officer and chief of the general staff at the beginning of World War I, was born at Gersdorff in Mecklenburg on May 25, 1848, the nephew of the great H. K. B. von Moltke. He became his uncle's adjutant in 1882 and subsequently commanded several guards' regiments. His dashing appearance and courteous manner brought him to the notice of the emperors William I and William II. This patronage, together with the inheritance of a great name, was to result in responsibilities for which he was totally unsuited.

Moltke became quartermaster general in 1903 and chief of the general staff, in succession to Alfred von Schlieffen (*q.v.*), in 1906. He thus inherited Schlieffen's master plan for war on two fronts against France and Russia, and his principal duty was to revise this plan to meet modern conditions. His task was a difficult one; he had frequently to combat the emperor's inflated ideas of his own military ability; Germany's potential ally, Austria-Hungary, constantly pressed for greater German strength to be deployed in the east; and the war ministry, which controlled armaments, was excessively conservative on the question of new weapons and equipment. Partly because of ill health but mainly because of lack of personality, Moltke failed to overcome these difficulties. His modification of the Schlieffen plan left the right wing of the armies in the west too weak, with the result that the speedy victory over France, which was essential to German strategy, did not materialize.

When war broke out in 1914 Moltke did not measure up to requirements. The campaign against France was characterized by lack of co-ordination by supreme headquarters; instead of a quick victory, stalemate and trench warfare supervened. On Sept. 14, 1914, Moltke was relieved of all executive responsibility in favour of Erich von Falkenhayn, though remaining as nominal chief of the general staff till the end of the year. He was then given the post of deputy chief of staff at home. He died in Berlin on June 18, 1916. His *Erinnerungen, Briefe, Dokumente, 1877–1916*, edited by Elisa von Moltke, appeared in 1922.

(C. N. B.)

**MOLTKE, HELMUTH KARL BERNHARD,** GRAF VON (1800–1891), chief of the Prussian and German general staff, the organizer of victory in the Seven Weeks' War and in the Franco-German War of 1870–71, was born on Oct. 26, 1800, at Parchim in Mecklenburg, of an aristocratic but impoverished family. His father was a man of unstable character, and the son undoubtedly inherited his great ability as a thinker and organizer from his mother, who came from an old Lübeck family.

Moltke was educated with the royal cadet corps at Copenhagen in Denmark, after which he joined a Danish infantry regiment. His early career was not a happy one, as he was extremely poor and had indifferent health. After a visit to Berlin in 1821 he decided to become a Prussian officer; and though his brothers remained in the Danish service, he became a lieutenant in the *Leibgrenadier* regiment. The next few years were spent chiefly at Frankfurt an der Oder, where, to improve his financial position, he took up literary work. He wrote a short novel, *Die beiden Freunde* (1827), and a military study of the Polish insurrection of 1830–31. He accepted a publisher's offer to translate Edward Gibbon's *Decline and Fall of the Roman Empire* but, after most of the work was completed, the publisher failed to produce it. Moltke then spent some years in the topographical office, but in 1833 was transferred to the Prussian general staff. Two years later he went to Turkey to learn the language and study conditions in the country and also to advise Sultan Mahmud II's government on the modernization of the Turkish army. Soon after his arrival, however, contrary to the original intention, Moltke entered the Turkish service; and in 1839, in the capacity of adviser, he accompanied the Turkish general Hafiz Pasha to Syria. The failure of the Turks to dislodge the Egyptian forces (under Muhammad Ali's son Ibrahim) from Syria was partly due to neglect of Moltke's advice.

Returning to Germany at the end of 1839, Moltke re-entered the Prussian service. He published a selection of his letters from Turkey, *Briefe über Zustände und Begebenheiten in der Türkei*, in 1841. In April 1842 he married Marie Burt, stepdaughter of his sister Augusta (who had married an English landowner, J. H. Burt, in 1834); and though he had no children, the marriage proved a very happy one. Further writings of this period were an essay on railway construction and operation (1843) and a his-

tory of the Russo-Turkish campaigning of 1828–29 in the Balkans (1845). Late in 1845, however, Moltke was appointed personal aide-de-camp to the invalid Prince Henry of Prussia, who was living privately in Rome. Though this appointment ended with Prince Henry's death in July 1846, it gave Moltke the opportunity to begin work on a splendid topographical map of Rome and its vicinity (published in 1852) and to write his "Wanderungen um Rom" (published in his *Wanderbuch*, 1879). Moreover, when the warship bringing Prince Henry's body back to Germany reached Gibraltar, Moltke left it and made his own way home across Spain, recording his impressions in his "Tagebuchblätter aus Spanien" (also published in the *Wanderbuch*). He has a place among the best writers of 19th-century German prose.

Working again for the Prussian general staff (at Coblenz in 1847, in Berlin in 1848 and subsequently in Magdeburg), Moltke started thinking about the bigger problems which confronted Prussia: the unification of Germany and the problem of security for a country surrounded by potential enemies and with no natural frontiers. He was convinced that only the army could provide a satisfactory solution to these problems; and his delight in the victory for reaction after the revolution of 1848–49 was expressed in 1850, when he wrote to his brother that the curtain had come down on Prussia's worst enemy—democracy.

A colonel from 1851, Moltke was in 1855 appointed personal aide-de-camp to Prince Frederick William, the future king of Prussia and German emperor (*see* FREDERICK III). This post involved more travels: to Scotland and thence to England in 1855–56; to Russia and to France in 1856. Even so, apart from the period of his Turkish service and his brief stay in Rome, Moltke's career up to this time had been mostly dull routine or concerned rather with the affairs of his princely masters than with the profession of arms. Only as junior regimental officer in Turkey had he commanded troops. To the French empress Eugénie, who met him in Paris in 1856, and to other contemporaries, he seemed a deep and intelligent thinker, but a man of silence.

**Chief of the General Staff.**—This was the man who was selected as chief of the Prussian general staff in 1857 and confirmed in that office in Sept. 1858. Thus began the era of the great triumvirate—Otto von Bismarck (chancellor), Moltke (chief of the general staff) and Albrecht von Roon (minister of war)—which within 13 years was to change the map of Europe, to procure the humiliation of France and to found the German empire under the leadership of Prussia.

The new chief of the general staff entered upon his duties at a time when a technical revolution was changing the whole conception of war. The rearmament of the German infantry with the breech-loading needle gun had been proceeding since 1848 and was almost complete. Breech-loading guns for the artillery were on the way, but were not finally introduced until 1861. These, however, were mere details of armament; much more significant was the introduction and rapid development of railways.

Moltke was the first military man to appreciate the important role which railways could play in the deployment, subsequent movement and supply of armies on a great scale. Hitherto the movement of troops had been restricted by the paucity of road communications; this had not only often set a limit to the size of armies and greatly increased the difficulties of supply, but also frequently led to the suspension of operations in the autumn, when troops were wont to go into winter quarters until the following spring. Thus the aim of strategy of the great captains, from Alexander the Great to Napoleon, had been to bring the strongest possible force, in the best possible condition, onto a small battlefield where the whole army would be within sight—almost within voice control—of its commander. Moltke saw that the advent of railways had changed this. He appreciated that many more men and much more equipment could be deployed much faster on vastly wider frontages. In place of battlefields of a few square miles there would be long battlefronts of perhaps hundreds of miles. The limited flank attack by a few battalions would give place to wide turning movements by armies of many divisions. Supplied by a network of railways, troops would be able to keep the field in all kinds of weather throughout the year.

Moltke at the same time appreciated that a new technique and a much more highly trained body of staff officers would be required to realize his new conception of warfare. The mounted staff officer with his purely local outlook would give way to one with a much wider view, capable of compiling intricate railway movement tables for vast numbers of men and animals and their equipment and arranging for daily trainloads of supplies. He saw too that changes were necessary in another direction. Whereas previously commanders had kept a very tight hold on their subordinates and had been able always to give short and explicit orders (whether verbal or written), it was clear to Moltke that this system would not work in an army of perhaps millions locked in battle along a front which might extend for hundreds of miles. He therefore instituted the system of "general directives" (known in World War II as "operation instructions"), in place of rigid "operation orders." In these the recipient was given a long-term task in general terms, but was allowed considerable latitude and was expected to use his discretion and initiative in carrying it out. When Moltke joined the general staff, its "chairborne" officers were held in little esteem by the "real" soldiers. It was Moltke who built up the Prussian general-staff system, which eventually became the model for all armies organized on modern lines.

Moltke was more fortunate than many who have had to initiate reforms and new methods. He became chief of the general staff in 1857 and it was not until 1870 that the really big test came. During these 13 years he was able to perfect the system, train a new type of staff officer and integrate into the military system civilian bodies such as the ministry of commerce and the newly formed railway department. Moreover, the comparatively minor ventures in which Prussia was involved between 1857 and 1870—the short war against Denmark in 1864 and the Seven Weeks' War (*q.v.*) against Austria and some of the other German states in 1866—provided the best possible experience for testing the new system and correcting any shortcomings.

The campaign of 1866 was particularly important as a test for Moltke's new theories and methods, still distrusted and occasionally disobeyed by the older generals. The move forward to the assembly positions in May and early June involved the deployment of three armies, of a strength of about 256,000 men, on an initial front of about 260 mi. After some preliminary actions the campaign was virtually ended by the decisive Prussian victory at Königgrätz. This cost Austria 45,000 casualties and Prussia 9,000. Nevertheless, Moltke had no cause for complacency. Many defects were revealed, the most conspicuous being the poor standard of training of some staff officers and the inadequacy of the intelligence service. The experience was invaluable as a curtain raiser for the bigger struggle which was to follow in 1870.

By this time the chief of the general staff had begun to show the qualities of a great soldier. In spite of shortcomings in the system and some mistakes, the quick success against Austria had vindicated Moltke's theories and greatly enhanced his prestige. He possessed the great virtue of recognizing his mistakes, and his subordinates now responded readily to the measures that he took to prevent their repetition.

**Franco-German War.**—The basic cause of the Franco-German War (*q.v.*) of 1870–71 was the same as that of 1866—Prussia's desire to seize the opportunity to eliminate a dangerous rival. Moltke and Roon had not wasted the years since the war against Austria and were able by the end of 1869 to assure Bismarck that the Prussian army was capable of defeating the French and that in their judgment the time was opportune.

Hostilities began on July 19, 1870. Moltke's aim was the speedy capture of Paris, which he judged would be decisive, and for this purpose he deployed three armies of a total strength of about 384,000 men. Bitter fighting took place in the early stages, and on Sept. 1 the Germans won their great victory at Sedan. This left the French without an organized army and politically brought about the downfall of the second empire; but it did not bring peace. The French continued to fight a losing war until the end of Feb. 1871, when peace talks were started. The French army had fought well and had won some notable local victories but was completely outmatched by the Germans' modern system of direc-

tion and command and by their superior staff work. It was a great triumph for Moltke, who had evolved and perfected the system.

Moltke continued as chief of the general staff for another 17 years. With the increasing threat from Russia much of his time was spent in study and in preparing the army for a war on two fronts—work to be continued by Alfred von Schlieffen (*q.v.*). He was created a field marshal in June 1871.

Disapproving of what he knew and saw of the new emperor William II, Moltke resigned in Aug. 1888 and went to live on the estate at Kreisau which had been his reward in 1866. He died on a visit to Berlin, on April 24, 1891. A collected edition of his writings and reminiscences, in 8 volumes, was published in 1891–93, an edition of his military works, in 15 volumes, in 1892–1912.

*See* F. E. Whitton, *Moltke* (1921); W. Görlitz, *History of the German General Staff 1657–1945*, Eng. trans. (1953). (C. N. B.)

**MOLUCCAS** (MALUKU), islands of the Malay archipelago (*q.v.*) lying between Celebes (Sulawesi) on the west, New Guinea on the east, Timor on the south and the open Pacific ocean on the north. Total area approximately 28,766 sq.mi. Pop. (1961) 789,534. These islands constitute the Indonesian province of Maluku, subdivided as follows: (1) Maluku Utara (North Moluccas) *kabupaten* (regency), comprising the Ternate group (of which Halmahera is the largest), the Batjan and Obi groups; (2) Maluku Tengah (Central Moluccas) *kabupaten*, with Ceram (Seram), Buru, Wetar and the Banda Islands; (3) the municipality of Amboina (Ambon), off the south coast of Ceram, with the provincial capital; (4) Maluku Tenggara (Southeast Moluccas) *kabupaten*, comprising the Tanimbar group, Babar, the Kai and the Aru islands. As a token of Indonesia's claim on Netherlands New Guinea (realized in 1963), the island of Tidore and central Halmahera were in 1958 separated from Maluku province, as the cradle area for the new province of Irian Barat (Western New Guinea), and were so considered in the 1961 census.

**Physical Geography.**—The Moluccas are tectonically an unstable zone; earthquakes are frequent and several islands have active volcanoes, especially Ternate and Banda. Most of the islands are mountainous (more than 9,000 ft. in Ceram), but the Tanimbar and Aru islands are low and swampy. Ceram contains an oil field. Temperatures at sea level fluctuate slightly from about 25° C. (76° F.) in the coolest month to 29° (84°) in the warmest month. Rainfall varies according to exposure from 80 to 150 in. annually. In some parts the evergreen rain forest, formerly covering most of the islands, has been cut down and the land cultivated. There are patches of open savanna, and the coasts are fringed with mangrove swamps. In fauna and flora the Moluccas are a transition zone between Asian and Australian forms, with many endemic species. In the 17th century G. E. Rumpf (Rumphius) wrote there his great book on native flora, and in the 19th century A. R. Wallace developed there his concept of evolution.

**People.**—The inhabitants show great diversity in ethnic type because this area is a transition zone between the Malays to the west and the Papuans to the east. Moreover, there has been much admixture with Javanese, Portuguese and Dutch. In general the way of life is primitive, but the small islands and the coastal fringes of the larger islands are somewhat more advanced, with Christianity and Islam as the dominant faiths; the people of the interior are still animists. There are different languages, all belonging to the Malayo-Polynesian family, except for those of north Halmahera. Most people secure their food by collecting the starch of the sago palm, fishing and hunting. Coconuts are widely grown and copra is the main export product.

**History.**—The cloves of the northern Moluccas and the nutmegs of the central islands were a focus of early Asian trade long before Europeans started their search for the legendary "Spice Islands." In the 16th century Ternate and Tidore, tiny islands off the west coast of Halmahera, were the seats of rival sultanates, each controlling part of the spice production. The Portuguese arrived in 1512 and made an alliance with the sultan of Ternate. There was a prolonged conflict between Portugal and Spain over control of the islands. The Dutch came in 1599, soon gained predominance in the south (Amboina, Banda) and gradually eliminated their rivals, including the English. Part of the population was converted to Christianity, especially on Amboina. The cruel struggles for monopoly meant great loss of life and property. The Dutch earned large profits, but by the end of the 18th century the spice trade had greatly diminished and the Moluccas became an economic backwater. After World War II the Moluccas became a part of the state of East Indonesia, and as such in 1949 an autonomous member of the independent United States of Indonesia. The change to a unitary Indonesian republic in 1950 caused the Christian Amboinese to revolt (*see* AMBOINA).

*See* also articles on the individual islands and island groups.

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**MOLY,** in modern times the name applied to a species of onionlike bulbous herb (*Allium moly*), native of southern Europe and grown in borders and rock gardens for its bright-yellow flowers. It bears no relation to the legendary moly, a mysterious plant with magical powers described in Homer, *Odyssey*, x. 302–306. Hermes pulls it up and gives it to Odysseus as a protection against the arts of Circe. It is further described as "having a black root and a flower like milk, and hard for mortals to pull up." This classical moly, the name of which is probably magical and derived perhaps from Phoenician or Egyptian sources, cannot be identified with certainty.

**MOLYBDENITE,** a mineral consisting of molybdenum disulfide $MoS_2$, containing 60% molybdenum. It is the chief source of molybdenum, which is used in the manufacture of special steels, such as tool steel, to which it imparts greater hardness and strength. The metal is used in the electrical industry, and certain compounds are used in chemistry, ceramics and dyeing.

Molybdenite closely resembles graphite, has the same greasy feel and likewise is soft enough to mark paper. Both minerals have a layer structure and as a result have perfect basal cleavage and are usually foliated. The name comes from the Greek *molybdos* (lead), with which both graphite and molybdenite were confused. The latter was first identified by P. J. Hjelm, who in 1782 discovered the element molybdenum in this mineral. It is distinguished from graphite by its greater specific gravity (4.7), a bluish lead-gray colour and a greenish streak on glazed porcelain, in contrast with the grayish streak of graphite. Its common association with quartz or acidic rocks may also help distinguish it, for graphite is more commonly associated with metamorphosed limestone and basic rocks. Molybdenite is hexagonal, but the six-sided platy crystals are rare. It is commonly in disseminated plates or scales which are flexible but not elastic. The lustre is bright metallic.

Molybdenite occurs in crystalline rocks, such as granites, pegmatites and schists, and also in quartz veins. It is fairly common in small quantities as one of the first minerals formed in high temperature veins, along with scheelite, wolframite, topaz and fluorite. The United States has been the chief producer, usually accounting for at least 70% of the world's production. In the second half of the 20th century Colorado was the leading state, followed by Utah, Arizona, New Mexico and California. Other major producers are the Soviet Union, Chile and the People's Republic of China. (L. S. R.; X.)

**MOLYBDENUM** is a metallic element resembling steel in colour and having an unusually high melting point of about 2,610° C. (4,730° F.). It is one of the most important of the alloying elements used in steels, irons and certain nonferrous alloys. It is also one of the most commonly used of the refractory metals.

Molybdenum (symbol Mo, element number 42, atomic weight 95.94) is in Group VI B of the periodic system and is therefore related to chromium and tungsten. There are seven natural stable isotopes with mass numbers (in order of decreasing abundance) 98, 96, 92, 95, 100, 97, 94; several artificial radioactive isotopes (91, 93, 99, 101, 102, 105) are known. The arrangement of electrons in the unfilled N and O shells is $4s^2$, $4p^6$, $4d^5$, $5s^1$.

## OCCURRENCE AND PRODUCTION

Molybdenum is not found free in nature. The only important production is from deposits containing the mineral molybdenite,

$MoS_2$; however, some powellite—calcium tungstomolybdate, $Ca(Mo, W)O_4$—a secondary mineral of the scheelite group, is treated to recover molybdenum and deposits containing wulfenite, lead molybdate, $PbMoO_4$, have been worked.

After World War I, when the usefulness of alloys containing molybdenum was recognized, the United States supplied about 90% of the world's production, most of which usually came from the Climax mine at Climax, Colo. The next largest source was the copper industry which obtains molybdenite concentrate as a by-product from several mines in the United States and Chile. Just after the middle of the 20th century, world production of molybdenum in concentrates was fluctuating from about 50,000,000 to 90,000,000 lb. a year.

At Climax, where the mine is operated primarily for the recovery of molybdenite concentrate, the ore may contain from 0.3% to 0.6% $MoS_2$. Separation of molybdenite concentrate is accomplished by crushing, fine grinding and oil flotation. Commercial concentrate contains about 80% to 95% $MoS_2$ on a dry basis.

The molybdenum sulfide in the concentrate is converted by roasting to molybdic oxide ($MoO_3$). There is no removal in this process of the siliceous gangue contained in the concentrate. The product may be referred to as technical molybdic oxide or roasted molybdenite concentrate.

Ferromolybdenum is produced from technical oxide by either thermite or electric furnace processes and usually contains between 55%–75% molybdenum. Molybdenum may be added to steel in the furnace in the form of technical oxide or ferromolybdenum. Ferromolybdenum is generally used for ladle additions to either steel or iron. Metallic molybdenum of high purity may be used in making the nonferrous alloys for high temperature service. *See* also METALLURGY.

## CHARACTERISTICS AND USES

**Metallic Molybdenum.**—Molybdenum powder is produced by the hydrogen reduction of purified molybdic oxide or ammonium molybdate. Metal boats containing the oxide are pushed through heated tubes reaching a maximum temperature of about 1,050° C. (1,922° F.). The process is commonly carried out in two stages; the first step produces molybdenum dioxide at about 600° C. (1,112° F.) which is reduced to metal at 1,000° to 1,050° C. (1,832° to 1,922° F.) in the second stage. Conversion of powder to massive metal may be carried out by either of two methods: the powder metallurgy (*q.v.*) process developed about 1910 or the arc-casting process developed about 1944.

In the first process, the powder is compacted at room temperature into ingots or bars under pressures of about 10 to 20 tons per square inch. The compacts are sintered by heating in hydrogen or vacuum at 1,100° to 2,200° C. (2,012° to 3,992° F.).

In the arc-casting process, a partially sintered bar serves as a consumable electrode and is melted into a water-cooled mold usually made of copper. The electrode may be prefabricated or may be continuously pressed and sintered within the melting unit. The operation is carried out in a high vacuum or an atmosphere of purified inert gases. In this process, alloying elements can readily be incorporated by mixing them with the molybdenum powder from which the electrode is made.

Small powder metallurgy compacts to be made into rod or wire may be worked by swaging or rolling, starting at about 1,300° C. (2,372° F.). After suitable reduction, wire may be made by drawing through carbide dies or, for finer sizes, through diamond dies. Arc-cast ingots may be broken down by extrusion at about 1,100° to 1,210° C. (2,012° to 2,390° F.). The extrusions may be rolled into bar products. For the production of plates and sheets, extrusions may be rolled or forged into sheet bars. They may also be used for the production of hand or die forgings.

Among the properties of metallic molybdenum responsible for its commercial use are its very high melting point, superior strength at high temperatures, high modulus of elasticity, high electrical and thermal conductivity, low coefficient of thermal expansion and relatively low absorption cross section for thermal neutrons. It is resistant to several common chemical solutions including hydrochloric, sulfuric, phosphoric and hydrofluoric acids under many conditions of concentration and temperature. It is attacked by oxidizing acids, molten oxidizing salts and fused alkalis. It is rapidly oxidized in air at temperatures above about 500° C. (932° F.).

Metallic molybdenum has been widely used in electronic tubes for anodes, grids and support members. Rod or wire is used for heating elements in furnaces operating up to 1,700° C. (3,092° F.). Oxidation is avoided by using a reducing or inert atmosphere. Sprayed coatings of molybdenum make a firm bond to steel and some other metals, and show excellent resistance to wear. In the glass industry, molybdenum has been used for resistance heating electrodes, stirring devices and wear parts. Molybdenum and its alloys have also been used for various parts of high-temperature engines. When excessive oxidation might be encountered, protective coatings are necessary.

**Molybdenum as an Alloying Element.**—In the 1890s, the use of molybdenum in steel was studied by various investigators. Until about 1918, however, the commercial development of molybdenum steels was hindered by the high price and uncertain supply of molybdenum. The development of the mine at Climax and the experiences of steel fabricators with wartime molybdenum steels led to further development work and to the adoption in the 1920s of various molybdenum steels for peacetime purposes, notably by the automotive industry. In steels for automotive and other machine parts, molybdenum may be used as the principal alloying element or in conjunction with other elements, especially chromium and nickel.

In machine construction, alloy steel parts are generally hardened and tempered to increase their strength and resistance to wear. The principal reason for adding alloying elements is to make it possible to harden the parts by less rapid cooling, as by quenching in oil instead of water. The alloying elements are said to increase the hardenability of steel. Molybdenum is one of the most effective elements in this respect.

Molybdenum contributes to the toughness of quenched and tempered steels especially by helping to prevent the development of temper brittleness. This effect together with its contribution to hardenability has accounted for the use of molybdenum in many applications where maximum toughness is required as in armour plate and guns.

High-speed tool steels contain molybdenum or tungsten to develop the property known as red hardness, or ability to cut at a red heat. It has been known since about 1900 that one part by weight of molybdenum is substantially equivalent to two parts of tungsten, but the commercial development of molybdenum high-speed steels began about 1934. Such steels contain molybdenum or molybdenum and tungsten, together with chromium and vanadium. Molybdenum is also used in other types of tool steel and is added to various types of stainless steel to further improve their resistance to certain kinds of corrosion. Molybdenum increases the strength of steel at elevated temperatures and has been widely used, for example, in pipes, valves, forgings and fittings in superheated steam plants, in superheater tubing and in cracking-furnace tubes. Molybdenum increases the strength, toughness and uniformity of gray iron (*see* CAST IRON), in which it is extensively used.

As in steel, molybdenum also increases the hardenability and elevated temperature strength of gray iron. Molybdenum cast iron has been used in chilled rolls and also in grain rolls, for rolling metal, cast in sand molds to increase resistance to breakage, chipping, heat checking and spalling. In automobile engines, molybdenum cast irons can be used in camshafts and tappets. Many of the nickel-base and cobalt-base alloys which have been developed for high temperature use as in gas turbine parts contain molybdenum to increase their high temperature strength. Molybdenum is also used in certain nickel-base alloys developed primarily for resistance to corrosion in chemical solutions. (*See* also ALLOYS.)

**Compounds.**—Molybdenum exhibits valences of +2, +3, +4, +5 and +6; it is considered zero valent in the carbonyl $Mo(CO)_6$. The most important compound is the trioxide, $MoO_3$, from which most of the known compounds containing the element can be prepared. The oxide obtained by roasting molybdenite in air can

be purified by sublimation, or pure oxide may be obtained by thermal decomposition of ammonium molybdate.

Molybdic oxide has found use as a catalyst. Molybdate chrome orange, a brilliant pigment of high covering power, may be made with molybdic oxide or sodium molybdate, $Na_2MoO_4$, as a source of molybdenum; these compounds are also used in the production of molybdated dyes and pigments. Ammonium molybdate is used in the production of molybdenum metal powder, in the preparation of catalysts and as an analytical reagent, especially for the determination of phosphorus. Molybdenum disulfide, $MoS_2$, of adequate purity for use as a lubricant can be prepared from regular molybdenite concentrate by further grinding and flotation or by leaching with hydrofluoric acid. It may be used as an additive to greases and oils or as a dry film or solid lubricant. The pentachloride, $MoCl_5$, may be prepared by the action of chlorine on molybdenum powder. It has been used as a chlorination catalyst.

Molybdenum has been proved an essential trace element in plant nutrition; in legumes, it assists bacteria in fixing nitrogen. Sodium molybdate or molybdenum trioxide may also be used (*see* FERTILIZERS AND MANURES, *Secondary Elements*). *See* also references under "Molybdenum" in the Index.

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**MOLYNEUX,** the name of a famous English family, one of whose members, Charles William Molyneux (d. 1795), was created 1st earl of Sefton in 1771, is derived from Moulineaux in France (Seine-Inférieure). The manor of Sefton in Lancashire was granted about the year 1100 by Roger, count of Poitou, to a member of the Molyneux family, probably one Robert de Molyneux, and has been held by the family ever since. A famous member of this family was Adam de Molyneux (d. 1450), bishop of Chichester and keeper of the privy seal. Richard Molyneux (*c.* 1594–1636) was created (1628) 1st Viscount Molyneux of Maryborough in the Irish peerage, a title now merged in the Irish earldom of Sefton. The present earl of Sefton is Hugh William Osbert Molyneux (1898– ).

Another Molyneux family of some importance is the Irish one, descended from Sir Thomas Molyneux (d. 1597), who, born in Calais, settled in Ireland in 1576 and became chancellor of the exchequer there. He was the great-grandfather of Sir Thomas Molyneux, Bart. (d. 1733), a well-known physician and zoologist, and of William Molyneux (d. 1698), the astronomer and philosopher, who was a friend of John Locke. William's son Samuel (d. 1728) was also a well-known astronomer.

**MOM:** *see* BAMUM.

**MOMBASA,** a town of Coast province, Kenya, East Africa, and the chief port for Kenya, Uganda and northeastern Tanganyika, is built on a coralline island about 3 mi. long and 2½ mi. wide, at the mouth of a deep arm of the Indian ocean. The population (Mombasa social survey census 1957) was 145,387 including 4,399 Europeans; the total population in 1962 was 178,400. Municipal area, including mainland districts, 27 sq.mi. The climate is warm and equable, with a mean maximum temperature of 86° F. and a mean minimum of 74° F. February and March are the warmest months, June and July the coolest. The annual rainfall averages 47.65 in.; the driest months are January through March, the mean relative humidity is 75%. Coral headlands enclose sandy bays and the striking vegetation includes mango and fig trees, coconut palms, flamboyant, baobab, bougainvillea and oleander. On the east side of the island Mombasa's old harbour serves dhows and coastal sailing vessels. On the west side Kilindini, the modern port, runs into the capacious harbourage of Port Reitz. Connections between island and mainland are by Nyali bridge and Makupa and Kipevu bridge-causeways; several ferries also carry vehicular and passenger traffic.

By the 1960s Mombasa had developed from an old-fashioned harbour town into a thriving modern seaport. Most Arab-style houses have been replaced by multistoried buildings. The commercial area is concentrated in the centre, but the movement of shipping and mercantile offices has been toward Kilindini. An industrial area covering 52 ac. is fully developed at Shimanzi in the northwest; Changamwe, on the mainland across the Makupa causeway, and the most recent industrial district, contains an oil refinery.

The old town clustered around Mombasa's old port is mainly occupied by Asian and Arab traders. The Portuguese relic Fort Jesus (1592), overlooking the old harbour, had been used as a prison since 1892, but in 1955 was handed over to the Kenya Royal National Parks administration for use as a museum. There are also Portuguese ruins of churches, watchtowers, blockhouses and remains of mosques. At the southeastern point of the island, government house and a golf club face the Indian ocean. Around a gardened square behind Fort Jesus are the treasury, municipal offices and head post office; near by stand the law courts and Mombasa club. Public buildings include Anglican and Roman Catholic cathedrals, mosques and temples; European, Asian, Arab and African schools; and hospitals. There are many hotels, clubs and cinemas, a theatre and a stadium.

The first train steamed from Mombasa to Lake Victoria in 1901. The rail terminus is in the centre of the island and the main line is carried by the Makupa causeway. The interterritorial East African Railways and Harbours administration maintains a daily service with up-country districts, Uganda and northern Tanganyika. Motor roads link the port with other parts of Kenya, and at Nairobi with the Cape-to-Cairo road. Local buses serve the town and all nearby points. From Port Reitz airport, about 6 mi. from the centre of the island, regular air services connect with transcontinental airlines at Nairobi and with other parts of East Africa. The landlocked port of Kilindini accommodates vessels of any size. Its first deep-water berth was built in 1926 and by the early 1960s it had 14, including those on the mainland at Kipevu. Passenger services connect the port with most parts of the world.

Mombasa is a market for the region's agricultural products, including coconuts, sisal, cotton, sugar, kapok, various fruits and vegetables, rice, maize and millet. The port handles the export of many of these and other goods such as coffee, minerals, soda ash, oilseed and cake. Industries include cement making, lime burning, coffee curing, brewing, machine shops, and the manufacture of glass, coconut oil, soap, aluminum ware and metal containers.

It is believed that Mombasa takes its name from Mombasa in Oman (Persian gulf). With the rise of Islam, Arabs established themselves on the East African coast and a Perso-Arabic settlement at Mombasa dates from about the 11th century. In 1331 the Arab traveler Ibn Batuta described it as "a large place," and in 1498 Vasco da Gama found it a seat of considerable commerce. The ruler of the city tried to entrap da Gama (or so the explorer thought) and with this began a series of Portuguese-Arab campaigns which gave full force to the island's Swahili name *Mvita* (war). The principal incidents were the capture and burning of the town by Francisco de Almeida (1505), Nuno da Cunha (1529) and Duarte de Menezes (1587), the revolt and flight (1631) of Yusuf ibn Hassan after massacring the Portuguese colony, and the three years' siege of Fort Jesus by the imam of Oman in 1696–98, ending in the expulsion of the Portuguese. From March 1728 to Nov. 1729 a Portuguese force from Goa once again held Mombasa, when they were finally driven out by Muscat Arabs.

In Dec. 1823 the ruling Mazrui family placed the city under British protection and in Feb. 1824 Lieut. J. J. Reitz was appointed commandant. He died soon after. The protectorate was never confirmed by the British government. The town was later captured by Said bin Sultan of Oman who, after repeated attacks, obtained possession in 1837. Said made Zanzibar his capital and Mombasa became of secondary importance. A revolt against Zanzibar in 1875 was put down with British assistance. In 1887 the town was handed over by the sultan of Zanzibar to the British for administration and it later became the capital of the East African protectorate (Kenya colony). In 1907 the seat of central government was removed to Nairobi. Mombasa became a municipality in 1928 and assumed council status in 1959; until Kenya became independent in 1963 Mombasa formed part of the sultanate of

Zanzibar and was included in Kenya protectorate as distinct from Kenya colony. (ED. R.)

**MOMMSEN, (CHRISTIAN MATTHIAS) THEODOR** (1817–1903), one of the greatest of 19th-century German classical historians as well as a notable scholar in jurisprudence, philology and numismatics, and winner of the Nobel prize for literature in 1902, was born at Garding, Schleswig, on Nov. 30, 1817. His years at Kiel university developed his talent for law, and a traveling scholarship to Italy led him to become a student of inscriptions, a classical scholar and a numismatist. The fruits of these years are to be seen in his *Inscriptiones regni Neapolitani Latinae* (1852), *Unteritalische Dialekte* (1850) and in the preliminary studies for his monumental *Geschichte des römischen Münzwesens* (1860). After a short period of editorial work in 1848, he began his academic career in the same year as professor of civil law at Leipzig. His liberal principles caused him to be dismissed as a result of political reaction in 1850. In 1852 he became professor of law in Zürich, and was transferred to Breslau in 1854. At the same time, the Prussian Academy of Sciences entrusted him with the publication of the giant *Corpus inscriptionum Latinarum*, and he moved to Berlin in 1858, becoming also professor of Roman history there in 1861. From 1874 he was permanent secretary of the philosophy and history section of the academy.

The three volumes of Mommsen's *Römische Geschichte* appeared while he was in Breslau (1854–56); all his later major works were published when he was in Berlin, including the *Corpus inscriptionum Latinarum* from 1863, the *Römische Staatsrecht* (1871–88), the fifth, supplementary volume of his *Römische Geschichte* in 1886 (volume four was never written) and the *Römische Strafrecht* (1899). In addition, he published numerous articles and editions, notably the *Digest* of Justinian, the Codex Theodosianus and the *Chronica* of Cassiodorus. He died on Nov. 1, 1903, in Berlin.

Mommsen embodied German 19th-century historical scholarship best by uniting jurisprudence and history, philology and archaeology. He saw in legal antiquities, inscriptions and coins the expression of social conditions, and gave administrative records the same weight as diplomatic ones. His work on the Roman legal system demonstrates most brilliantly how empirical observation and a critical interpretation of individual facts led him to a systematic grasp of great intellectual issues; and his *Römische Staatsrecht* down to Diocletian thus marks an epoch in the development of historical scholarship. The *Römische Geschichte* combines scholarly common sense with a passion for bringing the past to life. Objective though he was, he allowed himself personal judgments, reducing the stature of Cato, Cicero and Pompey and seeing in Caesar the inevitable and brilliant culmination of century-long constitutional development. Caesarism as a system, however, he condemned.

Toward religion Mommsen was indifferent, and he mocked at historical-philosophical speculation. The political ideas of his scholarly work are marked by his national and democratic faith. All his life he clung to the creed of 1848, hoping for a politically united and constitutional Germany. He was therefore reserved and critical toward Bismarck and increasingly skeptical of the attitude of the educated middle classes. He was a member of the German Progressive party from 1863 to 1867, a National Liberal from 1873 to 1879 in the Prussian *Landtag* and a member of the left-wing liberal secession in the *Reichstag* (1881–84). His extensive work as an organizer, however, prevented him from being drawn to mix history with politics. He created a school of epigraphy and numismatics, was for many years head of the *Auctores antiquissimi* section of the *Monumenta Germaniae historica*, founded the Archiv für Papyrusforschung, organized research on the Limes Germanicus and promoted the *Thesaurus linguae Latinae* (see LIMES). He supported the positivist development of particular disciplines and the mechanical aspects of scholarship, and he achieved an unequaled grasp of the totality of history.

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The *Römische Geschichte* has been translated into English as *The History of Rome* by W. P. Dickson (1862–75; new ed. 1868–86, including vol. 5, as the *Provinces*); in the "Everyman Series" (1911; reprinted 1929–30), abridged by C. Bryans and F. J. R. Hendy (1888; new ed. 1959); and by D. A. Saunders and J. H. Collins (1958). (FZ. W.)

**MOMORDICA,** a genus of annual or perennial vines belonging to the gourd family (Cucurbitaceae; *q.v.*), natives of the tropics, especially Africa, and known in cultivation chiefly as hothouse plants. They are grown for their ornamental fleshy fruits, which are oblong to cylindrical, orange to red, prickly or warted externally, and burst when ripe, generally with elastic force, into irregular valves. *M. balsamina* (balsam apple) is a very pretty annual, well adapted for trellises, etc., in tropical situations, as is also *M. charantia* (balsam pear), a somewhat larger species.

**MOMOTIDAE,** a family of tropical American birds comprising the small, greenish, jaylike motmots (*q.v.*).

**MOMUS,** in Greek mythology, the son of Night and the personification of censoriousness. He is frequently mentioned as a sort of licensed grumbler, finding fault with all that the gods do. He appears very seldom in serious works; a lost satyr play of Sophocles bore his name, and Lucian often introduces him.

**MON,** a historically significant minority people numbering in the 1960s about 350,000 in the eastern delta region of Burma and 65,000 in west central Thailand, now distinguishable from the Burmese only in language. The Mon were among the earliest Mongoloid people from west China who spread over the river lowlands of southeast Asia from the Irrawaddy delta to the Menam Chao Phya valley and south to the Kra isthmus. They are a remnant of the earliest known civilization of southeast Asia, having been exposed to Indian culture (Brahmanism) and Theravada Buddhism for more than a millennium prior to the arrival of Burmese and Thai. Principal ancient Mon sites in lower Burma were Thaton, Twante, Rangoon and Pegu. The 7th-century centre of power was the kingdom of Dvaravati at Lopburi on the lower Menam, an offshoot of the Khmer empire. In the early 9th century the centre of Mon power shifted west to Pegu on the lower Sittang river. There were Mon connections with the great Buddhist centre at Kancheepuram (Madras). Southward-migrating Burmese took over the Mon irrigation of the Kyaukse area in central Burma and this dry zone became their key economic area (culture hearth). Conquest of Thaton in 1057 by Anawrata (Anuruddha), first king of Burma, was culturally decisive: Mon monks and scriptures of Theravada Buddhism were based at the Burmese capital, Pagan; Pali superseded Sanskrit as the language of sacred books; the Burmese adopted the Mon alphabet and Talaing became the Burmese name for Mon. Burmese were brought into direct contact with Indian influences and the way was opened for late 12th-century contact with Buddhist centres in Ceylon. Intermittent warfare for supremacy between the Mon of Pegu and Burmese to the north was the principal feature of 11th- to 18th-century Burma history. The Mon bore the brunt of 16th-century Burmese-Siamese struggles; their land was laid waste and their people were conscripted for forced labour or military service. Desperate Mon rebellions were met with savage reprisals, resulting in periodic migrations of the Mon to Siam. Short-lived independence for the Mon (1740–1757) ended with the Burmese siege and sack of Pegu and Mon subjugation. Those Mon who were not enslaved found refuge in Siam. Lower Burma became depopulated and famine-stricken, and, when the British arrived in 1824, had reverted to uncultivated waste.

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**MONACO** (PRINCIPAUTÉ DE MONACO), a sovereign principality on the northern Mediterranean coast, 9 mi. E. of Nice, France, is bounded on all land sides by the French *département* of Alpes Maritimes. Pop. (1961 census) 22,297 (20,441 permanent residents), including 3,039 Monégasques (citizens of Monaco), 12,869 French, 4,217 Italians and 598 British. Area 387.9 ac. (0.6 sq mi.).

The Phoenicians and later the Greeks had a temple on the

Monaco headland dedicated to Heracles, whose local surname Monoecus may be derived from a pre-Indo-European root *mon-*, "raised site" or "rock." Monoeci Portus, or Portus Herculis, is mentioned by later Latin writers. In 1070 the Genoese Grimaldi family entered into possession. The Grimaldi for the most part allied themselves with France until 1524, when Augustin sided with the emperor Charles V. Honoré I, Augustin's successor, was made marquis of Campagna and count of Canosa, and special privileges were granted. The *droit de mer*, or the right to 2% of the value of the merchandise in ships passing within sight of the fortress, originated with the Genoese and had been confirmed by Charles VIII in 1497. It was confirmed again in the treaty of Péronne (1641), whereby Honoré II re-allied his house with France, losing Canosa, etc., but becoming duke of the Valentinois. In 1731 Antoine I, Honoré's great-grandson, was succeeded by his daughter Louise Hippolyte, wife of Jacques de Goyon-Matignon, count of Torigny, who succeeded his wife and took the name of Grimaldi. In 1793 the national convention dispossessed the reigning family and annexed Monaco to France. The treaty of Paris (1814) restored the family; that of Vienna (1815) put Monaco under the protection of Sardinia. In 1861 Menton and Roquebrune were purchased by France. By the Franco-Monégasque treaty of Feb. 2, 1861, Monaco was restored to independent sovereignty, and a customs union was established with France by treaty in 1865.

In 1911 Prince Albert granted the principality a constitution, providing for an elected national council. In 1918 a Franco-Monégasque treaty was signed. This contained a clause providing that, in the event of the dynasty's becoming extinct, Monaco would become an autonomous state under French protection. Albert was succeeded in 1922 by his son Louis II, who in 1949 was succeeded by his grandson Rainier III (b. May 31, 1923), son of the hereditary princess Charlotte Louise Juliette and of Prince Pierre, comte de Polignac. In 1956 Rainier married Grace Patricia Kelly, U.S. motion-picture actress. A daughter, Caroline Louise Marguerite, was born on Jan. 23, 1957, and a son, Albert Alexandre Louis Pierre, on March 14, 1958.

In 1951 Monaco and France signed a convention of mutual administrative assistance concerning customs, taxes, posts, telecommunications and monopolies, which replaced previous agreements of 1912, 1925 and 1945. In Jan. 1959 Rainier suspended part of the constitution and dissolved the national council, and in 1961 he appointed instead a national assembly. However, when in 1962 a crisis in Franco-Monegasque relations appeared to threaten Monaco's independence, Rainier restored the council and granted a new, liberal constitution. The crisis arose chiefly because of Monaco's refusal to impose direct taxation in the principality. In April, France, claiming that tax exemption gave an unduly privileged position to firms established in Monaco, served the requisite six months' notice prior to abrogation of the 1951 convention. In October, French customs controls were set up along Monaco's frontier, but after lengthy negotiations a new fiscal convention was signed (May 18, 1963). This provided, in the main, for the payment of income tax at French rates by French citizens of less than five years' residence in Monaco and of company tax by Monégasque firms deriving more than 25% of their profits from outside the principality.

The national council of 18 members is elected for four years by adult male suffrage and *scrutin de liste*. Government is carried on by a minister of state (who must be a French citizen) and three state counselors, acting under the authority of the prince. The ministry is assisted by a council of state, nominated by the prince, which prepares laws and ordinances. Legislative power rests with the prince and the national council.

Monaco forms a single commune administered by an elected council, but it is divided into four sections (pop. 1961): Monaco-Ville (1,774), the old settlement on the summit of a rocky headland defended by ramparts; La Condamine (11,007), on the west of the bay, with a business district and the all-season port for yachtsmen and pleasure boats; Monte Carlo (*q.v.*; 9,516), with casino and hotels; and to the west the newer quarter of Fontvieille, where various light industries (*e.g.*, pharmaceuticals, cosmetics) have developed.

The judicial system, since 1819, has been based on the French. There is a court of first instance and a *juge de paix*, and by arrangement two Paris judges form a court of appeal. There is a semi-military police force. The bishopric dates from 1887 and is directly dependent on the Holy See. Primary and secondary education are provided by both church schools and secular institutions, and there is also a school of music.

In Monaco-Ville are the Roman Catholic cathedral of St. Nicholas (on the site of the ancient church), the medieval Genoese and Renaissance palace and Prince Albert's oceanographic museum (1910). Another museum contains prehistoric exhibits from the grottoes near Menton and Roman antiquities from La Turbie.

In 1861 François Blanc of Homburg obtained a 50-year concession to run gambling tables. This concession passed to a company and was subsequently extended. The Monégasques are forbidden access to the tables but are exempt from taxation. The casino and the issue of postage stamps are important sources of Monaco's revenue, and the principality also depends heavily on the tourist industry. The Monégasque franc is equivalent to the French franc; both are legal tender. Radio Monte Carlo and Télé Monte Carlo broadcast and televise commercially sponsored programs; Trans World Radio in Monte Carlo, maintained by voluntary contributions, transmits exclusively religious programs.

VIEW OF THE PRINCIPALITY SHOWING THE MUSEUM OF OCEANOGRAPHY ON THE ROCK OF MONACO AT THE EAST END OF THE JARDINS ST. MARTIN OVERLOOKING THE HARBOUR

BIBLIOGRAPHY.—A. Smith, *Monaco and Monte Carlo* (1912); L. H. Labande, *Histoire de la Principauté de Monaco* (1934); F. de Bernady, *The Princes of Monaco* (1961). Current history and statistics are summarized annually in *Britannica Book of the Year*.

(K. F. E. X.)

**MONAGAS**, a state in eastern Venezuela, is bounded by the Orinoco river on the southeast, the Caño Mánamo on the east, the San Juan river and the Gulf of Paria on the northeast, and the states of Sucre and Anzoátegui on the north and west. Area 14,158 sq.mi. Pop. (1961) 246,217. Except for a coastal range on the north and marshes in the Orinoco delta area, Monagas is a land of savanna—typical llanos country. Cattle raising is dominant over most of the state, though the usual list of Venezuelan crops is grown in the northern uplands. Monagas has one of the largest oil-bearing areas in eastern Venezuela; among the principal fields are Campo Temblador, Campo Santa Barabara, Campo Jose-

pin and Campo Quiriquire. Pipelines connect the fields with the Caripito refinery and terminal. Maturin (pop. [1961] 53,445) is the state capital and chief trading centre. (L. We.)

**MONAGHAN** (Contae Mhuineachain) is one of the three counties of Ulster that are in the Republic of Ireland and forms an enclave of the Irish republic, projecting deeply into Northern Ireland. Area 498 sq mi. (excluding water); pop. (1961) 47,088. Most of the county boundary with its northern neighbours, Fermanagh, Tyrone and Armagh, winds through cultivated lowlands except on the Slieve Beagh, a desolate upland rising to 1,255 ft. For many miles the boundary with Tyrone runs along the Blackwater river, an affluent of the Bann.

Structurally, three main areas may be distinguished. The most northerly, Slieve Beagh, is characteristic of other Carboniferous plateaus of Ireland; the second, the Monaghan corridor, floored by Carboniferous beds, corresponds to many lowland areas of Ireland, at 200–400 ft. above sea level. It leads from the Erne valley to the Lough Neagh basin, and is used by roads, the railway from Clones to Armagh and the Ulster canal, which has been derelict for nearly 40 years. South of this corridor the third physical unit appears with a discernible edge; it consists mainly of Silurian slates and grits, though round Carrickmacross there is a basin floored by Triassic and Carboniferous beds. Generally about 500–600 ft. high, the Silurian hill country rises in long sweeping lines to more than 1,000 ft.

Despite the variety of rock formation, the whole landscape is made remarkably uniform by the presence of many hundreds of drumlins (whale-backed hills mostly 50–100 ft. high of varied length but in some cases as much as half a mile long). These drumlins give the lowland corridor of Monaghan a highly complicated drainage pattern, with an indeterminate divide between the waters of the Bann and the Erne. Characteristic also are numerous small lakes and peat flats, no doubt the relics of previous lakes and ponds for there is every sign that these waters are being reduced in size by sedimentation. In the Silurian hilly area similar drumlins and waters are found, varying from lakes of a few square miles to mere ponds and even peat flats.

Monaghan formed part of an ancient kingdom of Oriel which consisted of Monaghan, Louth and Armagh and was formed in A.D. 330 by three princes, descendants of Conn, who attacked Ulster. The Anglo-Norman advance broke up Oriel, but Monaghan remained dominated by the MacMahons and lay outside the main area of Anglo-Norman influence. In Tudor times the MacMahons tried to legalize their position by surrendering their land to the crown and receiving it back under English law. When Ross MacMahon, the reigning chief, fell foul of the government and was executed in 1559, a large area again came into the hands of the crown. Elizabeth I approved a settlement of Monaghan in 1591 by which the county was divided in estates between seven chief MacMahons and a McKenna. Monaghan was therefore not included in the later plantation of Ulster. With the establishment of the governments of the Irish Free State and Northern Ireland, a peculiarly large proportion of Monaghan's county boundary became interstate frontier.

The county council meets at Monaghan town and there is a county manager. Carrickmacross (*q.v.*), Castleblayney, Clones and Monaghan are urban districts. Ballybay is administered by town commissioners. The county sends three members to *dáil éireann*.

Agriculture in Monaghan is primarily of the northern type with small farms averaging 30 ac. and intensive cultivation; only one-eighth of the county's area is unimproved land. By tradition this is a flax-growing county, and beside streams the flax-retting troughs may be seen—though little flax has been grown since World War II. Grass, which is grown for seed, is sorted at Castleblayney. Little wheat is grown, but about one-sixth of the land is used for crops and one-sixth for hay. On many farms potatoes and oats are sold, and another main resource is cattle rearing, with dairying for the creameries.

Slightly over one-quarter of the population lives in towns and villages, which are mainly market centres at a distance of a few miles one from another. Boots and shoes are made in Castleblayney (pop. [1961] 2,127) and Carrickmacross (1,940). At Clones (2,107) there is a clothing works and an old-established factory making spades and shovels. Monaghan (4,013), the county town, has milling, bacon curing, furniture making and linen weaving. The main economic strength of these towns, however, lies mainly in their retail trade and monthly fairs. Carrickmacross lace is well known.

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(T. W. Fr.; Hu. S.)

**MONAGHAN** (Muineachán), the county town of County Monaghan, N.Ire., is 55 mi. S.W. of Belfast by road and on the Ulster canal. Pop. (1961) 4,013. It is an agricultural market centre with a market hall dating from 1792. There is a 19th-century Roman Catholic cathedral of St. Macartan and a diocesan seminary (1½ mi. N.) for the diocese of Clogher. The early monastery founded there and plundered in the 9th and 10th centuries was in existence until 1161. A Franciscan friary founded on its site was suppressed by the English in the 16th century. James I incorporated Monaghan in 1613, when its residents were mostly retired soldiers from the English garrison. Charles Gavan Duffy, who became prime minister of Victoria, Austr., was born there, and Gen. Don Juan McKenna, the Chilean military leader, was born nearby.

**MONA ISLAND** is a limestone shelf of 20 sq mi. raised 150 to about 300 ft. out of the Mona channel about 50 mi. S.W. of Puerto Rico. The island has no permanent inhabitants. Guided missile installations and a lighthouse are maintained. There is a small landing strip. In spite of excellent beaches and good fishing, government attempts to develop the island as a tourist attraction had produced no results by the early 1960s. (T. G. Ms.)

**MONAL** (Monaul), any of the beautifully iridescent short-tailed pheasants of the genus *Lophophorus*, living 8,000 to 15,000 ft. up in the Himalayas from Afghanistan almost to Tibet. In the Impeyan pheasant (*L. impejanus*) the rooster-sized, crested male has a shining green and blue body, gilded purple neck, white rump and short red-brown tail. Related species are found in northern Burma and Yünnan and in southeastern Koko Nor and western Szechwan. *See* also Pheasant.

**MONARCHIANISM,** a theological term designating the view taken by those Christians who, within the church, toward the end of the 2nd century and during the 3rd, opposed the doctrine of an independent personal subsistence of the Logos, and affirmed the sole deity of God the Father. The representatives of the extreme monotheistic view, which, while regarding Christ as Redeemer, clung tenaciously to the numerical unity of the Deity, were called monarchians, a term brought into general use by Tertullian. It is usual to speak of two kinds of monarchianism—the dynamistic (or adoptionist) and the modalistic (or Sabellian)—though the distinction cannot be carried through without some straining of the texts.

By monarchians of the dynamistic class Christ was held to be a mere man, miraculously conceived indeed, but constituted the Son of God simply by the infinitely high degree in which he had been filled with Divine wisdom and power. This view was taught at Rome about the end of the 2nd century by Theodotus, who was excommunicated by Victor, and at a later date by Artemon, excommunicated by Zephyrinus. About the year 260 it was again propounded within the Church by Paul of Samosata (*q.v.*).

Modalistic monarchianism, conceiving that the whole fullness of the Godhead dwelt in Christ, took exception to the "subordinatianism" of some church writers, and maintained that the names Father and Son were only different designations of the same subject, the one God, who "with reference to the relations in which He had previously stood to the world is called the Father, but in reference to His appearance in humanity is called the Son." It was first taught, in the interests of the "monarchia" of God, by Praxeas, a confessor from Asia Minor in Rome about 190, and was opposed by Tertullian in his well-known controversial tract. The same view—the "patripassian" as it was also called, because it implied that God the Father had suffered on the

cross—obtained fresh support in Rome about 215 from certain disciples of Noetus of Smyrna, who received a modified support from Calixtus I. For the subsequent history of modalistic monarchianism *see* SABELLIANISM. *See* also ADOPTIONISM.

*See* A. Harnack, *History of Dogma*, vol. iii, pp. 1–118 (1897).

**MONARCHY,** strictly defined, means the undivided sovereignty or rule of a single person. The term is applied to states in which the supreme authority is vested in a single person, the monarch, who is the permanent head of the state. The word has, however, outlived this original meaning and is now used, when used at all, somewhat loosely of states ruled over by hereditary sovereigns, as distinct from republics with elected presidents; or for the "monarchical principle," as opposed to the republican principle. A distinction must first be drawn between elective and hereditary monarchies. Of the former class the most conspicuous was the Holy Roman empire, but in Europe all monarchies were, within certain limits, originally elective. After the introduction of Christianity, the essential condition of the assumption of sovereign power was not so much kinship with the reigning family as the consecration or "sacring" by the divine authority of the church. The purely hereditary principle was of comparatively late growth, the outcome of obvious convenience, exalted under the influence of various forces into a religious or quasi-religious dogma.

The old idea of monarchy, viz. that of the prince as representing within the limits of his dominions the monarchy of God over all things, culminated in the 17th century in the extreme version of the doctrine of the divine right of kings, and was defined in the famous dictum of Louis XIV: *L'état c'est moi!* The conception of monarchy was derived through Christianity from the theocracies of the eastern Mediterranean and of Rome, though Germanic tribal concepts of kingship were also incorporated into the medieval monarchy. The Greeks knew monarchy mainly in two forms, the Homeric and the Macedonian. In the first the king was a hereditary ruler whose authority was intimately bound up with his prowess in battle. In the second he was an imperial ruler who acquired divine properties, as in Hellenistic times his conquests, like Alexander's, took him farther away from the restraints of Greek rationalism and democracy into an oriental despotism.

Monarchy was the underlying principle of the medieval empire and also of the medieval papacy, the rule of the popes during the period of its greatest development being sometimes called "the papal monarchy." As the unity of medieval Christendom broke up, monarchy acquired a new basis. The monarch was ideally placed to provide the centralized power needed by the new nation states of the 16th and 17th centuries. Frequently he became an absolute ruler, the only source of law, the only mainspring of administration. Sweden and Poland, among continental European states, maintained checks on royal absolutism. But in England, Tudor absolutism retained parliamentary institutions, so that when the Stuarts endeavoured to assert the divine right of kingship they were frustrated by forces that were determined to set limits to monarchical power. The execution of Charles I (1649) and the revolution against James II (1688) were decisive blows against monarchical absolutism. By the Bill of Rights of 1689 it was established that the king reigned not by divine right but solely with and by the consent of parliament. To this the Act of Settlement of 1701 laid down that the crown's ministers should be "responsible" for the acts of the sovereign. By this the essential basis was laid for a "constitutional" or "limited" monarchy, though the full working out of the principle took more than a century to effect. After 1717 the king ceased to attend cabinet meetings and gradually the office of prime minister (*q.v.*) evolved. With the passage of the Reform act, 1832, actual sovereignty was recognized to lie in the people as represented in parliament and the functions of the British monarch began to assume their modern form.

On the continent of Europe monarchical absolutism in general continued to thrive in the 18th century, accommodating itself even to the first impact of the "enlightenment" in the form of the "benevolent despot," of whom Frederick the Great of Prussia and Catherine the Great of Russia were notable examples. In 1789, however, the French Revolution dealt it a blow in some respects more shattering than it had sustained in Britain. Even when, as in many countries, the institution survived or when, as in others, it was restored in the reaction after the Napoleonic Wars, it was almost always in a modified form. The monarch accepted constitutional limitations on his power, abandoned his taxing and law-making functions to a representative legislature and devolved his executive powers, in varying degrees, on to ministers who ruled with the consent of parliament. In France, despite successive attempts, the monarchy failed to re-establish itself. In Latin America republics rose on the ruins of the Spanish and Portuguese empires; Brazil was unique in retaining a monarchy down to 1889.

World War I brought ruin to those monarchs who had retained so much personal power that they could not escape blame for defeat or social injustice. Among such victims were the monarchies of Russia, Germany and Austria-Hungary. In Spain the monarchy was overthrown in 1931 though the constitution of 1947 still called Spain "a kingdom," even while proclaiming General Franco as chief of state. World War II dealt further blows at monarchy, not only in Europe (*e.g.*, Italy) but also in the far east. In China the Manchu dynasty had been overthrown as lately as 1912. In Japan defeat produced a voluntary abandonment of the doctrine of imperial divinity; by the constitution of 1946 (adopted 1947) the emperor became merely "the symbol of the state and of the unity of the people." Elsewhere the continuing support of western powers, combined sometimes with a policy of wise concession to popular demands, often enabled monarchical rulers to maintain themselves. This was so in Thailand, Iran, the Hashemite kingdom of Jordan, Saudi Arabia and also in the African states of Ethiopia, Libya and Morocco.

In Europe monarchy survived in Britain, Norway, Sweden, Denmark, Belgium, the Netherlands and Greece. Of these, Denmark was the last to abandon absolutism (in 1849), but all the Scandinavian monarchies were notable for their scrupulous constitutionalism and their democratic unpretentiousness. The pattern of all these limited monarchies was set by Britain, a process in which the personal prestige and longevity of Queen Victoria played an important part.

The British monarch of the 20th century is the legal head of the state but the acts done in his or her name are in fact those of ministers responsible to parliament. The monarch is above party and outside politics. The only discretionary powers of the monarch are to choose a prime minister (and normally the clear working of a two-party system makes the selection automatic) and conceivably to refuse a dissolution of parliament. In relation to ministers the monarch has, in Walter Bagehot's words, "the right to be consulted, the right to encourage, the right to warn"; the monarch must never so act as to come into conflict with the people's elected representatives. As a symbol of national unity, a focus for loyalty and an embodiment of accepted standards, the monarch has great influence, intangible admittedly but also pervasive. The British monarchy has also a special role in relation to the commonwealth, where the fully self-governing countries all recognize the monarch as head of the commonwealth.

*See* also references under "Monarchy" in the Index.

(H. G. N.)

**MONASTERBOICE** (MAINISTIR BHUITHE, *i.e.*, "monastery of Buite"), the ruins of an ancient monastic settlement founded by Buite or Boethius (d. 521), which lie 5 mi. N. of Drogheda in County Louth, Republic of Ireland. The relics date from the 8th to the 12th century and comprise two churches, a round tower, three sculptured crosses, two simple tombstones and a sundial. The "South" and older church (c. 9th century) has both nave and chancel; the other is rectangular. The round tower, though incomplete at 110 ft., is one of the highest in Ireland. The crosses, sculpted in elaborate detail, are outstanding in magnitude, design and execution. The North cross is 18 ft. high, the High or West cross 21 ft. and Muiredach's cross is 17 ft. and monolithic.

**MONASTERY,** the home of a religious community (*see* MONASTICISM). The word is commonly used only of houses of men, but in what follows houses of women religious, widely though not properly known as convents, will also be considered; a monastery ruled by an abbot is called an abbey.

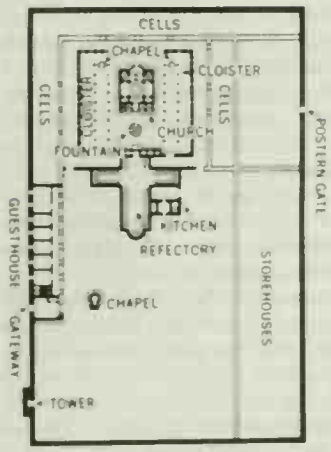



FIG. 1.—MONASTERY OF THE LAURA, MT. ATHOS, GREECE, FOUNDED IN 963

The earliest Christian monastic communities inhabited groups of cells or huts collected about a common centre, which was usually the abode of some anchorite celebrated for superior holiness. Such, for example, was the case with the disciples of Anthony in the Egyptian Thebaid in the early 4th century. The monastery properly so-called came into existence a few years later when Pachomius, also in Egypt, established the cenobitic life, which rapidly spread to Syria and elsewhere. The Pachomian monks lived in separate huts, forming a religious hamlet. They had no refectory but ate their common meal reclining on strewn grass, often out-of-doors. By degrees order was introduced in the groups of huts, and they were arranged in lines like the tents in an encampment or the houses in a street. From this arrangement a line of single cells came to be known by the Greek word *laura* (*q.v.*), meaning "lane" or "passage."

The necessity for defense from hostile attacks, economy of space and convenience of access from one part of the community to another by degrees dictated a more compact and orderly arrangement of the buildings of a monastic cenobium. Large piles of buildings were erected, with strong outside walls, within which all the necessary edifices were ranged round one or more open courts, often surrounded by cloisters, though very often also the buildings stood free inside the enclosure, with an ambulatory or colonnade running along the inner side of the wall. No fixed plan was adopted, but a usual eastern arrangement may be seen in the plan of the Laura, on Mt. Athos in Greece (fig. 1).

When monasticism was introduced to the west, its local habitation took various forms in harmony with the social conditions and situation of the community. Thus Celtic monachism preferred a group of cells and small houses built of stones, such as may be seen on various sites in Ireland or in the excavations at Iona (Scot.) or Whitby (Yorkshire). In Latin lands the buildings were larger and more compact, but the site was often such as to make elaborate or regular planning difficult, as for instance in the upper monastery of Subiaco or that of Cava de' Tirreni northwest of Salerno in Italy.

Monasticism in western Europe, as is well known, was progressively influenced by the rule of St. Benedict of Nursia, which was composed about A.D. 535–540 but was not widely followed before the end of the 7th century. Benedict in his early life had been familiar with the small, simple and almost casual buildings of the monasteries in the valleys and mountains of central Italy, and the home of his later life, where he wrote his rule, was the rugged hilltop of Monte Cassino. In the rule there is mention of an oratory, refectory, cells for monks and novices and quarters for guests; it is also laid down that all things necessary for the life of the monks should be contained within the enclosure, and water, a mill, a bakehouse and offices for all necessary crafts are specified, while the mention of a porter implies a wall and a single public entrance. No indication, however, is given of the size of the buildings or of their relation to each other, and there is also no mention of a cloister.

The cloister, soon to become the central feature of the monastic complex and used in some languages as a synonym for the whole monastery (as in Fr. *cloître* and Ger. *Kloster*), originated in northern Italy and was probably derived not, as was once suggested, from the court (atrium) of Roman domestic buildings but from the narthex (*q.v.*) or porticoed court at the west end of early basilical churches such as can still be seen at Sant'Ambrogio in Milan. When once this had been transferred to a position alongside the nave, with its eastern walk abutting on the transept of a cruciform church, it became the circulating area and the living

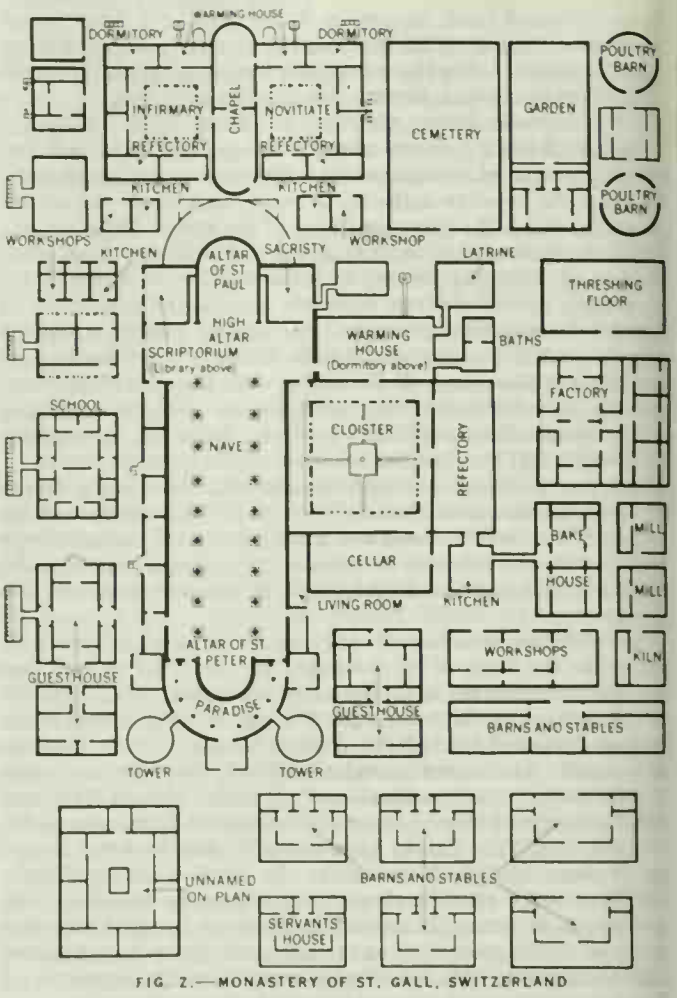



FIG. 2.—MONASTERY OF ST. GALL, SWITZERLAND

room of the whole establishment, with ranges of buildings on the three vacant sides: to the east the dormitory, novitiate, warming house and latrines; to the south, farthest from the church, refectory and kitchens; to the west, storerooms and guest rooms, adjacent to the one exit to the outer court. This, the classical layout, is seen in almost all its essentials, and with all possible additions and elaborations needed in what was to be a kind of religious civic centre or county town, in the interesting document known as the plan of St. Gall (Switzerland) which was in fact almost certainly the "blueprint" of a model monastery circulated

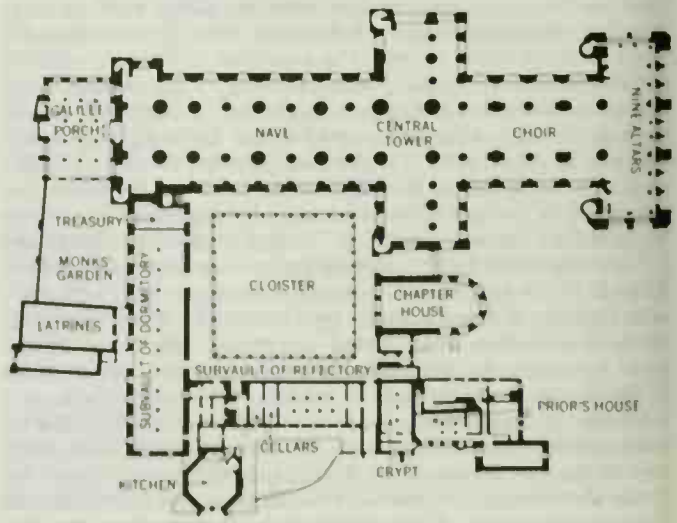
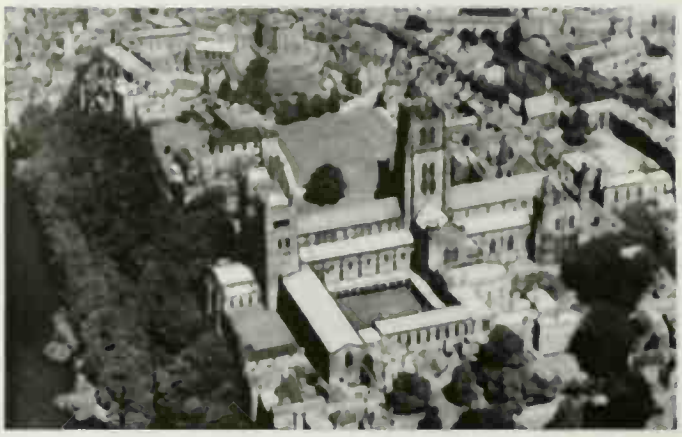


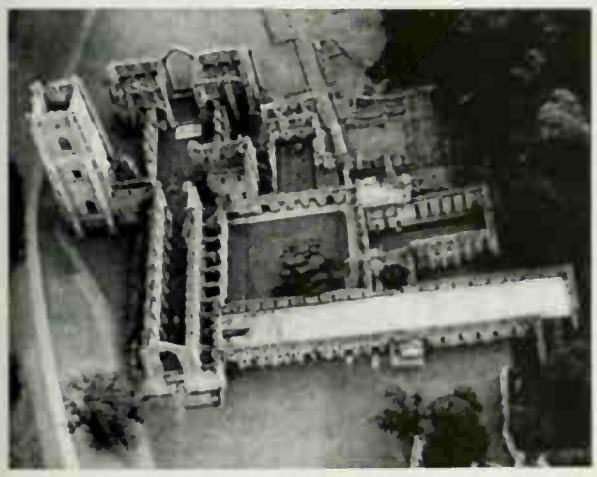

FIG. 3.—ABBEY OF DURHAM, ENGLAND, BEGUN c. 1071

Galleries of the Greek Orthodox monastery of Simopetra on Mt. Athos, Greece. Founded during the 14th century

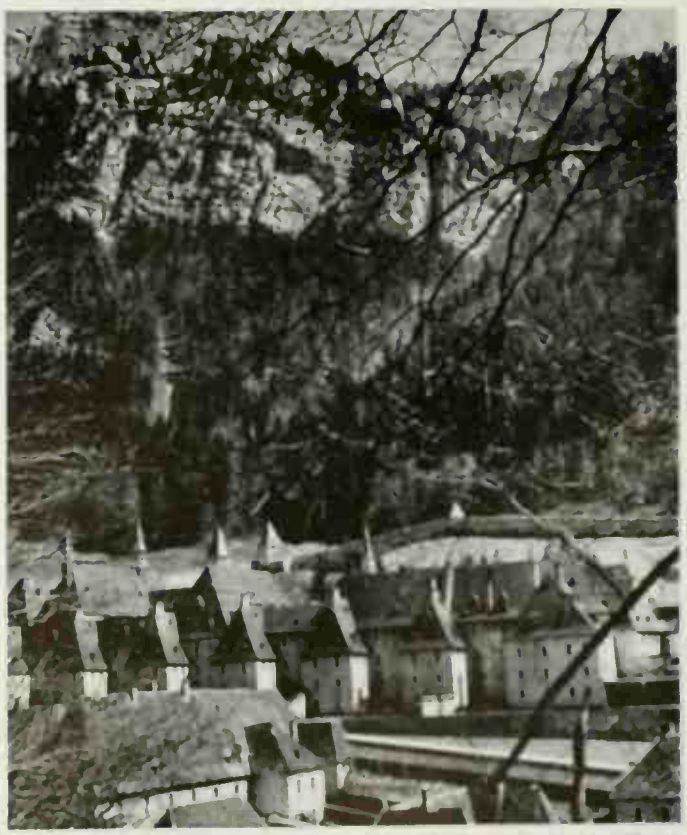
Benedictine monastery on Monte Cassino, Italy, as it appeared prior to World War II. Established by St. Benedict in 529



Cathedral priory, Durham, Eng. Founded by the Benedictine order in 1093



Ruins of Fountains abbey, Yorkshire, the best-preserved and most complete Cistercian house in England. Founded in 1132



La Grande Chartreuse, Carthusian priory near Grenoble, France, founded in 1084 by St. Bruno. Most of the buildings date from the 14th century and later

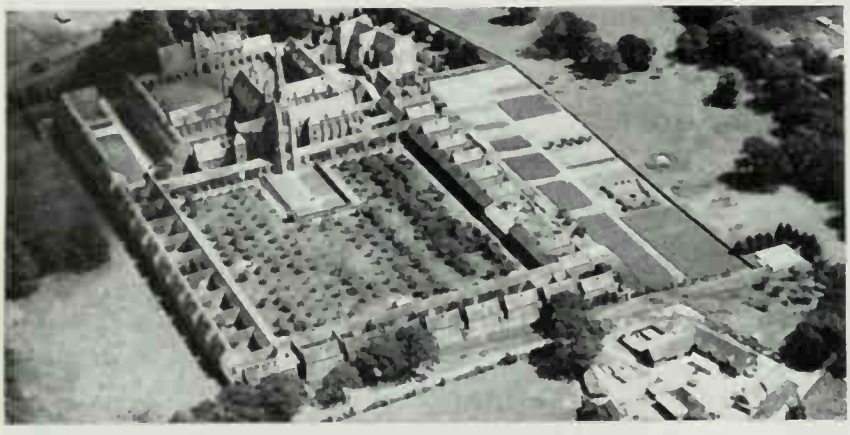
Cistercian abbey of Sénanque, Vaucluse *département*, France. Simplicity of style characterized early Cistercian monasteries. Founded 1148

## MONASTERIES DATING FROM THE 6TH TO THE 17TH CENTURY

# MONASTERY

Benedictine abbey of Cluny, France, as it appeared about 1765. Buildings in left foreground are drawn. Founded in 910, most of the buildings were destroyed between 1789 and 1814

Ettal abbey in Bavaria, Germany. Established by the Benedictine order in 1300, it was rebuilt during the 18th century



St. Hugh's priory, Carthusian charterhouse at Parkminster, Sussex, Eng., showing the characteristic Carthusian arrangement of small monks' houses surrounding the large cloister. Founded in 1883

Façade of San Lorenzo el Real del Escorial, Spain. Once a Hieronymite priory, it is now occupied by Augustinians. Begun 1563, completed 1584

Cloister and towers of the monastery of San Francisco, Quito, Ecuador. Founded in 1538 by the Franciscan order

Church of St. John's abbey, Collegeville, Minn. The abbey was founded by the Benedictine order in 1857, the church was built in 1961

MONASTERIES OF EUROPE, SOUTH AMERICA AND THE UNITED STATES

by Benedict of Aniane when he was acting as principal monastic reformer to the emperor Louis the Pious about 820. The buildings, with some exceptions, seem to have been of one story only, and possibly many of them were wooden.

Not all Benedictine abbeys, not even the greatest, had in practice all the appurtenances of the St. Gall plan, but almost all had, in one form or another, the four-sided cloister surrounded by the conventual buildings. In these only two significant changes had been made in the centuries between Charlemagne and the religious revival of the 11th century. The first was the addition of an assembly room (the chapter house) as an imposing architectural feature in the east range of buildings near the church; the second, perhaps not unconnected with this, was the lifting of the dormitory (dorter) to first floor (U.S. second story) level, with the consequent increase of available space below it on the ground floor. Of the four walks of the cloister the quietest, that alongside the nave of the church, was used as the place for daily work and study. Whereas south of the Alps the cloister was normally sited north of the church to secure a maximum of shade and steady light, north of the Alps the need for a maximum of light and warmth led to its transference to the south; where, however (as in England at Canterbury, Bury St. Edmunds and Gloucester), the ground to the south of the church was already occupied by churches or a graveyard, the planners had no hesitation in siting the cloister to the north.

In all monasteries the church, constructed on a scale that often had little apparent relation to the number of potential worshipers, was the principal architectural feature, and the multiplication of liturgical processions, of private Masses and often of popular shrines helped to lengthen the nave and multiply side chapels. In addition, the church, whenever the architect had a free hand, occupied the highest point of the site.

Round the cloister lay the sacristy, chapter house, treasury, novitiate and warming house, over which extended at first floor level the dorter, with "night" stairs giving direct access to the transept of the church and "day" stairs debouching in the cloister. At the end of the dorter and usually at right angles to it lay the rere-dorter or *necessarium* (latrines), a building of some size standing over the great drain. Along the south walk lay the refectory (frater), with the kitchen at its southwest angle outside the cloister range. To the west lay the cellarage and the cellarer's office with rooms for distinguished guests and (later) the abbot's chambers at first floor level.

Outside this nucleus lay two other blocks of buildings. To the southeast—that is, in the most secluded position—lay the infirmary, a monastery *in parvo* with a large hall containing beds, chapel, frater and often a small cloister and garden; to the west of the cloister lay an extension of the original (early) guest quarters. Beyond these, to the west of the cloister and church, lay the great court, bounded by a precinct wall, entered by a great gateway, and bordered by offices and stabling of every kind. It must be remembered that Benedictine abbeys were often ancient foundations in cities or on an eminence (*e.g.*, Sulzburg, Monte Cassino, Durham and Worcester) where the normal plan encountered hindrances, and radical modifications were often necessary.

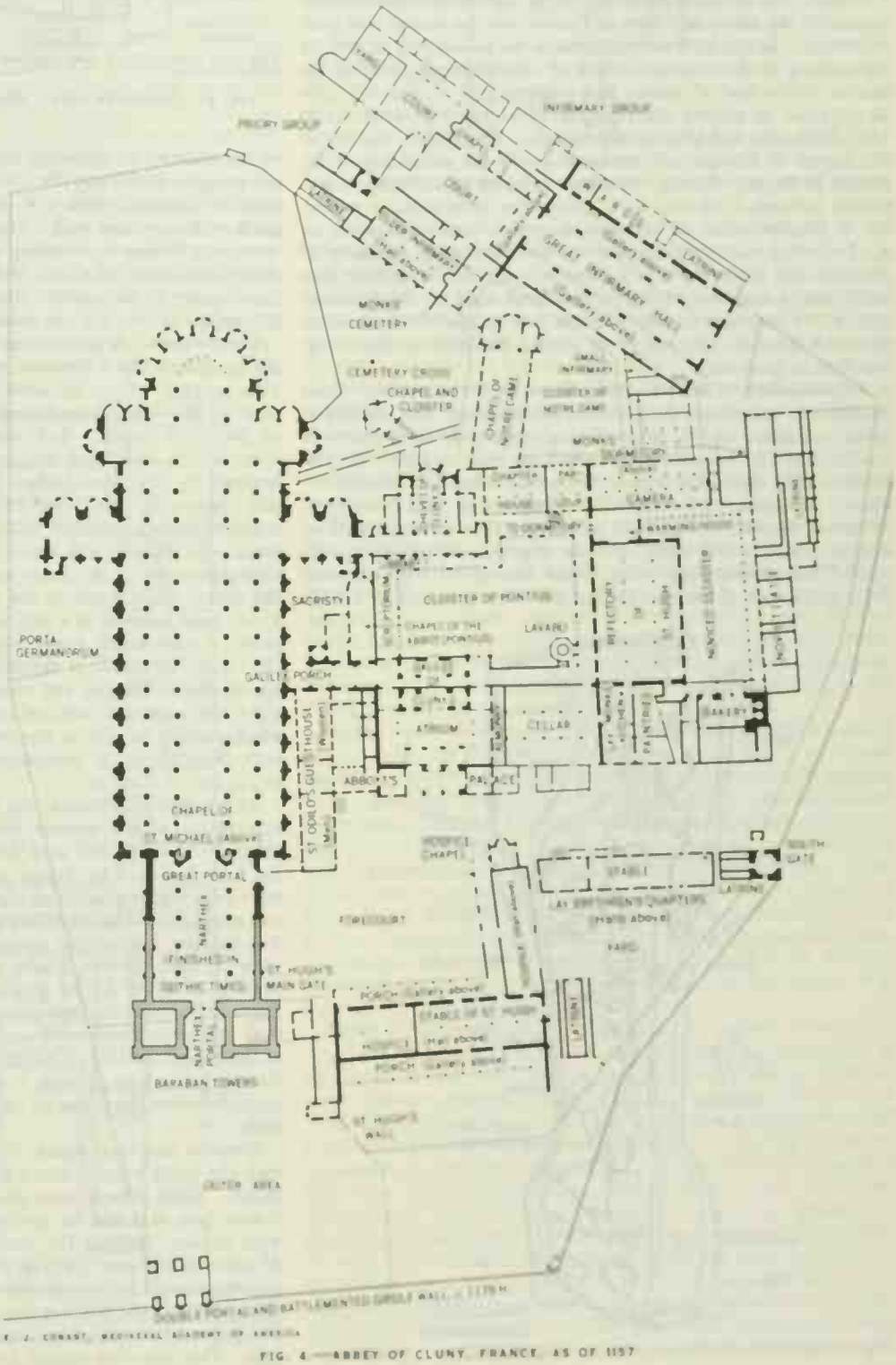



FIG. 4.—ABBEY OF CLUNY, FRANCE, AS OF 1157

It was not till the 14th century that a large room for books became common. Before that date, provision was made for books in presses against the wall of the cloister, and in particular against the wall adjoining the church, which, in a normal plan, would be the lightest. In Cistercian abbeys there was from the beginning a small book cupboard between the church and the chapter house. Writing and illumination were done either in the north walk of the cloister, where in the later centuries of the middle ages small studies or "carrels" were provided for individuals (as at Gloucester), or in a special room in or adjacent to the warming house (calefactory). (*See* LIBRARY: *History: Middle Ages and Renaissance.*)

**Cluny.**—Of all the monasteries of the west in the "Benedictine centuries" the abbey of Cluny in France was the largest and most celebrated. In the 12th century it housed a community of 400, to say nothing of the constant stream of Cluniac monks visiting the mother abbey and of guests and pilgrims, yet it was still able on occasion to receive the papal or royal court or even, as in 1245, both pope and king simultaneously. The church was by far the largest in Europe and remained so till the rebuilding of St. Peter's in Rome. Almost the whole complex of buildings disappeared between 1789 and 1814, during the revolutionary period, but a lengthy series of excavations, which were conducted by K. J. Conant under the auspices of the Mediaeval Academy of America, has made possible a reconstruction of the ground plan with some conception of the architectural style of the buildings (fig. 4). Cluny and its dependencies had no specific features of plan and differed from houses of similar size only in their magnificence of decoration.

**Augustinian Canons and Premonstratensians.**—These monasteries resembled those of the Benedictines, but the largest house of canons was no larger than a moderately sized abbey of monks, and the majority were small or even minute. As the canons rarely manned a cathedral (Carlisle is the only English instance) or a great city church (St. Mary Overy, now Southwark cathedral, London, is hardly an exception) they often planned on a small scale; if and when funds or numbers demanded or permitted enlargement they often found themselves without room for a south aisle of the church, the site being occupied by a walk

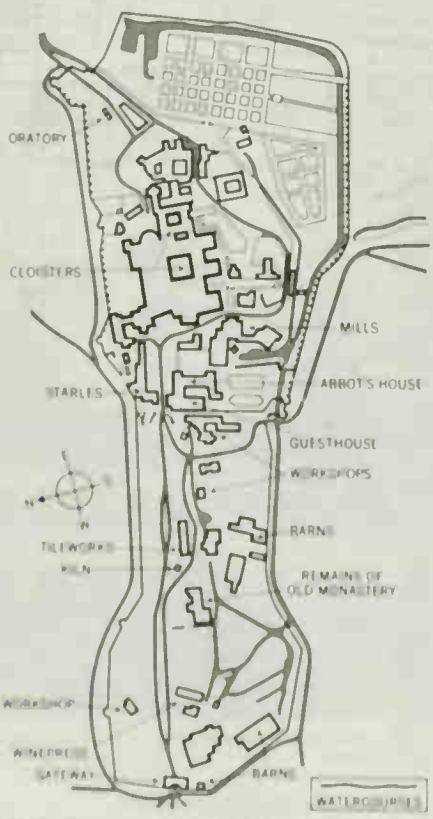
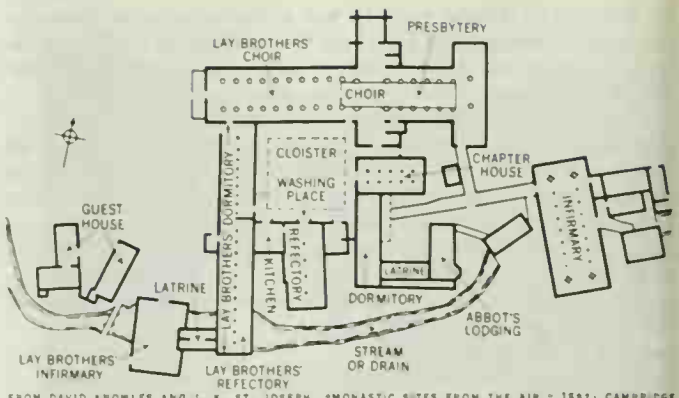



FIG. 5.—ABBEY OF CLAIRVAUX, FRANCE, FOUNDED IN 1115 (CISTERCIAN)




FROM DAVID KNOWLES AND J. K. ST. JOSEPH, "MONASTIC SITES FROM THE AIR," 1952; CAMBRIDGE UNIVERSITY PRESS

FIG. 6.—FOUNTAINS ABBEY, YORKSHIRE, ENGLAND, FOUNDED IN 1132

of the cloister, or forced to dislocate the buildings of the eastern range to make way for an enlarged transept. They also frequently dispensed with the western range, closing the cloister garth with a curtain wall. The Premonstratensians in particular were very flexible in planning, and even their larger houses show great irregularity of siting, and displacements from the conventional order in the various apartments and slightly rhomboid or trapezoid cloisters are not unknown.

**Cistercians.**—A new era in planning and building began with the spread of the Cistercian order in the early decades of the 12th century. Four circumstances, out of the many new features of the order, helped to distinguish their abbeys from those of the older monks: they were constructed rapidly on virgin sites, with a free hand for planning; uniformity of layout was imposed by their constitutions; simplicity of style and decoration was likewise imposed; and provision had to be made for large numbers of lay brothers within the monastic enclosure. Their architects, within these limits, were further bound by two considerations, one of sentiment and one of utility: the high altar of the church must stand on the highest point of the site, and provision must be made of a copious supply of water for sanitary purposes, a need which sometimes necessitated a northern site for the cloister to permit of drainage in that direction. Generally the apartments on the east and south range lay in the traditional positions, but when a Cistercian community increased greatly and it was necessary to enlarge the refectory lack of space in the south walk often led to the construction of a new frater at right angles to the line of cloister.

As for the lay brothers, the Cistercians solved the problem by making use of the western range, largely otiose in Benedictine abbeys. This was still used for cellarage at ground level, but on the first floor a long dorter accommodated the brothers, while their refectory was sited on the ground floor of the range, which was extended to the south beyond the angle of the cloister garth. The kitchen, common to monks and brothers, was placed at the angle between the two fraters. The lay brothers had also an infirmary on a site to the southwest of the cloister. There were thus to all intents two monasteries in a single complex. For worship, the lay brothers used some of the western bays of the nave of the church, and often, to protect the monks in the cloister from disturbance, a long passage, known as the lane, within the western range led from the frater to the church, with a door into the nave aisle.

Mention has been made of the drainage; this, closely linked with the water supply, was a matter in which the Cistercians excelled. Their abbeys were always sited where a swiftly flowing stream ran, or could be conducted, through the buildings from west to east, flushing the drains and carrying away the refuse. At some monasteries, such as Fountains in Yorkshire (fig. 6), the engineering and architectural devices are both ingenious and beautiful. Besides the flow for drainage, an entirely independent supply was available for drinking and washing throughout the buildings. This was often carried from a spring, at a distance from the

abbey, by stone conduits or lead piping, and distributed round the cloisters where needed.

The uniformity of Cistercian planning strikes the most casual observer. While the materials used show great local differences, as may be seen, for example, by comparing Fountains and Rievaulx (Yorkshire) with Furness (Lancashire) or Dundrennan (Kirkcudbrightshire), the plans are almost identical, and it is only in a few small abbeys that never flourished in numbers and wealth, such as Kymmer in Wales, that the primitive simplicity of the earliest buildings was never given full development.

**Carthusians.**—This religious order, which was in origin eremitical, always retained its character, though it domesticated the hermit's life to the extent of placing his cell within an architectural complex. The cloister garth, which was often of considerable size, was surrounded by the miniature houses of the brethren, each with its small garden plot. The church, often no more than a fair-sized chapel, adjoined the cloister on the side where the one means of egress led to the refectory, the prior's cell, the guesthouse and the outer gate. In early Charterhouses (the English corruption of the original Grande Chartreuse) the lay brothers lived in a group of buildings at some distance from the monks' cloister (*e.g.*, at Witham and Hinton in Somerset), but later, when urban Charterhouses became common, they were accommodated (as at the London Charterhouse) within the monastic enclosure. Normally, and in England universally, the buildings of a Charterhouse were modest, not to say mean, in size and in appearance (*cf.* the church and buildings at Mount Grace in Yorkshire), but on the continent of Europe (*e.g.*, at Florence and Pavia) they were constructed on a scale with materials of great magnificence. Thus, however, made no alteration to the solitude and simplicity of the individual Carthusian. (See also CHARTREUSE, LA GRANDE.)

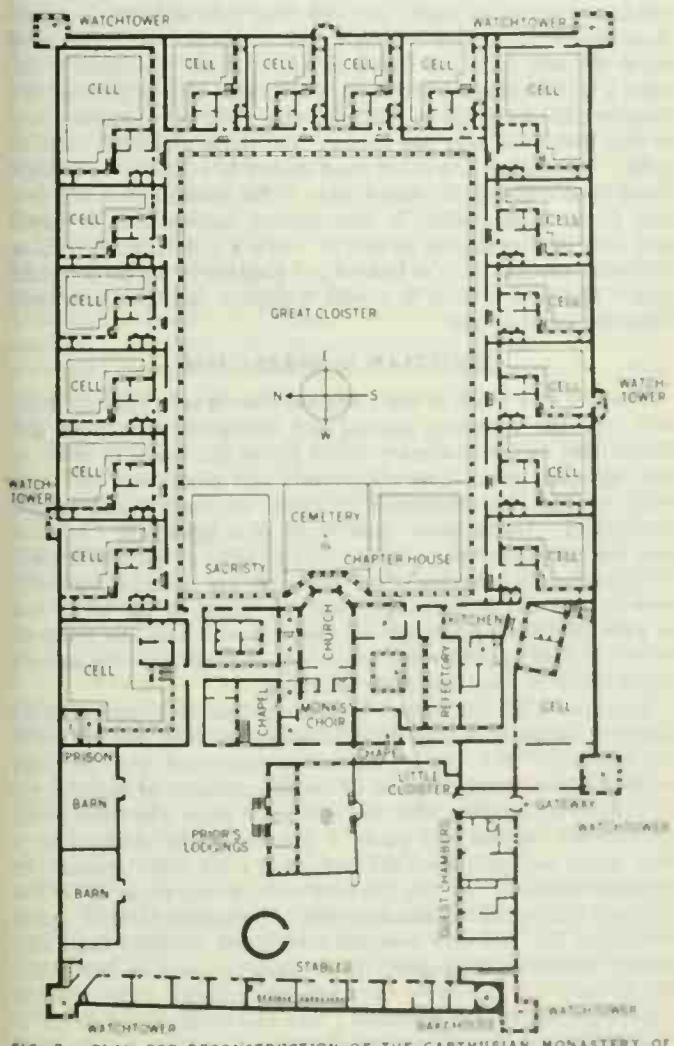



FIG. 7.—PLAN FOR RECONSTRUCTION OF THE CARTHUSIAN MONASTERY OF PORT STE. MARIE, NEAR CLERMONT-FERRAND, FRANCE, FOUNDED IN ITS ORIGINAL STATE IN 1219

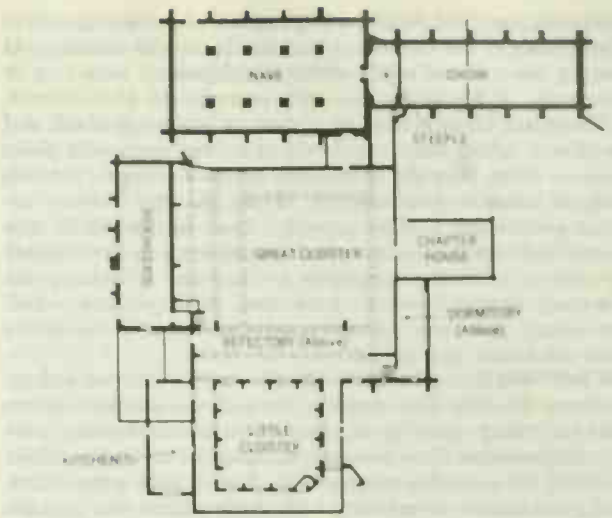



FIG. 8.—FRANCISCAN FRIARY, WALSINGHAM, ENGLAND, FOUNDED IN 1347

**Mendicant Friars.**—The orders of friars, poor by definition in the first century of their appearance, settled generally in towns in humble tenements given or lent to them by benefactors or the civic authorities. As time went on they, or their friends for them, constructed a permanent friary with a large church and the normal common rooms such as refectory and chapter room, but these were always on a small scale save at the most important houses in London and such academic houses of study as Oxford and Cambridge. This article is not concerned with the peculiarities of their church architecture. Access to the small cloister was customarily by means of a transit across the church, and the cloister was usually merely a corridor within the walls of the domestic buildings. As the sites of friaries were often valuable, the buildings disappeared rapidly at the dissolution of the monasteries in England, but exception must be made of a few friaries, especially of the Franciscans and Carmelites, which were situated in the open country. These followed, with some modifications, the normal plan of the small monastic house. The only large room, not found in monastic houses, was the school for lectures to the young members of the order.

**Nuns.**—The monasteries of women usually followed, on a smaller scale, the type of plan favoured by the men's branch of the order, though as the Cistercian nuns had no need to provide for lay brothers their houses showed none of the features peculiar to the White Monks. The Gilbertine order in England, which was one of nuns directed by a small group of canons, is an exception to this general rule. There the plan took the form of two similar monasteries, a greater (that of the nuns) and a less, separated by a church divided by a medial wall and accommodating both nuns and canons, all of whom had a view of the common high altar. An example of a large Gilbertine house can be seen at Watton, Yorkshire, where the whole plan was brought to light by Sir William H. St. John Hope in 1893–98.

**Later Developments.**—As the centuries passed, considerable modifications were made in the monastic buildings, almost all in the direction of greater comfort and individual privacy. Some of these changes reflected changing social conditions, while others were due to relaxation of the rule within the houses concerned. Chief among them was an increase in size and amenity in the accommodation provided for the abbot or prior. Originally merely a cell either in the western range (Benedictine) or near the dorter (Cistercian), it grew into a substantial house, with dining hall, oratory and guest rooms either near the infirmary (Cistercian) or west of the cloister (Benedictine). In the later centuries of the middle ages these houses were probably the most fully developed specimens of domestic architecture and planning in existence, with comfortable rooms, heated by fires of coal and provided with facilities for washing, including piped water at first floor level.

A similar tendency led to the multiplication of private chambers for the officials of the monastery and for doctors of theology, as well as for the sick and aged. Other developments were seen in the gatehouse, which in the late 14th century was often rebuilt, as at Thornton, Lincolnshire, on a scale of great splendour, and in the library, which came into being as a large room with desks and presses either over the north walk of the cloister or between the chapter house and the church. From the 16th century onward the private cell became general. Even in the middle ages the monks had come to occupy a wainscoted study or carrel either in the cloister or in the dorter, as at Durham. Gradually the cubicle study became common; this in time developed into a small private room, and only the reformed Cistercians retained the common workroom and dorter.

**Post-Reformation Changes.**—In the various reforms and revivals from the late 16th century onward the religious orders adopted the ruling styles in architecture, in which churches were sharply distinguished from domestic buildings of all kinds. These latter, in all the countries influenced by Renaissance architecture, became great masses of masonry with many stories and multiple fenestration arranged around a succession of quadrangles. Ecclesiastical institutions were indistinguishable from secular or private buildings of comparable size, and in almost every country such monasteries as remained in existence were clothed with thick layers of new buildings within which some of the old cloisters and rooms were embedded. Thus Citeaux, Monte Cassino, Einsiedeln and the abbeys in the valley of the Danube (to name but a few) became monuments of Louis XIV or baroque architecture and the traditional monastic plan was submerged or ignored. The library grew in size and became a splendid apartment, seen at its fullest development in northern Italy, Bavaria and Austria.

In the course of the revival of monastic life that began in France in the middle of the 19th century, spread gradually throughout Europe and later extended to North America and elsewhere, a great variety was seen in the design and planning of monasteries. All save the Carthusians and reformed Cistercians have been affected by the substitution of corridors of private rooms or cells for the public dormitory. Even in the case of the Cistercians the medieval layout had been so thoroughly overlaid that after the destruction at the time of the French Revolution the primitive plan fell into oblivion and the monasteries of the Trappists bear little resemblance to the medieval abbeys of the White Monks.

Similarly, Benedictine abbeys such as Solesmes in France were built with several stories of cells opening upon galleries and staircases, with the cloister merely a wide vaulted passage on the ground floor. Though the cloister and cloister garth have been usually retained, they now serve simply as a walking place; the cloister has lost its functional importance in the plan and is often covered by buildings; the dormitory has ceased to exist as an architectural feature, the library has continued to be an outstanding member of the plan and other buildings containing classrooms or lecture rooms and accommodation for pupils or students adjoin or surround the monastic nucleus of the complex. Such an establishment as for instance Ampleforth abbey in Yorkshire, which has the largest monastic community and houses the largest Roman Catholic boarding school in England, has developed in detached buildings on a sloping site and might well be taken from a distance to be simply a large educational or training establishment.

Other monasteries, both in Europe and America, such as St. Vincent's archabbey, Latrobe, Pa., or St. Meinrad's, St. Meinrad, Ind., show to the outer world lofty windowed façades that have nothing in them of the traditional monastic design. Few, even of modern Cistercian abbeys, have the simplicity of plan of those of the 12th century, and an abbey in full life and vigour, such as Gethsemani, Ky., lies at the centre of offices and outbuildings that have disappeared from most medieval sites.

In the 19th and 20th centuries there were some reversions to medieval design. Architects and antiquaries such as Viollet-le-Duc in France and Sir William H. St. John Hope in England restored by research and excavation the primitive plans of the various orders, and where a monastery was built on a virgin site care sometimes was taken to preserve much of the traditional plan. Speaking generally, however, the modern Benedictine monastery, however impressive in size and in the extent of its satellite buildings, has little resemblance to its medieval predecessor save in the presence of a large church (often, architecturally speaking, a large chapel without transepts or aisles) and of an adjacent cloistered walk.

At the same time, the preservation and study of the abandoned or ruined abbeys of earlier times have made great advances in the British Isles and in France, and monastic sites are visited yearly by many thousands. In Great Britain the ministry of works has rescued numerous monastic ruins from neglect or destruction and has surrounded them with a décor of green turf and taken every care to arrest further deterioration.

*See* also CLOISTER; and references under "Monastery" in the Index.

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**MONASTICISM** (MONACHISM), the system of life led in a religious community withdrawn from the world. Both the monastic way of life and the organization of institutions to promote such a way of life long precede Christianity and, in the east, where India has been particularly influential, developed independently of it. Monasticism may be defined as a renunciation of sexual pleasure, the ties of family life and most normal human occupations in order to devote oneself to the things of God. The word itself, derived from the Greek *monos* ("alone"), originally implied a withdrawal into seclusion, but it came also to denote both membership of a group of solitaries whose life was corporate only in that they lived near one another, and those who lived communally. The motive of a monk must always be religious, or at least based upon a highly developed sense of the potentialities and destiny of the human soul; in consequence, monasticism is found only in a mature society or one in which a fully mature religion has been preached, such as Ireland and England in the early middle ages. This article deals first with Christian and then with non-Christian monasticism.

## CHRISTIAN MONASTICISM

The aim of a monk in the Christian church is to separate himself from the unethical, sensual and irreligious attractions and distractions of the customary social life of the world in order to free his spirit from those allurements and hindrances that normally prevent the attainment of moral self-control and mental tranquillity. In the peace thus found or achieved the Christian may further endeavour to fit himself for union of spirit with God. In Christian monasticism three elements are at least implicitly present: the ascetic separation from the things of the world and in particular from marriage and the domestic life; the religious service of God by prayer and adoration; and the desire for an ever closer union of mind and heart with God.

Into such a life the gospel "counsels" of poverty, perfect chastity and obedience to a spiritual authority could be inserted without difficulty. Nor was it long before experience, and the basic social relations implied by the Christian command of neighbourly love, made it clear that while the number of those who could profit by absolute solitude was small, a communal life, directed by a wise leader and with fixed practices, had a far wider appeal. In cenobitic monastic life the physical solitude was replaced by the spiritual solitude of the abandonment of possessions and of family and social life, and very soon the term monk included (and ultimately primarily designated) those living a common life, while the solitary was known by the name of anchorite ("one who retires or withdraws") or of hermit ("one who dwells in the desert").

In the course of centuries the meaning of the term was widened still further, and at the present day the French derivative *moine* is applied to friars as well as to the monastic orders; but in tech-

nical ecclesiastical language "monk" is restricted to those bound by the vows of religion and belonging to an order whose members are physically separated from the world by life in a monastery within the bounds of which they spend their days, whether their family be quasi-eremitical or with the full common life. In this monastery they live under a rule and the government of a superior to whom they are bound by vow. (For the orders of friars, *see* MENDICANT and the articles referred to there.)

It may be added that from the earliest times the vocal adoration of God was recognized as an integral part of a monk's life and that the communal performance of the liturgy known as the divine office (*see* HOURS, CANONICAL) is a necessary ingredient of the fully monastic life. Of itself, therefore, the monastic life is a contemplative one, though here again in the course of centuries such active duties as teaching and preaching have come to be part of the employment of several monastic institutes. In the early middle ages the task of intercession for the rest of Christendom was looked upon as belonging to the monastic order, but this is not peculiarly part of the monastic life, save insofar as all Christians pray and work for others, in their various measures and ways.

(M. D. K.)

### EASTERN MONASTICISM

The ground was prepared for Christian monasticism in both Jewish and pagan culture. The monks looked back to Elijah, Elisha and St. John the Baptist as their prototypes. In the century before and after the birth of Christ, there were the Essenes and the community, perhaps Essene, whose "monastery" has been excavated at Qumran in connection with the Dead sea scrolls (*q.v.*). Christians of the 4th century thought they recognized the earliest Christian monks in the 1st-century Jewish community of Therapeutae described by Philo in the *De vita contemplativa*. (*See* JEWISH SECTS DURING THE SECOND COMMONWEALTH: *Ascetic Sects.*) Many elements of thought, language and practice current in contemporary Greek philosophy (Pythagorean, Neoplatonist, Stoic or Cynic) and in hellenized Egyptian religion were ready to be developed in a Christian sense. And the ways of Indian religion were not completely unknown.

Jerome's story of Paul of Thebes is of doubtful historicity, but its picture of anchorites withdrawing into the deserts from persecution in the 3rd century probably represents a true tradition. (*See* PAUL, SAINT, of Thebes.) With the conversion of Constantine I (*c.* 312), Christian monasticism, hitherto embryonic, developed up and down the Roman empire, as an attempt to retain the full rigour of the gospel in a world wherein nominal Christianity was at a premium.

**Egypt.**—Egypt was the first centre of the monastic movement. St. Anthony (*q.v.*) of Egypt was the pioneer of desert monasticism. After many years of solitary spiritual conflict in or near the Nile valley, he was joined by other solitaries on the edge of the Arabian desert east of the Nile in middle Egypt (*c.* 305). When Christian persecution ceased after the so-called Edict of Milan, he moved (313) across to his "interior mountain" near the Red sea, where he stayed till his death (a Coptic monastery still survives there), paying frequent visits to his "outer monastery," where high and low came to consult him. His life, written by St. Athanasius and early translated into many languages, is a spiritual classic. The pattern established by him was further developed in the monastic settlements of Nitria and Scete (Scetis), both founded well before his death, in the region west of the Nile delta—a group of solitary cells attached to a church centre where the monks would assemble on Saturdays and Sundays for worship and a common meal. This came in Palestine to be called a laura (*q.v.*).

Very soon men were flowing out by the thousands to these deserts. Most of them were unlettered Egyptians, but there was a sprinkling of highly educated men from many lands, among them Evagrius Ponticus (*q.v.*), whose writings played a formative role in subsequent monastic language and thought. Palladius, whose Lausiac history (written *c.* 420) gives the first general survey of the monastic world, had been Evagrius Ponticus' disciple in the Cells near Nitria. And Johannes Cassianus, who was in Egypt at much the same period, was also deeply indebted to Evagrius.

The interior desert of Scete (the Wadi en Natrun, where four Coptic monasteries still survive) provided the core of the great collection of *Apophthegmata patrum*, which was growing up from the middle of the 3th until at least the 7th century. It provides a priceless corpus of "case law" of the ascetic and spiritual life, wherein the sober wisdom and charity of the "old men of the desert" take into their ken all that is human.

Cenobitic (conventual; from *koenobion*, "life led in community") monasticism was first organized in upper Egypt by St. Pachomius (*q.v.*), whose monastic rule is the earliest extant. His monks, named Tabennesiotes after his great monastery near Dandarah, formed a single community distributed in a number of monasteries, all owing obedience to one head. Each monastery was enclosed within a wall and contained a church and a refectory, where the monks assembled daily for worship and food, and a number of houses into which they were distributed according to their occupation. The monks did not pass on from the cenobitic life to that of the solitary. By the end of the 4th century the community numbered about 5,000 and extended as far as Canopus near Alexandria. Neither Anthony nor Pachomius was ordained. Monasticism was primarily a lay movement, as it remains in the Eastern Church to this day.

**Mesopotamia and Syria.**—Elsewhere in the Roman empire and beyond, for example in Mesopotamia, monasticism developed independently but increasingly under Egyptian influence. In northern Syria the ideal of the solitary tended to fantastic expression, as in the pillar saints, or Stylites, of whom St. Simeon Stylites is the supreme example—committed to his pillar top after the pattern of his Lord nailed to the cross.

**Palestine.**—The really formative influence, after Egypt, is to be sought in Palestine, where a highly international monasticism was already developing in the 4th century. Mention must be made of the western pilgrims, Jerome and his ladies at Bethlehem, Rufinus and the two Melanias on the Mount of Olives. But the key figures are St. Euthymius (378–473) and his follower St. Saba (439–532), who "made a city of the wilderness" of Judaea, peopling its hilltops and its gorges with countless monasteries and hermits. The works of Cyril of Scythopolis (fl. *c.* 550), himself a monk of the wilderness, relate their story. In Greek hymns in honour of the ascetics, Euthymius and Saba are put second only to St. Anthony. For they are the founders of the Eastern Orthodox monasticism, which persisted when Egypt and Syria had largely gone aside into heresy.

To this Judaean monasticism Egypt, Syria and Asia Minor were all contributory. The cenobitic life was subordinated to the eremitic in a single system, of which the focus was the laura, to which monks graduated from the *coenobium*, now little more than a novitiate, while monks of the laura aspired to pass on in due course, permanently or for long periods, to the more absolute solitude of the utter desert or of walled-in cells or inaccessible caves closer to the laura. The greatest of these monasteries, the laura of St. Saba (Mar Saba) on the side of the Cedron gorge, has an unbroken history from his first settling in a cave there in 478 down to the present day. For centuries it continued to play a creative part in the development of the hymnology and the monastic office of the Eastern Church.

Alongside St. Saba in the fight for Chalcedonian orthodoxy stood St. Theodosius (d. 529), whose great hilltop *coenobium* below Bethlehem was more of the Basilian type (*see* below, *Byzantine Empire and Modern Greece*). From it later in the 6th century came John Moschus, author of the "Spiritual Meadow," which gives for the end of the period before the Islamic conquest the same kind of picture that Palladius gave for the 4th century; and his companion, St. Sophronius, whose life of St. Mary of Egypt sums up much of the spirituality of the same period. Sophronius, as patriarch of Jerusalem, had the task of surrendering the Holy City to the caliph Omar.

**Sinai.**—In the Sinai peninsula monasticism flourished from the 4th century, but more particularly from the construction by Justinian I of a fort that became the hub of monastic life in the peninsula and still exists as the monastery of St. Catherine (*see* SINAI). One of its 7th-century abbots, St. John Climacus, was

named from his great work, the "Ladder (*klimax*) of Divine Ascent," a classic textbook of the ascetic and spiritual life that every Orthodox monk is supposed to read during Lent.

(D. J. C.)

**Byzantine Empire and Modern Greece.**—Byzantine monasticism found its inspiration in the twofold eremetic and cenobitic tradition of Egypt which in the 4th century spread to Asia Minor, Syria and Palestine, as well as Europe. Though Basil of Caesarea left no rule in the strict sense of the word, his interpretation of the common life as shown in practical tradition and in his writings was widely followed (*see* BASIL, SAINT, the Great). In Asia Minor and the Greek provinces monasticism was as flourishing as that in Palestine and Syria described above. Archaeological surveys in southwest Asia Minor (Lycia) have revealed literally hundreds of monastic sites. Similar development took place in other areas, as Mt. Latmus near Miletus, or Mt. Olympus in Bithynia before the Seljuk invasions of the 11th century, or in south Italy before the loss of the provinces to the Normans. From the 10th century onward Mt. Athos (*q.v.*) developed into a monastic centre whose influence was felt far outside the empire, especially in Slav countries. Athos was also an increasingly potent factor in the Byzantine empire of the later middle ages, particularly in connection with the religious dispute known as hesychasm (*q.v.*). Within the capital city an important centre was the Studite house in the southwest district, whose early-9th-century abbot Theodore Studites both by example and writing greatly influenced the cenobitic tradition.

Conciliar and patriarchal rulings, foundation charters and imperial laws regulated the life of monastic houses, lauras and anchorites, defining their relation to diocesan authority. Foundations were freely made by churchmen and by laity. Normally they were eparchial and under diocesan control, but they might have the privilege of coming under direct patriarchal control; "imperial houses" were subject to the emperor or his representative, and completely independent houses (*autodespotai*) were withdrawn from all control. The regulation of ever increasing monastic temporalities was a perennial problem, and the system of entrusting monastic lands to a "protector" (*charisticarius*), though open to abuse, was much used.

Entry to monastic life was carefully regulated. For instance the position of children, slaves, married or betrothed parties was defined, as well as the problem of *stabilitas loci*; i.e., remaining always in the same monastery. The Council of Constantinople (861) laid down a normal three-year novitiate, but later practice sometimes reduced this to one year, e.g., St. Athanasius' foundation charter for the laura on Mt. Athos in the 10th century. In the liturgical book, the *Euchologion*, the ceremony of frocking a monk or nun is given, with the profession of poverty, obedience and chastity, as well as of *stabilitas loci*.

The head of the cenobitic house was an abbot (often called *hegumenos* or *kathegumenos*) elected in accordance with procedure laid down in the foundation charter; the election was normally confirmed by the diocesan bishop and was usually for life. Within his house the abbot could call upon absolute obedience and was ultimately responsible for its spiritual and temporal well-being. The common life was centred in the liturgical office, consisting of day and night services together with the "divine liturgy" (Eucharist). As in a western Benedictine house, side by side with corporate worship, time was found for instruction and private devotion. Each monk also had to share the daily work of administration and the performance of such other specific duties as might be assigned to the community by the founder, as for instance care of the poor or supervision of medical services (for Byzantine monasticism served the community in many such ways).

Though Byzantine monasticism did not produce "orders" exactly comparable with those of the Latin world, its houses, or groups of hermits, were sometimes federated under a leader (often called a *protos*), and a cenobitic foundation might have its dependencies or groups of individual cells or hermitages. Cenobitic and hermit life were indeed to some extent interdependent, in that a cenobite might become a solitary for a time and perhaps return to his house later on. Something of the significant place of monasticism in the life of Byzantium can be seen from the many extant lives of the saints, and its tradition of spirituality illuminates the writings of such great abbots as St. Simeon (*q.v.*), the New Theologian.

Some medieval foundations, as those of Athos or the houses of the Meteora (*q.v.*) in Thessaly, continue to maintain their unbroken tradition, though with greatly reduced numbers and depleted resources.

(J. M. Hy.)

**Slav Countries.**—Monasticism was brought to the Slav countries together with Christianity itself.

The outstanding representative of the ascetic life in Bulgaria was John Rylski (10th century), who founded the famous monastery of Ryla, the principal centre of spirituality in Bulgaria.

Serbian monasticism developed especially from the 12th to the 14th centuries, when it was under the protection of the kings of the Nemanya dynasty. The most famous monasteries, still decorated with Byzantine frescoes, were those at Studenitca, Zisa, Gracanitsa, Decany and Old Ravanica. After the fall of the Serbian kingdom and during the Turkish occupation, 30,000 Serbians emigrated *c.* 1690 into southern Hungary, where they built 16 monasteries on the Fruska Gora (now in Yugoslavia).

Popular monasticism in Russia is linked with the foundation of the Pecherskaya laura in Kiev by Anthony and Theodosius in the 11th century. The former was an eremitical ascetic, heir to the spirituality of Sinai and of Athos, while his disciple Theodosius gave to the laura the Studite rule and was the first to organize cenobitism in Russia. Thereafter monasticism increased and flourished around Kiev. One of the results of the Tatar invasion in the 13th century was the decay of monasticism in the cities, though the eremitical settlements in the far northern forests continued to flourish. The perfect example of the saintly hermit who became founder of a monastery is St. Sergius (*q.v.*) of Radonezh, who founded the Troitse-Sergiyevo laura at Zagorsk near Moscow in the 14th century. During the 15th and 16th centuries monasticism spread throughout the country, and two conflicting tendencies appeared: that of central Russia, around Moscow, where St. Joseph (*q.v.*) of Volokolamsk, the reorganizer of cenobitism, was the representative of the social and active life (which proved dominant); and that of northern Russia, where the Transvolgians inherited the evangelical spirit of poverty and Hesychastic spirituality. Their chief defender was Nil Sorsky (d. 1508), the great adversary of monastic property and of monks' undertaking social and political activity.

In the reign of Peter I the Great a severe control was kept over monastic property, which was secularized by Catherine II. The number of monasteries and of novices was strictly limited. In the 17th and 18th centuries it was in the monasteries that authentic Orthodox piety took refuge, and a great intellectual and spiritual movement of return to the patristic sources of Orthodox mystical tradition began. The influence of Paissy Velichkovsky, a Hesychast Athonite monk, spread over Russia thanks to his translation of the *Philokalia*, a collection of quotations on mystical theology from the Greek Fathers compiled by Nicodemus the Athonite. In the 19th century pilgrimages were made to the *startsi* of the Optina Pustynye and to St. Seraphim of Sarov, one of the greatest Russian saints.

After the Russian Revolution of 1917 the monks were expelled and the monasteries destroyed if they were not worth preserving as national monuments of art. But after World War II there was some renewal of monastic life. (*See* STARETS.)

**Rumania.**—In Rumania the eremitical form of monasticism predominated until the 14th century, when the Athonite monk Nicodemus began to reorganize cenobitic life in Walachia and Moldavia. The monasteries of Vodita and Tismana were built under his direct supervision, and his disciples helped found the powerful monastic centres of Neamtu and Bistrita. At the end of the 18th century Paissy Velichkovsky was associated with the penetration of Hesychasm into Rumanian spirituality. Rumanian monasticism maintains that tradition today. The laicizing tendencies at the end of the 19th century and the unfavourable political conditions after the Communists came to power in 1945 greatly reduced the outward influence of monastic life in Rumania.

**Nature of Orthodox Monasticism.**—The fact that the Orthodox Church has no variety of religious orders like the west and that its monks are devoted primarily to prayer does not mean that its monasticism is unrelievedly uniform or that it takes no part in active life. On the contrary, the hesychast spirituality, centred on the Jesus prayer, far from isolating a man from his ecclesiastical or monastic community becomes in fact the condition of his spiritual integration with the community. Although for historical reasons the Orthodox Church has usually appointed its bishops solely from hieromonks (monks who are priests), monasticism remains basically a lay institution, distinct from holy orders by its prophetic character and its own vocation to follow faithfully the whole call of the gospel. (B. A. Bo.)

## Western Monasticism

**Early Developments.**—Monasticism was slow in moving westward; its expansion was due at first to the inspiration of the exiled Athanasius and the subsequent diffusion of his *Life of Anthony*, but its beginnings were with individual ascetics or semiprivate groups in such cities as Rome and Trier. On reaching the west, the monastic idea bifurcated. On the one hand it was adopted in a modified form by Augustine at Tagaste and Hippo, by Eusebius at Vercelli, and elsewhere as a way of life for the clerics of the bishop's household or to perform the liturgical services at a city basilica. On the other hand it was followed more austerely by numerous individual ascetics and hermits, especially in Provence and Aquitaine, and in central Gaul it found a focus and leader in St. Martin (*q.v.*), bishop of Tours. From his great monastic complex of Marmoutier, evangelists went out in every direction. In particular, the Gallic monasticism took root in Ireland, where it blossomed into something unique in Christendom: large tribal monasteries controlled districts in which the abbot was in effect bishop while a monk under his obedience in episcopal orders performed the necessary consecrations. This monasticism, which, though physically austere and penitential, developed a high literary culture, swarmed over to the western isles and the Celtic fringe of north and south Britain, while pilgrims made their way farther afield to the continent, carrying fresh practices and learning to central Gaul, to the Jura (Luxeuil) and even to north Italy (Bobbio).

The early forms of monasticism in Italy and Gaul long lacked a comprehensive code of life. The basis of discipline and doctrine was provided by Johannes Cassianus, who was born in what is now Rumania and had become a monk in southern Gaul and subsequently visited the ascetics of the Egyptian and Syrian deserts. He transmitted their wisdom in his *Institutes* and *Collations*, both of which had immediate influence of incalculable force, the latter in particular becoming one of a small group of spiritual classics that have molded the form of Christian life. Neither Cassianus, however, nor his younger contemporaries provided a satisfactory rule. The need was met by Benedict of Nursia, first at Subiaco and then at Monte Cassino. His rule, possibly written for wide application at the command of authority, not only provided the essential legislation for a monastic family but revealed a personality and a master with a unique blend of wise humanity and evangelical strength. Though many of its precepts and phrases are derivative, the rule itself is profoundly original, giving in outline all the directions spiritual, ascetic and economic for the conduct of a self-contained and self-sufficient family, together with ripe and rich advice on both the human and spiritual level. (*See* Benedict, Saint: *Rule of St. Benedict*.)

The rule spread gradually, by virtue of its excellence, often coexisting with, and ultimately supplanting, other directories. The monk in St. Benedict's plan had no work to do for society apart from his duty of Christian charity to his neighbour and to strangers. A contemporary of St. Benedict, Cassiodorus, the former minister of Theodoric, had other views for his monastery of Vivarium in Calabria. There the monks, by copying manuscripts, were to keep alive and to transmit the heritage of literature and knowledge of Rome. Vivarium and its program did not long endure, but the idea remained and in due course was grafted upon the simpler scheme of Benedict. Hitherto, the monastic order had been essentially the search by the individual for integral Christianity in an ailing world. Henceforward for more than six centuries—the "Benedictine centuries," as they have been called—the monasteries were to become an established and influential part of contemporary life.

**The "Benedictine Centuries."**—The prime mover in this period was Pope Gregory the Great. Himself a monk, he encouraged and protected his order in every way. He did more: by using monasteries as bastions against the Arians and by sending a group of monks from his own monastery to preach the faith in England, he made of the monks a papal *corps d'élite* to be used in spreading the gospel among the new peoples of Europe and in binding them directly to Rome. Meanwhile, in the north, Celtic monasticism, after crossing from north Ireland and establishing itself at Iona under St. Columba, moved southward to Melrose and Lindisfarne with Aidan and Cuthbert. The Celtic stream met the Roman at Jarrow and Ripon, and in the end the Roman Benedictine current proved the stronger. From the union of the two sprang the wonderful flower of Northumbrian monasticism which re-created the simple patriarchal life of the Benedictine rule while at the same time producing in Bede and his contemporaries a focus of scholarship and art without rival in western Europe. With Anglo-Saxon England also began the three centuries of monastic evangelization. Willibrord of Ripon and York became the apostle of what are now the Netherlands and Belgium, Wynfrith (Boniface) of Crediton the still greater apostle of Germany. Nearer to home the Northumbrian Alcuin became under Charlemagne the schoolmaster of Europe, while English and Irish monks continued to found and fill abbeys in the area now covered by Germany, France and Switzerland.

By this time a great change had come about in monastic life on the continent. The monasteries found themselves the sole legatees of the learning, literature and education of the past, both sacred and profane; by copying manuscripts of the classics and the Church Fathers and by literary and historical composition they became the reservoirs and fountainheads of civilization to which the modern world owes the preservation of such Latin literature of all kinds as has survived. In this task the principal centres were France, the Rhineland and south Germany, with Tours, St. Gallen and Fulda among the sources of light. During this period the typical small, isolated, self-contained monastic family of St. Benedict's rule was replaced in almost every country by the landed abbey with its vast complex of buildings and services that formed the social and administrative centre of a great feudal estate. Within it some were occupied in administration, while others were engaged in teaching and studying, and the intellectual character of much of their work gradually converted the predominantly lay population of the monastery into one of priests and clerics, whose chief task was to perform lengthy liturgical services. The monks had become an essential part of Christian society, the class that praised God and made intercession on behalf of the rest.

With the lapse of centuries the need for external organization and disciplinary union between monasteries became more and more evident. Many abbeys in France and elsewhere were engrossed by magnates or bishops and thus lost their abbot in all but name; others became lax and decadent. The first serious attempt at widespread reform was made under Charlemagne, who decided to enforce unity of observance throughout his empire with the rule of St. Benedict as the governing code. Under his son Louis I the Pious, in 817, at an assembly of monks at Aachen, a detailed code and directory were promulgated that should be binding on all. The central authority and the statutes soon ceased to function, but the legislation was there to serve as a norm and model for future reforms, and for the first time monks of the empire had become conscious of their unity as a tribe under one patriarch, the *familia S. Benedicti*.

The 9th century was one of the darkest in monastic history, but the 10th saw the foundation (910) of Cluny in Burgundy. Cluny was blessed by a succession of able, saintly and long-lived abbots, who successfully maintained their independence of every authority, whether lay or ecclesiastical, save the papacy, and gradually acquired dependencies which the third of the great abbots, Odilo

(ruled 994–1049), began to form into a family. A common observance was imposed, and the dependencies were bound strictly to the abbot and chapter of Cluny. Cluniac houses gradually increased to well over a thousand scattered over the whole of western Europe save for the British Isles and portions of southern Germany. The share of Cluny and other monasteries in the church reform of the 11th century has often been exaggerated, but the great body of monks, from whose rank many of the principal reformers had issued, undoubtedly played a great part in giving that reform its strongly monastic character. (*See* also BENEDICTINES.)

Meanwhile an entirely new movement of monastic renovation appeared in north Italy in the shape of two new orders which combined in different measure the eremitical and cenobitic ideals. The family of Camaldoli (*c.* 1012) was composed of groups of hermits living within a single enclosed area; the order of Vallombrosa (*c.* 1030) added to a strict interpretation of the rule of St. Benedict a remote and solitary site. At both there was a further innovation: illiterate brothers performed the domestic and many of the administrative services. (*See* CAMALDOLESE; VALLOMBROSIANS.)

The conception of a reform in the direction of austerity and solitude soon crossed the Alps; at La Grande Chartreuse and Grandmont the eremitical element was foremost, while the monks of Tiron and Savigny adopted an austere form of the normal Black Monk life. All these new ventures, however, were soon overshadowed by the monks of Citeaux (*q.v.*). This house in Burgundy, founded in 1098, began as a small and remote abbey, but the presence of men of holiness and ability, such as the Englishman Stephen Harding, and the arrival in 1112 of the young St. Bernard (*q.v.*) with numerous relatives and friends, stimulated recruitment, and the stream soon assumed vast dimensions. The first fathers of the "White Monks" had stressed the literal observance of the rule, avoidance of all economic and social entanglement with "the world," and a timetable far simpler than that of Cluny, with set periods reserved for manual and field labour of every kind. When foundations were made, a short document, called the *Carta caritatis* ("Charter of Charity"), established a system of visitation and annual general chapters to preserve discipline, unity and absolute uniformity. In addition, the lay brothers or *conversi* were made an integral part of the monastic family and used to build and staff the monastery and to act as labourers and herdsmen on the land. In consequence, the Cistercians emerged as a closely knit federation of autonomous abbeys, a real religious order, forming with their economy, which was at once dispersed in granges and centralized in the abbey, and with their hosts of lay brothers, a vast, well-ordered family. Their success was spectacular. At the death of St. Bernard (1153) they had houses all over western Europe. They inspired other bodies, such as the Premonstratensians and military orders, to imitation, and their characteristic institutions of frequent visitation and annual general chapter were adopted by all subsequent religious bodies. (*See* also CISTERCIANS.)

With the death of St. Bernard, the "monastic centuries" entered their phase of decline. For another hundred years the monks continued to be a spiritual and a cultural force, though the friars (*see* MENDICANT) in one field and the universities in another were taking the place that had been theirs; and for yet two centuries more the greater abbeys filled an important place in society. There were, moreover, several new movements of reform in Italy which gave birth to new congregations destined to a long life, such as the Sylvestrines (1247), the Celestines (1264) and the Olivetans (1344). On the whole, however, it was as landed capitalists, as feudal magnates and as wealthy corporations that the influence of the monks was now felt. The wars and pestilences of the mid-14th century had their share in thinning the ranks and shaking the economy of the monks, but the real cause of their subsequent decline lay deeper.

**The Later Middle Ages.**—Meanwhile, the centralizing and formalizing tendencies of the age had their influence on the monks. At the fourth Lateran council (1215) Innocent III had united the Black Monks in provincial chapters for the purpose of legislation and visitation. In the following century Benedict XII imposed on both Black and White Monks a series of reforming decrees which, while aiming at uniformity and exactness of observance, and regulating the movement of monks to the universities, countenanced some of the changes and relaxations that had come in with the changing times. Thenceforward for more than a century the monastic order declined in regularity, stricken in most continental countries by the plagues of commendatory abbots (*see* COMMENDATION) and spiritually unfit recruits, and everywhere by gradual relaxation.

Nevertheless, the end of the middle ages saw two notable reforms. One was the congregation of Sta. Giustina of Padua, founded by Ludovico Barbo, a Venetian, in 1424, later known as the Cassinese congregation. To eliminate the evils of *in commendam* and of powerful, irresponsible superiors, the monks of the congregation were to form a single family. Local superiors were changed annually, and the supreme authority was vested not in an abbot or group of abbots but in the annual general chapter and its committees. This organization was widely copied by reformers after the Council of Trent, as was also its encouragement of learning and study. Equally significant for the future was the Spanish congregation of Valladolid, which originated in a reform of great austerity with perpetual enclosure (1390); in the 16th century it adopted the main lines of the constitution of Sta. Giustina, while preserving the individuality of each house.

**Reformation and Counter-Reformation.**—Meanwhile the monastic life was being radically challenged by powerful enemies. John Wycliffe had attacked the monastic institute as a depravation of the gospel teaching and had urged total secularization. Early in the 16th century Erasmus, using every weapon of irony, wit and learning, represented the monastic life as a mechanized, mercenary and hypocritical form of superstition, while a little later Martin Luther attacked the vows and spirit of monasticism as an anti-Christian and impracticable form of life. This was followed by a wave of suppression and secularization, and by the middle of the 16th century organized monastic life had disappeared from northern Europe, Switzerland and the British Isles, and was soon reduced to ruin in France by the wars of religion.

The Council of Trent and the new spirit of the Counter-Reformation brought about a gradual revival of monasticism, and a number of regional congregations came into being in the Habsburg empire. More significant than these were the two celebrated congregations of St. Vanne (1600) in Lorraine, and its daughter St. Maur (1618) in France. For these two the Cassinese congregation provided the pattern. The congregation, not the abbey, was the unit, and the authority was the annual or triennial general chapter and the superior general; the houses were priories, and the monks could be transferred from house to house. In both the observance was severe and strict, but the lessons of the Reformation had been taken to heart, and the monks devoted themselves to apostolic and theological work, to education and above all to study and learning. The Maurists (*q.v.*), in particular, with their élite of scholars housed at St. Germain-des-Prés (Paris) earned for their whole order the epithet of "learned." At the same time the Cistercians, who had revived after the Reformation, especially in Germany and France, were divided in the latter country by a bitter feud between the parties of moderate and strict reform. Among the latter a still stricter centre, with practices and a spirit all its own, appeared at La Trappe under Armand de Rancé; this community by an accident of survival at the Revolution became the nucleus of an influential congregation in the 19th century.

This period was for monks an untraditional and in some ways an uneasy one. The *ancien régime* and Gallicanism, with its commendatory abbots, royal control and traditions of wealth and birth, existed alongside the new and intense spirituality and new intellectual life, while after less than a century of existence the new institutes were in the grip of Jansenism and *philosophisme* and were avoiding suppression by secularization. Even the spectacular austerity of La Trappe had in it something of the rigidity and coldness of the epoch.

**After the French Revolution.**—During the French Revolution and the ascendancy of Napoleon I, almost all the monasteries of Europe disappeared in one way or another, and only about 30

battered survivors lived on into the new age after Waterloo, among them the three English houses founded in exile two centuries earlier (St. Gregory's, Douai, now at Downside, Somerset; St. Lawrence's, Dieulouard, Lorraine, now at Ampleforth, Yorkshire; St. Edmond's, Paris, now at Woolhampton, Berkshire). The revival, however, was quick in coming, marked among the Benedictines by the rise of the congregations in France at Solesmes under Prosper Guéranger (1837), of Beuron in Germany (1868) and of the Subiaco (later Cassinese) congregation of Primitive Observance in Italy (1872). All these in their final form were a conscious return to the original Benedictine scheme of autonomous houses; and they all became, by accident or design, supranational.

Meanwhile monasticism began to emigrate from Europe. Among the first were the two congregations of American Cassinese (1855) and Swiss-American (1870), engaged in teaching, missionary and parish work in the United States and Canada. Later monks and monasteries scattered all over the world, to South America, central and southern Africa, Australia, China and Japan. Thus the 19th century saw monasticism reviving its influence and appeal in two directions corresponding roughly to its diverse origin in Latin countries and the German and Anglo-Saxon lands—in the former toward a liturgical, claustral life, in the latter toward an expansive activity of teaching and missionary preaching.

Both continue to develop in the 20th century, and despite (perhaps even because of) the disasters and uncertainties of the period the losses and casualties of two world wars were more than made good. Alike in the number of houses and of their inmates, the monastic body has vastly increased since 1900. Since 1945, indeed, a new tendency has been visible; the expansion has been most notable in congregations or groups distinguished by the severity and "contemplative" character of their observance, such as the Carthusians, the Reformed Cistercians and the austere Benedictine congregation of Pierre-qui-Vire in France. It would seem that the primitive appeal of monasticism, the departure from the world to a simpler more austere life of solitude and penance, is more effective than any other, even in the countries of the new world.

In the course of 17 centuries Catholic monasticism has thus assumed many different outward forms and functions in society. Originally an individual retreat from the world for personal self-discipline and sanctification, it gradually became, and remained for a millennium, an important institution and component of medieval society, first as an agency of evangelization and civilization, then as the very heart of learning and reform, and finally as a great economic and social force. During this long period the monks left a permanent mark upon theology, upon literature, upon liturgy and upon the chant; for a century or more, indeed, they permeated the whole Western Church with their interpretation of the evangelical life, and in this their heyday they divided themselves vertically into three classes, monks, lay brothers and oblates or tertiaries, and horizontally into bodies comparable to the colours of the spectrum, ranging from the austere, eremitical Camaldolese and Carthusians, through Grandmont, Cîteaux and the great company of Black Monks, to the monachized regular canons and the later friars. This period ended in northern Europe with the Reformation, but in France, the Latin lands and the Austrian empire it lasted in diminished form till the French Revolution. Meanwhile, from the early 16th century onward, monasticism gradually became once more a vocation, a way of sanctification for the earnest seeker after God. This it remains in the present age. (M. D. K.)

**Anglican Monasticism.**—Although the Church of England in general during the 17th and 18th centuries shared the ordinary Protestant suspicion of monastic communities, there were some theologians and spiritual writers, notably Herbert Thorndike and William Law, who took a more positive attitude toward the monastic life. The example of Nicholas Ferrar and his family community at Little Gidding (*c.* 1630), Huntingdonshire, though not strictly monastic, also pointed the same way. However it was not until the time of the Oxford movement that any of these Anglican aspirations toward monasticism came to function.

The first Anglican communities of women were established in the years after 1845 and at once adopted rules and customs based on those of continental Roman Catholic communities (*see* Women's Religious Orders). They very quickly developed in numbers and undertook a great variety of active works. After J. H. Newman's "monastery" at Littlemore, Oxford, came to an end in 1845, with his reception into the Roman Catholic Church, no serious attempt was made to establish a men's community until 1866, when R. M. Benson founded the Society of St. John the Evangelist (*see* Cowley Fathers) at Oxford. Since then numerous other communities or brotherhoods have been founded in England, of which about eight have established themselves firmly. The largest men's communities are the Community of the Resurrection, Mirfield, Yorkshire (founded by Charles Gore in 1892; *see* Mirfield Fathers), Society of the Sacred Mission, Kelham, Nottinghamshire (founded by H. H. Kelly in 1894; *see* Kelham Fathers); and the Society of St. Francis, Cerne Abbas, Dorset (1921). In 1863 J. L. Lyne ("Father Ignatius of Llanthony") established a Benedictine brotherhood, finally disbanded after his death in 1908. Another attempt to revive the Benedictine life in communion with Canterbury was made by Aelred Carlyle in 1896, but he and 22 of the community on Caldey Island, South Wales, were received into the Roman Catholic Church in 1913. The following year a Benedictine community was reestablished at Pershore, and moved to Nashdom abbey, Burnham, Buckinghamshire, in 1926. It has a branch house in the United States at Three Rivers, Mich. The only indigenous men's community of any size in the Protestant Episcopal Church is the Community of the Holy Cross, West Park, N.Y. (1881). Several English communities of men and women have branch houses overseas. Some have established independent congregations.

The Church of England has never made provision for religious communities by way of canonical legislation, and their relations with the ecclesiastical authorities were at first vague and undefined. Since 1935 it has been possible for those in England to obtain formal recognition from the advisory council on religious communities established for the provinces of Canterbury and York. Anglican communities of men work in the British Isles, United States, Canada, Australia, Japan, India, South Africa and the West Indies. No up-to-date statistics are published, but in general these communities are not large. (P. F. A.)

**Protestant Monasticism.**—Protestants have been traditionally suspicious of monasticism, and particularly of any suggestion that it represents a higher form of life than can be lived within Christian marriage and engagement in the world. Nevertheless, insofar as the cloister offers a "parable" of Christian renunciation, Protestantism could not avoid reproducing some of its more positive features. It was the evangelical concern of Pietism which first produced a reexamination of the vocation to celibacy, community and obedience and which led in the 19th century to the foundation of the European deaconess orders, whose way of life approximates in certain respects the life of active orders of women in the Roman Catholic Church (*see* Deaconess).

During the 20th century the liturgical revival centring in the sacraments has led to the foundation of a number of societies of clergy and laymen, whose members continue to live in the world but are bound by a common rule, such as the Societas Sanctae Brigittae (1920) in Sweden and the St. Michael's brotherhood in Germany (1931).

Since World War II this movement has taken a further step among both Reformed and Evangelical Christians in Europe. Several communities for women have been established in Germany and Switzerland, while in France the Taizé community for men has developed in the village of Taizé near Cluny (*see* Grandchamp and Taizé Communities). The brothers accept life engagements to celibacy, poverty and obedience, and their life resembles in almost every way that of similar Roman Catholic communities. In all these communities the ecumenical element has been strong, and they have consciously sought to learn from all periods of the church's history.

These modest experiments did not come into being primarily as monastic ventures but should rather be seen as part of a greater movement for the renewal of the church's life and witness, which for any adequate treatment should include the Evangelical acade-

mies and lay centres in Germany, the Iona community in the Church of Scotland, Agape in the Waldensian church in Italy and the Christian *ashrams* in India. (R. S. P.)

**Conclusion.**—In all these centuries the basic ideal of monasticism has been the same: the conquest of spiritual evil by means of the renunciations expressed in vows of poverty, chastity and obedience, thus freeing the soul for the perfect love and service of God. But monasticism in the west has acquired certain additional notes in the course of the ages. Since the early middle ages it has devoted itself particularly to liturgical worship and intercessory prayer and to some forms of literary learning, and concurrently it has in varying extent undertaken works, and even external works, such as apostolic, pastoral and educational service. These latter, while fully consistent with a life of holiness and Christian perfection, can scarcely be contained within any definition of monasticism that is to be significant. This must always imply a large measure of retreat from secular activity and of personal solitude. The principal foes of the monk, human frailty apart, have always been wealth and entanglement with things of the world.

While monasticism will not, in any foreseeable future, regain its former social and economic importance, the ideal is as precious and powerful as ever in the spiritual life of the church, though it is in danger of being submerged in the waters of external activity. (M. D. K.)

## MONASTICISM IN OTHER RELIGIONS

Ethnic religion, whether primitive or developed, is generally world affirming and does not encourage withdrawal. Hence Shintō in Japan has no monasteries. Among more developed religions with a prophetic basis, Zoroastrianism, like Orthodox Judaism, is also nonascetic and world affirming.

**Beginnings.**—The earliest type of monk was probably the solitary or hermit; *shramanas* (Sanskrit "recluse") may already have existed in some of the earliest proto-Dravidian or pre-Aryan settlements in India (*i.e.*, before *c.* 1500 B.C.). In early Hindu times (*c.* 600–*c.* 200 B.C.) there were hermits who lived in groups (*ashramas*) although they did not lead a strictly organized communal life. Literary references indicate that such practices were probably widespread, and this readiness to abandon everyday life may be explained partly by the pressures of climate, famine, plague, overcrowding or poverty, and partly by the desire, clearly typical of the Upanishadic literature of the period, to achieve permanent communion with deity.

**Jainism.**—Organized monasticism seems to have evolved from the communities of *ashramas*. Perhaps the first religion that can properly be said to have had an organized monastic life was Jainism (*q.v.*), whose reputed founder, Mahavira, organized his followers into groups of monks and nuns, who were fully professed, and laity, who ministered to their needs and kept a less rigorous rule. Later the Jains split into two sects, and one of these, the Digambaras, disallowed nuns. In Jainism self-denial and mortification assumed an extreme form. Its monks eschew the destruction of any animal life; some reject clothing altogether, and many fast to death. The strictness of their rule remains unmodified in the 20th century.

**Buddhism.**—Buddhism, a preeminently monastic religion, led to a great increase in the number of large organized monastic communities, known in totality as the organization of the Sangha. At first the monks led the wandering life of beggars, gathering informally in huts for the rainy season; later permanent monasteries were built, and the system became more stereotyped. The Buddhists, like the Benedictines of Christianity, observed a moderate rule, avoiding extremes of self-indulgence and self-immolation; according to tradition, Gautama Buddha had practised and rejected extreme ascetic exercises, the austerity of which suggest that he was at one time a member of a Jain community. Like the Jains, the Buddhists ignored caste distinctions. Originally monks and laity were closely associated, a tradition which has continued in the Theravada countries, and in general the Sangha has adapted itself to the needs of the people; for example, it has admitted a great many young men as temporary novices who for a few months lead the life of a *bhikkhu* (Pali "monk") and receive education and religious instruction. This practice is still customary in Burma, Thailand and Cambodia.

The number of Buddhist nuns has never been large; indeed the Buddha is said to have been very reluctant to allow women to form communities. They lived apart from the monks and were always considered inferior to them. There are still a few communities to be found in Buddhist countries.

The Zen movement, which began in China in the early 5th century A.D., attempted a return to the early principles of Gautama and had a marked effect upon the monastic communities adopting it. It stressed frugality of diet, simplicity of dress and the duty of monks to work as well as to meditate. In these respects it was not unlike some reformed Benedictine communities among Christians. The monastery buildings are of severe pattern and austere furnishing, and Zen art, although it is extremely beautiful, is not ostentatiously displayed. There are three meals a day, the only one after noon being the remains of what is left over from the other two. The exacting meditation periods alternate with walking exercise round the central hall. Zen monks exhibit a Franciscan gaiety and cheerfulness during their daily occupations. *Koans*, or paradoxical aphorisms, are prescribed as subjects for meditation, and twice a week the head of the community interviews each member to see what progress he has made.

(*See* BUDDHISM: *Early Order of Monks* and *Modern Buddhist Practice*, which discusses the differences in the monasticism of the two great schools of Buddhism, Theravada and Mahayana; *see* also TIBETAN BUDDHISM.)

**Taoism.**—This movement in China, being essentially quietist, has developed a few monastic communities in which meditation can be practised and which are somewhat akin to those of the Buddhists. (*See* TAOISM.)

**Hinduism.**—In the 9th century A.D., possibly as a result of Buddhist influence, the Hindu philosopher and theologian Shankara founded four monastic communities (*maths*)—at Badrinath in the Himalayas, Dwarka in the west, Puri in the east and Mysore in the south—which are still active.

According to the rule Shankara laid down, there was no central head of the order, and each abbot nominated his successor. He was enjoined to travel through his own province, preaching *dharma*; *i.e.*, one's station and its duties according to the Hindu scriptures. In the 12th century another famous theologian, Ramanuja, founded several religious orders and is thought to have left behind him as many as 700 monastic communities; but these have not endured. It is said that he allowed members of his order to marry and that many of the institutions came to have hereditary abbots. Like the Buddhist and Jain monasteries before them, and their Christian counterparts in the near east and western Europe, Hindu monastic communities became centres of learning. (*See* also HINDUISM: *Asceticism*.)

**Islam.**—Muslim communities are discussed in the articles SUFIISM; DERVISH.

**Modern Developments.**—The decline of asceticism in India is marked, and with it there has been a decline in the number of monastic communities. The Indian Buddhist monasteries had disappeared by about the 13th century, partly as the result of the Muslim invasions, and they are now only deserted ruins. The aggregations of ascetics and hermits at Varanasi (Benares) have diminished considerably. India is, in fact, so busy transforming itself that it has less and less time for world renunciation. In China, Buddhism and Taoism are being superseded by Marxism.

*See* also ORDERS AND CONGREGATIONS, RELIGIOUS; WOMEN'S RELIGIOUS ORDERS; separate articles on the major orders and congregations; and references under "Monasticism" in the Index. (A. C. B.)

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**MONAZITE,** a mineral consisting of the phosphate of the cerium and lanthanum group of rare-earth elements including neodymium. Small and variable amounts of thorium, 2%–12%, and of yttrium are usually also present. The world's supply of thorium (*q.v.*) was very largely obtained from monazite. Thorium is converted by neutron bombardment into a fissionable isotope of uranium and can be employed in atomic power reactors; the oxide thoria formerly was used on a large scale for the manufacture of mantles for incandescent gas lighting. The cerium (*q.v.*) is used for chemical and ceramic applications, and alloyed with iron it forms the sparking flints of automatic lighters.

Monazite is of wide distribution as minute crystals in granites and gneisses, being present in very small quantity as an accessory constituent of these rocks. By powdering the rock and washing away the lighter minerals in a stream of water, the heavy minerals (zircon, rutile, magnetite, garnet, monazite, ilmenite, etc.) may be collected. This separation has been effected naturally by the weathering and disintegration of the rocks and the accumulation of the heavier minerals in the beds of streams. Under these conditions monazite has been found as rounded grains in alluvial gold washings and as a constituent of the black-sand fraction of beach and river sands. It also occurs in geologically old placer deposits (cemented conglomerates), as in the Witwatersrand in South Africa and the Black hills of South Dakota. Large masses of monazite are found in pegmatite veins, as in Madagascar, Quebec and North Carolina (where a crystal weighing 59 lb. was found). Vein deposits of massive granular monazite are known in San Bernardino county, Calif., and the van Rhynsdorp district, Cape of Good Hope, S.Af.

Important commercial deposits of monazite are found in the beach sands of Travancore in southwestern India, in the states of Espirito Santo and Bahia, Braz., in New South Wales and Queensland and in Ceylon. In the United States, monazite deposits are found in Florida, the Appalachian region, Idaho and Montana. The crude sands, known as monazite sands, usually are first concentrated by washing, and the monazite and other minerals are then separated magnetically.

The composition of monazite is represented by the formula $(Ce,La,Nd)PO_4$; thorium is present as thoria ($ThO_2$). Crystals of monazite belong in the monoclinic system, and are usually flattened parallel to the orthopinacoid. The large crystals from pegmatites usually are reddish brown, dull and opaque and simple in form, while the small translucent honey-yellow crystals from the Alps are bounded by numerous bright faces. The hardness is 5.5 and the specific gravity 5.1–5.2. *See also* Rare Earths. (L. F.)

**MONBODDO, JAMES BURNETT,** Lord (1714–1799), Scottish jurist, nonconformist and imaginative writer on natural history and the origins of society, was born at Monboddo, Kincardineshire. A classical scholar, he studied at Aberdeen and Edinburgh. He was made a lord of session in 1767 with the title of Lord Monboddo.

In his *Antient Metaphysics* (1779–99) Monboddo conceived man as gradually elevating himself from an animal condition to a state in which mind acts independently of body. In *The Origin and Progress of Language* (1773–92), he related man to the orangutan. His speculations were an odd jumble of insight and fancy with some curious points of contact with Darwinism. He died on May 26, 1799.

Boswell's *Life of Johnson* gives an account of Johnson's visit to Burnett at Monboddo, and is full of references to the popular notion of an eccentric man who thought that the human species could be related to apes.

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**MONCEY, BON ADRIEN JEANNOT DE,** Duc de Conegliano (1754–1842), French marshal remembered for his successes in Spain during the French Revolutionary and Napoleonic Wars, was born in Besançon on July 31, 1754, the son of a lawyer. The light infantry regiment in which he was an officer was stationed in the western Pyrenees from 1788 and was one of the few regular units there when Spain declared war on Revolutionary France in 1793. After the repulse of the Spanish attack on the Bidassoa river (Feb. 1794) he was promoted to the rank of general. He then led a division in a long march that outflanked the Spaniards; the frontier was cleared and the French took San Sebastian. The Jacobin *représentants en mission* gave all the credit for this to Moncey, and in Aug. 1794 he was given the command of 50,000 men. With these he executed wide encircling movements, from which the Spanish forces usually escaped with the loss of their materiel. Moncey took care not to antagonize the Spanish people by acts of terrorism. He had taken Bilbao and reached the Ebro and was preparing to besiege Pamplona when the Franco-Spanish peace of Basel (June 1795) brought the war to an end.

Moncey, after holding corps commands in Italy, was in Dec. 1801 appointed inspector general of the gendarmerie. He thus uneasily shared the police control of Napoleonic France with Fouché and Savary. He was made a marshal in 1804 and duc de Conegliano in 1808. He served in Spain again in 1808 and, after the Bourbon Restoration, in 1823. Governor of the Invalides from Dec. 1833, he died in Paris on April 20, 1842. (I. D. E.)

**MÖNCHENGLADBACH,** a town of Germany in the *Land* (state) of North Rhine-Westphalia which after partition of the nation following World War II became part of the Federal Republic of Germany. Pop. (1961) 152,185. It is situated between the left Lower Rhine and the Meuse, 16 mi. W. of Düsseldorf, and is an important centre for main roads and railways. It also has a civil airport. Mönchengladbach is a noted textile centre, producing cloth (particularly worsted). It also has metallurgical and machine industries (especially textile machinery), iron foundries and assembly plants for aerotechnical equipment. Other factories produce paper, chemicals, leather, foodstuffs and petroleum.

The town developed around a Benedictine monastery (founded in 792 and suppressed in 1802, whence *Mönchengladbach* ("monks Gladbach"), and was chartered in 1316. Historic buildings in-

clude: the 11th-century Romanesque minster with an Early Gothic choir (attributed to Gerhard von Riehl of Cologne), an early 13th-century nave and an 8th-century crypt; a baroque town hall, formerly a Benedictine abbey; the Late Gothic church of St. Mary's Ascension; and a 12th-century convent in the Neuwerk quarter. The town is well endowed with parks and has a botanical garden (Bunter Garten) and several sports arenas (including bicycle and roller-skating stadiums, a race course and, on the outskirts, a motorcycle and racing-car circuit called the Grenzlandring). Institutes of higher learning include the Franciscan John Duns Scotus academy (philosophy and theology), colleges of textile engineering and agriculture and a higher school of economics. The municipal museum houses a notable collection of Coptic textiles. The town is renowned for its choral societies and has a municipal theatre. It is the headquarters of the North Atlantic Treaty organization forces in north-central Europe.

**MONCK** (MONK), **GEORGE,** 1st DUKE OF ALBEMARLE (1608–1670), English parliamentarian general and architect of the Restoration, was born at Potheridge in Devon on Dec. 6, 1608. He was the second son of Sir Thomas Monck, who belonged to a well-established family in the west of England. Little is known about his education, but at the age of 16 he volunteered to fight under a kinsman, Sir Richard Grenville, in the duke of Buckingham's military operation against Cadiz and later went on the expeditions to the Ile de Rhé and La Rochelle, all of which were failures. Later he served under Lord Vere in the Netherlands, fighting for the Dutch against the Spaniards and distinguishing himself at the siege of Breda in 1637. Through the influence of the earl of Leicester, he was appointed lieutenant colonel of a regiment of foot which took part in the two Bishops' Wars against the Scots. In 1642, again with Leicester's help, he was given acting command of a foot regiment in Ireland which was used against the rebels.

The following year he joined a force sent from Ireland to England to help Charles I against the parliamentarians in the Civil War, but was captured at Nantwich, in Cheshire, in Jan. 1644. He spent the next two years as a prisoner in the Tower of London where he wrote a book, *Observations Upon Military and Political Affairs*, published posthumously in 1671, which reveals him as a deep-thinking professional soldier. He had evidently made a reputation in his profession, for when the Civil War was over the parliamentarians sent him back to Ireland where he served them as major general in Ulster. After the execution of Charles I an alliance concluded between the English royalists, Irish nationalists and Ulster Scots compelled Monck to agree to an armistice. He was afterward censured for this action by parliament on political grounds but excused because of military necessity. Nevertheless he was deprived of his regiment and retired to Devon.

Oliver Cromwell, who respected Monck's military ability, took him to Scotland in 1650 and formed a foot regiment for him which later became the Coldstream guards. Monck played an important part in the battle of Dunbar on Sept. 3, 1650, and when Cromwell returned to England in 1651 he left Monck behind as commander in chief with an army of 5,000 men. Monck completed the subjugation of Scotland. By some he was blamed for his severity at the storming of Dundee on Sept. 1, 1651, but on the whole his discipline was complete and effective. Later that year he was taken ill and retired to Bath for treatment, though he remained a parliamentary commissioner for Scotland. In the autumn of 1652 a new phase in Monck's career opened when he was appointed one of the three generals-at-sea at the outbreak of the first Dutch War (1652–54). Possibly his experience in handling artillery explains his appointment. He took part in the principal sea battles and appears to have influenced the development of naval tactics. According to the naval historian C. T. Atkinson, Monck can stand comparison with the famous Dutch admiral M. H. Tromp (*see* TROMP) as a strategist and tactician, if not as a seaman.

While the Dutch war was in progress a rising had begun in the Scottish Highlands and at the end of 1653 Monck was ordered to return there as commander in chief. After he had collected the necessary funds and forces and received the support of Cromwell, who was then lord protector, he carried out a brilliant campaign in the Highlands and afterward organized their security with so much success that he was able to reduce the size of the English garrison in Scotland. His loyalty to the Cromwellian protectorate was complete.

When Cromwell died Monck advised Oliver's son, Richard, who was no soldier, to rely on the "new courtiers," who had served his father well, rather than upon the intriguing generals, and to amalgamate some of the regiments so as to rid himself of disloyal officers. But the new protector did not follow this advice. "Richard Cromwell forsook himself," Monck is said to have remarked later, "else I had never failed my promise to his father or my regard for his memory." Monck acquiesced in the overthrow of the protectorate and the recall of the Rump parliament, the remnants of the original Long parliament of 1640. But when in Oct. 1659 Maj. Gen. John Lambert (*q.v.*) dissolved the Rump by force, Monck refused to recognize the new rulers and informed the speaker of the house of commons that he would free his country from "the intolerable slavery of a sword government." He then began to purge his own army in Scotland and although, to gain time, he entered into negotiations with Lambert he insisted finally that he must restore parliament. Monck set up his headquarters at the village of Coldstream on the Scottish border on Dec. 8 and on New Year's day, 1660, led an army of six infantry and four cavalry regiments into northern England. He entered York on Jan. 11. Lambert's army, which was to oppose Monck, melted away, and Monck reached London on Feb. 3 to receive the thanks of the Rump parliament, which had reassembled the previous Christmas.

Although royalist agents had approached him in the preceding autumn there is no reason to suppose that when Monck marched on London he had any intention other than to obey parliament. However, during his march petitions had reached him asking for the summoning of a "free parliament" and he told the Rump that it should fill up its vacancies and then dissolve. The council of state ordered Monck to impose discipline on the City of London which refused to pay its taxes until the house of commons filled up its vacancies; Monck at first obeyed, but then himself insisted that the commons should fill up their vacancies and afterward give way to a "free" parliament. It was not until parliament was dissolved in March that he entered into direct communication with Charles II. The new Convention parliament, as it was called, invited Charles II back to England; on May 25 Monck welcomed the king when he landed at Dover. For his services in contributing to a peaceful restoration of the Stuart monarchy Monck was made duke of Albemarle, created a knight of the Garter and awarded an annual pension of £7,000. He was also made master of the horse, lord lieutenant of Ireland and captain-general. But, apart from the Coldstream guards, the splendid army he had fashioned was disbanded. When the plague broke out in 1665 Albemarle stayed at Whitehall to assuage the panic in the capital. In the second Dutch War he returned to active service and defeated the Dutch at St. James's Fight on July 25, 1666. When the Dutch appeared in the river Thames the following year, and also attacked Chatham, he helped to save the English navy from extinction. Nevertheless it is doubtful whether he recovered from this disgrace. Monck died at Whitehall on Jan. 3, 1670.

Monck was above all a fine professional soldier who believed in the virtues of obedience and deference to the civil authority. Only in 1660 was he reluctantly driven to intervene in politics. He had a reputation for being fond of money and close with it. He married Ann Ratsford Jan. 23, 1653. The widow of a farrier, she had been his laundress when he was in the Tower, and his mistress. She bore him several children, only one of whom, Christopher, survived. He became governor of Jamaica and second duke of Albemarle. At his death in 1688 the title became extinct.

*See* also references under "Monck, George" in the Index.

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**MONCTON,** a city and port in Westmorland county, New Brunswick, Can., 25 mi. from the mouth of the Petitcodiac river, a navigable stream at high tide, and 89 mi. N.E. of Saint John by rail. Pop. (1961) 43,840. It is the Atlantic regional headquarters of the Canadian National railways and an air and highway transport centre serving the maritime provinces. Originally settled by French Acadians, it was resettled by Germans from Pennsylvania in 1763. It was named after Robert Monckton (1726–82), lieutenant governor of Nova Scotia from 1756 to 1761. A notable tourist attraction is the tidal bore, a flood of water that advances up the river every 12½ hours at an average height of 3½ ft. (C. W. Rd.)

**MOND, LUDWIG** (1839–1909), British chemist and industrialist who perfected the Solvay ammonia-soda process of making alkali and devised a process for the extraction of nickel, was born at Kassel, Ger., March 7, 1839. After studying at Marburg under H. Kolbe and at Heidelberg under R. Bunsen, and holding several industrial positions in Germany, he went to England in 1862 and became associated with a well-known alkali manufacturer at Widnes, where he elaborated the practical application of a method he had patented for recovering the sulfur lost as calcium sulfide in the black ash waste of the Leblanc alkali process, which he introduced into some 30 works in England and France. He became a naturalized British subject in 1880. In 1873 he entered into partnership with Sir John Tomlinson Brunner (1842–1919), and thus founded the great chemical manufacturing firm of Brunner, Mond and Co. They began to make alkali by the Solvay ammonia-soda process, which process was significantly improved by Mond. About 1879 Mond began experiments in the economical utilization of fuel and his efforts led him to the system (patented 1883) of making the producer gas known by his name, "Mond gas." Further, he worked out a gas battery.

His discovery of nickel carbonyl made possible a successful process for the extraction of nickel from its ores, which involved the finding, acquisition and development of mines in Canada, the elaboration of new and suitable smelting operations there and the invention of highly specialized apparatus for the refining works in Wales.

Mond was elected a fellow of the Royal society in 1891. A liberal contributor to the purposes of research, he founded in 1896 the Davy-Faraday Research laboratory in connection with the Royal institution. He was a notable art collector, most of his paintings being bequeathed to the National gallery. He died in London on Dec. 11, 1909.

*See* Carl Langer in *Berichte der deutschen chem. Gesellschaft*, p. 3665 (1911), which contains a list of his papers; J. P. Richter, *The Mond Collection*, 2 vol. (1910), describes his art collection.

**MONDEGO,** the largest of the exclusively Portuguese rivers, rises at 5,250 ft. on the northern slopes of Serra da Estrêla and its drainage basin covers 2,615 sq.mi. The chief tributaries are the Dão, Alva and Ceira. The Mondego generally follows an antecedent course southwest to the Atlantic for 136 mi. in a broad basin, partly tectonic, with incised meanders in its lower valley. Coimbra stands where it leaves the Beira plateaus for a broad flood plain. A sandbar prohibits navigation above Figueira da Foz, though small craft can sail 53 mi. upstream to Fozdão, the river is tidal to Montemór o Velha (12 mi.). The Mondego and Alva have several hydroelectric stations completed or under construction. Cabo Mondego, a promontory north of the river, rises steeply to 750 ft. above the coast. (J. M. Ho.)

**MONDINO DE' LUZZI** (DE LUCCI, DEI LUZZI MUNDINUS) (1270?–1326), Italian physician and the founder of modern anatomy. He reintroduced the study of body structure from human dissections after this practice had been abandoned for about 1,700 years. Born in Bologna in the latter part of the 13th century, he received his medical training in the famed university of that city. After graduation he taught and studied anatomy and surgery at his alma mater while carrying on active practice in both medicine and surgery. He died at Bologna in 1326.

Anatomy, previous to Mondino's time, was taught from the books of Galen and occasionally from the dissection of pigs or monkeys. It was Mondino's great service that he revived the practice of human dissection for study as well as student demonstration. His *Anathomia* was written in 1316 and became the standard text on the subject for more than 200 years. It was first printed in Pavia in 1478 and went through about 40 editions. In this book, the teachings of Galen are perpetuated with no attempt to challenge or change them. It instructs the student in the technique of dissection as well as in the description of the parts. Adaptation of structure to function, morbid changes and even therapeutic suggestions are added to the anatomical descriptions.

Mondino wrote other books on medicine and surgery and commentaries on Hippocrates and Galen, but his assured place in the history of medicine rests upon his classic little treatise on anatomy and upon the initiation of human dissection upon which it is based.

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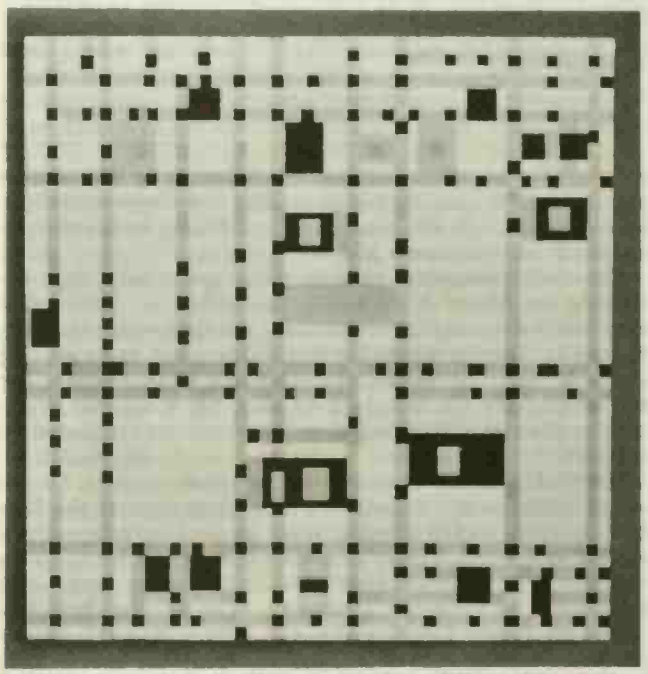
**MONDRIAN, PIET** (PIET CORNELIS MONDRIAAN) (1872–1944), Dutch painter, critically regarded as one of the purest nonobjective painters, was born in Amersfoort on March 7, 1872.



BY COURTESY OF THE MUSEUM OF MODERN ART, NEW YORK, PHOTOGRAPH BRUCE LONDON

"BROADWAY BOOGIE WOOGIE," OIL ON CANVAS, BY PIET MONDRIAN (1942–43). IN THE MUSEUM OF MODERN ART, NEW YORK

He received early instruction at home from his father, who was an amateur painter, and then attended the Amsterdam Academy of Fine Arts for three years. He achieved moderate success with his early landscapes, which emphasized mass and absence of detail, but in later years he drifted away from traditional techniques and began to explore the realm of abstractions. In 1910 he moved to Paris, where he came under the influence of French cubists. He developed an antipathy for curved lines, and his compositions were notable for their vertical and horizontal lines, which formed crosses and rectangles. In 1914, with Theo van Doesburg, he founded the Dutch de Stijl group of painters and architects, with whom he worked in the Netherlands for the next six years. On his return to Paris in 1920 he explained "neoplasticism" in a published report. Three years later he formed the nucleus of an abstractionist group. He left Paris for London at the start of World War II, and went to the U.S. in 1940. He died in New York city on Feb. 1, 1944.

Mondrian's influence may be felt in European architecture and in general trends in design. His pictures hang in museums in New York, Philadelphia and Buffalo and at Yale university, as well as in Amsterdam, The Hague, Dresden and Hanover. In 1943 the

Museum of Modern Art in New York city acquired his composition entitled "Broadway Boogie-Woogie," which became a source of controversy in professional circles; his "Composition in White, Black and Red" also is there. A representative showing of his work was held at the Museum of Modern Art in 1945.

**MONEL.** "Monel" is the registered trademark of the International Nickel Co., Inc., for a group of nickel-copper alloys, the first of which was developed in 1905, containing about 66% nickel and 31.5% copper, with small amounts of iron, manganese, carbon and silicon, and now designated Monel Alloy 400.

The alloy can be melted readily in all types of furnaces; is nickel-white in colour; has good mechanical properties; is highly resistant to corrosion under saline, sulfuric acid, and other reducing conditions; can be fabricated readily by hot and cold working, machining, and welding; is available in all commercial forms; and has more than 700 uses in the chemical, petrochemical, petroleum, chlor-alkali, pulp and paper, marine, and other industries. Its corrosion rate is low in moist atmosphere, fresh and sea water, and neutral and alkaline salt solutions including chlorides, carbonates,

*Important Properties of Monel Alloy 400*

| | |
|---|---|
| Density, g/cc at 20° C. (68° F.) | 8.84 |
| Melting range, ° C. | 1,300–1,350 |
| Modulus of elasticity (tension), lb. per square inch | 26,000,000 |
| Tensile strength, lb. per square inch | 80,000–150,000 |
| Elongation, percent | 50–10 |
| Thermal expansion, cm/cm/° C., 25°–100° C. | 0.000014 |
| Thermal conductivity, cal./sq. cm/cm/° C./sec.; 0°–100° C. | 0.062 |
| Electrical resistivity, microhm-cm | 48.2 |
| Hot working range, ° C. | 700–1,175 |

sulfates, nitrates, and acetates, and in nonoxidizing salt solutions such as zinc chloride, ammonium sulfate and aluminum sulfate; but is high in nitric and other strongly oxidizing acids and ferric and cupric salts, sulfurous acid, and halogens.

Important commercial varieties which are equally corrosion-resisting are Monel Alloy K-500, age-hardenable nickel-copper alloy which contains 3% aluminum and was the first age-hardening nickel alloy having strength and ductility equal to many alloy steels; Monel Alloy R-405, free-machining nickel-copper alloy; and Monel Alloy 403, nickel-copper alloy, which is higher in copper than the other varieties of nickel-copper alloys and is used for nonmagnetic applications. (W. A. Mu.)

**MONEMVASIA** (anc. Minoa), a Greek town in Laconia *nomos* (department), lies on the southeastern coast of the Peloponnese, at the foot of a rock crowned by the ruins of a medieval fortress and a 14th-century Byzantine church, and joined to the mainland by a causeway, from which it derives its name, which means "city of the single approach." The ruins of Epidaurus Limera are nearby (*see* Epidaurus). Pop. (1961) 487 (mun.). The island is about a mile long, and its cliffs rise to about 600 ft. During the Slav incursions into the Peloponnese it was a place of refuge for Greeks from Laconia, and it became one of the principal fortresses and commercial centres of the Levant in the middle ages. Its name, in various forms (It. Malvasia; Fr. Malvoisie; Eng. Malvesie or Malmsey), became familiar throughout Europe from its extensive trade in a special wine, mainly imported from the Cyclades and Crete.

In the 6th century the Byzantine emperor Maurice raised it to an independent bishopric, and later emperors, notably Andronicus II in 1310, granted it special privileges. It was captured after a three years' siege by Guillaume de Villehardouin in 1248, but restored to the Byzantines in 1262. After the Turkish conquest of Greece it placed itself first under the papacy (1460–64), and then under the Venetians, who were forced to cede it to the Turks in 1540.

In 1689 it was the only town of the Peloponnese which held out against the Venetian, Francesco Morosini, though his successor Giovanni Cornaro reduced it by famine in 1690. In 1715 it again capitulated to the Turks; but it was the first fortress to fall to the Greeks in the War of Independence in 1821.

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**MONET, CLAUDE** (1840–1926), French painter, a leader in the practice of open-air painting and one of the chief founders of Impressionism, was born in Paris on Nov. 14, 1840. The family moved to Le Havre about five years after. As a child, he much preferred excursions by the sea to the schoolroom, where he drew cartoons of his teachers. By the age of 15 he had gained a local reputation and a small income as a caricaturist; but it was not until meeting Eugène Boudin, the marine painter from Honfleur, that he began painting the sea and sky he so much loved.

Monet first visited Paris in 1859–60, where he was impressed by the paintings of Charles Daubigny and Constant Troyon. To his family's annoyance, he refused to enroll in the École des Beaux-Arts, but frequented the haunts of the advanced artists and worked at the Académie Suisse, where he met Camille Pissarro. This informal training was interrupted by a call to military service in Algeria. He was excited by the African light and colour, but returned to his family's home in Sainte-Adresse (near Le Havre) in 1862 because of illness. Again he painted the sea with Boudin, and met the Dutch marine painter Johann Jongkind. Later that year, and in 1863, he continued his study in Paris, this time with the academician Charles Gleyre, in whose atelier he met Frédéric Bazille, Alfred Sisley and Pierre A. Renoir. After disagreements with their master, the group departed for the forest of Fontainebleau where, two years later, at Chailly, Monet was to paint one of his best known early works, "The Picnic" ("Déjeuner sur l'Herbe"), in the spirit of Edouard Manet and Gustave Courbet, both of whom he already knew and admired. It was also during this period—sometime between 1858 and 1871—that Monet discovered Japanese prints, the decorative flatness of which was to play such an important role in the development of modern painting in France.

By 1872 Monet's direction was clear. He had settled in the Seine village of Argenteuil with his wife Camille and his five-year-old son Jean. His painting was already mature, and he had met his future dealer, Durand-Ruel. He had battled with changing outdoor light at Le Havre and Honfleur, in England and Holland, on the Seine and in the forest. He was also known for figure and still-life painting. In 1867, moreover, he had finished a huge figure composition, the "Women in the Garden," entirely in the open air. During his London visit (1870–71) he had seen the outdoor oil studies of John Constable and the romantic landscapes of J. M. W. Turner. He may have known James Whistler's early "Nocturnes." By 1874 Monet's radical art had become both a rallying point and a focus of attack; his "Impression," when shown in the first large exhibition of the expanding group of insurgent painters, caused them all to be labeled by the press, in derision, as Impressionists.

During the 1870s the river, rather than the sea, became Monet's primary subject. Already in 1868 he had begun the sequence of impressions of the Seine which formed a major part of his work before 1900. At Argenteuil, and later at Vétheuil, he constantly sought a more direct perceptual response to the changing appearances of nature, thus breaking sharply with the studio-conceived landscape painting of the past. In the 1880s, after Camille's death, he painted both the river and the seacoast, striving to reconcile first impressions with colour harmony, expressive manipulation of pigment and composition. Monet moved to his final home at Giverny with his second wife, Alice Hoschedé, in 1883. It was there, after 1890, that he systematized his method of developing several studies of the same motif in series, changing canvases with the light or as his interest shifted. These "series" were usually dated and often exhibited, in groups: "Poplars" (1890–91), "Haystacks" (1891), "Rouen Cathedrals" (1894), "Mornings on the Seine" (1896–97), "Scenes of the River Thames" (1899–1904), "Venice" (1908), etc. The most renowned of the works identified with Giverny, however, were those of the unique "water garden" which Monet had created by diverting the tiny Epte river. Before long paintings of water lilies, irises, weeping willows and his Japanese bridge could be found in most of the major art collections and museums of the world along with his other famous works. The last years, though hampered by failing eyesight, were almost entirely devoted to these "water landscapes." During

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STILL LIFE BY CLAUDE MONET. IN THE NATIONAL GALLERY OF ART, WASHINGTON, D.C.

World War I, encouraged by his friend Georges Clemenceau, Monet planned a gift to the French government. He died on Dec. 5, 1926, before it was completed; but the following spring a series of large paintings of the garden were finally installed in two oval rooms in the Orangerie of the Tuileries.

*See* also PAINTING: *France: 19th Century: Monet and the Impressionists;* IMPRESSIONISM.

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**MONETA, ERNESTO TEODORO** (1833–1918), Italian patriot, journalist, pacifist and winner of the Nobel peace prize, was born in Milan on Sept. 20, 1833. Having taken part in the Milanese rising of March 1848 against Austrian rule, he emigrated to Piedmont after the final Austrian victory over Sardinia-Piedmont in 1849 (*see* ITALIAN INDEPENDENCE, WARS OF) and began studies at the military academy of Ivrea. He served in the war of 1859 in a corps of mountain troops organized by Garibaldi, in the campaign of 1860 in southern Italy and in the war of 1866 as an officer in the Italian army. In 1867 he resigned from the army to become editor in chief of the democratic Milanese newspaper *Il Secolo*, with which he remained till 1896. Impressed by the suffering that he had seen during his military career, Moneta in 1887 founded the Unione Lombarda per la Pace e l'Arbitrato, on the lines of the International Peace society organized in England by Hodgson Pratt, to promote disarmament, the formation of a league of nations and the settlement of international disputes by arbitration. To propagate his ideas, he launched a periodical *La Vita internazionale*, in 1898. The Nobel peace prize for 1907 was shared between Moneta and Louis Renault.

Moneta, however, was never ready to sacrifice his notion of justice to his pacifism. In 1911 he supported the impending Italian occupation of Libya (*see* ITALO-TURKISH WAR) as a means of civilizing a territory misruled by the Turks, and in 1915 he advocated Italian intervention in World War I against Austria-Hungary. Moneta died in Milan on Feb. 10, 1918.

**MONETARY AGREEMENT,** an agreement between countries concerning monetary matters of common interest to them. A special form of monetary agreement is that by which two or more countries adopt a common regulation of their currencies and thus create a monetary union.

An outstanding example was the Latin Monetary union founded in 1865 that embraced France, Belgium, Switzerland, Italy and later Greece. Each country kept its own nomenclature for its currency, France, Belgium and Switzerland terming their monetary unit the franc, Italy the lira, Greece the drachma. In 1873, because of the depreciation of silver, all the members of the union agreed to limit the coinage of new silver five-franc pieces, thus dropping the double standard of gold and silver to which they originally adhered, and placing their currency virtually upon the gold standard. All public offices of the member states were obliged to accept the union currency in payment. Subsidiary currency (silver token money ranging from 20 centimes to 2 francs) remained national, *i.e.*, was not union currency, nor were bank notes recognized as such. World War I broke up the Latin Monetary union in fact, if not in name.

Another important monetary union of the same type was the Scandinavian union, comprising Sweden, Norway and Denmark. There the national monetary units had a common name, the krone, or krona. The union was formed between Sweden and Denmark in 1873, and Norway joined two years later. The monetary union among the Scandinavian countries was much closer than that among the Latin countries. It embraced all subsidiary currency issued by the participant countries. The foreign exchange quotations were discontinued and the whole region could be considered, so far as monetary matters were concerned, as one country. During World War I the union broke up *de facto*, and was never revived. *See* also INTERNATIONAL PAYMENTS; STERLING AREA; INTERNATIONAL MONETARY FUND.

**MONEY,** the medium in which prices are expressed, debts discharged, goods and services paid for and bank reserves held. When used in the sense of the money supply, the term is synonymous with circulating medium and may be regarded as comprising demand deposits and common money or currency (q.v.); *i.e.*, paper money issued by the government, bank notes and coins. The term is used still more broadly to embrace money that does not enter into hand-to-hand circulation. This applies to the standard money, often gold, which may be held as a basic monetary reserve without at any time entering into general circulation. In the United States it includes gold certificates that constitute the legal reserves of the federal reserve banks. The term may even be extended to include abstract units that have been employed at different times for stating certain prices, the best-known example being the guinea, which is still used in England for stating certain types of monetary payments though it no longer circulates as part of the coinage. The expression "near-money" is sometimes used to denote liquid assets, such as time deposits and short-term government obligations, which are regarded as possessing some of the important characteristics of money and as having significant effects on the working of the monetary system.

The difficulty of arriving at a single clear-cut definition of money has led economists to describe money in terms of the functions it performs. The British economist Sir Ralph Hawtrey stated: "Money is one of those concepts which, like a teaspoon or an umbrella, but unlike an earthquake or a buttercup, are definable primarily by the use or purpose which they serve." (*Currency and Credit*, 3rd ed., Longmans, Green & Company, New York, 1928.) Alternatively, it may be said that money is anything, regardless of its physical or legal characteristics, that customarily and principally performs certain specified functions. Many writers, singling out the medium of exchange function as paramount, define money as synonymous with circulating medium. Others extend the definition to include reserve money, abstract units of account and even near-money.

The functions of money are closely interrelated, but it is nevertheless useful to differentiate among them. The most familiar is that of medium of exchange, whereby goods and services are paid for and debts and other contracts discharged. Money is also the unit of account, in which records are kept, costs computed and values compared. It is a means of stating the prices of goods and services and of expressing debts, salary and wage agreements, rents, insurance obligations and innumerable other contracts. The third major function of money is to serve as a reserve of ready purchasing power. Money is the only completely liquid asset. Ownership of a cash balance in the form of currency or demand deposits makes it possible to act quickly in matters calling for the payment of money. The convenience and other benefits conferred by the possession of ready cash are entirely different from the more or less pathological considerations that motivate the miser.

Certain functions of money that were of major importance at

one time declined, while other functions became more important, and entirely new functions arose. For example, the use of money as a store of value was important in earlier societies but became of relatively little consequence in more advanced economies. People now prefer to store values in savings deposits, insurance policies or securities where the unit-of-account function of money (particularly as a standard of deferred payments) is of primary concern. With the rise of commercial banking and central banking, came a corresponding increase in the importance of the use of money as reserves of the banking system.

Money is unique among economic goods because it is usually not regarded as wealth (though gold or other commodity money should be included as part of wealth) but as a device for exchanging and measuring wealth. An increase in the quantity of money in a country does not necessarily constitute an increase in the country's wealth. More money results in higher prices or greater liquidity but does not necessarily, except possibly through some roundabout process, mean greater wealth. Money is neither a production good nor a consumption good. It is sometimes given the rather abstract title of *numéraire*, something used for counting or expressing relationships among other things. The value of money in the sense of what it exchanges for is ordinarily measured in terms of index numbers of prices. Changes in the value of money are shown as the reciprocal of percentage deviations of the index from some established base. A rise of 100% in the index number of prices would signify that the value of money, *i.e.*, its purchasing power, had fallen by one-half. (*See* INDEX NUMBERS.)

**Origin and Development of Money.**—Scores, perhaps hundreds, of different objects have served as money at one time or another, including such things as slaves, gunpowder and the jawbones of pigs. Perhaps the heaviest money ever used was the stone money of the island of Yap in the South Pacific, and the lightest, the feather money of the New Hebrides. For centuries, salt circulated as money among the natives of Ethiopia without being supplanted by the gold or silver coins of the traders with whom the Ethiopians came in contact.

At one time it was thought that particular types of money came into existence when the most generally bartered economic good gradually came to serve as a common medium of exchange. Such an explanation is hard to reconcile with the adoption of a great many of the monetary types known to history. The ox of Homeric Greece (*pekus*, from which comes the word pecuniary), the elephant of Ceylon or the skull money used in Borneo during the 19th century can scarcely have served widely as a medium of exchange. On the other hand, it is easy to suppose that oxen or elephants were used as a basis for comparing the wealth of persons or tribes and thus became the standard for measuring other values as well. Human skulls enjoyed unique prestige in the social system of Borneo; it became customary to relate pigs or palm nuts to this highly regarded unit when comparing their values for purposes of actual exchange. In this way, skulls served as the standard, and pigs and palm nuts as the medium of exchange, just as in western societies gold has served as the standard, and coins and paper money as the medium of exchange.

Money is to be thought of as having originated out of religious and social custom rather than directly out of barter. Commodities that later came to be important as a standard of value or medium of exchange seem first to have been important as ransom, ceremonial offering or means of ostentation. The application to economic ends generally developed out of the earlier discharge of religious, legal and ritualistic uses.

Early money was often some useful substance. In the evolution of the money material there seems to have been a tendency to move from the more useful substance to the less useful and more ornamental. The popularity of gold and silver, two of the most ornamental of metals, attests to the close relation between money and ornamentation. So also does the frequent use of coins as ornaments and the issuance of coins with holes in them to facilitate stringing. Terms associated with monetary units were once generally related to bases of measurement. Drachma meant handful (originally a handful of iron nails); pound, livre, lira and ruble were terms of actual metallic weight.

In contrast with such terms as pecuniary, drachma and pound, which reflect the commodity origins of money, are the words note and bill, which relate to debt. The step from terms denoting physical assets to terms indicating debt is of great significance in the history of monetary development. It reflects the transition from predominantly commodity money to predominantly debt money. At first, debt money retained a link with the past in the form of legal and other connections with a commodity base, such as gold or silver; thus the bank note was originally a promise to pay some sort of asset, *i.e.*, commodity, money. In many modern countries, however, debt money stands alone without any pretense to commodity backing or to convertibility into any form of asset money. Debt money has assumed a variety of forms, of which demand deposits (so-called checkbook money) are now the most common.

Resort to the use of debt money eliminated the automatic regulation of the money supply by means of market changes affecting a commodity used as money. As long as the monetary structure was directly tied to gold or silver, the volume of money was limited by the amount of gold and silver available for coinage. Although it would be possible to devise a system of debt money that would operate automatically, the effect of the spread of debt money was to lessen the influence of automatic forces and to increase the importance of monetary management and control throughout the world. Because the character of the money itself does not establish effective limits to its issue, the prevention of abuse in the issuance of debt money depends upon the exercise of due restraint by the issuing authority. The satisfactory functioning of noncommodity money is dependent on strength and responsibility of the government and reasonable stability of economic conditions. Such notable instances of monetary breakdown as occurred in Germany in the early 1920s and in China, Greece and Hungary in the middle 1940s resulted when these requirements were not fulfilled.

Commodity standards embodied a technique of monetary regulation and control. Abandonment of commodity standards and subordination of automatic influences, even where the link with some metallic base remained, contributed to the devising of substitute procedures for governing monetary behaviour. These included an expansion in the number and powers of central banks and, most notable of all, the establishment of the International Monetary fund (*q.v.*) at the end of World War II. If the functioning of these alternative techniques left much to be desired, the same could also be said of the methods employed earlier.

**Monetary Standards.**—The type of money that serves as the basis for the monetary system of a country and to which other kinds of money are customarily related, through convertibility or otherwise, is known as standard money. The effect of adopting a particular monetary standard is to make that the basis for measuring value in the same sense that the adoption of the foot or the pound establishes it as the basis of measuring distance or weight. It is to be noted, however, that monetary standards have never provided a unit of measurement comparable with these others from the standpoint of uniformity and constancy. Monetary standards are of two main types, commodity standards and noncommodity, or paper, standards.

The most widely known commodity standard is gold. The general principles of the gold standard apply to any commodity standard, whether monometallic or not. The essence of the gold standard is maintenance of equality between the value of the domestic currency unit and a stipulated amount of gold. The various provisions for establishing and maintaining the gold standard are to be regarded as means to this end. The international gold standard exists when countries maintain convertibility between currency and gold and allow the free export and import of gold. With these provisions in effect, the domestic currency unit will be equal in value to a given weight of gold in world markets.

Various types of gold standard have existed at one time or another, differing primarily with respect to the provisions governing convertibility between currency and gold. The gold coin standard was common until World War I and in some countries until the

depression of the 1930s. Under this standard currency is convertible into gold at the initiative of anyone and for quantities as small as the smallest gold coin available. Under the gold bullion standard, currency and gold are convertible only in large amounts. Convertibility may be further restricted, as by providing that currency will be redeemed only at the initiative of specified groups, such as foreign central banks. The gold exchange standard exists where currency is convertible not into gold coin or bullion but into drafts payable in the currency of some country that is on the gold standard. Because this provision will presumably result in equality between a unit of domestic currency and a given weight of gold, the gold exchange standard is to be regarded as a true form of the gold standard.

As a result of the events of the 1930s, government officials in various countries were given unusual powers in connection with the administration of the gold standard. Authorization was granted, for example, to alter the legal ratio between gold and currency, as well as the conditions under which convertibility was allowed. Certain of the discretionary features were subsequently removed, but it remained customary to speak of the modified gold standard in contrast with the traditional gold standard, such as formerly existed.

Bimetallism exists when two metals are standard money, each at a fixed price in terms of the domestic currency unit (and therefore, of course, at a fixed ratio in terms of one another). Bimetallism using gold and silver was widely adopted in the 19th century, but its success was far from uniform, partly because different countries attempted to maintain legal ratios that were incompatible with one another. Proposed commodity standards include symmetallism and composite commodity reserve money. Under symmetallism the monetary standard would consist of two or more metals exchangeable at a fixed price in terms of the domestic currency unit when combined in legally fixed proportions to form an amalgam. Composite commodity reserve money would differ from symmetallism in that the standard unit would comprise an assorted group of staple commodities rather than a small number of metals. The aim of the various compound standards is to improve on the gold standard by extending the general principles of monometallism to a broader commodity base.

Under a paper standard, currency is not convertible on fixed terms into any specific commodity or combination of commodities. The paper standard is said to be controlled if transactions involving foreign exchange, and therefore exchange rates in terms of foreign currencies, are strictly regulated. Degrees of control may vary greatly; sometimes multiple exchange rates are maintained, with different quotations for different types of transaction. A free paper standard differs from the controlled in that transactions involving foreign exchange are relatively unrestricted and exchange rates are allowed to fluctuate. The authorities may undertake, however, to exercise a steadying influence on exchange rates, as through the operations of an exchange stabilization fund.

**Circulating Medium.**—Money as a medium of exchange consists of currency and demand deposits at commercial banks. The use of bank deposits for effecting current payments largely superseded the use of bank notes and became especially far advanced in Anglo-Saxon countries. In the United States the issue of circulating notes by commercial banks was narrowly restricted after 1866 and prohibited after 1936; only the federal reserve banks now have the privilege of note issue. A similar monopoly was given to the Bank of England in 1844.

The chief distinction between bank notes and demand deposits lies in their physical form. Bank notes are engraved or printed certificates made out for designated amounts; demand deposits consist merely of book entries acknowledging the bank's commitment to pay currency upon demand. Deposits circulate by means of checks made out on printed forms for amounts and at times that are determined according to the convenience of the depositor. Bank notes are looked upon as just another kind of paper money, whereas the public is hardly conscious of the fact that deposits are money. The difference, though superficial, largely accounts for the fact that the issue of bank notes was strictly regulated and then taken away from commercial banks entirely, but the privilege of providing circulating medium in the form of demand deposits has been accorded with relative freedom.

An explanation of the process whereby the operations of commercial banks result in the creation of circulating medium is part of the theory of banking. It is sufficient to say that banks are responsible for by far the largest part of the money supply in terms both of monetary value and of payments effected. (See BANKING.)

Throughout the world the volume of circulating medium has expanded at a more rapid rate than population or physical volume of business. In 1900 currency and demand deposits in the United States amounted to $52 per capita; by the middle of the 1960s they were over $630. The total, particularly of deposits, tended to decline in depressions. It expanded greatly during wars, with currency growing at a faster rate than deposits. The aggregate of circulating medium is governed by forces largely outside the control of individuals. The proportions that are held in the form of deposits and currency, respectively, and the particular denominations of currency held, however, are almost wholly determined by the actions of individuals. Increases or decreases in the amount of currency outstanding or of any particular denomination are largely automatic. The commercial banks, the central bank and the treasury are at any given moment merely the agents through which the preference of individuals is expressed.

**Monetary Principles.**—Because money came into existence as a result of certain valuable commodities assuming money functions, it was natural enough that value in the commodity use should have been looked upon as the source of value in the money use. The value of commodity money was explained in terms of the value of the commodity used as money; the value of money that had ceased to be convertible into gold or some other commodity was explained in terms of the prospect of future redemption in some valuable commodity. As long as commodity money was predominantly used, this conception of the source of the value remained common. After the collapse of the international gold standard in the decade of the 1930s, however, much of the world continued year after year to employ money that had no commodity value, was convertible into no money commodity and had no prospect of future convertibility. Yet in many countries the money continued to maintain its value as successfully as when it had been attached to some commodity base.

When a person accepts a piece of money, he does not stop to consider whether it is convertible into gold or has gold reserves behind it, nor does he take account of the fact that the government has declared it to be legal tender. If he were to analyse his motives, he would at once realize that he is willing to accept money in exchange for things of value because he has no doubt that he will be able to pass the money on to others in the same way. Thus the value of money is a reflection of the value of the goods and services that the users of money find that they can get for it when they choose to pass it on to others and is not directly dependent on the money substance or on government authority.

This explanation of the source of money value has been criticized as involving circular reasoning on the ground that it amounts to saying that "money is accepted because it is accepted." Instead of this being a valid criticism, it is precisely the point that is being made: to explain why money has value, it is necessary to introduce acceptability, i.e., behaviour. How the social behaviour or custom that lies behind the ready acceptance of money came into existence in the first place is a separate question and one that relates to the origin of money rather than its value. The explanation has likewise been attacked as making money merely a reckoning device, similar, for example, to poker chips. This observation is also to be regarded as a rough approximation of the fact rather than a valid criticism: money is indeed a means of reckoning—a *numéraire*. In the case of money, as of poker chips, the value that a given unit possesses results from the fact that it will be accepted by others. Where the acceptance of poker chips is limited and temporary, however, that is not the case with money.

The commodity feature may conceivably have a bearing on the value of money through affecting its acceptability. This consideration is likely to be important, as has been noted, in the origin

of money. Similarly, the action of government in making money legal tender may influence its general acceptance. Once money has become established, however, the absence of these features seems to have little effect on the acceptability of money and therefore on its value. Instead, the principal reason for continuing to base money on some valuable commodity is that this provision is believed to afford a necessary safeguard against overissue. Either the commodity aspect or governmental authority is to be regarded as part of the possible technique of determining the quantity of money, not as a precondition of money's having value.

**Money and Prices: the Quantity Theory of Money.**—Throughout most of the 19th and early 20th centuries the major attention of monetary theorists was directed toward the question of what causes the purchasing power of money to change. The most familiar interpretation ran in terms of the so-called quantity theory of money, an explanation generally attributed to the Scottish philosopher and historian David Hume, though some traced its origins back to the ancient Greeks. In the United States the theory is usually presented in the transactions form popularized by Irving Fisher of Yale. The formula used in explaining the quantity theory is derived from the self-evident fact that what is sold is equal in value to what is given in payment. Thus the quantity of goods (including securities) and services traded ($T$) multiplied by their average price ($P$) is equal to the quantity of money ($M$) multiplied by the number of times the money is used ($V$) during the period. This is the so-called equation of exchange —the total value of what is bought ($PT$) is equal to the total value of the money payments made ($MV$); *i.e.*, $PT=MV$ or $P=MV/T$.

There are statistical difficulties in actually applying the equation of exchange. Conceptually, however, it is a simple statement of identity, and it is not to be confused with the quantity theory of money. This theory results only when certain assumptions are introduced with respect to the factors in the equation of exchange. The most important such assumption is that $P$ is passive; *i.e.*, is determined by, and not determinant of, the quantities $M$, $V$ and $T$. The theory then amounts to saying that the value of money changes inversely with, and as a result of, changes in the quantity of money and its rate of use, and directly with changes in the volume of trade.

Formerly there was a tendency to assume that $V$ and $T$ were relatively stable and therefore that the value of money could be regarded as varying inversely with the quantity of money alone. Considerable importance later came to be attached to changes in $V$ and $T$, especially the former. The emphasis on $M$ is regarded as being justified only for major inflations and then only approximately.

Another form of the quantity theory of money (usually known as the cash-balance form), which has been particularly popular in Great Britain, replaces the quantities $V$ and $T$ with $k$ and $R$ where $R$ represents real income and $k$ the proportion of $R$ that the public desires to hold command over in the form of money. The equation $P=M/kR$ amounts to saying that the value of money as measured by the goods and services entering into real income varies inversely with, and as a result of, changes in the amount of money and directly with the desire of the public to hold resources in the form of money. The quantity $k$ is similar to, though not quite the same as, the reciprocal of $V$. This form of the quantity theory has the advantage of emphasizing psychological influences through $k$ but in general has much the same shortcomings as the transactions formulation of the theory.

Such theories as the foregoing are designed to account in general terms for significant changes in the purchasing power of money. When it comes to a consideration of more specific factors, it is to be noted that major price rises have been associated primarily with war. In economically advanced countries serious inflation has seldom occurred in peacetime except as a direct aftermath of war. The financial burdens arising out of war result in strong pressures toward expansion of the circulating medium and in a weakening of the power of governments to resist these pressures.

**Money and Business Activity: the Income-Expenditure Analysis.**—Partly as a result of the depressed conditions of the 1930s, the main interest of monetary theorists shifted to the relation of the operation of the monetary system to the level of business activity. This reorientation of monetary theory was signalized by the publication in 1936 of the *General Theory of Employment, Interest and Money*, by John Maynard Keynes. Formerly, money had been discussed chiefly in relation to its usefulness in facilitating production, exchange and the division of labour generally and to its effect on changes in the price level. Thereafter much greater attention was devoted to the bearing of money payments on levels of employment and output. The theory of money came to be more closely integrated with general economic theory.

The assumption underlying this approach was that the level of business activity is determined by aggregate monetary expenditures for final products. Changes in the level of business activity are then explained in terms of factors governing the total volume of expenditures.

Implicit in the total spendings analysis is the conception that at any given time there is some ideal level of monetary spending at which the economy would be fully employed with no tendency for prices to change in an inflationary or deflationary manner. Below this ideal level there would presumably be a tendency toward deflation accompanied by falling prices and an increase in unemployment and idle capacity. Above the ideal level there would be a tendency toward inflation. Even though the ideal level of spending is not quantitatively determinable, it constitutes a point of reference for purposes of analysis. An approximation to the ideal level of spending by the community is presumed to be a necessary condition for the attainment of full employment.

The idea of a flow of money payments through the economy is basic to the total spendings approach. Payments are necessarily two-sided—whenever someone pays, someone receives. It is no less true—and this is the application that is given much attention in periods of depression—that when someone does not pay, someone does not receive. Income resulting from the expenditures of others becomes available for further spending. If it is in fact spent it thereby generates income for still others. Income is quantitatively the largest source of funds spent. Special importance attaches to the determination and disposition of income in relation to the flow of money payments through the economy.

Funds available for spending may also be derived from two other sources. One of these consists of existing balances of currency and demand deposits, and possibly also the conversion of time deposits, government securities and certain other kinds of relatively liquid assets. Such reserves of cash and other liquid assets have presumably been accumulated out of past income. The other possible source of funds available for spending is newly created money, of which demand deposits resulting from an expansion of bank lending and investing are ordinarily the best example.

All income originates in expenditure, and expenditure on new goods and services necessarily generates income; in fact, income and expenditure are the same thing viewed respectively from the standpoint of receivers and payers. It follows that total income must be equal to total expenditures incurred at the same time. In this gross sense, total income is bound to be sufficient to pay, at prices corresponding to the costs incurred in producing them, for all the final goods produced. This is what is meant by saying that any level of production is potentially self-financing at the existing level of prices. In other words, if all incomes generated by a given volume of production were spent on what was produced, they would exactly cover the costs, *i.e.*, expenditures, incurred in producing. In that simple fact lies the answer to the fear of lack of purchasing power sufficient to pay, at prices that will cover costs of production, for what society produces.

The difficulty, of course, is that incomes are not necessarily all spent. It is true enough that expenditure arising out of production creates adequate potential purchasing power in the form of the incomes that it generates. But only the actual exercise of this purchasing power can translate the potential demand into effective demand. If all spending were just equal to income, the flow of money payments would continue at a constant level. Incomes

would be generated in each successive spending period in exactly the same amounts as in the preceding period. Presumably, current production of final products entering the market would be fully absorbed. There is no assurance, however, either that income will all be spent or that expenditure out of income will not be augmented by the spending of funds drawn from one of the other sources, namely, liquid assets or newly created money. Thus it is possible for expenditure to be greater or less than income in the preceding period and, therefore, for total effective demand to increase or decrease and business activity to tend to rise or fall.

The question that arises next is why aggregate spending, *i.e.*, total effective demand, may exceed or fall short of the ideal level that is necessary in order to achieve full employment without inflation. The answer, it is said, lies in various factors or combinations of factors affecting the flow of money payments. One of the most important of these is liquidity preference. As was noted above, money is the only completely liquid asset. The anticipated advantages of holding resources in the form of money vary chiefly because of uncertainty concerning the future. An increase in the preference of the community for liquidity, *i.e.*, for holding resources in highly liquid form, would tend to reduce the flow of money payments and therefore aggregate demand. It will be seen that this reasoning views money as being desired for itself, because of the quality of liquidity that it possesses, and not merely as something to be exchanged as soon as possible for other economic goods.

Directly related to liquidity preference is the rate of interest, which Keynesians defined as the price demanded for parting with liquidity. The rate of interest was assumed to be determined by two factors—the community's liquidity preference and the amount of money in existence. A change in the rate of interest because of either or both of these factors would raise or lower the cost of borrowing for investment purposes. Thus it would tend to alter the volume of investment, *i.e.*, expenditures on final goods to be added to capital, and thereby to alter the flow of money payments and aggregate demand.

The relations of saving to investment occupy a position of great importance in the explanation of how levels of business activity are determined. The issues, partly technical and partly terminological, are rather complicated. It is sufficient to say here that the inclinations of the public with respect to current saving and investment greatly affect the volume of money payments, which governs the level of business activity.

Saving is generally regarded as being primarily determined by, rather than a determinant of, the prevailing level of income. Changes in investment are looked upon as ordinarily the principal immediate factor contributing to variations in aggregate demand. The great strategic importance of investment rests partly on the autonomous influences that may originate with it and partly on the extent to which it can be made the object of governmental policies, such as those involving changes in interest rates, the money supply and public works.

Total monetary expenditures may also be analyzed as originating with the three classes of spenders—consumers, investors and government. At one time it was customary to concentrate attention on the first two categories only, but in most countries of the world governmental expenditures had assumed such large proportions by the middle of the 20th century as to warrant separate consideration. Changes in the volume of spending by the government are likely to have a decisive effect on total effective demand in time of war and may remain significantly high even in peacetime. Spending by consumers is much the largest element in aggregate demand. One of the modifications of earlier Keynesian monetary theory was to attach greater importance to possible changes in the volume of consumption expenditures. Great importance, though perhaps not so great as at first, continues to be ascribed to spending by investors, with changes in inventories being looked upon as the most significant element contributing to short-run fluctuations in the volume of investment.

**Integration of Monetary With General Economic Theory.**—A further development of the theory of money was its closer integration with the general theory of value. This was largely an outgrowth of Keynesian theory and was particularly influenced by the writings of J. R. Hicks, N. Kaldor and D. Patinkin. The starting point of this analysis is that money is merely one among various types of assets. Individuals have the choice of holding resources in the form of money, real goods and income-yielding securities. If more is held in one form, it is at the sacrifice of holdings less in another. Presumably individuals will shift holdings from one form to another until the benefit or satisfaction derived from the marginal unit held in each is the same.

The relationship of real goods to money is expressed in terms of prices, inasmuch as prices represent the amount of money that must be surrendered to obtain real goods. The relationship of money to income-yielding assets is expressed in terms of interest, inasmuch as this equals the current income foregone when an individual holds resources in the form of money rather than, for example, a bond or mortgage. The equilibrium relationship among the three categories of assets, therefore, predicates a suitable adjustment of prices and interest rates. And the process whereby individuals adjust their asset holdings among money, real assets and securities in order to equalize marginal preferences determines both the level of prices and interest rates. The further effects on economic activity are, of course, recognized as in the income-expenditure analysis.

This line of reasoning integrates price theory, interest theory, the theory of income determination and the theory of money. It embodies a conception of general equilibrium wherein every element in the system is determined by, and is mutually determinant of, every other element. It also offers a basis for decisions on policy by indicating that measures directed toward one element in the structure of assets, as by the central bank altering the discount rate or the treasury offering additional securities for sale, may be expected to react upon other elements throughout the system.

Earlier theories, as was seen above, emphasized the role of money as a medium of exchange. The later interpretation placed major stress upon money as an asset. What causes money to be particularly desired is the quality of liquidity suggested in the familiar expression "liquidity preference." In addition to the amount of money required in active circulation, people also desire to hold a portion of their resources in money balances that give them ready command over real and financial assets. At one time it was maintained that the balances desired were a relatively constant fraction of real income.

There has been a tendency to apply the notion of liquidity more broadly than was once the case. As Hicks and others have pointed out, the quality of liquidity is not confined to money but can be identified in diminishing degrees with a whole range of assets stretching away from money, which is, of course, ordinarily to be regarded as the most liquid of all assets. The liquidity available in the form of nonmonetary assets can be expected to affect the public's preference for the liquidity provided by money.

In extensive writings during the 1930s and 1960s, Gurley and Shaw stressed the effect of nonbanking financial intermediaries on the volume of highly liquid assets and thereby on the monetary system. Some critics of this point of view insisted that the effect was implicit in the velocity factor in the quantity theory of money and already adequately recognized by monetary theorists. Others contended that in emphasizing similarities between the credit extended by commercial banks and that extended by other financial institutions the significance of differences was seriously understated. There is validity in both criticisms. Nevertheless, a useful service was performed in helping break down the tendency to identify liquidity exclusively with money. Indeed, the argument can be extended to embrace still other financial assets, especially treasury and high-grade corporate obligations, and conceivably even nonfinancial assets, since these may also be found, under some circumstances at least, to possess significant degrees of liquidity.

**Monetary Policy.**—Monetary policy ordinarily refers to measures carried out by the central bank of a country to control the volume and availability of money and credit for the purpose of influencing economic activity. It may be directed toward such

related or additional ends as facilitating economic growth and financing a war. The concept may embrace other measures that affect monetary relationships; *e.g.*, the issue of fiat money (inconvertible currency) and regulation of foreign exchange rates. In all these matters, as also in management of the public debt, the activities of the central bank are likely to overlap with those of the treasury.

Monetary policy is distinguished from fiscal policy, even though the two may be directed toward similar ends. Fiscal policy includes taxation, public works expenditures and related activities where these are employed or modified with a view to influencing economic activity. With the enlarged scale of treasury operations in the 20th century, fiscal policy assumed greatly increased importance.

In the division of functions between monetary and fiscal policy, monetary policy is often looked upon as the more effective in combating inflation, and fiscal policy as more effective in overcoming deflation. A major problem is that of integrating monetary policy with fiscal policy (including debt management). The two (or three, if debt management is considered separately) are to be regarded not as alternatives but as complementary. Complete independence of the central bank and the treasury is impracticable. The activities of the one inevitably involve those of the other; the problem of relationships between them is one of co-ordinating their activities.

The principal instruments of monetary policy may be classified into the two categories of general and selective controls. The general instruments of control in the U.S. include the discount rate, open-market operation and changes in reserve requirements (*see* FEDERAL RESERVE SYSTEM). The discount rate was usually looked upon as most important until the decade of the 1920s, and open-market operations as most important after that time. Instruments in this category are general in the sense that they are directed toward influencing the volume and use of money and credit without regard to any particular use or class of user. The selective instruments, on the other hand, are designed to control the use of money and credit in particular areas; *e.g.*, the stock market, installment sales, real estate and possibly inventories. While any of the instruments of monetary policy is presumed to alter the market compared with what it would be in the complete absence of control, the general instruments are less open to criticism on the grounds of interfering with the freedom of adjustments through the operation of market forces.

At one time, monetary policy was thought of primarily in terms of maintaining a fixed relationship between domestic currency and a given weight of gold, or, what amounts to the same thing, an approximately constant exchange value in terms of other currencies on the gold standard. After World War I, considerable interest was attached to the idea of maintaining stability in the value of money as measured in terms of some standard index number of prices. Later the goals of monetary policy assumed broader proportions: they came to be thought of in terms of price level stability, a high and stable level of economic activity and economic growth. Maintenance of relatively stable foreign exchange relationships is still a highly regarded consideration. In England some contribution to the economic development of other countries has also been mentioned as a policy objective.

The great difficulty lies in the fact that the various possible aims, each of which is likely to be desirable in itself, may come into conflict with one another. The authorities are certain to be confronted with the necessity of choosing among desirable goals. Considerable controversy has arisen at different times concerning the relative importance that should be attached to particular goals and the degree to which pursuit of one objective, *e.g.*, price stability, may involve the sacrifice of another, *e.g.*, full employment. The problem is basically that of the balance that should be effected among the various objectives, recognizing that the price of making progress in one direction may be to fall a little shorter in some other direction.

One of the unresolved questions is that of "rules v. authorities in monetary policy." It is argued on the one hand that the monetary authorities should have wide discretion in meeting problems as they arise, and on the other that an attempt should be made to lay down a framework of rules designed to produce the results desired while at the same time permitting individuals to act freely without the threat of unpredictable interference by the authorities. The issue is largely the historic one of government by men or government by laws. A solution turns partly on the possibility of central bankers' adapting themselves wisely to changing economic conditions, partly on the possibility of discovering a sufficiently definite and lasting framework of monetary rules.

A further question closely related to the preceding is that of secrecy or publicity in the conduct of monetary policy. It is not easy to determine how far central banks should go in indicating what their future policies will be. Is it better to establish certain rules and criteria indicating when monetary controls would be strengthened or relaxed, or would that tie the hands of the authorities unduly and perhaps commit them to actions that might prove undesirable under circumstances presently unforeseen? The issue of secrecy or publicity is not to be divorced from the nature of the policies that would be announced. Full knowledge of the exact nature of future policy is impossible, if only because it is certain to change with changing conditions. But this is not to deny the usefulness of indicating the general outlines of monetary policy for the guidance of central bankers, as well as the public.

The task of monetary policy, including the balancing of different and potentially conflicting objectives, has become more complex, but at the same time the means at the disposal of the monetary and fiscal authorities have become more numerous and, in total, more powerful. This fact gives rise to the problem already noted of effectively integrating monetary policy with fiscal policy. It also involves the problem of co-ordinating the various instruments of monetary control—the general controls with the selective and one general or selective measure with another. A satisfactory solution of the problems of integration and co-ordination would open the way, despite the greater difficulty of the task, to more comprehensive and effective monetary policy than was possible under former conditions.

**International Aspects of Money.**—The fact that different currencies are involved gives rise to special problems in connection with international monetary transactions. In general, however, the international role of money is mainly an extension of the place it occupies, and the functions it performs, within the country. Theoretical principles, also, are basically similar, though with the necessary elaboration and adaptation. Thus the quantity theory analysis is integrated with the discussion of the movement of specie reserves between countries, such movements traditionally being regarded as governing the quantity of circulating medium. And in terms of income-expenditure analysis, the emphasis placed on saving and investment has its counterpart in the attention devoted to the balance between international debits and credits.

The key to operations in current monetary claims abroad is found in the so-called balance of international payments, which is a statement showing for a specified period the payments to and from a particular country in its relations with other countries. In substance, it is to be viewed as an expression of the current supply and demand for foreign exchange between one country and the rest of the world. Actual transactions in such monetary claims are effected through various types of foreign exchange dealers. (*See* INTERNATIONAL PAYMENTS.)

Because of both the quantitative importance of trade in comparison with other foreign economic transactions and the responsiveness of trade to price considerations, price level adjustments occupy a strategic place in international monetary affairs. It is no less true that money and monetary policy may exercise an important influence internationally by way of interest rates in different countries, the movement of short-term and long-term capital, changes in levels of income and other economic developments. Moreover, domestic and international policies are integrally related. Experience after World Wars I and II clearly demonstrated that unless domestic budgets are brought under reasonable control there can be little hope of solving problems of the international balance of payments.

There are two principal methods of bringing the price level of

one country into adjustment with the levels in other countries. The method of the international gold standard is that prices should be subjected to pressures calculated to bring them in line, while exchange rates are allowed to remain approximately constant. The method of "free" inconvertible paper currencies is to bring about the adjustment by changes in exchange rates, while price levels are allowed to remain more or less stable. The gold standard method seeks to make price levels conform to established exchange rate relationships; the paper standard method seeks to make exchange rates conform to prevailing price levels.

Under the international gold standard, exchange rates were anchored to the mint par of exchange, *i.e.*, the ratio of the pure gold content of one monetary unit to the pure gold content of the other. Exchange rates could fluctuate on either side of the mint par by no more than the cost of transferring gold from the mint of one country (or similar place of redemption) to the mint of the other country. These limits are known as the gold shipping points. Whenever the exchange rate moved to one of the gold points, gold reserves would move from the country whose price level was too high to the country whose price level was too low. In addition to directly contributing to balancing international accounts, this movement of gold would tend to bring about a contraction of circulating medium in the country where prices were high and an expansion of circulating medium in the other country. This in turn would presumably bring their price levels into proper adjustment. Supplementary influences, as by way of changes in incomes and interest rates, were expected to facilitate the entire process.

Under a system of free paper currencies, exchange rates are regarded as being anchored to what is technically known as "purchasing power parity." This is a much less definite point than that which the gold standard provided; it represents a relationship that theoretically will equalize the purchasing power of the two currencies over goods, and can be calculated by comparing changes in price level indexes from some base year.

In actual practice, neither method of price level adjustment worked as perfectly as the description might suggest. The drain of gold reserves sometimes had an unsettling effect on public psychology and might even aggravate the existing disequilibrium in the balance of international payments by leading to hoarding or to flights of capital. In addition, countries losing or gaining reserves did not always adjust circulating medium in the manner that was expected of them. Likewise, under paper standard conditions, the foreign exchange value of paper currencies sometimes exhibited erratic fluctuations that, far from serving any useful purpose in effecting an orderly adjustment of supply and demand, might have just the opposite tendency.

The International Monetary fund (*q.v.*) was established at the end of World War II as an alternative to either a gold standard or a paper standard system. It undertook to promote exchange rate stability by facilitating the adjustment of minor fluctuations in the demand and supply of foreign exchange and to permit orderly changes in exchange rates when fundamental disequilibrium in international balances of payments arises. The bulk of foreign exchange transactions are handled through ordinary channels. Operations involving the fund are carried out between the fund on the one side and the treasuries, central banks or similar agencies of member countries on the other side. Member countries are allowed to draw on the fund to meet temporary shortages of foreign exchange, each member country having an assigned quota within which it must stay. Payments in and out of the fund because of short-run variations in the demand and supply of foreign exchange operate in substantially the same manner as the various exchange stabilization funds that have been set up at different times on a more local basis.

*See* also BANKING; BILL OF EXCHANGE; CENTRAL BANK; CHECK; CURRENCY; DOLLAR; GOLD STANDARD; INFLATION AND DEFLATION; MONEY MARKET; MONEY, MEDIEVAL; QUANTITY THEORY OF MONEY; TRADE CYCLE, etc. *See* also references under "Money" in the Index. (C. R. WY.)

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**MONEY, MEDIEVAL.** The Roman monetary system as reorganized by Constantine the Great included reduction of the weight of the gold coin *solidus* to $\frac{1}{72}$ of the Roman *libra* (pound). This system was inherited by the Byzantine empire and copied by the western barbaric rulers. For centuries after the reform the Byzantine *solidus* (also called *nomisma*, *bezant* or, later, *hyperperon*) continued to be struck regularly and remained the main medium of exchange in both international trade and domestic transactions involving large sums, enjoying an incomparable prestige throughout the Mediterranean area. Silver and copper coins continued to be used in local and petty trade. In the west the social and economic disturbances that followed the barbaric invasions progressively disrupted the monetary system inherited from Rome. The economy shifted toward a natural domestic economy where monetary units were increasingly used as units of account rather than means of payment.

The appearance of the Muslims in the Mediterranean did not immediately produce a change in the monetary situation. In the early period of their expansion they continued to use Byzantine and Persian coins. Caliph Abd-el-Malek established an independent Muslim bimetallic monetary system whose two basic units were the silver *dirham* and the gold *dinar* which broke the monopoly of the Byzantine *solidus* in the Mediterranean and even gained in prestige outside the Muslim border.

From this period there were three monetary areas: the Byzantine, the Muslim and the western European, which was in a state of general disorganization. An important step in restoring order to the monetary affairs of western Europe was a set of reforms launched by the Carolingians. In their final cast, these reforms consisted of the establishment of silver monometallism, the increase of the pound-weight from about 325 to about 410 grams and the adoption of a new monetary unit, called after the old Roman *denarius*. The latter was a silver penny, 240 of which were cut from a pound-weight of silver (one penny contained about 1.7 grams of silver). For roughly three centuries the penny remained the only official denomination coined by western mints. Since the Roman era prices and debts had usually been expressed in terms of *solidi* (shillings), which were still the unit of account at the time of the Carolingian reforms. In the final stage of these reforms it was determined that the *solidus* was to be equivalent to 12 of the new monetary units (pennies). The relationship, therefore, of 1 *libra* = 20 *solidi* = 240 *denari* emerged: these equivalents were to remain the basis of the European monetary system until the French Revolution. Of the three elements, only the penny was an actual coin when the reform was introduced; shilling referred to an old coin no longer in use; and the pound was simply a measure of weight. However, the use of only one denomination proved cumbersome and people began to use the equivalents 1:20:240 for reckoning.

From the 5th century, apart from a few unimportant exceptions, the west did not strike gold coins. The only gold pieces used in international trade were the Muslim *dinar* and the Byzantine *solidus*. Both gold coins displayed an extraordinary ability to remain intrinsically stable in their weight and fineness until the beginning of the 11th century; other coins did not display similar long-run stability. In a manner of speaking, in each of the two empires, Muslim and Byzantine, two monetary systems coexisted side by side, one of considerable stability, based on gold coins and used for international transactions; the other, unstable, based on silver and other metals.

The universal law that seems to make every unit of money lose its value with the passage of time worked throughout the Middle Ages. The progressive lowering of the value of currency took in practice the form of debasement, *i.e.*, reduction in either weight or fineness of coins or both. Debasement was particularly fre-

quent and intense in the case of silver coins, but it did not proceed at the same rate in the various countries: in some it was rather violent and considerable; in others mild and slow. The penny, which originally had been the same throughout Europe, eventually acquired different values in the various regions. The continuous and uneven debasement of the penny meant a reduction in the value of its abstract accounting multiples, shillings and pounds.

For many generations economists and historians interpreted currency debasement as a case of royal falsification of money, clipping or wearing of coins; however, a more complex set of factors must be sought to explain the secular debasement of currency. Among these are long-run increases in the demand for money in the face of relatively inelastic supplies of precious metals, pressures of entrepreneurial groups, deficits in the balance of payments and budgetary deficits.

With the long-term economic expansion in Europe a monetary system of virtually only one local denomination, itself plagued by constant debasement, was becoming increasingly unwieldy and impractical: a need for larger denominations arose. In the 12th century, Venice issued a coin worth 24 pennies; in 1252 Genoa and Florence coined a gold piece. The gold coins of Florence (*fiorino*) and Genoa (*genoino*) represented a piece of pure gold of the weight of 3.53 grams. The example was quickly taken up by other Italian and European states and from the middle of the 13th century to the end of the Middle Ages the *fiorino* and the Venetian *ducato* enjoyed the highest reputation: they became the international currencies *par excellence*. Throughout western Europe the emission of a coinage in gold became common and with it the monometallism inaugurated by the Carolingians was finally ended.

Generally speaking, the gold coins of Byzantium and the Muslim empire, and later the gold coins of western Europe, were used as international currencies. Every effort was made to maintain their fineness and weight, yet the fact that they remained generally stable while the silver pieces were progressively debased complicated the monetary structure of many countries. This created social conflicts and the problems of so-called internal exchange rate movements that represented one of the tangled aspects of monetary policy in the Middle Ages.

In order to evaluate the economic implications of secular debasement it should be stressed that debasement did not necessarily coincide with inflation. Throughout the Middle Ages the supply of silver and gold was quite inelastic, causing deflationary pressures that were partly offset by the debasements of silver coins. In point of fact, prices expressed in local currencies did not generally increase proportionately (reciprocally) to the debasement of the currencies themselves. Toward the end of the 15th century, discoveries of great silver deposits in Saxony, Bohemia and Tirol permitted an increase in the supply of big silver coins. In particular, the *testoni* and the *thaler* were introduced. *Testoni* were first struck in Milan and Venice; *thalers* in St. Joachimsthal in Bohemia in 1519.

Aside from metallic currency the monetary systems of the Middle Ages included bank money or circulating credit. Credit developed considerably after the 11th century, especially in the Italian trading centres; there, early developments in banking practices and the letter of exchange made credit an important monetary medium. Transfer banks (*banchi di scritta*) were in operation in the centres of international trade (Constantinople, Venice, Genoa, Florence and Bruges) to facilitate payments through transfer orders. Although the refinement of banking techniques made great progress, quantitatively the most important kind of credit involved delayed payments. This type of transaction allowed a more efficient use of the stock of metallic money and enjoyed a wide spread diffusion in the Middle Ages.

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**MONEY, QUANTITY THEORY OF:** *see* QUANTITY THEORY OF MONEY.

**MONEYLENDING.** Exacting a charge for borrowed goods or services was foreign to the mores of community life in primitive societies. Because loans were primarily to relieve distress, the accepted custom was to expect no more than repayment in kind. With the beginning of trade and commerce and the introduction of money, the practice grew of making a charge for a loan of money. This charge was originally called usury (*q.v.*). Ever since, protecting borrowers in necessitous circumstances against the avidity of lenders has been a constant concern of the state.

Among ancient non-Christian countries, a charge for loans was treated as a civil matter. Abuses by moneylenders were condemned as harmful to the temporal welfare of the state. In Hebraic and Christian dogma, usury became a matter of ecclesiastical concern. Taking advantage of the necessitous circumstances of a member of the same community was frowned upon and all usury on loans for consumption purposes was condemned and prohibited. The great moral influence of the Bible projected the scriptural injunction against usury through the centuries. Nevertheless, the growing need of commerce for money and credit in production forced a re-evaluation of the usury concept over the ages. The canon doctrine on usury gave way to secular laws that recognized situations in which the lender was legitimately entitled to a charge for a loan.

**Europe.**—By the end of the 15th century, statutory maximum rates began to appear. These distinguished between interest and usury. Interest is the charge for a loan of money permitted by law; usury is a charge in excess of the legal maximum. By the statute of Henry VIII, England in 1541 legalized the taking of interest at a rate of 10%. Within a few years this law was repealed by Edward VI but it was re-enacted several years later by Elizabeth I. The rate was reduced to 8% in 1624, to 6% in 1660 and to 5% in 1713. Setting a specific figure as a socially acceptable rate draws a quantitative line of demarcation between legal and illegal transactions. This numerical pattern was picked up by the American colonies where any rate of charge beyond a certain figure, which varied from colony to colony, was usurious and illegal.

Meanwhile an able line of thinkers, prominent among whom were Anne Robert Jacques Turgot of France (1775) and Jeremy Bentham of England (1787), attacked the basic idea of legal control over interest rates. By 1867 their teachings had led to the abandonment of all control over interest rates in England and in most of the countries of Europe. The states that succeeded the American colonies, with three or four exceptions, continued to impose a statutory maximum rate of interest. Exaction of more interest than such a maximum was a simple test of unfairness in a loan contract.

Repeal of the statutory maximum interest rate in England left unsolved the question of the fairness of the rate charged in particular transactions. Through innumerable cases of abuse and extortion, particularly in personal loans, the courts groped their way to a method of providing relief when the transaction was harsh or unconscionable. They finally found a qualitative rather than a quantitative way to do so by a decision in 1880 that established the power of chancery to reopen any interest transaction to relieve a borrower of excessive interest and in other ways to soften the terms of an offensive contract.

This power to recast an objectionable contract in the interest of equity was subsequently incorporated in the Money-Lenders act of 1900. As rewritten and amended in 1927, this act provides that a transaction shall, unless the contrary is proved, be deemed harsh and unconscionable if interest exceeds 48% a year. This figure is not a statutory maximum in the sense of U.S. laws, but merely a convenient guidepost. If satisfied that the rate charged, though not exceeding 48%, is excessive the court may at any time reopen the transaction and relieve an oppressed borrower from payment of any sum in excess of what the court considers reasonable. If the excess payment has already been made, the court may order a refund. On the other hand, the courts may find justified interest rates in excess of 48% and they have, on occasion, approved rates of 100% and more on loans.

Sources of consumer credit other than licensed moneylenders governed by the Money-Lenders act in England include unlicensed

lenders, check traders, pawnbrokers and the indirect types of financing known as credit sales and hire purchase. Unlicensed lenders deal with the poorest risks who cannot get credit elsewhere. Transactions are informal without a written contract. The lender may be a "hip pocket" operator without a specific address at which he carries on business. Rates are 100% per year and up. A common rate is 1s. for £1 for one week or until the borrower's next payday.

Check traders issue checks to approved persons. The checks are accepted in payment for goods purchased in designated stores, the check trader taking a discount from the merchant. This method of borrowing is popular among working people in the industrial areas. Check traders make weekly collections from customers.

Pawnbrokers in England have been in business for centuries. They trace their ancestry to the *montes pietatis* founded in the 15th century by the Franciscans to aid needy small borrowers who could turn to no other resource for help. Money was lent on pawns pledged as security and a small sum was demanded in return, payable each month, to meet administrative expenses. In the early years the average rate ranged from 1% to 5% a month. In some European countries the *montes* subsequently became state institutions. The English Pawnbroking act of 1872 allowed a charge of up to 25% a year on loans of £2 or less, and a rate of 20% a year on larger loans. A small ticket fee and a small valuation fee are also allowed.

Indirect financing is either through credit sales where title is passed immediately or through hire purchase where title is retained until hiring charges have been satisfactorily paid for a specified period of time. The British Hire Purchase acts of 1938 and 1954 were designed to give the maximum amount of protection to the small installment buyer. The 1957 Advertisements (Hire Purchase) act went a step further. It required prescribed information in advertisements of goods offered for sale under a hire purchase contract. The acts apply where the price does not exceed £1,000 in the case of livestock or £300 for any other goods.

Although installment trading in Great Britain goes back over a century, the system has enjoyed popularity with the masses only since World War I. It was helped by the development of hire purchase or finance companies. At first the banks stayed aloof from this development, but later they participated by buying into hire purchase companies. Finally, in 1958, British banks, for the first time, began to offer to depositors personal loans without security for any reasonable purpose in amounts from £50 to £500. The effective rate is about 10% with repayment monthly over a period of 6 to 24 months. The German banks followed similarly in 1959 with loans of 300 to 2,000 DM.

Special legislation regulates consumer cash loans and sales credit in Austria, Belgium, France, Sweden, Switzerland and the Federal Republic of Germany. After 1960 the U.S.S.R. and other Communist countries passed similar laws to regulate consumer sales credit.

**United States.**—General interest and usury statutes of the several states often authorize two rates of interest on loans: a legal rate that an obligation will bear in the absence of an agreement for a different rate; and a contract or maximum rate that may be charged by written agreement. In the second half of the 20th century, legal rates were as follows: 4% in North Dakota; 5% in Illinois, Iowa, Louisiana, Michigan and Wisconsin; 6% in 40 states; and 7% in California, Georgia, Nevada and Wyoming. Colorado, Maine, Massachusetts and New Hampshire had no maximum contract rates; Rhode Island had fixed 36% on loans of more than $50; 10 states had set the contract rate the same as the legal rate; and the remaining states allowed a contract rate which was from 1% to 6% above the legal rate.

Colorado, Maine, Massachusetts and New Hampshire prescribed no penalty for usury. In other states penalties for usury varied from forfeiture of interest or excessive interest to forfeiture of three times excessive interest or twice total interest, or made the loan void; or imposed a fine, imprisonment or both.

In Delaware, Maryland, Minnesota, Missouri, New Jersey, New Mexico, Ohio, New York, Pennsylvania, South Carolina, West Virginia and Wisconsin, corporations may not interpose the defense of usury but may defend or sue to rescind the contract if legality is negated by fraud, *ultra vires* acts (acts outside its objects) or impossibility of performance.

Commissions, brokerage or legal fees, which when bona fide are legitimate, are sometimes perverted by lenders to cloak spurious charges to evade statutory rates.

Usury statutes had been written with the businessman in mind rather than the consumer. As the United States became industrialized and workers concentrated in cities, granting credit to consumers changed from the informal accommodations of colonial days to legalistic written contracts payable in installments to conform with weekly and monthly pay envelopes.

By the beginning of the 20th century, changes in the economy had created an acute need for sources where workers could obtain small loans to meet emergencies in family life. Such loans could not be made profitably to workers at usury or contract rates; thus no legitimate capital was available for consumer use. When a consumer needs several hundred dollars to take care of an emergency or opportunity, relief rather than money cost is paramount. Such situations open the door to loan "sharks" who flout the law and charge exorbitant rates. Shocking abuses finally stirred the social conscience into devising various ways to meet the legitimate loan needs of workers.

Three different approaches were formulated into law within a period of three years. Each law permitted a rate higher than that allowed by the general interest and usury statute.

The credit union approach in 1909 is the co-operative one of members in a homogeneous group—such as employees in one company—contributing to a common pool from which loans are made to members in need. Overhead is low because space, time and effort are contributed by employer and employees; rates are generally 1% per month.

The loan and investment approach (Morris plan, 1910) follows the traditional bank method for business loans. The borrower contracts for a term loan at the statutory rate and agrees to make periodic deposits or buy an investment certificate on the installment plan. Deposits or the paid-up certificate are sufficient to liquidate the loan at maturity. The economic effect of the dual transaction is to double the contract rate and to make the effective rate 16% to 24% per annum.

The third approach is based on the economic principle that adequate capital in the hands of responsible businessmen can only be attracted if a rate is permitted that yields a reasonable profit over cost. This type of legislation in the several states follows a pattern formulated by the Russell Sage foundation in a model small loan law, which requires verification of fitness and character of the lender, licensing, supervision and annual reports; imposes severe penalties for infractions; sets a maximum loan; and permits a rate of 2% to 3.5% per month on the unpaid principal balance on the smallest loans and graduated lower rates of charge on the larger loans. Lenders are called small loan companies, licensed lenders or consumer finance companies.

An indirect type of financing developed through sales finance companies that buy, at a discount from dealers, notes given by consumers in connection with time-payment purchases, which they are unable or unwilling to pay in a lump sum. Effective rates in the early 1960s ran from 12% to 24%. In the late 1930s commercial banks also became heavily engaged in consumer credit, at effective rates of 7% to 14%. *See* also BANKING; INSTALLMENT CREDIT.

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**MONEY MARKET.** Every country that has a monetary system of its own has some kind of money market—a set of institutions or arrangements for handling what might be called the "wholesale" transactions in money and short-term credit. The need for these wholesaling facilities arises in much the same way that it does in the process of distributing any of the products of a diversified economy to their final users at the retail level. If

the retailer is to provide reasonably adequate service to his customers, he must have active contacts with others who specialize in making or handling bulk quantities of whatever is his stock-in-trade. The money market is made up of specialized facilities of this kind. It exists for the purpose of improving the ability of the retailers of financial services—commercial banks, savings institutions, investment houses, lending agencies and even governments—to do their job. It has little if any contact with the individuals or firms who maintain accounts with these various retailers, or purchase their securities, or borrow from them.

The elemental functions of a money market have to be performed in any kind of modern economy, even one that is largely planned or socialist, but the arrangements used in the socialist countries do not ordinarily take the form of a market. Money markets exist in countries that use market processes rather than planned allocations to distribute most of their primary resources among alternative uses. The general distinguishing feature of a money market is that it relies upon open competition among those who are bulk suppliers of funds at any particular time, and among those seeking bulk amounts, to work out the best practicable distribution of the existing total volume.

In carrying out a succession of transactions to "clear the market" from hour to hour and day to day, those with bulk supplies of funds, or demands for them, usually rely upon groups of intermediaries who act as brokers or dealers. The characteristics of these middlemen, the services they perform, and their relationship to other parts of the financial mechanism vary widely from country to country. In many countries there is no single meeting place where the middlemen get together; yet in most countries the contacts among all participants are sufficiently open and free to assure each supplier or user of funds that he will get, or pay, a price that fairly reflects all of the influences (including his own) that are currently affecting the whole supply and the whole demand. In nearly all cases, moreover, the unifying force of competition is reflected at any given moment in a common price (that is, rate of interest) for similar transactions. Continuous fluctuations in the money market rates of interest result from changes in the pressure of available supplies of funds upon the market, and in the pull of current demands upon the market.

*Commercial Banks.*—Commercial banks are at the centre of most money markets, both as suppliers and as users of funds; and in many markets a few large commercial banks serve also as middlemen. The banks have a unique place because it is their job to furnish an important part of the money supply. In some countries they do this through issuing their own notes that circulate as part of the hand-to-hand currency. More often, it is checking accounts at commercial banks that constitute the major part of the country's money supply. In either case, the outstanding supply of bank money is continually circulating, and any given bank may for a time have more funds coming in than going out; later, the outflow may be larger. It is through the facilities of the money market that these net excesses and shortages are redistributed, so that the banking system as a whole can at all times provide the means of payment required for carrying on each country's business.

In the course of issuing money the commercial banks also actually create it; but they are not at liberty to create all they wish whenever they wish. The total is limited by the volume of bank reserves in each country, and by the prevailing ratio between these reserves and the deposits in commercial banks—a ratio that is set by law, regulation or custom. The volume of reserves is controlled and varied by the central bank (such as the Bank of England, the Bank of France or the federal reserve system in the U.S.). The central bank is usually a governmental institution, and is always charged with governmental duties; but it almost invariably carries out a major part of its operations in the money market.

*Central Banks.*—The reserves of the commercial banks, which are continually being redistributed through the facilities of the money market, are in fact mainly deposit balances which these commercial banks have on the books of the central bank, or possibly notes issued by the central bank, which the commercial banks keep in their own vaults. As the central bank acquires additional assets, it pays for them by crediting depositors' accounts or by issuing its own notes; thus the potential volume of commercial bank reserves is enlarged. With more reserves, the commercial banks can make some additional loans or investments, paying for them by entering credits to depositors' accounts on their books. And in that way the money supply is increased. It may be reduced by reversing the sequence. The central bank can sell some of its marketable assets in the money market or in markets closely interrelated with the money market; payment will be made by drawing down some of the commercial bank reserve balances on its books; and with smaller reserves remaining, the commercial banks will have to sell or reduce some of their investments or their loans. That, in turn, results in a shrinkage of the outstanding money supply. Central bank operations of this kind are called open market operations.

The central bank may also increase bank reserves by making loans to the banks or to such intermediaries as discount houses, bill dealers or dealers in government securities. Reduction of these loans correspondingly reduces bank reserves. Although the mechanics of these lending procedures vary widely among countries, all have one feature in common: the central bank establishes an interest rate for such borrowing—the bank rate or discount rate—pivotally significant in the structure of money market rates.

Money market assets may range from the highest form of liquidity—deposits at the central bank—through bank deposits and various forms of short-term paper such as treasury bills, dealers' loans, bankers' acceptances, and commercial paper, and including government securities of longer maturity and other kinds of credit instruments eligible for advances or rediscount at the central bank. Although details vary among countries, the touchstone of any money market asset other than money itself is the closeness of its substitutability for money. So long as the institutions making use of a money market regard a particular type of credit instrument as a reasonably close substitute—that is, treat it as "liquid"—and so long as the central bank acquiesces in or approves this approach, the instrument is in practice a money market asset. Thus no single definition or list can apply to the money markets of all countries, nor will the list remain the same, through the years, in the money market of any given country.

*International Money Market.*—Each central bank usually holds some form of reserve that would be acceptable in settling flows of funds, on balance, from one country to another. International monetary reserves are mainly gold, or "money market assets" in some country whose currency is widely used, such as the United States dollar. The monetary laws of each country also provide for establishing some kind of parity between its own currency and the currencies of other countries. This parity may be defined in terms of gold, or in relation to one of the key currencies such as the British pound sterling or the United States dollar, both of which also have a fixed parity with gold. A country maintains the "convertibility" of its currency by standing ready to buy and sell gold or other currencies in exchange for its own, at prices within a fixed and rather narrow "spread" above and below the "exchange rate" for its own currency that is implied by the declared parity.

Because world trade continually gives rise to various needs for payment in various currencies, an international money market exists through which traders with an excess of one currency can use it to buy another currency for which they have a need. This trading in currencies is carried out, within the scope of existing convertibility arrangements, by skilled intermediaries, usually banks or specialized foreign exchange brokers and dealers. Trading in currencies is extensive both for immediate use ("spot") and for future ("forward") delivery. Quotations vary, with changes in supply and demand, over the range between the upper and lower buying and selling prices set by official parity. If no parity has been set the quotations may fluctuate widely. If a currency is subject to exchange controls, some of it may be more useful than the rest, so that there may be two or more quotations for different kinds of the same nominal currency.

The behaviour of the overall balance of payments of each country, as well as expectations at home and abroad concerning its future performance, have an important influence upon the longer-run usefulness or standing of a currency. For example, a sustained and substantial balance of payments deficit (outpayments larger

than inpayments) will result in continuous large increases in the world supply of its currency, possibly leading to some decline in its acceptability abroad and to a loss of international monetary reserves. At the same time, an outward drain may reduce the reserves of the commercial banks (the base for the domestic money supply), unless the central bank takes offsetting action.

Since 1944 most of the countries that have domestic money markets or that play a role in the international money market have been joined together in the International Monetary Fund (*q.v.*), which represents a pooling of part of the foreign exchange reserves (including gold) of more than 100 member countries. Drawings may be made on the pool by member countries to meet some of the reserve drains arising from balance of payments deficits, and in amounts related to the quota which each has subscribed.

The internal money markets of a surprisingly high proportion of the countries of the world are quite rudimentary. The work of the money market in these countries is done largely by transfers of deposit balances, government securities or foreign exchange among a few banks, and between them and the central bank. But in nearly all such cases there is genuine discontent with the rigidity of these limited facilities and a desire to develop a structure, as well as instruments and procedures, which would provide the open-market attributes of the arrangements that have evolved in the leading countries. Several of the more fully developed money markets are described below. (*See* also BANKING; CENTRAL BANK; COMMERCIAL PAPER; INTERNATIONAL PAYMENTS.)

**United States.**—The domestic money market in the United States carries out the largest volume of transactions of any such market in the world; its participants include the most heterogeneous group of financial and nonfinancial concerns to be found in any money market; it permits trading in an unusually wide variety of money substitutes; and it is less centralized geographically than the money market of any other country. While there has always been a clustering of money market activities in New York city, and much of the country's participation in the international money market centres there, a process of continuous change during the 20th century has produced a genuinely national money market.

This trend became pronounced with the establishment in 1914 of the federal reserve system as the nation's central bank. Before that time, major movements of funds were accomplished by transfers of deposits on the books of larger banks in a few money centres; settlement among them was made largely on the books of New York city banks; and they in turn effected settlements through purchasing or selling money market assets, including gold and foreign exchange. The principal instruments of short-term liquidity were loans to brokers or traders in the securities markets and commercial paper, the latter arising from underlying transactions that were considered self-liquidating in character. When the federal reserve system began operations, it "rediscounted" or made loans to banks on such paper, and set up criteria for identifying its eligibility. The federal reserve banks also bought and sold government securities in the market, and later traded in bankers' acceptances as well. By the mid-1920s the unifying influences among the regions had progressed so far that the individual federal reserve banks discontinued independent trading and delegated all such responsibility to the Federal Reserve bank of New York.

By 1935 the lessons of the great depression were incorporated in a basic revision of the banking laws. All gold had been withdrawn from internal circulation in 1933 and was henceforth held by the U.S. treasury for use only in settling net flows of international payments among governments or central banks; its price was raised to $35 per ounce; and the U.S. dollar became the key currency in an international gold bullion standard. Domestically, the changes included legislative recognition of the primary importance of unified open market operations by the federal reserve system; and delegation to the board of governors of the federal reserve system of authority to raise or lower within limits the ratios required between reserves and commercial bank deposits. Although about half of the 30,000 separate banks existing in the early 1920s had disappeared by the mid-1930s, the essential character of commercial banking in the U.S. remained that of a "unit" banking system, in contrast with most other countries which have a small number of large branch banking organizations.

The existence of a unit banking system has led inevitably to many striking differences between money market arrangements in the United States and those of other countries. Some smaller American banks, almost inevitably, find at times that the wholesale facilities of the money market cannot provide promptly the funds needed to meet unexpected reserve drains, as deposits move about the country from one bank to another. To provide transitional relief, pending a return flow of funds or more gradual disposal of other liquid assets in the money market, such banks have the privilege, if they are members of the federal reserve system, of borrowing for reasonable periods at their own federal reserve bank. Some large banks, which serve as depositaries for part of the liquid balances of many of the smaller ones (including those who are not members of the federal reserve system) find that the demands converging on them are at times much greater than expected. These large banks, too, can borrow temporarily at a federal reserve bank, if other money market facilities are not wholly adequate. Because these borrowing needs are unavoidably frequent in a vast unit banking system, and do not in most cases indicate poor management, the discount rate charged by the federal reserve banks on such borrowing is not ordinarily put at punitive or severe penalty levels—that is, unlike many other countries, the central bank does not always maintain its bank rate well above the rates of interest prevailing on marketable money market instruments. To avoid abuse, there is continuous surveillance of the borrowing banks by the federal reserve banks.

One of the facilities that has developed alongside this residual facility of borrowing at a federal reserve bank has been what is called the market for "federal funds." This specialized part of the money market provides for direct transfers of balances on the books of a federal reserve bank, in return for payment of a variable rate of interest called the "federal funds rate." These are immediately available funds. There are transactions, too, in funds that are on deposit at commercial banks—by means of loans between banks, or through loans by one large depositor to another. Because these must be collected through a clearing process, they are usually called "clearinghouse funds."

Transactions in these two kinds of money, federal funds and clearinghouse funds, are then further supplemented by transactions in which either kind of money is exchanged for some other liquid, money market instrument. The largest volume of these is in government securities, and the magnitude of the market for government securities became so great after World War II that it overshadowed all other elements of the money market. Trading in outstanding "governments" is virtually all done through dealers who buy and sell for their own account at prices which they quote on request (standing ready to "bid" for or to "offer" any outstanding issue). Most of them have head offices located in New York city but all are engaged in nationwide operations. Their transactions, and the lending arrangements through which these dealers finance the carrying of their own inventories of government securities, have evolved into a particularly sensitive indicator of the pressures of supply and demand upon the money market from day to day. The most common form of dealer financing is the repurchase agreement, through which dealers sell parts of their inventory temporarily, subject to repurchase.

Closely interrelated, often through trading operations conducted by the same dealers, are the much smaller markets for bankers' acceptances and commercial paper. Alongside these other markets, and actually somewhat larger in outstanding volume, are the markets for securities issued by various "agencies" created by federal statute such as the Federal Home Loan banks and Federal Land banks. Another money market instrument is the negotiable time certificate of deposit (CD), issued in large volume by commercial banks, which first became significant in 1962. While the owner of a time CD cannot withdraw the deposit before the maturity date initially agreed upon, he can sell it in the secondary market which is conducted by government securities dealers.

The federal reserve system conducts day-to-day operations in the money market on its own initiative in order to assist the smooth working of the nation's financial machinery, and to exert a gen-

eral influence aimed at fostering economic growth and limiting economic instability. Its transactions include substantial outright purchases or sales of government securities, relatively small purchases and run-offs of bankers' acceptances, and a considerable volume of loans made for a few days at a time to dealers in government securities or acceptances in the form of repurchase agreements. While it is still the commercial banks as a group which have the greatest continuing need for the combined facilities of the nationwide money market, there is also frequent and continuous participation by a great variety of institutional investors who channel the public's savings into various uses and who must always also make some provision for their own liquidity.

Perhaps the most unusual feature in the composition of the U.S. money market is the great importance attained by nonfinancial business concerns and local units of government since World War II. Corporate treasurers and the treasurers of many states and local political subdivisions and authorities have become so keenly sensitive to the profitable possibilities of managing their own liquid holdings, instead of relying on the commercial banks as most had done formerly, that this group provides at times nearly as large a part of the volatile financing needs of government securities dealers, for example, as comes from the banks. Moreover, banks outside New York city sometimes supply more of the financing needed by these dealers than do the traditional "money market banks" in New York city. The nationwide character of the money market is also shown by the participation of nearly 200 banks in the federal funds market—banks that are widely scattered among all federal reserve districts, although the bulk of all transactions is executed through facilities located in New York.

While the U.S. money market has become truly national, it still needs a final clearing centre upon which the net impact of changes in overall supply or demand can ultimately converge, and where the final balancing adjustments of the market as a whole can be accomplished. In filling that need, New York city continues to be the centre of the national money market. (*See* also FEDERAL RESERVE SYSTEM.) (R. V. Ro.)

**Great Britain.**—In Great Britain the money market consists of a number of closely linked markets and is concentrated in London. Of these markets, one that has grown rapidly in recent years is a market in which brokers arrange loans to local authorities (municipalities) for periods of time ranging from a few days to many years. But the two markets that are commonly regarded as the centre of the money market proper are those in call money and in bills. More than 100 banks operate actively in these markets; among them are the 11 clearing banks (which include the major commercial banks), the 6 Scottish banks, merchant banks, commonwealth banks and many foreign banks with London offices. At the centre are the 12 specialist banks called discount houses.

The discount houses trace their origins to the London bill-brokers. Very broadly, in the early 19th century Britain consisted of growing industrial and urban areas which were short of capital and agricultural areas with a surplus of savings. Firms in the industrial areas were able to borrow money by issuing commercial bills which went to the London market, through the hands of the bill-brokers, and finally to the banks in the agricultural areas. Thus the bill of exchange and the bill market allowed capital to flow more freely between surplus and deficit areas within Britain.

During the 19th century many bill-brokers began to hold bills themselves against borrowed money, instead of simply acting as intermediaries, and thus became discount houses. The inland bill described above declined during the 19th century; its place was largely taken for a time by the international bill, but it also declined relatively during the 20th century. During World Wars I and II there were great increases in the treasury bill issue and by the middle of the 20th century treasury bills formed the chief asset held by the discount houses. During the 1930s, however, there was a relative shortage of treasury bills and discount houses began to hold substantial amounts of short bonds. Under the pressure of these changes the bill-brokers almost entirely disappeared, some large discount houses were set up and many smaller ones amalgamated, bringing the total to 12.

All banks hold some liquid assets, which in London means cash, money at call and bills. The clearing banks hold a minimum of 28% of their total assets in the form of such liquid assets, while other banks hold much more variable proportions. Money at call is a very convenient liquid asset for them as it earns interest, which cash does not, and it is more liquid than bills. The discount houses deposit most of their bills and bonds as security with the various banks which have lent them money at call. This security, together with the right of the discount houses to borrow from the Bank of England, makes money lent at call to a discount house an absolutely safe asset for a lending bank.

The greater part of the day-to-day work of a discount house consists of operating in money at call. A bank such as Lloyds may expect its customers to make net payments by check to customers of other banks; Lloyds will have to meet these checks by cash in the clearing, and to maintain its cash reserve it will therefore call in some of its money at call when the managers of the various discount houses make their customary morning visits. When money is called, the discount house writes out a check for the amount and delivers it to the calling bank, receiving in exchange the parcel of bills or bonds which was the security for the loan. By midday, when calling ends, the 12 discount houses together may have written out checks for £100,000,000 or more. They have an equivalent amount of bills and bonds which were the security and the rest of the day's work consists of getting money into their accounts to meet these checks, chiefly by borrowing fresh money against this security, but also by selling bills.

Since the banks which have called in money have paid it to other banks, these banks should have an equivalent amount to relend to the discount houses in the afternoon. Thus the discount houses should be able to "balance their books"—borrow enough money to meet the money that has been called—without difficulty. There is one main reason why this is not always so. The British government accounts are kept at the Bank of England, which does not lend at call like the other banks. Thus net payments into or out of these government accounts will cause a net shortage or surplus of money for the discount houses in the afternoon and will cause money rates either to rise or fall. By dealing in treasury bills the Bank of England can offset or intensify such shortages or surpluses of money and can thus influence money rates. A shortage of money could prevent the discount houses from borrowing enough to meet all the checks drawn to meet calls. But they are safeguarded against this by their right to borrow from the Bank of England ("the lender of last resort") at bank rate.

The Bank of England's importance in this way to the discount houses helps to make bank rate the key short-term rate in the London money market. The main source of the profits earned by the discount houses is the margin between the rate of interest they pay upon the money they borrow at call and the interest they receive on the portfolio of bills and bonds which they hold. These rates are always below bank rate and to the extent that the discount houses have to borrow at bank rate, this profit margin is turned into a loss. It is the danger of having to incur this penalty that makes the discount houses bid up money rates when money is short and makes them willing to buy bills and bonds only at rates not too far below bank rate. Competition and willingness to switch maintains the structure of money, bill and bond rates, which is also influenced by some administered short rates, such as the deposit and advances rates of the clearing banks, which for historical reasons are linked directly to bank rate. Through their control of bank rate the Bank of England and the treasury can control the general level of these short rates; by making money short or plentiful for the discount houses they can affect the level of money and bill rates with a given level of bank rate.

The discount houses make the market in bills, quoting buying and selling rates for all sorts of commercial bills and selling rates for treasury bills. The treasury bills are issued weekly by tender (in effect, by auction) and the discount houses bid for all that are offered, chiefly at a rate agreed among themselves. At the tender they compete as a group (the "syndicate") with a large number of other buyers and on the average they buy about half the bills offered. Most other buyers do not expect to sell treasury bills, but the discount houses sell theirs on the average when about

a third of their 91-day life has passed. A large proportion of these bills is sold to the clearing banks which do not tender on their own account. The discount houses also play a considerable part in making the market in short bonds, often dealing actively and on a large scale.

The money market which centres upon the discount houses plays an important direct part in financing the government. It plays only a very small direct part in the commercial capital market, but a significant indirect role through making a market in call money in which banks, particularly the smaller ones, can employ funds and remain highly liquid. (*See* also BANK OF ENGLAND; MERCHANT BANKERS.) (R. F. G. A.)

**Canada.**—The Canadian money market was substantially broadened in 1955 with the introduction of day-to-day bank loans against Government of Canada treasury bills and other short-term government and government-guaranteed securities. Treasury bills of 91 days' and 182 days' maturity are issued weekly with the occasional offering of a longer maturity of up to one year. Government of Canada bonds and Government of Canada guaranteed bonds are issued at less regular intervals.

Groups involved in the money market are the following: the government, as the issuer of the securities; the Bank of Canada, acting as issuing agent for the government and as a large holder of market material; the chartered banks, as large holders and as distributors and potential buyers and sellers of bills and bonds at all times; the security dealers, as carriers of inventories and traders in such securities; and the public (mainly provincial and municipal governments and larger corporations), as short-term investors. The rate of interest on day-to-day loans is set competitively and larger loans are reported to an independent, anonymous intermediary.

Treasury bills are sold by competitive tender in which the Bank of Canada, the chartered banks and a small number of investment dealers participate. Bonds are normally issued at a price at which the yield is in line with outstanding comparable issues.

The central bank, through its tender at the weekly treasury bill sale, active manipulation of its own bill and bond portfolio, and regulation of the money supply, has workable instruments for active monetary control. For both banks and qualified dealers, the Bank of Canada acts as lender of last resort. The rate is set slightly above the average rate of the last treasury bill auction to discourage regular borrowing.

**France.**—The French money market is fairly well established but its size is restricted by the fact that in France currency still plays an important role in the money supply whereas by regulations the nonfinancial private sector of the economy is excluded from dealing in the market. Banks as well as a few public or semipublic agencies working in the financial sphere and intermediaries—brokers and discount houses—constitute the market. Transactions take place in commercial paper and in treasury bills. The monetary authorities maintain a special bookkeeping system for all the treasury bills held by banks and other financial institutions, under which such bills are not represented by actual certificates but by entries in special accounts administered by the Banque de France for the treasury.

The central bank's open-market operations have been limited to smoothing out the periodic disturbances in the flow of funds in the market. The bulk of its transactions, outright as well as under repurchase agreements, are in treasury bills issued with maturities of up to two years. The central bank's possibilities of influencing the monetary situation through the money market are limited to the large government needs for short-term funds, no market for long-term government borrowing being established.

**The Netherlands.**—The Dutch money market is located primarily in Amsterdam. After World War II, the total disruption of the financial mechanism in the Netherlands hampered the normal functioning of the money market, but with the country's financial recovery the market began to function again. An important difference from the prewar period is that short-term stock market credit transactions have declined considerably in importance, while commercial bills and bankers' acceptances have been replaced almostly entirely by treasury bills with maturities of up to one year and treasury notes with maturities of up to five years.

The main participants in the money market are the commercial banks, institutional investors and large corporations. In addition, 10 discount houses perform an important role in the market; these houses finance their holdings of marketable paper by call money and the most important of them are allowed to borrow from the Netherlands bank.

The Netherlands bank attempts to offset conditions of temporary ease and tightness in the money market through open-market operations; the bank is also empowered to change the over-all liquidity ratios which the banks have to maintain. In addition to this passive open-market policy the Netherlands bank at times conducts an active open-market policy through which the bank deliberately seeks to bring about an easing or tightening of the market because of general economic, capital-market, or balance of payments considerations. Co-operation between the Netherlands bank and the treasury, necessary for open-market policy to be successful, is very close.

**Federal Republic of Germany.**—In West Germany, where the money market developed strongly after World War II, transactions are to a large extent confined to interbank loans. In addition, insurance companies and other nonbank investors are also important lenders of short-term funds. Treasury bills and other short-term bills and notes from government agencies (railways and post) were gaining in importance by the 1960s, whereas in 1955 certain nonmarketable securities (the so-called equalization claims, created during the 1948 currency reform) held by the Bundesbank were transformed into short-term marketable securities in order to obtain suitable market material for the open-market operations of the Bundesbank. Banks are not used to deal in short-term government securities between each other. They generally either hold these securities to maturity or resell them to the central bank at its buying rates, so that a true money market has not developed.

The market for commercial paper is of some significance; dealings in this paper between banks take place from time to time, especially in times of tight market conditions. Comprehensive regulations have been given through the Bundesbank about the rediscountability of the several kinds of commercial paper.

The influence of the Bundesbank on the monetary situation through open-market operations by the 1960s was greatly hampered by the vast liquidity of the banking system as a consequence of the persistence of Germany's favourable balance of payments situation. (C. GL.)

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**MONEY ORDER,** the term used for an order on the issuer to pay a certain sum of money upon demand to the person named in the money order. Money orders are widely used for the safe, fast and convenient transmission of small sums of money. The buyer pays the issuer the amount of the money order plus a service charge, which is known in the United Kingdom as poundage. Money orders are a generally accepted means of payment because of the unquestionable ability of the issuer to exchange the money order for cash upon demand.

Money orders are issued by sovereign governments (usually postal authorities), banks and other qualified institutions. These issuers compete on the basis of service and convenience rather than in terms of the cost of their services. In the United Kingdom, postal authorities themselves first issued money orders in 1838. They are now of two kinds—postal orders, which may be used for payments from 1*d* to £2, and money orders for payments up to a maximum of £50. Approximately £200,000,000 ($560,000,000) were remitted each year by this means in the early 1960s.

In the United States the postal money order system was started in 1864 and modernized in 1911. The maximum amount of a single postal money order was set at $100. Annual sales of postal money orders in the early 1960s totaled about $6,000,000,000 each year.

The American Express company, which began issuing money orders in 1882, is the largest nonbank issuer of money orders. American Express money orders are used in most parts of the world. Telegraph companies also provide money order services.

*See* American Bankers Association, *Money Order Services* (1956).
(R. M. S.)

**MONGE, GASPARD** (1746–1818), French mathematician, the inventor of descriptive geometry, was born at Beaune on May 10, 1746. He was educated at the college of the Oratorians at Beaune and at their college at Lyons, where at 16 he was made a teacher of physics. Returning to Beaune for a vacation, he made a large-scale plan of the town, inventing the methods of observation and constructing the necessary instruments; the plan was presented to the town and preserved in the library. An officer of engineers who saw it wrote to recommend Monge to the commandant of the military school at Mézières. He was received as a draftsman and pupil in the practical school attached to that institution; the school itself was of too aristocratic a character to allow his admission to it.

His manual skill was duly appreciated: "I was a thousand times tempted," he said long afterward, "to tear up my drawings in disgust at the esteem in which they were held, as if I had been good for nothing better." An opportunity, however, presented itself when Monge was required to work out from data supplied to him the gun emplacement of a proposed fortress. At that time such an operation could be performed only by a long arithmetical process, but Monge, substituting for this a geometrical method, obtained the result so quickly that the commandant at first refused to receive it. Upon examination the value of the discovery was recognized and the method adopted. It was considered so valuable that it long was guarded as a military secret.

Continuing his researches, Monge arrived at that general method of the application of geometry to the arts of construction that later became known as descriptive geometry.

In 1768 Monge became professor of mathematics and in 1771 professor of physics at Mézières; in 1780 he was appointed to a chair of hydraulics at the Lyceum in Paris (held by him together with his appointments at Mézières) and was received as a member of the Académie; his intimate friendship with C. L. Berthollet began at this time. In 1783, quitting Mézières, he was, on the death of É. Bézout, appointed examiner of naval candidates.

Monge wrote various mathematical and physical papers. Among these may be noticed the memoir "Sur la théorie des déblais et des remblais" (1781), which, while giving a remarkably elegant investigation in regard to the problem of earthwork referred to in the title, establishes in connection with it his capital discovery of the curves of curvature of a surface. Monge's memoir gives the ordinary differential equation of the curves of curvature and establishes the general theory; the application to the particular case of the ellipsoid was first made by him in a later paper in 1795.

In 1792 Monge became minister of marine, but he remained so only until 1793. He accompanied Napoleon on the Egyptian expedition. When the committee of public safety made an appeal to the savants to assist in producing the *matériel* required for the defense of the republic, he applied himself wholly to these operations and distinguished himself by his indefatigable activity.

Monge took an active part in the measures for the establishment of the normal school (which existed only during the first four months of the year 1795) and of the École Polytechnique and was at each of them professor for descriptive geometry. His later mathematical papers were published (1794–1816) in the *Journal* and the *Correspondance* of the polytechnic school.

On the formation of the senate he was appointed a member of that body, with the title of count of Péluse. On the fall of Napoleon he was deprived, as a Bonapartist, of all his honours and excluded from the list of members of the reconstituted institute. He died at Paris on July 28, 1818.

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**MONGHYR,** a town and district located in the Bhagalpur division of Bihar, India. The town, 77 mi. E.S.E. of Patna, is on a firm right-bank loop of the Ganges formed by a suballuvial spurline projecting from the Kharagpur hills in the south. Pop. (1961) 89,768. The original town was focused on the riverside fort, which dates back before 1580, when it was repaired by Todar Mal, Akbar's general and governor. Inside the fort is the tomb of a saint, Shah Mushk Nafa, erected in 1497. The present town lies along the roads radiating from the fort largely between the river bank on the west and north and the Monghyr-Jamalpur railway on the east. There are two large tanks northeast of the fort. The suburban section on the south and east contains extensive rural enclaves. A steamer ferry service connects the town with north Bihar at Monghyr Ghat on the North Eastern railway. Monghyr was formerly famous for its manufactures of swords and firearms and is still noted for them. It has one of the largest cigarette factories of India.

Monghyr appears as Mudgagiri in a 9th-century inscription and was a strategic centre under the Muslim rulers and frequently the seat of local governors. Shah Shuja built himself a palace there and in 1761 Nawab Mir Kasim made it his capital.

MONGHYR DISTRICT, with an area of 3,975 sq.mi. and a population (1961) of 3,387,082, is administratively a district, but the Ganges river divides it physically into two unequal parts. The northern part, consisting of the Begusarai and Khagaria subdivisions, is 1,484 sq.mi.; the southern covers 2,491 sq.mi. The northern section, traversed by the Burhi Gandak and the Kosi, is a flat, closely cultivated country subject to inundations. There are many marshes, representing abandoned river channels, of which the largest is the Kabar Tal (7 sq.mi.). The principal crops are rice, maize (corn), wheat, grain, barley, oilseeds, millets, sugar cane and tobacco. The northern section is traversed by the main line of the North Eastern railway.

To the south of the Ganges, the Sadar subdivision is an alluvial plain, except for the residual, quartzitic and wooded Kharagpur hills rising to 1,607 ft. at Ambinath, but it is drier and has greater declination than north Monghyr and is provided with indigenous canal and tank irrigation. The rest of south Monghyr forms the wooded and hilly fringe of the Chota Nagpur uplands. At Jamalpur (57,039), 6 mi. from Monghyr, is the largest railway workshop of Bihar. Slate is quarried in the Kharagpur hills. The main line of the Eastern railway passes through the southern part.
(E. AH.)

**MONGKUT** (RAMA IV, also known as PHRA CHOM KLAO), king of Siam from 1851 to 1868 who opened his country to western influence and directed its development toward reform and modernization. During the quarter century before he became king, Mongkut was a Buddhist priest. He studied Latin, mathematics and astronomy and also learned about the English language, English literature, western science and liberal government. As king, he invited foreign teachers and advisers to Siam. With their help he undertook the reorganization of the army, the establishment of a civil service, reform of the law system, the construction of highways and canals, and the general improvement of the welfare of his people.

In foreign affairs he energetically encouraged the flow of western influence into Siam. In 1855 he negotiated with Sir John Bowring, the British ambassador, a treaty that defined the conditions of Siamese trade with all nations. The only bitterness that Mongkut experienced in his dealings with the west was occasioned in 1867 when the French forced him to cede a protectorate over his former vassal Cambodia. King Mongkut set the stage for the phenomenal progress that Siam made under his son and successor, King Chulalongkorn, or Rama V (1853–1910). (C. A. B.)

**MONGO,** a people who live in the equatorial forest, south of the main Congo river bend and north of the Kasai and Sankuru rivers in the Republic of the Congo. In the 1960s they numbered about 2,000,000 and included such tribes as the Bokote, Ekonda, Bolia, Sengele, Ntomba, Ndengese, Songo Meno, Mbole, Bongando, Boyela, Nkutu and the Tetela-Kusu, although this last group differs greatly from the others. They speak dialects of a common language, *lonkundo* or *lomongo*, and show strong cultural

resemblances. Many of the tribes are slowly disappearing through a falling birthrate.

The Mongo cultivate manioc and bananas but also rely much on food gathering, fishing and hunting. Material culture is generally simple although some hunting and fishing techniques are well developed. The patrilineal tribes are grouped in segmentary lineages often of very wide span, so that a whole tribe is comprehended in a single genealogy. Polygyny is widespread and results in matrilateral links. The lineage elders are invested with authority which derives partly from religious sources. As there is no other organization than the lineage, feuds, covenants between lineages and marriage payments are means of solving social maladjustments between lineages. The techniques used for this are often original solutions permitting interlineage co-operation. There exists among some of the southern tribes a true chieftainship, based on divine right.

Mongo religion lays strong emphasis on ancestor worship, beliefs in nature spirits responsible for fertility, magic, sorcery and witchcraft. Witch-finding cults are prominent and divination plays an important role in them. Mongo art is mainly oral and they have such epics as the highly esthetic *Lianja*, which relates the origin of the Mongo, but talking-drum literature and songs also show a rich artistic content. Dance and music, although little studied yet, are most sophisticated. *See* also, CONGO, DEMOCRATIC REPUBLIC OF THE: *The People;* AFRICA: *Ethnography* (*Anthropology*): *West Central Africa.*

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**MONGOL,** one of the chief ethnographic divisions of Asiatic or oriental peoples (*see* also TURKS OR TURKIC PEOPLES). In the 1960s the world population of Mongols was estimated at 2,500,000 to 3,000,000.

## AFFILIATIONS AND ORIGINS

**Ethnic Affiliation.**—Paralleling the usage of the words Caucasoid and Negroid, the term Mongoloid (*q.v.*) is used to refer to all ethnic types present in the so-called "yellow race," by which the Chinese, Japanese, Thai and others (*e.g.*, American Indians), as well as Mongols, are included. The Mongols proper belong to the classic or extreme Mongoloid type, with their stocky builds, short limbs, yellow to dark-brown skin colour, and dark hair (which is sparse on the face). They are short-headed (brachycephalic), with oval or round faces in which the high cheekbones and configuration of the eyes and nose create the impression of a flat setting. The axis of the eye is tilted, giving the characteristic Mongol slant, and eye colour ranges from black to brown. In the view of some scholars these physical features represent an adaption to cold climate. The degree of prognathism (jutting out of the jaw) is medium in comparison with other races. The Mongols are not tall, seldom exceeding a height of 5 ft. 6 in. All Mongols are genetically similar, although admixture is sometimes found with immediately adjacent Chinese, Tungusic or Turkic peoples (*see* CHINA: *The People;* TUNGUS).

**Homeland.**—The original homeland of the Mongols appears to have been the area between the Onon and Kerulen rivers southeast of Lake Baikal; also, on the courses of the upper Nonni and Argun rivers. Mongols today form the bulk of population in the Mongolian People's Republic, formerly called Outer Mongolia until the establishment of a Communist state there in the early 1920s (*see* MONGOLIA). About 18% of the population in the Inner Mongolian autonomous region of the Chinese People's Republic is Mongolian, and there are enclaves of Mongols in Sinkiang (Chinese Turkistan), Tsinghai, Tibet, Manchuria and Siberia (*qq.v.*). The Mongols in the Soviet Union are Buryats, who have their own autonomous republic on either side of Lake Baikal north of Mongolia proper (*see* BURYAT). There are also Kalmyk (*q.v.*) Mongols in an autonomous republic on the lower reaches of the Volga river in the U.S.S.R. All of these people speak Mongolian languages, which, although divergent, are clearly to be grouped in the same linguistic subdivision; many do not use the term Mongol as their national self-designation, but have separate ethnic names such as Dagur (*q.v.*), Buryat and others. The name Mongol, according to Mongolian folklore and legend, was bestowed on the people by Genghis Khan (*q.v.*) in the early 13th century. Mongol is also the source of the term Mogul (*q.v.*), coming from the name of the powerful Mongolian conquerors of India.

**Linguistic Affiliation.**—The Mongols form a major branch of the Altaic peoples, who take their name from the Altai mountain chain northwest of Mongolia (*see* ALTAIC PEOPLES). The central plateau of Mongolia has been inhabited by Altaic tribes for at least two millennia; from here and from the central Russian steppes many waves of Altaic (Turko-Mongolian) nomads swept out to lay waste to neighbouring kingdoms, and even to reach Europe itself in 1240 A.D. The existence of an Altaic linguistic family is postulated upon the basic similarity and demonstrable correspondence in vocabulary, grammatical forms and syntactic structure found in Mongolian, Turkic and Manchu-Tungusic languages. Although some researchers would explain these similarities in terms of cultural borrowings at different points in time, the resemblances are so far-reaching and varied (pervading all levels of the languages) as to make this a minority view. Less certain, however, is the postulated connection between the Uralic or Finno-Ugric-Samoyed group of languages (*see* FINNO-UGRIC LANGUAGES; SAMOYED) with the Altaic family, the so-called Ural-Altaic hypothesis, to which some would also add Korean and ultimately Japanese. Though there is clear evidence even of some specific correspondence, the notion that Mongols can be blanketed into a group that extends from Finland and Hungary to Korea and Japan is still to be viewed with caution. It is better termed Uralic-Altaic to indicate the co-ordinate status of each member, rather than Ural-Altaic, which would imply a proto-language from which both evolved (*see* URAL-ALTAIC LANGUAGES). Clearly the use of related languages does not imply racial homogeneity or similarity; although Altaic languages are spoken by genetically different tribes, ethnic correlations among those groups need not be inferred. Likewise, racial differences cannot deny the facts of Altaic linguistic affinity. (*See* also MONGOLIAN LANGUAGE.)

**Origins.**—The exact origins of the Mongols will probably never be known with precision, but they indubitably descend from one of the Altaic or Turko-Mongolian ethnic groups that ranged the Mongolian plateau and central Asian steppes in the millennium preceding Genghis Khan. Such early Chinese dynastic histories as the *Shih Chi* and *Han Shu* report invasions by non-Chinese tribes well before the Christian era. These accounts speak of cattle breeders who lived in felt tents, had no writing and reckoned time by the change of grass. Some of these peoples were surely direct ancestors of the Mongols, but the tantalizing information given in the laconic records is inadequate for precise identification. Chief among these early invaders were the Hsiung-nu (*q.v.*), a people apparently pre-Turkic in speech, to judge from a few words, names and titles preserved in Chinese transcription. Considerable scholarly effort has been expended to connect the Hsiung-nu, about whom little enough is known, with the Huns of almost equally obscure origin who ravaged Europe under Attila (*q.v.*) about seven centuries later, but the equation must be considered tentative. Next come the Hsien-pi who, according to Chinese sources, are related to the Hsiung-nu, but many investigators think they may have been proto-Mongols. Their successors, the Toba (Chinese T'o-pa, Turkic Tabgach), left several hundred names and titles that seem to be early Turkic in form. About A.D. 400 another nomadic group, the Juan-juan (*see* AVARS) achieved importance by threatening the Toba; existing evidence suggests they were Mongolian rather than Turkic. In later centuries still other Turkic groups are recorded, as the Uighurs and the T'u-chüeh (this name possibly being a Sinified form of *turk* plus a plural ending). About this time, too, came what is thought to be the first reference to the Mongols, the words *meng-ku* in the annals of the T'ang (*q.v.*) dynasty (618–907). The succeeding Liao dynasty of later centuries, the so-called Kara-Kitai (Khara Khitay), are thought by most to have been Mongolian in origin. The Liao fell to the Tungusic Jurchen (Chin dynasty) in about 1125, who in turn were replaced by the armies of Genghis Khan,

who conquered all of north China by 1227. His grandson Kublai Khan (*q.v.*) established the Yüan or Mongol dynasty in the 1260s and was the first person to unite north and south China under one rule. The Yüan held sway until 1368 when the last of the Genghis line, Togon Temür (Togan Timur), was driven out.

Thus during the first millennium of our era the central Asian steppes and the northwestern frontier of China evidently were the homeland of various nomadic groups of Altaic speakers (chiefly Turkic, but with sizable Mongol enclaves and some Tungusic forces). These warrior herdsmen made periodic incursions against the settled Chinese agriculturalists and, in the light of repeated devastations, the Chinese earlier built the Great Wall to protect their flank. Various Altaic peoples achieved political ascendancy over the north Chinese, but none succeeded in retaining supremacy for much more than 200 years. The confederations of those times were most often coalitions of different groups, so that the language of the rulers may have been different from that of the bulk of the population. Thus the leaders of a movement may have been Turks commanding a body of Mongols, or vice versa.

**Traditional Origins.**—Better knowledge of Mongol customs, history and lore begins with the rise of Genghis (more properly, Chinggis in Mongolian, but usually transcribed in English from the Persian spelling), a minor tribal leader probably born in 1155 or 1162. He succeeded in grouping about him the rather loosely confederated Turkic and Mongolian peoples, welded this agglomerate into a powerful striking force, and made the Mongol name one with which to reckon. Before Genghis there was no strong central organization, but a continual rise and fall of powerful leaders whose collective forces held territory of varying sizes, extending in the general area of modern Mongolia, Manchuria and the Russian central Asian steppes, with strong claims on Turkistan and the kingdoms north of Persia.

Much of the information about the Mongols and their near-conquest of medieval Europe came from Arabic and Persian historians, whose works were studied in Europe before native Mongolian historical chronicles became available. However, more reliable material is found in indigenous sources, particularly the earliest major document of Mongolian history, the *Secret History of the Mongols*. This remarkable work, often cited by its Chinese title, *Yüan-ch'ao Pi-shih*, was written about 1240 by someone in the royal household, and is a private history and genealogy of the ruling family. It takes much for granted and also ends abruptly, but gives a fairly detailed picture of Mongolian society at that time. It is preserved not in the cursive vertical Mongolian script but by a clumsy, yet ingenious transcription into Chinese characters used phonetically to convey Mongolian words. Accompanying it is a Chinese paraphrase, earlier known to the west. Since its true title is "The Origin of Genghis Khan," it sketches but briefly the traditional tale of the Mongol totems, the blue (*i.e.*, blue-gray) wolf (Börte Chinua) and the gray or fawn-coloured doe (Gooa Maral) who mated to produce the first Mongols. Later histories of the Mongols give a different picture of Mongol origin, because they are influenced by the impact of Buddhistic religious literature coming from India via Tibet. Thus such native histories as the *Altan Tobchi* (*c.* 1604) or Sagang Sechen's *Erdeniyin Tobchi* (1662) begin with the creation of the world from primordial elements, the sinning of the first humans and the origin of kingship among the Indians. They unite the Indian succession with the Tibetan line and tie this in turn into the Mongolian succession, in a manner reminiscent of medieval European noblemen who traced their ancestry back to Jesus, David or even Adam. The *Secret History*, however, has none of these later trappings, but presents a straight-forward narration. (*See* also Mongolian Literature.)

About 12 generations after the mating of Blue-Wolf and Gray-Doe is found Alan Gooa who, after the death of her husband Dobun Mergen, managed nevertheless to produce three children fathered (she alleged) by a beam of yellow light entering the rooftop smoke hole. Even her own two elder children could not believe that, but she made all five boys promise to remain united. The youngest (Bodonchar) took over a small nomadic tribe with the aid of his brothers and became their ruler. Eight generations later is found the name of Yesugei, a petty chieftain whose son was Temujin (the future Genghis Khan). Falling victim to poison through treachery, Yesugei died, leaving his widow to rear the boy as best she could; no easy task when his people elected not to follow her as leader, and Temujin was not old enough to help. After some narrow escapes from death at the hand of enemies who wanted to nip any future revenge in the bud, Temujin managed to build up a following, claimed the friendship of a powerful ruler (Wang Khan) and started up the ladder of success. At the height of his power he united all of the Mongols, and assumed the rank of khan (khagan) and the name Genghis in 1206. From there he went on to even greater attainments in eastern and central Asia.

For an exposition of the kingdoms of Genghis Khan's successors and their descendants, from Ogadai's ascension in 1229 to the fall of Togon Temür in 1368, and their subsequent history into the 20th century *see* Mongol Empires; Golden Horde.

## ETHNIC DIVISIONS

**Post-Yüan Dissensions.**—Mongolian world supremacy was not to be long-lasting, and the expulsion of Togon Temür was followed by an age of incessant internecine wars of Mongolian princes with each other and with the Oirat kingdom that gained prominence in the western regions of Mongolia after the Yüan collapse. The broad pattern that emerged was characterized by the opposition of eastern Mongols (Khalkha, Chahar and Ordos), to the western or Oirat Mongols. This enmity later provided the basis for Manchu control of the Mongols in the 17th century.

Separatist tendencies (which had existed even among Genghis' four sons) arose among the descendants of Genghis who were leaders of the central authority, and led to wars between them and the other powerful princes and lords. The need to maintain large garrisons severely strained the pastoral economy of the Mongolian regime. Thus plagued, Mongolia was frequently invaded by Chinese forces of the new Ming dynasty, which led to a loss of markets, decline of urban life, a general lowering of culture, and impoverishment.

The Mongolian princes passed their property to their sons through division. Repeated through generations, this process reduced principalities to a size no longer sufficient to support a ruling prince. Internal quarrels and power struggles led to the formation of new estates and the disruption of old ones, because the Mongolian khans (after their expulsion from China) could no longer match authority with force. Lesser princes usurped power as a result; from 1388 to 1400 there were five khans, no one of whom died a natural death.

**Rise and Fall of the Oirat.**—Beginning about 1400, there arose in Mongolia a period of rulership by two khans, an eastern (Khalkha) and a western (Oirat). The Oirat, composed of four tribes (dörben oyirad), the Choros, Khoshut, Dörbet and Torgut, were a western Mongol group of Turkistan, who first opposed the rule of Genghis Khan, but later united with him. The culmination of this east-west split was reached in 1434, when the Oirat leader Toghon slew Arugtai, the Khalkha leader. In spite of this, Toghon did not become ruler of all the Mongols. In 1439, Toghon's son, Esen Taiji, came to the throne and immediately set out to reunite Mongolia. The Chinese had allied themselves with the nominal Khalkha ruler, Togto Buqa, but were shown to be ineffectual when Esen captured the Ming emperor Ying-tsung in 1449. The unity attained by Esen was short-lived; he was slain in 1453 and Oirat-Khalkha wars began again, not to be concluded until the rule of Dayan Khan (1470–1543). Under Dayan Khan Mongolia was again united but far from tranquil since there were still many rebellions.

With the death of Dayan Khan a new series of wars began; Mongolia split into a northern Khalkha territory (ruled by Geresendze, Dayan's youngest son) and a southern territory (modern Inner Mongolia) of the Chahar and Ordos peoples (ruled by Dayan's elder sons). Geresendze divided the Khalkha land among his seven sons, surely contributing to later separatism. (Some of the present administrative divisions [aymags; *see* Aimak] of the Mongolian People's Republic correspond approxi-

mately to the lands held by these sons and their descendants.) In 1577, the Khalkha Tüshetü khan, Abatai, was victorious over the Oirat and installed his son Subagatai as khan. In 1586 the Oirat rebelled again and declared themselves independent. In the early 1600s, a Torgut prince led his people to the Volga river to escape depredations of a Dzungar prince. These Torgut were later followed by some other Oirat bands. A sizable Mongolian settlement grew up there, and became known as Kalmyk Mongols.

The Ming dynasty of China was succeeded by the Ch'ing or Manchu dynasty in the early 1600s. Although the Mongols of Inner and Outer Mongolia eventually accepted Manchu jurisdiction, the Oirat not only refused to ally themselves, but were sufficiently strong to attack the Manchu. The left wing (Dzungars) of the Oirat had already been the cause of the Torgut departure when they subdued the remaining Oirat. In 1640, a sort of mutual nonaggression pact had been concluded by Khalkhas and Oirats. This lasted until the great Oirat resurgence under the khan, Galdan Boshogtu, who sallied into Khalkha territory in 1688 so viciously that the Khalkha princes were driven to seek help elsewhere. After dickering with emissaries of the Russian tsar, the Khalkha turned to the Manchu then ruling China. In return for Khalkha allegiance and tribute, the Manchu were to put an end to the Oirat state. The K'ang Hsi emperor had established contacts with Europe through Jesuit priests who brought knowledge of cartography, mathematics and explosives. Faced with superior Manchu firepower, Galdan was defeated and took his own life in 1696. The Congress of Dolon Noor (1691) brought about a Manchu protectorate over Outer Mongolia. The Mongols stipulated that they would pay tribute, but declined to have Chinese governors, troops or settlers. These privileges gradually disappeared, and insurrections began again.

Although the Oirat seemed completely subdued, sporadic outbreaks of violence continued, both in the form of Oirat attacks on Khalkhas and in internal Oirat conflicts. These went on until 1755 when the Khoit leader, Amursana, who wanted to reestablish Oirat power, began a revolt. The final pacification of the Oirat regions (*e.g.*, the Kobdo district) came about by 1758 with the slaughter of an estimated 500,000 nomads, and centuries of Oirat war finally came to an end. As a result of such heavy loss of life, much of Chinese Turkistan was depopulated and in 1771 about 200,000 Torgut from the Volga region were persuaded to return to their homeland. The journey proved hazardous, and only about a tenth of them reached the Ili province. They were well-received as Chinese subjects and given land, cattle and provisions by the government. Considerable numbers of Oirat still live in the Sinkiang and Tsinghai regions of northwest China, where an estimated 100,000 speak Oirat dialects; another 50,000 speakers live in the western portions of the Mongolian People's Republic, where they have generally been subject to Khalkha dominance in recent years. In the period 1912 to 1923 a Russian Kalmyk called Ja Lama claimed to be a grandson of Amursana, or was utilizing a legend that Amursana would return to unite his people. He was partially successful in building a new western Mongolian kingdom until he was hunted out by Khalkha assassins, sent because he posed a threat to the new Mongolian state that was still wavering between China and Russia. The dialects spoken by Oirats are the Dörbet, Torgut, Bait, Dzakhachin, Mingat and Dambi-Olets.

**The Khalkha Mongols.**—At the beginning of the 1600s, the power of the Ming dynasty was waning under the increasing influence of the Manchu invaders. When Ligdan Khan (1604–1634) of the Inner Mongolian Chahars was defeated, the southern Mongolian region fell subject to Manchu overlordship, from which it did not emerge until 1911. With the subjection of the southern (Chahar and Ordos) Mongols to the Manchu, an important step in the divisinn of Mongol territory into Inner and Outer Mongolia was taken. Whereas under Dayan Khan northern (Outer) Mongolia and what is now Inner Mongolia were one, the northern territory became known as the Khalkha region, a confederation of three princedoms ruled by Geresendze. By mid-17th century one of the three major rulers, the Tüshetü khan, had become dominant in the confederation, aided by the fact that his son had become the first Jebtsun Damba Khutuktu, the supreme religious authority. As a result of the growing power of the Oirat leader Galdan in western Mongolia, the Jebtsun Damba Khutuktu and other Khalkha princes had to flee their territory when Galdan's armies overran them. Although making some overtures to the tsar the Khalkha concluded an alliance with the Manchu; in return the Manchu defeated Galdan. Since Khalkha territory was farther from the seat of Manchu power in Peking, it became known as Outer Mongolia; the closer inner regions were called Inner Mongolia.

The Manchu dominated Inner Mongolia more strongly than Outer Mongolia, since they did not take over the Khalkha territory (comprising the eastern two-thirds of the present Mongolian People's Republic) until 1691. This Manchu domination resulted in a delimitation of the territories of individual khans, neutralizing their power and reducing them to petty princes. There was little cause for discontent, since the social order remained unchanged. After the fall of the Manchu in 1911, the Outer Mongols claimed independence on the grounds that their allegiance had been to the Manchu, and not to the Chinese. The new government of China could hardly have been expected to recognize such a subterfuge, but to avoid bringing their boundaries up to those of Russia chose not to dispute this by force. The Russians likewise found it expedient to maintain Mongolia as a sort of buffer state. Thus the status of Outer Mongolia remained somewhat vague until the establishment there of the Mongolian People's Republic in 1921–22. The new government did not disrupt the ecclesiastical status of the theocratic ruler, the Jebtsun Damba Khutuktu, but when he died (of natural causes) in 1924, a decree was issued forbidding the search for his reincarnated successor, with the practical effect of removing the last obstacle to their progress.

The Khalkha today form the most populous and important group of Mongols; Khalkha speakers number about 700,000 or about 70% of the population of the only politically independent Mongolian state. (Since the formation of the Soviet-style government there in the early 1920s, the country has been a satellite of the U.S.S.R.) Their language is a sort of lingua franca understood by most other Mongols. There are two major dialects: the Khalkha proper and the Khotogoitu. Khalkha is now written in a modified Russian alphabet, the old vertical script having been abandoned in 1946, although it continues widely in private use.

**Inner Mongolia.**—Inner Mongolia is now considered to be the Inner Mongolian autonomous region of China. Mongols form a minority in the territory as a whole (although in certain districts they are numerous) and probably amount to less than 1,000,000. The Chahar Mongols live in Chahar province and in Shilin gool, the Urats live in the Ulan Tsab region, Kharchins in the Jostu region, Ordos Mongols in the Ordos country in the bend of the Yellow river. There are also Bargus in the Bargu district of Manchuria (now part of the Chinese People's Republic), and a divergent group, the Monguor, speaking an archaic dialect, in the Kansu province; also in the Manchurian province are the Dagur.

**Kalmyks.**—Those Torgut who left the Oirat country in the early 1600s to settle in Russia on the lower Volga became known as Kalmyk Mongols. As the westernmost branch of Mongols, they came into contact with various European investigators in the succeeding centuries and opened relations with the Russians. About 70,000 families migrated back to Turkistan in 1771 to take up residence there in the Ili province. The Mongols who remained behind continued as subjects of the tsar, and after the Russian Revolution in 1917 formed their own small autonomous republic there until World War II when they were accused of treason by collaborating with Nazi invaders. They then numbered about 130,000, and were divided into groups that spoke the Dörbet, Torgut and Buzawa dialects. Their republic was dissolved and the population reportedly dispersed to other parts of the U.S.S.R. In recent years, they have been "rehabilitated," and a new Kalmyk autonomous republic has been formed. Hundreds of Kalmyks reached the U.S. via Germany, some settling in Philadelphia, Pa., and in New Jersey where they have several small Lamaist temples.

**The Buryat.**—The Buryat were a forest people living around Lake Baikal who never came under the sway of Genghis Khan's

empire. When Russian colonists expanded into Siberia seeking trade and land, they encountered Buryats and defeated them in the mid-17th century. The Transbaikalian region was thus early incorporated into the tsarist empire. As a result of M. M. Speranski's protective minority legislation, the Buryat had the opportunity to continue their traditional culture, while acquiring a western (Russian) education that produced a new intellectual leadership. In the 1960s they number about 300,000 and live chiefly in their own autonomous republic on either side of Lake Baikal. Their language differs somewhat from Khalkha; among its chief dialects are the Aga, Khori, Barguzin, Ekhrit, Alar and Selenga.

## ANTHROPOLOGY

**Social Organization and Economy.**—This section concerns the Mongol inhabitants of the Mongolian People's Republic and of the Chinese People's Republic, and the other smaller Mongol groups in Siberia and Sinkiang. All Mongols are ethnically similar and culturally close; social structure, culture and language in many cases have shown very little change over many centuries.

The 15 aymags are the largest administrative divisions of the Mongolian People's Republic. The next division is the *hoshun* (banner), followed by the *sumun* or *somon* (arrow), a division of some dozens of households, perhaps equivalent to a county or township. The smallest unit is the *bag*, consisting of from 10 to 15 nomadic households that are jointly transhumant at times. The individual Mongol household consists of the parents with their children; they support themselves by herding their flocks of sheep, goats, cattle and horses, to which occasional camels, oxen or yaks are added. These animals are the basis of Mongol economy, and represent the principal investment of the household. Hides and skins provide clothing and tent walls; milk, cheese and butter form the bulk of daily diet, to which tea and some meat is added. On special occasions an animal will be slaughtered to provide meat for festivities. The oxen serve to carry such loads as the large collapsible tent (yurt) that is the primary form of dwelling. Horses are used for swift travel, and camels for commerce and transporting loads. The milk of mares is widely used to make a fermented drink (*see* KUMISS). Even the dried droppings of animals are important as fuel in a land with little wood; this dried dung burns with an acrid, pungent smoke that also serves to repel insects in the summer.

A completely sedentary agricultural life is barred by the Mongolian climate and topography, and by the nomadic temperament of the people, who consider the untrammeled life of the steppe to be the only kind worthwhile. When the animals exhaust grass at one spot the herds must move on. Nomadism actually takes place over a relatively restricted area, the distances over which any unit may range being strictly regulated. If everyone wandered at random, inequalities would result, and no area could long support families. To cross into another *hoshun*, for instance, would mean changing allegiance to another prince. In such dire emergencies as famine or drought people of one *sumun* may move to another, after securing approval of the elders.

The different transhumances (nomadic resettlements) depend on the season; in winter, mountain valleys are best, since there is shelter from wind and snow, and some grass may still be found under the snow. In spring, the only grass available is that which has survived the winter snow. Summer brings grass, but also a need for water (melted snow being used in winter); the pools of spring runoff may be dry by summer. In the fall, fuel and quarters must be readied for winter again.

Social organization among the Mongols reflects the essentially nomadic life; the bulk of the people are in the *arat* (free nomad) class. They owe allegiance to the *taiji* (nobles) and *noyan, wang* (khans or princes). After the death of Genghis Khan, his sons and descendants ruled appanages that were still further subdivided as time went on. Later, with the rise of Buddhism, secular power largely passed into the hands of a clergy ruled by theocratic reincarnations of former Buddhas and saints. Social status is thus a matter of hereditary rank and of wealth as measured in animals and Mongols keep little that cannot be moved. Even the yurt poles and felt sections are dismountable and can be fitted on one or two oxcarts, with all other possessions on a third.

**Religion.**—Although Genghis Khan prided himself on worshipping only the blue sky (*tengri*), while tolerantly permitting the exercise of all other faiths, the Mongols are traditionally shamanists and naturalistic animists. They worship spirits held present in such phenomena as mountains, forests, rocks and wind. As intercessor between these forces and man stands the shaman, a figure roughly equivalent to the medicine man or witch doctor. The shaman's function is to influence natural forces with primitive magic designed to alleviate illness, make trips propitious and weddings fortunate, as well as to attend births and deaths (*see* SHAMANISM).

Nestorian Christianity was known among some Mongols of the 13th century, but soon disappeared (*see* NESTORIANS). In the 1500s, Buddhism (*q.v.*) finally penetrated Mongolia after several earlier unsuccessful attempts to establish it as the state religion. This had a profound effect on Mongolian society. As a religion stressing improvement of the self by good actions to acquire merit and ultimate release from the cycle of rebirth (the attainment of Nirvana), its adoption considerably lessened the warlike nature of the Mongols and contributed to their domination by the Chinese. The Buddhism that found its way to Mongolia was the Mahayana branch as practised in Tibet. There a reformer named Tsong kha pa had founded the Yellow Hat (Gelugpa) order in the 14th century. Their idea was that salvation was best attained by a monastic existence in which one could avoid sin and practise good deeds. This led to institutionalism as the church expanded in size, function and power; most monasteries were headed by an abbot (an elaborate hierarchy soon grew up) usually considered a reincarnation of some former saint or Buddha. The idea of transmigration and reincarnation was greatly developed in this theology, and a cosmology arose embracing many Buddhas of past, present and future. Under influence of the Tibetan theocratic ruler, the dalai lama (*q.v.*, an incarnation of Avalokitesvara), the Mongols acquired their own reincarnated theocratic head in 1635: the Jebtsun Damba Khutuktu, a rebirth of the scholar Taranatha. Curiously, the Jebtsun Damba Khutuktu was the son of the major Khalkha prince, the Tüshetü khan; even stranger, successive reincarnations continued to be born in this family. The Manchu supported the Jebtsun Damba Khutuktu, who in turn encouraged Mongol dependency on China, with its resultant stagnation.

Inevitable friction between the existing shamanism and the new doctrines of Buddhism led to Lamaism, essentially shamanism overlaid with Buddhistic ritual and dogma. Lamaism centred in the monasteries, to which the eldest son in each family was usually dispatched to become a lama (priest). This practice was a severe economic drain since these men remained unmarried and unproductive. At the height of Lamaism, fully 25% or more of the able-bodied men were connected with the church. As is often the case in other religions, Mongols tend to follow external form and ritual in the hope of securing favour in this world or the next, and few show any real understanding of the philosophy underlying genuine Buddhism. Lower-grade lamas were largely restricted to the rote recitation of liturgical texts in the sacred language (Tibetan) and few understood much of what they read. Thus, although the shedding of blood is abhorrent to strict Buddhism, shamanistic sacrifices were carried out to the accompaniment of Buddhist prayers. As a result of modern political developments, Lamaism has lost its extensive holdings and manpower, and survives but furtively. The monasteries have been closed, their holdings confiscated, their staffs dispersed. Although a few old-time shamans (complete with such paraphernalia as bells, rattles, drums, mirrors, animal bones and wands) could be found in the 1920s and 1930s, it seems unlikely that any who are left bruit their presence about. The typical herdsman, however, no doubt holds fast to his beliefs in the greater efficacy of shamanist procedures for relief of distress, in spite of the fate of the practitioners.

**Culture and Customs.**—Mongol life is governed by the nature of the nomadic economy, itself a demonstration of geographic determinism. Life on the steppe is difficult, and requires systematic co-operation. Mongols tend to be a happy people, hos-

pitable to the traveler and stranger, and love the free life nomadism allows in spite of its rigours. The most popular amusements are archery, wrestling and horse racing, these three events composing an annual *naadam* (tournament). Chess (in which the moves are somewhat different from those in the west) is popular, too. There is a considerable epic literature relating the deeds of real and legendary heroes; ballads or lays are often as long as 10,000 verses. Other folklore includes tales from Buddhist (ultimately Sanskrit) sources, and from Chinese story collections. Formerly, bards and storytellers went about reciting the epics from memory. However, changing times and the pressures of modern life have contributed to the decline and disappearance of the bards, shamans and the once numerous lamas. In their place come the "Red Corner" reading rooms, modern movies (to replace the age-old pantomimic festivals of the *Tsam* and *Maidar*) and meetings of the Young Communist league.

**Modern Mongolia.**—The brief theocratic rule that succeeded the Manchu dynasty in the 1910s gave way to a Soviet-style state in the early 1920s in Outer Mongolia, and in Chinese Inner Mongolia with the advent of the Communists in 1948–49. In 1961 the Mongolian People's Republic achieved representation in the United Nations. Many new ways of life resulted from these political changes. The power of the clergy and nobles has been placed in the hands of elected representatives. A complete educational system has been created; hospitals and medical care replace shamanistic treatment. Roads and railroads have been built, and Ulan Bator, a city of 204,000 people (1963), is easily reached by air from Moscow. Although the economy is still based on livestock, herds are largely collectivized to plan production toward state-set goals. Winter shelters have been built which reduce the former heavy losses from inadequate food and severe weather. Yet many facets of life remain traditional and unchanged.

*See* also references under "Mongol" in the Index.

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**MONGOL EMPIRES.** This article deals with the growth of the empire of Genghis Khan (*q.v.*; d. A.D. 1227) and summarizes the history of China, central Asia, Iran and southern Russia under his descendants. It is organized according to the following outline:

I. Origin and Growth
II. Organization of Genghis Khan's Empire
III. The Period of Relative Unity (1227–60)
IV. The Mongol (Yüan) Dynasty in China (1279–1368)
V. Later History of the Mongols
VI. Genghis-khanid Empires in Central Asia
VII. The Il-khans in Iran
VIII. The Golden Horde

## I. ORIGIN AND GROWTH

The year 1206, when Temujin, son of Yesugei Ba'atur, was elected Genghis Khan of a federation of tribes on the banks of the Onon river, must be regarded as the beginning of the first Mongol empire. This federation not only consisted of Mongols in the proper sense, *i.e.*, Mongol-speaking tribes, but also included tribes of Turkish descent (*see* TURKS OR TURKIC PEOPLES). Before 1206 Genghis Khan was but one of the tribal leaders fighting for supremacy in the steppe regions south and southeast of Lake Baikal; his victories over the Kerait and then the Naiman Turks, however, gave him undisputed authority over the whole of what is now Mongolia. A series of campaigns, some of them carried out simultaneously, followed.

The first attack (1205–09) was directed against the Tangut kingdom of Hsi-Hsia, a northwestern border-state of China, and ended in a declaration of allegiance by the Hsi-Hsia king. A subsequent campaign was aimed at north China, which at that time was ruled by the Tungusic Chin dynasty. The fall of Peking in 1215 marked the loss of all the territory north of the Yellow (Hwang Ho) river to the Mongols; during the following years the Chin empire was reduced to the role of a buffer state between the Mongols in the north and the Chinese Sung empire in the south. Other campaigns were launched against central Asia. In 1218 the Khara-Khitai state in east Turkistan was absorbed into the empire. The assassination of Muslim subjects of Genghis Khan by the Khorezmians in Otrar led to a war with the sultanate of Khorezm (Khiva) in west Turkistan (1219–25). Bukhara, Samarkand and the capital Gurganj were taken and sacked by Mongol armies (1220–21). Advance troops (after crossing the Caucasus) even penetrated into southern Russia and raided cities in the Crimea (1223). The once-prosperous region of Khorezm suffered for centuries from the effects of the Mongol invasion which brought about not only the destruction of the prosperous towns but also the disintegration of the irrigation system on which agriculture in those parts depended. A similarly destructive campaign was launched against Hsi-Hsia in 1226–27 because the Hsi-Hsia king had refused to assist the Mongols in their expedition against Khorezm. The death of Genghis Khan during that campaign (1227) increased the vindictiveness of the Mongols. The Hsi-Hsia culture, a mixture of Chinese and Tibetan elements, with Buddhism as the state religion, was virtually annihilated.

In 1227 the Mongol dominions stretched over the vast regions between the Caspian and the China seas, bordering in the north on the sparsely populated forest belt of Siberia, and in the south on the Pamirs, on Tibet and on the central plains of China. This empire contained a multitude of different peoples, religions and civilizations, and it is only natural to seek the motivating force behind this unparalleled expansion. Certainly the traditional antagonism between pastoral, nomadic steppe-dwellers and settled agricultural civilizations has to be taken into account. Raids by nomads from the steppe had always occurred from time to time wherever powerful nomadic tribes lived in the proximity of settled populations but they had not usually taken on the dimensions of a bid for world hegemony or domination as in the case of Genghis Khan's invasions. The idea of a heavenly mission to rule the world was certainly present in Genghis Khan's own mind and in the minds of many of his successors, but this ideological imperialism had no foundation in nomadic society as such. It was most probably due to influences from China where the "one world, one ruler" ideology had a long tradition. The creation of nomad empires in the steppes and the attempts to extend their rule over the more civilized parts of central Asia and finally over the whole known world may also have been influenced by the desire to control the routes of intercontinental land trade. The looting instincts of a warlike population cannot be ignored and it was certainly not by accident that the first attacks by nomad federations were usually directed against those states which benefited from the control of trade routes in central Asia such as the famous "silk route."

**Military Practices.**—The amazing military achievements of the Mongols under Genghis Khan and his successors were due to superior strategy and tactics rather than to numerical strength. Cavalry was the chief arm of the Mongols, whose forces therefore possessed a high degree of mobility and speed. Their movements and maneuvers were directed by signals and a well-organized messenger service. In battle they relied mainly on bows and arrows and resorted to man-to-man fighting only after having disorganized the enemy's ranks. Mongol armaments and tactics were more suited to open plains and flat countries than to mountainous and wooded regions. For the siege of walled cities they frequently secured assistance from artisans and engineers of conquered countries with technically advanced civilizations (*e.g.*, Chinese, Persians, Arabs). Another factor contributing to the overwhelming success of their expeditions was the skilful use of spies and propaganda. Before attacking they usually asked for voluntary surrender and offered peace. If this was accepted, the population was spared. If, however, resistance had to be overcome, wholesale slaughter or at least enslavement invariably resulted, only those being spared whose special skills or abilities were considered useful.

In the case of voluntary surrender, tribesmen or soldiers were often incorporated into the Mongol forces and treated as federates. Personal loyalty of federate rulers to the Mongol khan played a great role, as normally no formal treaties were concluded. The "Mongol" armies, therefore, often consisted of only a minority of "real" Mongols. *See* also ARMY: *Medieval Armies.*

## II. ORGANIZATION OF GENGHIS KHAN'S EMPIRE

During the early stages of Mongol supremacy the empire established by Genghis had absorbed civilizations in which a strong, unified and well-organized state power had developed. The social organization of the Mongols was, however, characterized by pastoralism and a decentralized, patrilineal, tribal and clan system. Antagonism existed between a primitive society of this nature and the subjugated higher civilizations, between a relatively small number of foreign conquerors and a numerically strong conquered population. In the early phases of conquest the Mongols usually attempted to impose the social structure of the steppes upon their new subjects. It was customary for the Mongols to enslave a conquered tribe and to present whole communities to distinguished military leaders as a sort of personal appanage. These slaves became sooner or later an integral part of the conquering tribe. In the conquered areas a similar procedure was adopted. Groups of the settled population, usually those living in a certain territory, became the personal property of Mongol military leaders who exploited the local economic forces as they liked. No use was made of the existing state machinery or bureaucracy and the former political divisions were entirely disregarded. Nor was there any attempt to organize the numerous local Mongol leaders who enjoyed a high degree of independence from the court of the khans. Ruthless exploitation under strong military pressure was therefore characteristic of the early phase of Mongol domination, which may be said to have lasted until *c.* A.D. 1234.

The central power rested with the khan, who was assisted by military and political councilors. No departmental administration was, however, established during the early stages of Genghis Khan's empire. The highly hierarchized military organization of the Mongols had no political or administrative counterpart. The influence of the councilors, who were appointed by the khan regardless of their nationality, was nevertheless great. It was a former Chin subject, the Khitan Yeh-lü Ch'u-ts'ai (1190–1244), a man of high talents with an excellent Chinese education, who dissuaded Genghis from converting the whole of north China into pasture land. Other councilors were Uighurs, and for some time the Uighur language was as much used in the court chancery as Mongol. The Uighur script was also adopted for writing Mongol. The oldest known document in the Mongol language is a stone inscription of 1224/25.

The economy of the conquered areas was not properly organized during the period of conquest. The abolition of highly organized governments gave an opportunity for the exploitation of local production by the Mongol appanage-holders who relied to a great extent on non-Mongol tax-farmers. There was no single financial system for the whole empire or even for large parts of it. The absence of civil organization at the top, the great independence of the various appanages and the high priority accorded to military affairs had a strongly disintegrating effect and were, at least in the early phases of Mongol rule, detrimental to economic progress and prosperity. The Mongol empire was, under Genghis and his successors, not yet a state in the normal sense of the word but a vast agglomeration of widely different territories held together by military domination. As the empire grew through new conquests after Genghis' death, the same pattern repeated itself: a period of military, and at the same time decentralized, rule marked the first stage of Mongol domination. The result was a noticeable variation of practice within the empire: whereas the newly conquered areas were still subject to primitive exploitation bearing the imprint of a nomadic and military mentality, in those areas which had been subjugated earlier, attempts were made to build up a state machinery and bureaucracy in order to consolidate Mongol rule, mostly in accordance with the traditional administrative system of the individual territory.

This general tendency, together with the absence of an original Mongol concept for ruling a settled population, accounts for the entirely different development that occurred in various countries. It is, of course, in most cases for the individual historian to state from what time onward a Mongol empire was no longer "Mongol" but was a Chinese, Persian or central Asian empire with a Mongol dynasty, particularly because the absorptive power of the various civilizations differed in intensity. In China, for instance, the Mongols could maintain their rule better than elsewhere because the strong Chinese tradition of centralized state-power supplied a stable framework of governmental organization.

The original absence of a state-concept on the part of the Mongols is reflected in the ruling clan's attitude to the empire. The empire was not considered to be the khan's personal property, but to be the heirloom of the imperial clan as a whole. Already in Genghis' lifetime the empire was divided among his four favourite sons into *ulus*, a Mongol word which rather denotes the supremacy over a certain number of tribes than a clearly defined territory. Tului, the youngest (d. 1232), received the eastern part; *i.e.*, the original homeland of the Mongols together with the adjacent parts of north China. Ogadai became ruler of the western part of the steppes (the former territory of the conquered Naiman Turks); Chagatai (Jagatai) of the lands of Khara-Khitai in east Turkistan; whereas the eldest son Juchi (d. 1227), followed by his son Batu Khan (*q.v.*; reigned 1227–55), ruled over southwest Siberia and west Turkistan (the later Golden Horde, *q.v.*). To these four Mongol empires a fifth was added when Hulagu (*q.v.*), a son of Tului, completed the conquest of Iran, Iraq and Syria and became the founder of the so-called Il-khan dynasty in Iran. The unity of the Mongol empire was therefore from the beginning undermined by disintegrating factors, and the history of the empire after Genghis' death may consequently be subdivided into two periods, the first being characterized by relative unity in the empire ruled by a great khan who was recognized by all branches of the royal clan, the second showing a more or less complete independence of the separate empires, which thereafter had no common history.

## III. THE PERIOD OF RELATIVE UNITY (1227–60)

After the death of Genghis Khan a general assembly of Mongol nobles (*quriltai*) was convoked in order to elect the new great khan according to traditional custom. Although the law of primogeniture was usually observed by the Mongols, it was not the eldest surviving son Chagatai but the second son, Ogadai, who was eventually appointed great khan (1229–41). His residence was Karakorum on the Orhon river in central Mongolia whence he directed his campaigns. Yeh-lü Ch'u-ts'ai continued to act as his chief adviser; the Kerait, Chinkai, a Nestorian Christian, served as head of chancery. Ogadai himself is described in contemporary sources as a man of stern temper, energetic but given to pleasure, and a heavy drinker. His campaigns, like those of his father, were carried out simultaneously under generals acting independently in the field but always directed by orders emanating from the khan himself and transmitted by a messenger system covering practically the whole of Asia.

In east Asia a war was launched against the remnant of the Chin state of the Jurchen in north China. The Chin emperor found himself in a hopeless position because he was attacked from both sides: the national Chinese empire under the Sung dynasty, motivated by the wish to revenge themselves on the Jurchen who had, during the preceding century, taken north China from the Sung, had become an ally of the Mongols. In 1234 the Chin capital of K'ai-feng fell through a combined attack by Mongols and Chinese; the last Chin emperor Ning-kia-su committed suicide.

**Campaigns in the West.**—In 1236 new campaigns were launched against the west, apparently with the intention of subjugating Russia and even eastern Europe and adding them to the *ulus* allotted to Batu Khan. The empire of the Volga Bulgars was annihilated in 1237/38, a victory which opened the way to Russia proper. Central and northern Russia at this time consisted of city-states and independent princedoms which fell one by one to

the fierce attacks of the Mongol armies. The Mongol advance toward the Baltic sea was brought to a standstill only by the Russian winter; the rich trading centre of Novgorod was thus one of the few Russian towns not to be sacked. Resistance in Russia ceased after the fall of Kiev (Dec. 1240). Further raids hit Poland, Galicia and Volhynia; advance parties even reached Breslau (Wroclaw) in Silesia. A joint force of German and Polish knights under duke Henry II of Silesia suffered a crushing defeat near Legnica (April 9, 1241), but the Mongols preferred not to penetrate farther into central Germany; instead they turned south in order to join forces with their armies operating in Hungary.

The attack on Hungary did not come as a surprise to King Bela IV. The tribe of the Kumans, a Turkish nomad people in southern Russia, had been subject to Mongol rule but under their chieftain Kuten a great part of them had fled from the Don and Dnieper steppes into Hungary, and placed themselves under the protection of the Hungarians. Batu claimed that the Kumans were his vassals and asked the king of Hungary to send them back to Russia, announcing his intention to fight Hungary if his request was not granted. When he received no reply he sent his southern army against Hungary.

This army, led by Subutai, an able general, succeeded in defeating the Hungarians at Mohi in April 1241. King Bela IV was forced to flee into Croatia. It does not seem that the Mongols ever intended to establish themselves permanently in Silesia and Moravia; in Hungary, however, they began to create a nucleus of Mongol administration and even struck coins, some of which have survived. The Hungarian plains may have appealed to them as possible pasture lands because of their similarity to the grasslands of southern Russia where the Mongols installed themselves permanently (the later Golden Horde, *q.v.*).

During the preceding years Mongol armies had also been operating in Iran, Georgia and Greater Armenia. The Khorezm sultan, who had fled before Genghis Khan's attacks, had become ruler of a kingdom in northwestern Iran and tried in vain to defend himself against the Mongols. He was murdered in 1231. Georgia had to recognize Mongol sovereignty in 1236. The advance of the Mongols in Europe and the near east was, however, stopped by the death of the great khan Ogadai (Dec. 11, 1241). The necessity to be present at the *quriltai* which had to elect a successor and the necessity to assert their claims made some of the descendants of Genghis change their plans. Batu and his generals gave up whatever territory they had held in eastern Europe. The year 1241 therefore marks a turning point of the greatest importance in European history because in all probability Hungary at least would have become a Mongol dominion but for the sudden death of Ogadai.

**Electing a New Khan.**—The election of a new great khan proved difficult because no agreement could be reached. In the meantime Töregene, Ogadai's widow, ruled by common consent of the Mongol nobles (1242–46). She wished the appointment of her son Güyük but met with bitter opposition from Batu who believed he had a better claim, as a descendant of Genghis' eldest son. She succeeded in securing Güyük's election in 1246. There is an eye-witness account of this election by Joannes de Plano Carpini, who happened to be in Karakorum at that time as papal envoy. Güyük himself was, as a person, very different from his rival Batu. He was strongly influenced by Nestorianism and favoured Christian advisers, whereas Batu still adhered to traditional Mongol Shamanism (*q.v.*) and was entirely indifferent to any higher religion. The two rivals began to prepare for war against each other, but Güyük's premature death (1248) ended at the same time the family feud with Batu and the chance of a Mongol court dominated by Christian influence. The empire was entrusted to Güyük's widow Oghul Khaimish, who ruled as regent for three years before the nobles could reach agreement. Batu himself in the beginning still showed some eagerness to assume the supreme power of great khan but gave up in the end because of old age and persuaded the Mongol nobles to give their votes to Mangu (Mongke) Khan, son of Tului. This meant that the overlordship of the empire passed away from the house of Ogadai and went to the descendants of Genghis' youngest son. The Chagatai branch of the family felt slighted after Mangu's election (1251), and bitter hostility soon developed between the two families.

**Reign of Mangu.**—Mangu himself had won fame during Batu's western campaigns and distinguished himself in the field. He was a benevolent monarch and continued Güyük's policy of universal tolerance toward all religions. In his reign the capital Karakorum reached a splendour which reflected the vastness of the empire. A European guest at the court in Jan. 1254, the Dutch friar William of Rubruquis, has left an interesting account of the Mongol capital, where Christian churches, Muslim mosques and Buddhist temples flourished and envoys from the whole known world met. At the same time Mangu continued to expand the empire and prepared for the conquest of hitherto unsubdued neighbouring countries. In this he was assisted by his two brothers Hulagu (*q.v.*) and Kublai. To Hulagu he entrusted the campaign against Iran of which only a northern province had come firmly under Mongol control. In 1255 Hulagu started on his campaign. He wiped out the resistance of the powerful Assassin (*q.v.*) sect in 1256 and advanced toward Iraq where Baghdad, the capital of the caliphate (*q.v.*), fell to the Mongols in 1258 and the last Abbasid caliph was put to death. These events had a far-reaching influence on the religious situation in the near east. Christians and Shi'ites welcomed the Mongols because they had been antagonized by the Sunnite orthodoxy of the caliphate. In other countries such as Syria, Palestine and Asia Minor the Christians hoped for a further advance by Hulagu, who was regarded as a protector against their Islamic rulers and whose wife was a Nestorian Christian. In 1259 Hulagu's armies moved into Syria, took Damascus and Aleppo and reached the shores of the Mediterranean sea. The road to Egypt seemed open but in 1260 the Mameluke army inflicted a crushing defeat on the Mongols. Egypt was saved and the further expansion of the Mongol empire was blocked.

**Election of Kublai.**—At the other end of Asia a campaign with similar success took place against China. The leader was Kublai, whose generals outflanked the Chinese defenses by moving toward Annam via the southwest of China which was occupied by the independent Tai kingdom of Nan-chao. Later on Mangu himself took command of the China campaign (1257). But again, as in 1241, fate intervened and brought Mongol operations to a temporary standstill. Mangu died in Aug. 1259 in the field during the siege of a provincial town in Szechwan. There followed, as usual, an internal feud between various claimants to the title of great khan. Kublai secured his own election while still in the field (1260), but his younger brother Arik Böge proclaimed himself khan in Karakorum. Hulagu was too far away and moreover too immersed in his Syrian campaign to exert any influence over the election. He seems, however, to have favoured Kublai's election, and these two brothers at least remained friendly although (or because) Kublai's dominion was so distant and his overlordship therefore more or less nominal.

The year of Kublai's accession to the throne marks, in any case, a turning point in the history of the Mongol empires. In theory Kublai was, as grand khan, the ruler of an empire stretching from China and Korea to Iran and southern Russia, but the diversity of the subjugated countries made itself more and more felt. Kublai came to regard himself as a Chinese emperor more than anything else, and similarly the other dominions developed on lines which were less and less Mongol, a tendency which may be regarded as concomitant with the conversion of the various khans to other religions, chiefly Islam and Buddhism. In Kublai's case this conversion from Mongol to Chinese civilization was accentuated by the transfer of his capital to Peking (1260) which he began to rebuild in 1267. Mongolia was no longer the real centre of the empire, not even of Kublai's dominions.

## IV. THE MONGOL (YUAN) DYNASTY IN CHINA (1279–1368)

Kublai Khan (*q.v.*) was one of the greatest emperors that China ever had. He achieved the unification of that country by annihilating the national Sung empire (1279). Contrary to former custom he treated the deposed imperial family well and also for-

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THE MONGOL EMPIRE AS IT APPEARED AROUND 1300

bade his generals to resort to indiscriminate slaughter. After 1279 no new territories were added to the Mongol-Chinese empire, and several attempts to expand Mongol rule overseas failed. The political history of China under the successors of Kublai is soon told. None of them reached the stature of Kublai. His immediate successor was his grandson Timur (Chinese name, Ch'eng-tsung, 1295–1307), who was able to maintain Mongol rule intact and maintained his position against repeated attacks from the Ogadai branch of the Genghis-khanid family. The pretender Qaidu was defeated in 1301 and peace was restored in the northwestern parts of the empire. Although minor rebellions against the government could be still quelled by Mongol troops, the power of the court gradually began to decline. Family feuds and court intrigues weakened the power of later emperors. In several cases boys were enthroned who were nothing but puppets in the hands of ambitious ministers. The growing degeneracy of the emperors is almost clinically reflected in their surviving portraits. The influence of Chinese culture made itself more and more felt at court and among some of the Mongol nobility, although other Mongols remained hostile to everything Chinese. The last Mongol emperor, Togon Temur (reigned 1333–68), had become emperor at the age of 13. He had received the rudiments of a Chinese education and was, like some of his predecessors, a pious Buddhist and a benevolent though weak ruler. During the first years of his reign, however, power was in the hands of a minister Bayan, who belonged to the anti-Chinese faction and whose measures deepened the resentment of the educated Chinese against Mongol rule.

**Decline of Mongol Power in China.**—The final decline of Mongol power in China and the chaotic conditions during Togon Temur's reign were but one of the many "times of trouble" in Chinese history. There was widespread unrest which often took the form of local rebellions against the Mongol authorities. The reasons for this development were chiefly economic, and it was, as usual in China, in the countryside that insurgents first ventured their attacks on the local administration. The situation of the peasantry was in many areas desperate; small farmers and tenants had to shoulder the burden of excessive taxation and *corvée* duties. The arbitrariness of Mongol nobles and officials caused general resentment among all Chinese. It appears that the Mongol ruling class was never able to establish satisfactory relations with the agricultural population of China. Their lack of sympathy for agricultural problems was also reflected in the Mongol legislation on hunting: the peasants were forbidden to protect their crops against game animals and had moreover to assist the Mongols in hunting expeditions which invariably caused great damage in the fields. In the big towns, relations between Mongols and Chinese were usually better than in the countryside. Conditions became particularly strained in 1351 when the government proceeded to carry out an enormous plan for water conservation in the Yellow river region, which had been suffering from catastrophic floods. The leaders of local rebellions came without exception from the lower strata of society. They included salt-smugglers, petty officials, sectarian leaders, monks and shamans. In the southeastern provinces, agriculturally the richest and therefore most ruthlessly exploited region of the whole empire, rebellions were particularly numerous. The province of Chekiang had for centuries been the greatest rice surplus area and the capital Peking with its big population had always been dependent on supplies from this region. When the lines of communication between north and south were cut by rebellions, the situation in the capital became precarious. The paper money on which the currency was based became entirely valueless and the treasury was soon depleted. This again impaired the military efforts of the government.

It is a remarkable feature of the history of these years that at first the various rebellions, occurring independently of each other, were not motivated by nationalist feeling among the oppressed peasants, but were directed against the upper classes, regardless of their nationality. Contemporary sources provide abundant evidence that the Chinese gentry had as much to fear from the insurgents as had the Mongols. This explains why so many Chinese continued to assist the government. They apparently preferred the harsh rule of the foreigners to the murderous, anarchist, popular movements of their compatriots who committed atrocities which for a number of years proved a great obstacle to a more widespread rebellion. Gradually, however, more and more educated Chinese were won over to the cause of the rebels, who in their turn learned from them how to tackle the problems of administration and warfare. The most successful rebel leader was a former monk Chu Yüan-chang (Hung Wu [*q.v.*]; 1328–98). Born of a family of poor peasants, he showed more energy, patience and military talent than his rivals. He succeeded not only in establishing himself firmly in the key economic areas but also in eliminating his rivals in the struggle for power. He finally drove the Mongols out of Peking (1368) and made himself emperor of a new dynasty, the Ming dynasty. Assisted by able generals, he had extended his rule over the whole of northern China by 1369, but Mongol provincial commanders in the southwest continued their resistance so that Ming power was not established there until much later (Szechwan, 1371; Yünnan, 1382). The last Mongol emperor, Togon Temür (Togan Timur), fled into the steppes and died there in 1370.

Thus ended more than a century of Mongol rule over China. The Mongols' defeat cannot, however, be attributed to degeneracy or corruption by the mollifying influences of life in a highly civilized Chinese atmosphere. Subsequent events showed that the Mongols had lost nothing of their military vigour and they remained a menace to the northwest Chinese frontier. A realization

of this potential danger possibly made Chu Yüan-chang at first establish his capital not in Peking, which was more or less a frontier town, but in the heart of China, in Nanking, where he had set up his residence already in 1364. Chu's rise to imperial power and the re-establishment of Chinese rule led to the elimination of political and economic activity not only among the Mongols but also among the many non-Mongol foreigners who had held office or made fortunes as merchants under the Mongols. Those foreigners who chose to stay in China changed their family names and gradually became assimilated. Foreign religions such as Islam and Christianity lost their privileges. Christianity was in fact completely wiped out as a consequence of the strong nationalist feelings of the Chinese.

**Effects of Mongol Rule.**—The general impact of Mongol domination over China is difficult to assess. The suspension of literary examinations, the exclusion of Chinese from higher offices and the resulting frustration of the former ruling class of scholar-officials led to a sort of intellectual eremitism. Traditional forms of Chinese literature and art continued to be practised by a class which was barred from participation in political affairs. The only branches of the civil service where the co-operation of educated Chinese was absolutely indispensable had been those concerned with ritual and historiography. The Mongol language never wholly replaced Chinese as the medium for historiography or for official documents, and most of the inscriptions surviving from the Mongol period are bilingual. Chinese literary life remained remarkably free, perhaps because the ruling minority was indifferent to, or even unable to read, what their subjects wrote in Chinese. It is surprising to see how freely Chinese writers after 1280 expressed their national, loyalist and anti-Mongol feelings. The period of Mongol rule over China is, in the field of literature, also marked by a considerable output of drama and of popular novels, written in the vernacular. This phenomenon is, however, not directly connected with Mongol rule, for it is difficult to visualize a Mongol audience in front of a Chinese stage. A social cause, the growing influence and prominence of the merchant class, may have been instrumental. The traders and merchants were among the very few groups in the population who actually benefited from Mongol rule. Another such group comprised the priests of non-Chinese religions (Islam, Christianity, Judaism) who enjoyed the exemption from taxes which was customary in China for the Buddhist and, to a lesser extent, the Taoist clergy. The Mongols themselves, at least at court, gave up their primitive forms of worship and became to a great extent converts to Tibetan (Lamaist) Buddhism which was already flourishing in China under Kublai Khan. The growing influence of Tibetan Buddhism can be seen in the increasing number of Mongols who were given Buddhist names derived from Tibetan. Chinese Buddhism, on the other hand, remained on the whole hostile toward the Lamaist clergy, who were despised not only for their exotic, semibarbaric creed but also for being a favourite ally of the invaders. Furthermore, many Chinese Buddhist monasteries were strongholds of Chinese traditional culture. The same is true of Taoism. Although the Taoist clergy had originally been granted the same privileges as the Buddhists, the Taoist religion had already under Kublai begun to suffer from official persecution, chiefly perhaps because the Lamaist clergy regarded Taoism as a dangerous rival and because Taoist sects and monasteries were, not without justification, looked on as centres of secret activities and unbridled nationalism. All things considered, it may safely be said that Chinese civilization as a whole was influenced surprisingly little by Mongol rule. It was, however, responsible for a certain barbarization, a deviation from accepted standards of ethical behaviour as far as the law and government were concerned. The autocratic and totalitarian features of China under the Ming dynasty are perhaps to be attributed to the fact that the country had been under barbarian rule for more than a century.

The Mongols themselves, taken as a group, remained aloof from Chinese culture although some of them, including a few central Asians, became good Chinese scholars and produced poems or calligraphy like native Chinese. The later emperors, after some initial efforts under Kublai, encouraged translations from Chinese into Mongol, and the earliest specimens of printing in Mongol were produced in China. Most of these translations are now lost as a consequence of Ming nationalism, but the few existing fragments, mostly Buddhist texts, are of the highest importance for the history of the Mongol language. The Mongols were expelled from China in or soon after 1368. For the next two centuries they lived in Mongolia just as they had before their conquests: a warlike nomad people with only a few traces of their long sojourn among the Chinese.

## V. LATER HISTORY OF THE MONGOLS

For several centuries after 1368 the Mongols were confined to their original homeland in the steppes, but the memory of their past grandeur and of their domination over China led to intermittent attempts to regain their lost position. The Ming emperors on the other hand regarded the Mongols as their subjects and Mongolia as a part of their empire. The history of the Mongols in these years is, apart from the usual feuds between rival tribes and clans, dominated by their relations with China. The early Ming emperors tried repeatedly, but without lasting success, to occupy the plains of Mongolia. In 1388 Toquz Temür, grandson of Togon Temür, was defeated by a Chinese expeditionary force in northeastern Mongolia near Lake Bor. A generation later, in 1410, another Chinese expedition reached the Onon river and defeated Oljai Temür (reigned 1403–12). Oljai later lost his hegemony to the Oirat tribe. The power of the Oirats reached its height in the mid-15th century when Esen Taiji (reigned 1439–55) launched a campaign against the Ming empire (1449) and succeeded in capturing the Ming emperor Ying-tsung and taking him as a prisoner of war to Mongolia. He even besieged Peking, but the stubborn resistance of the Chinese garrison, together with dissension in the Mongol camp and skilful Chinese diplomacy, brought about a turning of the tide.

**Pacification of Eastern Mongols.**—In the 16th century the Mongols gradually ceased to be the chief danger to China, and their energies were mostly absorbed in internal rivalries and in the formation of temporary federations of various tribal groups. A decisive change was brought about under the Tümed king Altan Khan who, after some frontier warfare with the Chinese, finally made peace with them (1571) and even received a princely rank from the court in Peking. At the same time he worked for the conversion of the Mongols to Tibetan Buddhism and in 1577 proclaimed this creed the state religion of Mongolia. This made Tibet with its Buddhist clergy the spiritual centre of the Mongols; the Mongol title of dalai lama became the official designation of the head of the Tibetan Buddhists in Lhasa. This "second conversion" of Mongolia had far-reaching results as an ever-greater number of Mongols entered monastic life, and the warlike traditions of the race were less and less put to the test. This pacification of a people whose ancestors had conquered a whole continent was naturally viewed with approval by the Chinese, to whom the Mongols were never again a serious threat. During the early 17th century Inner Mongolia fell an easy prey to the imperialist ambitions of the Manchus, whose ruler Abakhai defeated the Chahar ruler Ligdan Khan in 1634 and made him swear allegiance to the Manchus. Until 1912 the Mongols of Inner Mongolia remained faithful subjects of the Manchu emperors, who had made themselves rulers of China in 1644.

**Western Mongols.**—Whereas the eastern Mongols had gradually lost their ambition and expansive energy, two tribes of the western Mongols, the Torgut and the Dzungars, for a while continued to follow a policy of expansion and conquest. The Torgut migrated into the steppes north of the Caspian sea (1616) and were for some time allies of the Russian tsars against the Islamic Uzbeks in Fergana. In 1770 however they decided to leave Russia and settle in east Turkistan in the Ili region where they were welcomed by the Chinese authorities. The Dzungars directed their energies first against Tibet, where they established a sort of protectorate (1636). Their khan Galdan (reigned 1676–97) proceeded to conquer central Asia and brought the Islamic kingdom of east Turkistan under Dzungar rule (Kashgar 1678, Turfan 1681). He then turned to Outer Mongolia and expelled the

Khalkha Mongols from their pastures in the Orhon region. The Khalkhas appealed to the Chinese emperor, K'ang-hsi, who did not hesitate to accept the submission of the Khalkhas and to send troops against Galdan. In 1696 Galdan was defeated south of Urga (Ulan Bator). His nephew Tzewang Rabtan (reigned 1697–1727) fought with equally little success against the Manchu-Chinese armies which finally drove the Dzungar armies out of Lhasa (1720). Tzewang Rabtan withdrew his remaining forces into that part of east Turkistan which is to this day called Dzungaria, but there, too, the Chinese eventually succeeded in eliminating the remnants of Mongol independence. Amursana, the grandson of Tzewang Rabtan, was the last Dzungar ruler. In 1757 he lost his territory to the Chinese and fled to Siberia, where he died shortly afterward. That year may be regarded as the end of the Mongol empires and even of the Mongols as a self-governing political entity. After that all Mongols, regardless of tribal affiliation, became the subjects of foreign powers. Inner and Outer Mongolia as well as Dzungaria became parts of the Chinese empire; other Mongols such as the Kalmyks in the Astrakhan region or the Buryats near Lake Baikal lived under Russian domination. A new Mongol state was founded in the 20th century when Outer Mongolia declared its independence after the fall of the Manchu dynasty in 1912 and, as a result of Soviet intervention in the turmoils of central Asia following the disintegration of the Manchu empire, the Mongolian People's Republic was founded in 1924.

The eventual elimination of the Mongols as an independent political entity was chiefly due to the relentless expansionist tendencies of the Chinese, who did not content themselves with a purely defensive strategy. A world-historic consequence of the Dzungar wars was the annexation of east Turkistan by the Chinese and the establishment of a Chinese protectorate over Tibet. The political map of present-day China therefore goes back to the abortive attempts of the western Mongols to establish themselves as a principal power in central Asia.

## VI. GENGHIS-KHANID EMPIRES IN CENTRAL ASIA

The Chagatai line of Genghis Khan's family had received the *ulus* consisting of the former Khara-Khitai empire stretching east of Lake Balkhash, including the whole Tarim basin as well as Transoxiana and Afghanistan. Their empire had a predominantly Turkish population, and there the traditions of the steppe remained much stronger than in the contemporary Mongol empire in China. The civilization of the Muslim oasis-dwellers influenced the nomadic character of the Chagatai empire only to a very limited degree, and the expansionist tendencies inherited from the earlier rulers made themselves repeatedly felt. The history of the Chagatai empire seems rather confused because there are few reliable sources; even the reign dates of the khans cannot always be ascertained. From 1267 to 1301 the Chagatai empire was subject to Ogadai's descendant Qaidu, and it was only after the fall of the latter that the Chagatai khans regained their independence.

In foreign policy the Chagatai empire was notable for its continuous attempts to conquer India by way of Afghanistan and the Punjab. The conquest of India had been one of the aims of Genghis himself but had soon been abandoned in favour of other campaigns. The Chagatai rulers on various occasions sent their armies through Afghanistan into India, chiefly because on all other frontiers relatively stable states prevented a policy of aggression, viz., the Yüan empire in the east and the Il-khan state in the west. This left the south as the only promising direction of attack. For several decades the Mongols remained a dangerous enemy for the Muslim sultans of Delhi. The Mongol invasions from Afghanistan became particularly fierce under Du'a Khan (1301–05), and the Delhi sultan 'Ala ud-din Khalji was able to defend his capital only with great difficulty against the Chagatai expeditionary forces.

The situation of Islam had, in spite of the conversion of earlier khans, remained precarious. When, after a short period of internal stability (1301–25), the khan Tarmashirin again adopted Islam (1326), there followed a temporary division between the eastern and western parts of his empire. Some sources even state that Tarmashirin was murdered by the adherents of Buddhism and Shamanism because of his conversion to Islam. Under Tughluk Temür (1347–63) the empire was reunified, but his successors were mere puppets. Actual power lay in the hands of the amir Timur (*q.v.*, Tamerlane, 1336–1405) who continued the Chagatai rule although he was no Mongol himself. Turkish influence had become very strong during the 14th century but Mongol was still used as an official language in the Turfan region as late as 1369. In Timur's reign, however, the Chagatai *ulus* had ceased to be a Mongol empire and had become a Turkish and Islamic state. Nevertheless, there remain to this day traces of Mongol rule over Afghanistan; the so-called Moghol tribe still speaks a Mongol dialect with some archaic features dating back to the period of the Mongol conquest in the 13th century. Persian supplanted Mongol and, to a certain degree, even Turkish as the official and literary language.

Another kingdom which, though ruled by Genghis-khanids, must be regarded as basically Turkish was that of the Shaibanids. Shaiban, a son of Juchi and a grandson of Genghis, ruled over the territories east and southeast of the Ural range. One of his descendants, Abul Khair (reigned 1428–68) made himself ruler of the Turkish Uzbeks. His grandson Mohammed Shaiban took Bukhara and Herat from the Timurids, and his descendants continued to rule in Bukhara until 1599. Other branches of the same family such as the Nogai khans and the Astrakhan khans ruled over parts of Transcaspia. All of these states were Mongol only insofar as their sultans were patrilineal descendants of Genghis. Otherwise they showed no Mongol features at all. Their language was Turkish, their culture Islamic with a strong admixture of Persian elements. The khanate of Khiva was from 1512 in the hands of the Shaibanids, and its last khan Abdullah was deposed by the Soviet government as late as 1920, although Russian domination had already been established over the whole region in the 1860s and 1870s.

## VII. THE IL-KHANS IN IRAN

The *ulus* of Hulagu (*q.v.*) was from the beginning in a peculiar political situation as a consequence of the religious tendencies of the Mongol rulers in Iran. The negative attitude of Hulagu toward Islam and his attack against the caliphate led to a breach with the Golden Horde in southern Russia where Berke, Batu's brother, had adopted Islam. The Il-khans (*q.v.*, "regional khans") in Iran, on the other hand, remained at first loyal allies of the great khan Kublai in China whereas Berke supported the pretender Arik Böge who rose against Kublai. Hulagu remained hostile toward Egypt, the chief Islamic power in the near east, so that the alliance between Berke and the Mamelukes in Egypt, concluded in 1261, followed almost naturally. For the first time in history a Mongol ruler allied himself with a foreign power against another Mongol. Even European powers became partners of this political constellation. The Christian states of Tripoli and Akkom (Acre), founded by the crusaders, enjoyed the protection of the pope and the kings of France. It is therefore not surprising that in Rome and Paris the Il-khans were regarded as potential allies against Islamic Egypt. Hulagu's son Abaqa, who succeeded his father in 1265 and whose wife was a Byzantine, a daughter of the emperor Michael Palaeologus, tried to establish closer political and military ties with the Holy See and England and France through the Nestorian patriarchs whom he favoured greatly. His repeated attempts to conquer Syria and Egypt, however, failed conspicuously as no co-operation with Byzantium or the Christian powers could be effected. Abaqa, who was still very much a true Mongol insofar as he had his father's strong liking for intoxicating drink, died in 1282. Under Arghun (1284–91), who was himself inclined toward Buddhism, the tolerant policy toward the Christians was continued. He, too, favoured the Nestorians and sent a Nestorian ecclesiastic Rabban Bar Sauma (*see* BAR SAUMA, RABBAN) as his ambassador to Europe in order to establish closer contact with the Christian powers. Bar Sauma went first to Byzantium, then to Paris, where he was received by Philip the Fair (1287). In Bordeaux he met king Edward I of England and in Rome he was granted an audience by Pope Nicholas IV (1288). But again no tangible results followed. Arghun's subsequent letters to Philip of France (1289) and to Pope Nicholas IV (1290) are documents

of great linguistic and historic interest.

In domestic affairs Arghun relied greatly on the services of the Jewish physician Sa'd al-Dawla, who was appointed inspector general of the treasury in 1288. Sa'd soon made himself obnoxious, however, by his cruel exactions and ruthless exploitation, which even provoked anti-Jewish riots. The financial situation of the empire became even more precarious when Arghun's successor Gaikhatu (1291–95) introduced paper currency on the Chinese model. This paper money proved a failure and resulted in complete economic confusion. The reign of Ghazan (1295–1304) brought changes in several fields. He introduced fiscal and monetary reforms and reorganized the administration of the whole empire. His conversion to Islam marks a definite break in Mongol and Iranian history. Buddhism was persecuted as idolatry and even the Jews and Christians had to suffer. The adoption of Islam by the Mongols facilitated the assimilation of Mongols and Turks in north Iran by eliminating their religious differences. Ghazan also declared himself formally independent of the court in Peking and any reference to the great khans in coin inscriptions or official documents was dropped. He no longer called himself Il-khan but khan in order to underline his sovereignty. This emergence of Iran as an independent state was perhaps prompted by the death in 1294 of Kublai Khan, whose relations with his nephews and great-nephews in Iran had always been friendly. After Ghazan's premature death at the age of 31 (1304) his brother Ulja'itu (1304–16) became khan. He had originally been a Christian and was baptized Nicholas but later became a Muslim. He continued the reform policy of Ghazan and also kept his advisers, among them the famous statesman and historian Rashid al-Din Fadlullah (*q.v.*). The capital of the Il-khans had hitherto been Tabriz but Ulja'itu moved his residence to Soltaniyeh near Kazvin (1307). In foreign policy the new khan followed the pattern set by his predecessors: he decided to resume contact with European powers. His letter of 1307 addressed to Philip IV of France offering to continue friendly relations has survived. Both Ghazan and Ulja'itu were distinguished patrons of the arts and literature. Under the influence of Islam, the absorption of the Mongols by Iranian civilization became more and more pronounced. Although Ulja'itu's letter to Philip was written in Mongol, he calls himself not khan but sultan, and uses a Muslim date along with the traditional Mongol designation of years arranged according to the animal cycle. The seals, like those on Arghun's letters, are in Chinese. This co-existence of Mongol, Turkish, Iranian and Chinese elements in the Il-khan empire lasted for more than half a century, but finally Islamic and Iranian influences proved to be the strongest.

Nevertheless, Iran remained for a long time under the influence of Chinese culture. Its miniature paintings of the 13th and 14th centuries are clearly modeled on Chinese traditions. Iran produced under Mongol rule a historian who was perhaps the first ever to try to write a real world history. This was Rashid al-Din Fadlullah (1247–1318), who incorporated in his work not only the history of the Mongols but also that of India, China and even Europe (the Franks). This universality could be expected only in a country like Iran where cultural and political ties existed simultaneously with China, the European powers and the other Mongol empires.

Ulja'itu's son and heir, Abu Said, was the first of these rulers to bear a Muslim name. As he was only 12 years old when he came to the throne (1317), actual power remained largely in the hands of local amirs. There followed two decades of internal struggles and gradual disintegration. When Abu Said died childless in 1335, the Il-khan empire practically ceased to exist as a political unity. *See* also PERSIAN HISTORY.

## VIII. THE GOLDEN HORDE

The situation in Batu's *ulus* was for a long time dominated by antagonism to the Il-khan empire. For more than a century the rulers of the Golden Horde (*q.v.*), or Kipchak empire, tried to occupy the Caucasus and to advance into Iran. This led, as described above, to an anti-Persian alliance with Egypt. In the economic field, too, relations between the Golden Horde and Egypt developed remarkably and a flourishing sea trade carried goods between the two countries. Artisans and artists came from Egypt to the khan's court at Saraï Batu on the lower Volga, so that Egyptian influence can be found in many of the works of art and architecture of the Golden Horde empire.

The religious situation differed very much from that in Iran although both Mongol empires were eventually converted to Islam, which favoured the amalgamation of Turks and Mongols. In Iran, Islam was the religion of the subjugated population, but at the same time Nestorianism and Buddhism had been powerful rivals. In southern Russia, however, Nestorianism had never played a prominent role and Buddhism was practically nonexistent. This religious vacuum facilitated the adoption of Islam, and the native pagan Shamanism of the Mongols was soon supplanted by the new creed. The khans, on the other hand, observed tolerance toward the Greek Orthodox church of their Russian subjects. The patriarchs enjoyed a number of privileges not unlike those granted by the khans in China. This noninterference in Russian religious life later proved a major political factor because the Orthodox church assumed a national function under the foreign rulers, not unlike that of the Orthodox clergy in Greece and the Balkan countries under Turkish rule, when the Christian religion and nationalism were closely allied.

The various Russian city-states and principedoms remained under Mongol rule; the khans contented themselves with levying tribute that was collected by specially appointed officials (*baṣqaq*). An important consequence of Mongol rule was the gradual transfer of Russian national life from Kiev to Moscow. There were contacts with western Europe, but they were mostly of an economic nature. The republic of Genoa had as early as 1267 established a trade post at Kaffa (Feodosiya) in the Crimea. In spite of several local incidents Genoese merchants continued their activities for a long time in the Golden Horde empire. Relations with Byzantium were mostly friendly and Mongol rulers even occasionally sent armies to assist the emperors of Constantinople in their wars against Bulgaria. The Mongols themselves were deeply affected by their surroundings. The majority of their subjects in the steppe regions of southern Russia were Turkish (Kumans, Kipchaks, etc.) and this strong Turkish element led comparatively soon to the disappearance of distinctively Mongol features. The Mongol language was given up in favour of Turkish, and continuous intermarriage resulted finally in the formation of a new Islamic population, the Tatars of Russia. In addition to Turkish and Mongol elements, there was in the Tatar population an admixture of other indigenous populations such as the Volga Bulgars and the Volga-Finnish tribes.

Under Mangu Temur (1267–80), Berke's successor, the Golden Horde khanate became virtually independent of the great khan Kublai in Peking. Under his successors, actual power rested with Nogai, a prince who had distinguished himself in several campaigns and had united the eastern tribes of the Tatars against the authority of the central court. His pretensions finally led to war and his defeat in 1299 by the legitimate khan Toqtu (1290–1312). Under Uzbek, (1312–42) the political power of the empire reached its peak and Islamic culture flourished under the energetic ruler whose name survives to this day in that of the Turkish Uzbek nation. He also granted to Ivan I of Moscow the title of grand duke for his services as a collector of tribute from the Tatars, a measure which strengthened the predominance of Moscow in Russia. The later rulers of the Horde were confronted with a new problem on their frontiers when the Ottoman Turks reached the Dardanelles in 1354. This not only weakened their maritime ties with Egypt but also cut the khanate off from the Mediterranean and thereby from southern Europe. This growing isolation did not prevent the khans from making several attempts to advance toward the south. Djani-beg (1342–57) defeated the Persians and took Tabriz in 1357, but his early death prevented the consolidation of the Horde in Azerbaijan; the Caucasus also was given up. Another dangerous enemy of the khanate was Lithuania, which for some time occupied large parts of Ukrainia. The last khan of the Golden Horde who was undisputed ruler over the whole territory was Tokhtamish (1378–95). He joined forces with

the White Horde, an agglomeration of tribes in western Siberia which had been led by the descendants of Orda, Batu's eldest brother. Tokhtamish also renewed the vassalage of the Moscow princes but shortly afterward met a new enemy in Timur (Tamerlane). The latter's campaigns in south Russia brought no lasting results but weakened the political and military power of the Horde.

The later history of the Mongols, or rather of the Tatars, in Russia followed a course similar to that of the other Islamic Mongol empires: internal struggles and feuds, disintegration and finally division into independent states. Meanwhile the Moscow kingdom emerged as a major power and the history of the Tatars became a part of Russian history. In the mid-15th century there remained, apart from the remnants of the Golden Horde, three khanates: those of Astrakhan, Kazan and the Crimea. Only these three survived into the 16th century. In 1783 the last Genghisid ruler in Europe, the Crimean khan Shahin Girai, was deposed by the Russians. (*See* CRIMEA.) The long contact between Russia and the Tatars had its effect upon both nations. For Russia, Tatar influence has been an important factor in many fields. Turkish and Mongol loan-words are not infrequent in Russian, and the financial, political and military organization of medieval Russia showed many Tatar elements.

Among historic effects of the Mongol campaigns not only the destruction of ancient civilizations like that of Khorezmia or of the Tangut state of Hsi-Hsia should be remembered. All the conquered regions and states underwent a social, racial and linguistic transformation through Mongol domination. On the other hand, Mongol imperialism for some time during the 13th and 14th centuries favoured contact between east and west, and many elements of material culture were transmitted from eastern Asia to the west and vice versa. At this time Europe and Asia had closer commercial and cultural contacts than ever before, and the age of maritime exploration was inaugurated in Europe by the attempts to reach by sea the fabulous eastern countries that Marco Polo and other travelers described after their journeys through the Mongol empires. *See* also MONGOLIA: *History*.

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**MONGOLIA,** the name given a vast plateau in central Asia, the traditional homeland of the Mongol peoples, and now divided into two distinct political entities, Inner Mongolia, an autonomous region (*ch'ü*) of the People's Republic of China (*see* MONGOLIA, INNER), and Outer Mongolia, now the Mongolian People's Republic (*q.v.*). Traditionally Mongolia has been a region of Russian-Chinese rivalry. However, with these two nations now under the same political system, the rivalry has become somewhat less intense, while the Trans-Mongolian railroad completed in 1955 connecting Peking with Ulan-Ude in Siberia emphasizes Mongolia's new position as a connecting link and thoroughfare between Communist China and the Soviet Union.

The entities represented by the physical, ethnic and political Mongolias do not coincide. The plateau includes areas no longer inhabited mainly by Mongols, such as the Chinese farming regions in southeastern Inner Mongolia. On the other hand, Mongol nomads roam over areas outside the Mongolian plateau, such as the Tsaidam basin of the Tibetan plateau and Dzungaria in Chinese Turkistan. The political boundaries of both Outer Mongolia and Inner Mongolia have varied at different periods in history and at present do not include all of the plateau.

This article contains the following sections and subsections:

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  1. Geology and Physiography
  2. Climate
  3. Vegetation
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  8. Manchu Domination
  9. The 20th Century
VI. Population

## I. PHYSICAL GEOGRAPHY

**1. Geology and Physiography.**—Mongolia is essentially a plateau varying from 3,000 to 5,000 ft. above sea level and composed of granites, gneisses and crystalline schists of the Pre-Cambrian and Paleozoic ages. Surmounting the plateau and bordering it on the northwest are the extensive Altai, Tannu-Ola and Sayan mountain ranges, and on the northeast the Transbaikalian highlands. On the southeast the plateau is separated from the loess plateau and the North China plain by a belt of pronounced scarps whose continuation northward in the Greater Khingan mountains delimits Mongolia on the Manchurian side. On the southwest the plateau abuts against the lofty Nan Shan range, which walls up the northeastern section of the Tibetan plateau. Farther west the plateau is bordered by the rims of the low Tarim and Dzungaria basins of Turkistan. The highest point on the plateau is Kuiten Peak in the Altai Range, which rises to 15,266 ft. The lowest areas are in the extreme northeast as at small Chuchu Nor near the Soviet border which is only 1,745 ft. above sea level. High, glacier-producing mountains are found on the plateau along with worn-down mountains half-buried in their own erosional debris. In other areas of the plateau volcanic cones rise over outpourings of lava. Thus, in the Dariganga region in the extreme east there is a typical volcanic landscape evidencing recent volcanism. Between the mountain ridges and peaks stretch wide basins in the lowest parts of which are salt lakes or salt pans.

Physiographically, Mongolia falls into three clearly marked divisions:

1. The northwestern mountain complex, an uplifted massif with a number of basins (Kobdo, Tannu Tuva, Selenga) enclosed by mountain ranges (Altai, Sailjumen, Khangai, Sayan, Khentei) in places marked by faulting. The whole is well-drained by rivers.

The Altai is the most prominent and longest range of Mongolia.

Its linear distance of 932 mi. stretching in an arc from the Russian Altai south-southeastward and then eastward to end in the Gobi desert sets it apart from the more massive plateaulike Khangai and Khentei. In the high Altai in Mongolia are numerous glaciers, including the Potanin with a length of 12 mi. The Altai slopes northeastward down to the Kobdo basin, which has a lowest elevation of 3,390 ft. This basin is bounded on the west by the incurving arc of the Sailjumen range. The Kobdo and other rivers contribute water to this internal drainage basin in which the several lakes expand and shrink seasonally. A section of the faulted Altai extends into the Gobi east of longitude 95° E. with elevations between 6,000–11,000 ft. generally diminishing eastward. The eastern section of the Altai comprises four ranges from west to east: Igo Bogdo (Ta-fo Shan), Bog Bogdo (Hsiao-fo Shan), Acha Bogdo and Gurban-zagan. The first is a narrow range and has a precipitous north face. The Bog Bogdo rises more than 11,000 ft. but is only about 4,000 ft. above the plain. The elevated block of the Acha Bogdo is under 8,200 ft. The Gurban-zagan differs in being not a single range but several parallel ranges.

The Khangai occupies a central position in the Mongolian People's Republic; this range rises to more than 13,000 ft. and has its gentle slopes facing northward, with steeper southern faces. Most of its northern drainage flows into the Selenga river, which, together with its chief tributary the Orhon (Orkhon), drains into Lake Baikal in Siberia. The rivers of the southern slopes of the Khangai end in salt lakes or disappear in the Gobi.

2. The central or Gobi region is on the whole the lowest and most uniform portion of the plateau. Isolated and weathered hill ranges of low altitude characterize the surface of the Gobi. The strong winds of this region have blown the finer soil particles out of Mongolia into China, leaving behind bare rock, gravel or sand as a cover, sometimes with a thin soil holding a grass cover. Rivers are absent except on the margins. In the northeast the Kerulyen (Kerulen) flows out of the Khentei to enter the eastern Gobi. It flows across the Outer Mongolian boundary into the waters of Hulun Nor, a lake 46 mi. long by 15 mi. wide whose outlet runs into a tributary of the Amur. About 30 mi. northwest of the lake between Lu-Pin and the border is the historic defensive wall, the Outer Willow Palisade, and frontier earthworks, which extend for a distance of 185 mi.

South of latitude 44° N. and west of longitude 114° E. in the driest part of the Gobi begins an extensive region of sand dunes. It spans Outer and Inner Mongolia in a belt 125 mi. wide and about 300 mi. long, reaching as far west as the western elbow of the Yellow river loop. South of the eastern end of the Altai is another large patch of sand dunes about 60 mi. in diameter. Sand dunes also cover large areas in the Ala Shan desert west of the Yellow river (Hwang Ho). In the large area between the latter two dune regions is the largest of the river systems that flow from the Tibetan plateau into the Mongolian plateau. This is the O-chi-na Ho (Etsin Gol), which runs in several separate branches about 370 mi. north into two interconnecting salt lakes near the Outer Mongolian border. Another important river farther west is the Su-lo, flowing past Yü-men at the inner Asian end of the Great Wall and draining westward down toward the Tarim basin.

3. Southeastern Mongolia, on the inner or Chinese side of the Gobi, resembles the northwest in that it is much more diversified than the central portion of the plateau. It contains an outer and an inner series of mountains. Between these is an intermediate zone of lower elevation, which is economically the vital part of Inner Mongolia. Eastern Inner Mongolia as constituted in the Inner Mongolian autonomous region (I.M.A.R.) in 1960 included both slopes of the north-south Greater Khingan mountains eastward to the Nen Chiang river in Manchuria. In the southeast the plateau region includes the western part of the Jehol hills, although the I.M.A.R. boundary there extends along the water divide between the Pacific and interior drainages and excludes the territory of three Mongol *banners* (provinces). The northern part of the I.M.A.R. is very hilly, and near latitude 48° N. the Greater Khingan mountains rise to a high knot, above which protrude several peaks including Chih-wei Shan, 6,074 ft. above sea level. South of this knot the low eastern Silingol basin drops off into the Liao river plain of southern Manchuria, forming a corridor between the Mongolian plateau and the Manchurian plains. The scarps north of the Yellow river facing the Ordos desert include those of the Yin Shan (Ta-ch'in and Lang mountains) and the Pai-yen Shan farther west. North of the Kuei-sui (Huhehot) basin to the east of the Yellow river loop, a large number of short streams flow from the water divide into the Gobi depression.

**2. Climate.**—The regional differences noted above are accentuated by differences in climate and vegetation. Certain general characteristics may be ascribed to almost all of the plateau, however. Among these are dryness and great seasonal temperature changes, aspects shared with the rest of central Asia. During the winter the Asiatic high-pressure air masses are centred over the northern edge of the plateau; low-pressure air masses are centred over the southern Gobi during June, July and August. Cold winter winds move out from the high-pressure region, while summer winds flow inward toward the low-pressure region of rising air. The latter are rain-bearing and come from two main directions: northwest, affecting Outer Mongolia, and southeast, affecting Inner Mongolia. The general rainfall pattern shows decreasing amounts from the Siberian border southward to the Gobi, and then increased amounts south from the Gobi toward the Great Wall. The difference in mean temperature between the northwestern and southeastern sections of the plateau is considerable, the annual average for the southeast being about 11° C. (52° F.) warmer than that of the northwest. Summer temperatures are relatively uniform for the whole area, but there are considerable regional contrasts in winter temperatures. The Altai-Sayan mountain complex in the northwest has a Siberian-type climate; the winter is cold and the annual range of temperature is greater than in any other part of Mongolia.

The average annual temperature in this northern region is about −6.7° C. (20° F.). The lowest January average temperature recorded was −35° C. (−31° F.) at Ulan-Gom near the south shore of Ubsa Nor (lake) in the extreme northwest. At Ulan Bator the January average is −26.7° C. (−16° F.) and the coldest temperature on record is −47.8° C. (−54° F.). The average temperature for the warmest month, July, is 17.8° C. (64° F.). The total annual rainfall (including heavy snowfall) in this region averages 10–20 in., brought mainly by cyclonic-type weather coming from the west. About 75% of the precipitation falls during the three summer months. Precipitation ranges from more than 12 in. at the central Siberian borders to 8.6 in. at Ulan Bator.

The Gobi has a continental climate. Winds blow unimpeded almost the year around, mainly from the northwest. The average temperature for January at Dalan Dsadagad is −19° C. (−2° F.); for July 21.7° C. (71° F.). The precipitation is less than 2 in. annually in the driest area. Southerly winds lose most of their moisture along the high southeastern marginal ridges before reaching the Gobi. On the other hand, the Pacific monsoon influence is reflected in the climate of southeastern and eastern Inner Mongolia. In the winter winds are predominantly from the northwest, bringing extreme cold, while dust storms arising in the Gobi are a common feature. The summer monsoon winds from the southeast bring rains averaging 10–15 in. annually along the plateau fringes, beyond which they rapidly diminish.

**3. Vegetation.**—The varieties of vegetation in Mongolia correspond closely to the climatic regions. In the northwest on both sides of the Sayan mountains are dense woods of larch, cedar, pine and deciduous trees characteristic of Siberian flora. These decrease toward their southern limits, the higher northern slopes of the Khangai and Tannu-Ola ranges. With the exception of these forests the surface of the northwest mountain region is marked by prairie land, furnishing excellent pasture in the wide basin-like valleys or plains, especially in the Selenga and upper Yenisei (Tannu Tuva) drainages. From the Tannu-Ola southward, the treeless zone extends to the unforested Altai where the steppe grasses merge into the alpine meadow and sedge land without a wooded transition belt.

The Gobi region must be regarded as a desert steppe rather than a desert proper. On its northern limits around the Kerulyen river, high mountains bearing larch and spruce alternate with river valleys which afford areas of good pasture. Steppes succeed southward, merging into the barren central Gobi where a sparse desert vegetation appears only in spring and early summer. Farther southeastward the grasses gradually become more luxuriant, reflecting the increased rainfall. This also has made the southeasternmost fringes suitable for agriculture, leading to the immigration of Chinese farmers who have converted the better grasslands to crop lands. The result of this change has often been the destruction of the soil by the high winds.

**4. Animal Life.**—There is an abundance of animal life on the plateau. A large number of the animals are of the domesticated varieties, such as sheep, goats, cattle, horses and camels, as well as some dogs owned by each nomad household. However, a large array of wild animals shares the plateau habitat. In the north the fauna of the Siberian taiga, such as the elk, lynx and snowshoe hare, predominates. In the south the faunal relationships are with those of central Asia and include the saiga antelope, gazelle and wild ass. Eastern Mongolia is relatively poor in animal species. The harsh environment has produced some interesting biological effects. Hooved animals and rodents, for example, are reported to have a month longer period of gestation than the same species in parts of Soviet central Asia. Marmots do not shed their fur until the end of July and then immediately begin to grow new winter coats, as contrasted with the same species in Transbaikalia which begins shedding in May and wears a summer coat for two months.

In 1954 the Soviet author A. G. Bannikov listed 110 species of mammals in Outer Mongolia, including insectivores, bats, carnivores, hooved animals and rodents. The single-hooved animals include the wild ass and the rarer Prjevalsky's (Przhevalski's) wild horse. The few insectivores and bats reflect the unfavourable environment for their prey, while, by contrast, the large number of rodents and split-hooved animals indicate the abundant food for them. The latter include elk and musk deer in the north and gazelles and antelopes in the drier south. Most of the meat-eating mammals are found in the northern forests and include the brown bear and such valuable fur bearers as the sable, ermine, beech martin, weasel, polecat, wolverine, fox and badger. The most widespread predator and the most dreaded is the wolf, which yearly slaughters many thousands of livestock as well as wild life.

Among the many varieties of birds found in Mongolia are the grouse, snowy owl, golden eagle, sparrow hawk, quail, waxwings and finches. Mongolian lakes in summer abound in waterfowl, including grebes and loons. Fish also are found in the northern lakes, including varieties of carp in Ubsa Nor and species similar in type to those of Lake Baikal in Lake Khobsogol (Höbsögöl).

## II. NATURAL RESOURCES

Several hundred million acres of moderately good pasturelands form the primary resource of Mongolia. Forest resources are very limited. On the higher northern slopes of the Khangai and Khentei mountains small forests of Siberian larch appear. These grow more luxuriantly on the northern slopes of the Tannu-Ola and in northeastern Tuva Autonomous Soviet Socialist Republic where typical Siberian-type forests of larch, spruce, fir and cembra pine are found, with some admixture of birch and aspen. They are similar to the forests of the northern Greater Khingan mountains, which provide extensive lumber supplies to the Inner Mongolian autonomous region of Communist China. In Outer Mongolia, about 7% of which is forested, lumber resources are of some local importance in the north, and there is a small sawmill in Ulan Bator. The Bogdo Ula near Ulan Bator has a dense forest, but is a park preserve.

Wildlife, especially fur-bearing animals, forms another important resource in Mongolia. In the 1930s furs constituted an estimated 15%–20% of the total exports of Outer Mongolia. Furs are also important both in Tuva and in northeast Inner Mongolia. Marmots provide the bulk of the furs, about 70% of Outer Mongolia's catch, and are followed in importance by squirrels, foxes and wolves. In Inner Mongolia, Kalgan has been an important fur-dressing centre and export mart. Antelope and gazelle provide occasional supplementary food supplies to Mongol herdsmen and hunters. Fisheries are somewhat negligible, although locally of importance; the lakes Hulun Nor, Koso Gol and Ubsa Nor are among the leading centres.

Mongolia is rich in minerals, though most are found in the fringe and mountain areas. Coal is widespread. In Outer Mongolia it is mostly brown coal of low quality heavily mixed with fossils. The seven mines at Nalaikha 20 mi. from the Ulan Bator supply the capital with fuel for light and power. Coal deposits of several billion tons near Choybalsan (Choibalsan) and at four other localities in Outer Mongolia were first exploited in 1957. At Lu-Pin on the Chinese-Soviet border northeast of Choybalsan are the largest coal mines in the Inner Mongolian autonomous region. Coal of fairly good quality also is found in Tuva. In the southern fringes of the plateau north of the Yellow river loop Jurassic coal series appear as small isolated strips and patches in a great range of quality. Good coking coal is found in the eastern part of the belt in former Chahar, while several anthracite fields have been worked in the western part of Sui-yuan. Coal also is found along the Alashan mountains and in the mountains between former Kansu and Ningsia.

Oil-bearing regions of the Mongolian plateau include the southeastern Gobi desert, where producing wells are found at present at Sain-Shanda (Sayn Shanda), and in the western half of the Ho-hsi corridor of Kansu, where producing wells are found near Yü-men and Chiu-ch'uan. There have also been indications of the presence of oil in the Tannu Tuva basin.

Iron ore occurs mostly in the southern and southeastern fringes of the plateau. In the east at Hsuan-hua south of Kalgan is one of China's important iron-and-steel-producing complexes. The ore obtained there is readily accessible in large tonnages and, although it is high in silica content, is of better quality than the Manchurian ores. In 1957 a major iron ore deposit was found on the flanks of the Ch'i-lien mountains of Kansu, not far from Lan-chou.

In northern Mongolia minerals in the beginning stages of exploitation in the early 1960s included copper, lead, zinc, silver, manganese, antimony, tungsten, tin, mercury, graphite and sulfur. The richest mineral deposits appeared to be in the Siberian borderlands, including the Tuva A.S.S.R. Among the precious metals, gold long has been worked in a small way in the Khentei mountains. Common limestone for cement and lime manufacture is available and salt is extracted from desert lakes and salt pans.

(H. J. Ws.)

## III. ANTHROPOLOGY

Outer Mongolia differs markedly in ethnic composition from Inner Mongolia. In Outer Mongolia, the Mongols predominate, while in Inner Mongolia they are a minority. The principal people of Outer Mongolia are the Khalkha Mongols, who number about 700,000, or about 70% of the total population of 1,019,000 (1963). In the steppe-forest margin of the north live Buryat Mongols and in the east the Barguts, who together number no more than 30,000. Speakers of western Mongol (Oirat) dialects occupy the lake region of the west. They include the Dörbet, Mingat, Khoton, Dzakhachin, Ölöt, Torgut, Bayit and Khotogoytu groups, totaling about 60,000. A small number of Darkhats live in the northwest and Darigangas in the southeast. The sum total of Mongols is about 900,000, or 90% of the population, a highly homogeneous composition. Turkic peoples in Outer Mongolia include 30,000 Kazakhs (*q.v.*) and a smaller number of Tuvinians (in Tuva A.S.S.R.), Uighurs and Tungus (*q.v.*). Finally there are Chinese and Russians who live mainly in the urban places.

The population of Inner Mongolia is primarily Chinese. Of a total population of 9,200,000 (1957 est.), the Chinese number about 7,000,000. The Mongols total about 1,700,000, or approximately 18% of the total. In addition, there are small numbers of Dagurs, Tungus, Orochis, Solons, Manchus, Uighurs and Koreans. The Chinese settlers have appeared in large numbers during recent generations. The chief Mongol groups are the

Chahars and Ordos Mongols, Sunits, Khuchits and Uzumchins in the south; Dörbets and Ölöts in the west; and Buryats, Barguts and Dagurs in the northern parts of the country.

*See* also MONGOLIAN LANGUAGE; MONGOLIAN LITERATURE; MONGOL. (L. K.)

## IV. EXPLORATION AND ARCHAEOLOGY

The earliest documented European exploratory missions to Mongolia were those of the Franciscans Joannes de Plano Carpini and William of Rubruquis (*qq.v.*). The latter, who began his journey in 1253 and reached the Mongolian imperial capital at Karakorum (*q.v.*), left a particularly detailed account of his observations on Mongol society. After the collapse of the Mongol empire in the 14th century, communications with Europe were interrupted until the journeys of the Russians V. Tumenets in 1616 and Ivan Petlin in 1618. During the next two and a half centuries topographical and other information was amassed by Russian and other travelers and exiles, and by Jesuit missionaries active in China, but serious scientific exploration of Mongolia did not begin until the late 19th century. The first journey of N. M. Prjevalsky (Przhevalski) (1870–73), the two journeys of G. N. Potanin (1876–77 and 1879–80) and A. M. Pozdneev's expedition of 1892–93, especially, resulted in the collection and publication of rich material on archaeology, ethnography, folklore, history and topography.

Systematic study of the archaeology of Mongolia began with the discovery by N. Yadrintsev in 1889 of the site of Karakorum and of the nearby 8th-century Orkhon inscriptions (*see* TURKISH LITERATURE). His expedition was followed in 1891 by that of V. V. Radlov, during which a number of sites of various epochs were surveyed. In 1897 the Turkish inscription at the tomb of Tonyukuk near Nalaikha was found by Mrs. D. Klementz. A first edition of this important inscription was published by Radlov in 1899. A further important monument discovered in these years was the isolated rock known as the Taikhir stone, situated near the Khoit Tamir river not far from the city of Tsetserlig. The glyphs and inscriptions of this rock, dating back to Turkish times and beyond, have been only partially studied.

**1. Inner Mongolia.**—In Inner Mongolia systematic archaeological exploration was initiated by the Sino-Swedish expedition of 1927–35 led by Sven Hedin, though the American Central Asiatic expedition of 1922–30 under Roy Chapman Andrews, which explored parts of southern Outer Mongolia, also carried out some investigations inside Inner Mongolia. Both expeditions encountered the difficulty that the majority of their finds lay on the surface, so that the stratigraphy was confused. Nevertheless, the Sino-Swedish expedition was able to point to the existence of an extensive Stone Age culture in present-day desert as well as steppe areas, locating 327 sites between Manchuria and Sinkiang. Signs of Paleolithic culture occurred, but J. Maringer, who wrote up the finds of the expedition, did not come to any definite conclusion about the existence of an Old Stone Age in Inner Mongolia. Artifacts from Mesolithic and Neolithic times point to a way of life dependent on hunting and fishing which continued to the end of the Stone Age. Maringer noted the absence of agricultural implements among the finds, except in the Sino-Mongol borderland.

The scientific section of the American expedition proved Mongolia as a whole to have been a breeding ground of prehistoric mammals and reptiles. Dinosaur eggs were discovered in a remarkable state of preservation and the skull and parts of the skeleton of the *Baluchitherium*, a giant hornless rhinoceros.

**2. Mongolian People's Republic.**—Some archaeological exploration and excavation took place in the years following the Mongolian revolution of 1921. Perhaps the most significant finds were the Hunnish royal tombs of the early 1st century A.D. at Noyon Ula excavated by P. K. Kozlov's expedition of 1924–26 and again by A. D. Simukov in 1927. Finds included woolen carpets, woolen trousers and silk underclothes belonging to the dead, silk burial flags, fragments of clay and wooden vessels, wheel naves and items of harness. The objects found were partly Chinese, partly of western origin and partly of local workmanship.

Archaeological work since World War II has been carried on increasingly by Mongolian scholars, though with the co-operation of foreigners, principally from the U.S.S.R. and Czechoslovakia. It has aimed mainly at tracing back the history of human life in Mongolia, as far as the mid-Paleolithic, and studying the development of settled life and its relation to nomadism. A site relating to the mid-Paleolithic was unearthed in 1960 at Otson Mamit in East Gobi province, and a layered site on the left bank of the Orkhon river, excavated in the same year, showed a transition from the culture of the upper Paleolithic to that of the Neolithic. Sites of Mesolithic times were discovered in Central and East Gobi provinces, while a great amount of material from the New Stone Age has been discovered. Work on Neolithic sites was done in particular in 1945 by A. P. Okladnikov and in 1960 by N. Ser-odjav. Of special interest is a site at Bayan-zag in South Gobi province where a Neolithic workshop was found.

Bronze Age objects show similarities both with artifacts of Karasuk type from Siberia (1200–700 B.C.) and with objects found at Anyang, capital of the Yin dynasty of China. Later Bronze Age finds, of Scythian provenance, were made from tombs in the Tola river valley and elsewhere.

Much work has been done on Turkish monuments of the 6th–8th centuries. In 1957 the tomb of Tonyukuk, minister of the Turkish khagan Qutlug (d. A.D. 691), was excavated, revealing fragments of painted plaster, and Turkish inscriptions scratched into plaster while it was still damp. A joint Czech and Mongol expedition cleared the cult-building at the Kül Tegin burial site in 1958. Among the finds was the head of a marble statue, possibly representing Kül Tegin (son of Qutlug) himself (8th century A.D.). In 1949 excavations at the ruined city of Khara Balgasun revealed it to have been the administrative and cultural centre of the Uighurs.

Interesting archaeological work has been devoted to the question of fixed settlements in Mongolia. Mongolian experts who knew in 1947 of only 47 sites of fixed settlement, had registered more than 200 by 1958. Of these cities and towns many have been investigated. Three Hunnish settlements were excavated during 1954–57 and some Khitan cities of the 10th to 12th centuries in the years 1952–57. Excavations at the site of Züün Kerem in Khentei (Kentei) province revealed a quadrilateral wall with sides of roughly 500 m. The city within the fortified walls was divided into four parts by broad streets. Pottery and building materials were produced in the city, but the basis of the local economy was agriculture and herding. Many bones of domestic animals were found and also hand mills, pestles, remains of cereals, and plowshares.

Several similar town sites are known inside Mongolia proper, *e.g.*, at Khadasan and Chingtolgoi westward from Ulan Bator, and in 1957 a Soviet expedition investigated similar city sites from the pre-Genghis Khan period (11th century) in outlying parts of the Khitan realm in Tuva A.S.S.R. and in Transbaikalia near the railway station of Otpor. A city site here measured about 1.5 km. from east to west, being thus almost equivalent in size to the later Mongol capital of Karakorum.

Karakorum is itself the most important city site of imperial Mongol times. Considerable excavations were carried out in 1948–49, laying bare the 64 bases of the columns of the royal palace of Ogadai. The city was seen to have been both an administrative centre and a centre of handicrafts, agriculture and trade. Iron plowshares, wheel bushes for carts, and iron spear tips, for instance, point to agricultural activity and military manufactures, while the presence of Mongol, Chinese and Khoresmian coins hints at Karakorum's commercial interests.

Even later sites have been investigated, *e.g.*, Bars khota, the city established by Togon Temür, after his expulsion from China (1368), and also some Manchu military settlements.

Attention has also been paid to the existence of many petroglyphs. According to D. Dorj these belong to three distinct periods: the Bronze Age in the 2nd and 1st millennia B.C.; the Scytho-Siberian age between the 7th century B.C. and the 1st century A.D.; and the period of the ancient Turks. At least one early Mongol drawing, depicting a Mongol woman, survives on a rock. (C. R. BA.)

## V. HISTORY

**1. Earliest Period.**—Mongolia, once the basin of various diluvial seas with their surrounding mountains, became toward the end of the Mesozoic era a region of fertile swamps, harbouring various kinds of dinosaurs. In Neolithic times it was the home of small groups of hunters, reindeer-breeders and nomads. During the 3rd century B.C. it became the centre of a Hunnic empire, wherein all the Turkish, proto-Mongolian and Tungusic groups of that region were united. From the Mongolia of that day strong pressure was exercised on China's northern and northwestern frontiers. The different way of life of these nomadic warriors and steppe dwellers earned them the name among the Chinese of "barbarians" and it was as barbarians that the Chinese treated them in all their negotiations and dealings with them. The eastern Turks (T'u-Küe) became particularly prominent in Mongolia during the 4th–10th centuries A.D., while the Uighurs, coming from eastern Turkistan, formed another empire in northern Mongolia in the region of the Selenga river during A.D. 745–840; thereafter they fell victims of the rising Kirgiz khanate.

**2. The 12th and 13th Centuries A.D.**—In the 12th century, the arid Gobi bowl was surrounded by a number of states, mainly Turkish and highly civilized. The Naiman Turks, who had embraced Christianity, occupied northwestern Mongolia; south of the Tola river lived the Keraits, another Turkish tribe which also professed the Christian faith. South of the desert lay the powerful Tangut empire (Hsi-Hsia), a Buddhist state of Tibetan culture, with its own script. All these states had permanent capital cities; their agriculture was carried out mainly by hired Chinese labour; they had cultural and economic intercourse with their eastern neighbour, the Chin empire, the successor of the Sung dynasty in north China; and they were governed by a Mongol-Tungus ruling group. Khara-Khitai, the eastern neighbour of Khorezmia in Transoxiana, formed a solid roadblock on the way to the west.

From all these groups and states cultural and religious influences entered Mongolia proper and helped the creation there of a Mongol empire. The Mongols (Meng-ku ta-ta) and their closest neighbours and rivals, the Tatar (Ta-ta), nomadic hunters and cattle breeders inhabiting the eastern part of Mongolia southeast of Lake Baikal at the source of the Onon river, were constantly threatening the peace at the borders of the Chin empire, need for additional agricultural produce as well as the other products of a settled economy being their main incentive. The Meng-ku Mongol tribe is mentioned for the first time in 1146. Being too strong to be subjugated, the Chin empire in that year entered into a treaty agreement with them.

Under Yesugei, the father of Temujin, later called Genghis Khan (*q.v.*), the position of the Mongols became even stronger. The murder by poisoning of Yesugei by enemy Tatars was a temporary setback, but Temujin carried on his father's plans and strove for unification of the steppe dwellers. Leading a group of young aristocrats, he gained supremacy over the Shaman leaders of the tribes. After defeating the Tatars, with the Keraits as his allies, Genghis was declared "Khagan of the Mongols" (1206) and having subjugated his former allies, the Keraits, he became the leading personage in eastern Mongolia. In 1206 he also defeated the Naiman, his most powerful enemies. His military and political successes were mostly due to the excellent organization of his army, in which he amalgamated the fighting men from various tribes, both friendly and formerly hostile. These were held together by a rigid discipline and code of law. Well-educated Uighurs and other west Asians became his advisers. Though his political orientation was originally focused toward China, which he wanted to conquer for its agricultural resources, he later became conscious of central Asia and its Muslim states. Having destroyed the Chin empire in north China in 1215 he proceeded to conquer the central Asian states, thus extending Mongol power as far as the Indus, the Persian gulf and the southern Caucasus. He died on a campaign against the state of Hsi-Hsia in 1227.

**3. Expansion of Mongol Power.**—In spite of the extension of Mongol power into Iran and Russia, where the Mongols built their own empires, and the conquest of China in the reign of Kublai Khan (*q.v.*; 1264–94) (*see* MONGOL EMPIRES), Mongolia proper remained the cradle of the Mongols. It never became depopulated, though most of the Mongols lived in the new territories they had conquered. The first capital, Karakorum, was originally built by Genghis Khan's son and successor Ogadai (1229–41). It was a walled city, with permanent palaces of great splendour, which attracted western merchants, missionaries, envoys and travelers wishing to visit the Mongol court. Karakorum lost its importance after the transfer of the court to Peking under Kublai Khan. During the 13th and 14th centuries other permanent buildings and cities were constructed throughout the country. Mongolian sources mention besides Daidu (*i.e.*, Peking), the new Mongol capital, three big cities constructed by Kublai Khan. Japanese archaeologists discovered in Inner Mongolia, north of Peiling-miao, the remnants of a Roman Catholic church built in the Gothic style by Giovanni di Monte Corvino for a Mongol prince, Georges.

The advance of Mongol armies into Galicia and central Europe had secured for the whole territory occupied by the Mongols a kind of armed truce, a *pax Mongolica*, which allowed secure traveling. Joannes de Plano Carpini (*q.v.*), a Franciscan friar, was the first European traveler to come to Mongolia (1246). Emissaries of the French kings, legates of the pope and many merchants followed. Catholic, Nestorian, Manichaean, Buddhist and Muslim religious communities lived at that time in Mongolia. The influence of Tibetan Buddhism became predominant during the reign of Kublai Khan. Tibetan monks of the Sakyapa order, led by a lama, Phakpa ('P'ags pa), influenced Kublai and taught him Buddhist statecraft. Phakpa invented a new Mongol seal-script based on the Tibetan alphabet, the so-called Phakpa script, which was used for official documents only. Another Tibetan monk, C'os kyi 'od zer, modernized the commonly used Uighur alphabet in a form almost identical with the modern Mongol script.

**4. Decline of Mongol Power.**—The historical pendulum swung back to Mongolia proper in 1368 when Togon Temür (Togan Timur; Chinese, Shun-ti), the last Mongol emperor of China, fled before the onslaught of the Chinese national movement which led to the accession of the Ming dynasty. Togon Temür was able to escape to Mongolia, where he established his capital at Bars khota on the banks of the Kerulen river. He died there in 1370. His successor was his son Biligtü Khan (1338–78). Only a small number of the Mongols serving the Mongol dynasty in China had been able or willing to return with Togon Temür to Mongolia proper. Mongol tradition puts the number at only 60,000, whereas rough estimates mention 1,000,000 Mongols and other foreigners serving the Mongol (Yüan) dynasty. The majority must, therefore, have remained in China in the service of the newly established Ming dynasty. They were mostly soldiers garrisoned outside the Chinese cities and in the course of centuries were absorbed by the Chinese population. These Mongol troops fought their own Mongol brethren when the latter invaded the Chinese frontiers. In the first years after the fall of the Mongol empire the successors of Togon Temür, who still kept the title of "Great Khagan," tried to recapture their lost position in China, attacking the Ming armies again and again. The Ming dynasty, for their part, and particularly Emperor Yung Lo (1403–24) sent a number of military expeditions into Mongolia to destroy the formation of any new Mongol power. In 1380 Karakorum, the old Mongol capital, was destroyed during one of these Chinese raids into Mongolia.

The first successors of Togon Temür still tried to maintain the position of the great khagan, but the central power of the government was weakened when rivalries arose between the various Mongol princes and tribal leaders. At the beginning of the 15th century the west Mongolian Oirat tribe gained supremacy over the southern and eastern Mongols. Under the leadership of the Oirats, Esen and Togon, the warring tribes were for a short time reunited. The hegemony of the western Mongols was broken by the eastern Mongols under Dayan Khan (reigned 1488–1504 or to 1543 according to some sources). Dayan Khan inflicted a severe defeat on the western Mongols; Mongol sources speak of a decisive battle at Tas Bürtü. In spite of this struggle for

supremacy the idea of the dominating role of a great khagan remained unchanged and even the Oirat chieftains when they usurped the central power had their rank as great khagan confirmed in a ceremony of investiture before the sanctuary of Genghis Khan. This had been moved in the 15th century to the Ordos bend of the Yellow river when the Ordos tribe, the guardians of Genghis Khan's remains, took possession of this arid district.

**5. Internecine Strife.**—The position of great khagan was held after Dayan Khan's death by the descendants of his son Törübolod, who was chief of the Chahar (Chakhar) tribe. The descendants of Dayan Khan's other sons, however, became quite independent of the great khagan during the 16th century, particularly Altan Khan (1507–82), the chief of the Tümed tribe. At the end of the 16th century the chiefs of the Tümed, Kharatsin and Ordos tribes rivaled in power the chief of the Chahar tribe, who was the legal holder of the title of "Great Khagan of all the Mongols." In 1552 Altan Khan won a decisive victory in northern Mongolia over the west Mongolian Oirat tribe, which was still settled in the Karakorum district. This made way for the migration of the Khalkha tribe into its present homeland in northern Mongolia. During all these years of internecine strife the Mongols, coveting the produce of Chinese agriculture, particularly grain, had been constantly endangering and raiding the northern and northwestern frontier districts of China. The payment of ransom money, the bestowal of Chinese military ranks on Mongol leaders and the opening of markets and centres of barter after 1550 by the Ming government did little to ease the constant pressure of the Mongols on the Chinese border. Chinese fugitives and revolutionaries in the Mongol service, particularly members of the pseudo-Buddhist White Lotus sect, outlawed in Ming China, helped as advisers and labourers to build up the power of Altan Khan, who founded the city of Köke khota (Kuei-hua) in the Tümed territory.

**6. Revival of Buddhism.**—The fall of the Mongol empire in China in 1368 led to a weakening of the Tibetan Buddhist faith throughout Mongolia. The old popular religion of Shamanism (*q.v.*) gained ground again and Taoist beliefs spread to Mongolia from China. There still remained in Mongolia, however, many monasteries of the unreformed orders of the Sakyapa and Nyingmapa (*see* TIBETAN BUDDHISM). During the first decade of the 16th century the western Mongols, particularly the Torguts and Dzungars, because of their geographical situation near Tibet, were the first to have contact with the new, reformed version of Tibetan Buddhism, the Gelugpa. Neyici toyin (1557–1653), who was later to become the first Buddhist missionary to the eastern Mongols, and the first Jaya Pandita (1599–1662) are the most prominent representatives of the new west Mongolian Buddhism. The Tümed campaigns (1566–73) directed by Altan Khan against Tibet brought about the first contacts of the Tümeds with Tibetan Buddhist monks and led subsequently to a renewal of the Buddhism latent in the Tümed and Ordos territories. Visits of the third dalai lama in 1577 to the Tümed and Ordos and in 1587 to the Kharatsin tribe led to the mass conversion of these Mongol tribes. The old popular religion of Shamanism was suppressed, its ideas being incorporated in the doctrine of popular Buddhism. The foundation of many Buddhist monasteries; the conversion of many members of the Mongol nobility to religion and their entry into the monastic life; the formation of an educated class able to read and write and to translate into Mongol from Tibetan and Sanskrit; and the translation of religious works into Mongol and the subsequent creation of a written secular literature in the Mongolian language are the particular features of this period. The residences of the chiefs of the Ordos, Tümed, Kharatsin and Chahar tribes became centres of literary activity not seen before in Mongolia. The missionary activity of Neyici toyin and his disciples who converted the eastern Mongols to Tibetan Buddhism originated in Köke khota in the land of the Tümed. Buddhist missions during the period 1579–1629 based their teaching mainly on the beliefs of the old, unreformed sects of the Sakyapa and Nyingmapa. A Tibetan Buddhist mission finally entered the Khalkha territory and converted this Mongol group to the faith.

**7. Ligdan Khan (1604–34).**—The domination of southern Mongolia by Altan Khan and the movement of the Khalkha tribe under the leadership of Dayan Khan's son Geresanja into northern Mongolia after the defeat of the west Mongolian Oirats started an eastward movement of the other south Mongolian tribes. The legitimate great khagan, Darayisun of the Chahar tribe, moved east of the Khingan range to the Liao Ho, making the territory of the present-day Küriye *banner* (subdivision) the centre of the new Chahar homeland, while the Kharatsin tribe occupied his former lands around the old Yüan summer residence Kaiping. The last Mongol great khagan, Ligdan Khan (b. 1591, reigned 1604–34) made great efforts to strengthen his legitimate position as overlord of all the Mongols, and to unite them against the rising power of the Manchu in eastern Manchuria. His attempts at unification, however, did not meet with the approval of either the Tümed or Ordos tribes in the west or of the Kharatsin and other eastern Mongol tribes under his immediate power (the Khortsin, Bagharin, Dzarut, Dzalait, etc.). The east Mongolian tribes were the first to seek help against Ligdan Khan from the Manchu, to whom they finally submitted. In 1623 Ligdan fought the Kharatsin to the west of his territory and crushed them, thus forcing the remnants of the tribe into submission to the Manchu. A treaty between Ligdan and the Ming dynasty could not prevent the crumbling of Mongol power. The Manchu army had since 1629 shown its intention to march against Ligdan, particularly to outflank the position of the Ming armies in central China. This intention they carried out successfully in 1632 after Ligdan had moved to bar their way. Ligdan then menaced the Tümed of Köke khota and marched on to Tibet, ravaging on his way the Ordos country and the sanctuary of Genghis Khan. He died unexpectedly on the shores of Lake Kökenuur in 1634. An ardent follower of Buddhism, he had been guided most of his life by the Sharba Khutukhtu, a Sakyapa priest, but he fell out with him in the last years of his life.

Ligdan failed in his political aims despite his clear recognition of the necessity of a strong Mongol monarchy which would be a match for the Manchu and a third power in the coming reorganization of eastern Asia. He was successful only in organizing the translation of the Buddhist canon into the Mongol language, for which purpose he had assembled 35 of the most famous monks and scribes from all over Mongolia. In 1628–29 they carried out the big task of producing an edition of the canon in 113 volumes. For this edition they made use of some of the older translations also.

**8. Manchu Domination.**—After the death of Ligdan Khan and the submission of his two wives and his small sons together with the rest of the Chahar tribe, practically all the southern and eastern Mongols became subjects of the Manchu conquerors. In 1644 the Manchu dynasty was established in China. After submission the Mongol princes became vassals of the Manchu emperor, who bestowed ranks of nobility and yearly revenues on them. They married imperial princesses, and the daughters of the Mongol nobility were accepted as imperial concubines. In this respect the east Mongolian Khortsin tribe was particularly closely related with the Manchu. The Mongols of south and east Mongolia were organized in 49 *banners* under their own Mongol chiefs, who were recruited only from noble families trusted by the Manchu. Only the Chahar were denied the privilege of being ruled over by their own princes after the abortive revolt in 1675 of Ligdan Khan's grandson Burni. They were governed instead by Manchu administrators. The submission of the Mongols to the Manchu, however, was for a long time not complete. Throughout the 17th century small revolts and uprisings occurred here and there in Mongolia and there always existed a certain amount of discontent with Manchu rule. During this period the north Mongolian Khalkha had only loose tributary relations with the Manchu. They were forced into closer political relationship with the Manchu when in 1688 the Oirat Galdan Boshugtu Khan, the overlord of the Dzungars, invaded the Khalkha territory in an attempt to unite all the Mongols in an all-Mongolian state. Most of the Khalkha princes as well as their Buddhist high priest, the Jebtsun Damba Khutuktu, fled to Inner Mongolia and asked for Manchu protection. In 1691 the Manchu emperor K'ang-hsi re-

ceived in Dolon-nor an oath of allegiance from all the Khalkha princes. Manchu and Mongol troops finally fought Galdan in a decisive battle in 1696. Galdan fled and died in 1697, apparently from poison. The Khalkha then returned to their old territory in northern Mongolia.

In this period the first attempts were made by the Russians to secure Russian influence in northern Mongolia. Since Ivan Petlin's journey in 1618 through Mongolia down to the Tümed of Köke khota Russian merchants had traded with the Mongols and Oirats. In 1640–41 the Mongols of Altyn Khan in northwest Mongolia were engaged in skirmishes with Russian troops. Russian feelers were then extended toward the Khalkha princes and in 1665 the Russian envoy V. Buhennoi met them in Urga (Ulan Bator) and raised the question of the Khalkha recognizing Russian sovereignty. The next year saw Mongol negotiations with the Russian envoy P. Kulvinski. As a result of these negotiations the town of Selenginsk was founded. In 1667 Ghantemür, a Mongol chief in the Barga district, applied for Russian citizenship. In 1675 Khalkha envoys were negotiating in Moscow, but the Ölötian invasion of Khalkha territory compelled the Khalkha at the last minute to seek the protection and recognize the sovereignty of the Manchu. The treaty of Nerchinsk (1689) defined the frontiers between Manchu China and Russia. To maintain their overlordship over Mongolia the Manchu still had to deal with the Dzungarian independence movement in western Mongolia during 1754–58. Amursana, one of the Dzungarian leaders, died, a fugitive, of smallpox in Siberia in 1757. After the subjugation of the Dzungars and Ölöts Mongolia was fully dominated by the Manchu.

The inclination of the majority of the Mongolian reigning princes to adopt the Chinese way of living; the intensive immigration of Chinese settlers following the sale by the princes of large areas of fertile land; and dissatisfaction with their Manchu overlords led, in the mid-19th century, to unrest among the Mongols and the birth of a Mongol national consciousness. The first secret societies directed against Manchu tax policy and Chinese immigration were founded. Criticism of the debased forms of Buddhism became more outspoken. Some well-educated monks, including Danjilwangcil, a lama monk from Ordos, contributed with satirical pamphlets to the general unrest and discontent. Another Mongol lama, Rabjai, became one of the foremost poets of Mongolia. Modern ideas also came to Mongolia from the Buryats, Mongols who lived under Russian rule and had had western-style schooling since 1790, when the first Buryat school had been opened in Irkutsk. Christian missionaries were active in various parts of Mongolia after 1783, when Catholic fathers of the Lazarist order started missionary work in the east Mongolian *banner* of the Ongnighud. The idea of autonomy spread everywhere in Mongolia.

**9. The 20th Century.**—After the fall of the Manchu dynasty in China in 1912 and the foundation of the Chinese republic, the Mongol princes, supported by tsarist Russia, declared the independence of Mongolia from China. The Mongols of the northeast Mongolian Barga district as well as the Khortsin *banners* in Manchuria also tried to achieve independence, but Chinese troops prevented their incorporation into independent Outer Mongolia. The south and Inner Mongolian *banners* remained faithful to China. The Barga Mongols continued their fight and China was forced to grant them autonomy in 1915, but the grant was revoked in 1928. The claim of Outer Mongolia was supported in 1912 by a Russian-Mongol agreement which pledged the Mongolians Russian support. (For the later history of Outer Mongolia, *see* MONGOLIAN PEOPLE'S REPUBLIC.)

In the years following 1911 Inner Mongolian autonomy was severely curtailed by Chinese minority policies. Mongol nationalists were therefore either attracted to Japan when Japanese forces invaded Chinese territory or drawn into Communist underground activities in Outer Mongolia. When Japan occupied the Chinese northeast and in 1932 set up the puppet state of Manchukuo, the eastern Mongol *banners* were organized in four autonomous Hsingan (Khingan) districts, which thus obtained a certain degree of local and cultural autonomy. Similar local autonomous regions were formed in Inner Mongolia in the wake of the Japanese occupation of 1935–37. After the end of World War II and the Japanese surrender, Inner Mongolian autonomous movements came under Communist leadership. The anti-Communist Mongol groups were defeated. The Inner Mongolian *banners* were organized within the Chinese People's Republic as an Inner Mongolian autonomous region. For further details of the history of Inner Mongolia, *see* MONGOLIA, INNER.

(W. Hg.)

## VI. POPULATION

By the mid-20th century the Mongols were divided under three political sovereignties. Southern, or Inner Mongolia, as it was called after the mid-17th century when it had been absorbed by China, has been since 1947, and with increased territory since 1954, an autonomous region of the People's Republic of China (*see* MONGOLIA, INNER). The major part of the former Outer Mongolia was from 1921 an autonomous state under Soviet protection and since 1945 has been the independent Mongolian People's Republic (*q.v.*). Four territories along the northern frontier of this republic are parts of the Russian Soviet Federated Socialist Republic, namely: the Buryat Autonomous Soviet Socialist Republic; the Agin-Buryat national *okrug* (*qq.v.*), the Ust-Ordynski Buryat national *okrug* and the Tuva Autonomous Soviet Socialist Republic (*q.v.*).

While the Mongolian People's Republic has common frontiers with the Buryat A.S.S.R. and the Tuva A.S.S.R., the Agin-Buryat national *okrug* is an enclave within the Russian Chita region, though at one point the Russian corridor between the district and the Mongolian People's Republic is only about 12 mi. wide. The Ust-Ordynski Buryat national *okrug* is an enclave within the Russian Irkutsk region; this district is separated from the Buryat A.S.S.R. by a Russian corridor about 55 mi. wide.

The total area of the six political units enumerated in the table is 1,264,981 sq.mi., with a total population of 11,246,434. About 90% of the population of the Mongolian People's Republic is Mongol (*i.e.*, 833,000 in 1961) and there is a 4% Kazakh or Turkic minority. Of the population of the Mongolian autonomous region of China only about 18% (*i.e.*, 1,700,000) is Mongol. Although the total population of the Buryat A.S.S.R., the Agin and the Ust-Ordynski national *okrugs* in 1959 was 855,506, they comprised only about 251,504 Buryat-Mongols. The Tuvinians are of the Turkic group. The total number of Mongols living in the territory of historic Mongolia was therefore estimated in 1959–61 at about 2,784,504.

(K. Sm.)

*Partitioned Mongolia*

| Political units | Area (sq mi.) | Population (1959 census) |
|---|---|---|
| Mongolian People's Republic (independent) | 592,664 | 1,019,000* |
| Mongolian Autonomous Region (China) | 454,633 | 9,200,000† |
| Buryat Autonomous Soviet Socialist Republic | 135,637 | 673,326 |
| Agin-Buryat National Okrug (R.S.F.S.R.) | 7,954 | 49,109 |
| Ust-Ordynski Buryat National Okrug (R.S.F.S.R.) | 8,263 | 133,071 |
| Tuva Autonomous Soviet Socialist Republic (R.S.F.S.R.) | 65,830 | 171,928 |

*1963 census. †1957 est.

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**MONGOLIA, INNER,** an autonomous region (*ch'ü*) of the Chinese People's Republic, lies in northeastern China adjoining the Mongolian People's Republic. Its traditional nomadism has been replaced in the 20th century by agriculture and pastoral farming, largely due to Chinese influence.

In 1636, after the Manchus had succeeded in building an empire in northeastern China, they included in it southern Mongolia. In 1644 a Manchu prince became the first emperor of China of the Manchu or Ch'ing dynasty, and from that time southern Mongolia was known as Inner Mongolia, as opposed to northern or Outer Mongolia which remained independent. In 1691 Emperor K'ang Hsi subjugated Outer Mongolia also but the division of Mongolia into two parts remained.

Up to the end of the 18th century Chinese colonization of Outer Mongolia was strictly forbidden, but it made a considerable advance in Inner Mongolia. At the time of the Chinese revolution of 1911, which brought about the fall of the Manchu dynasty, there were more Chinese than Mongols in Inner Mongolia. As Outer Mongolia became autonomous under tsarist Russian protection, the Chinese republican government concentrated on the defense of Inner Mongolia against possible insurrections and stationed about 10,000 Chinese troops at Kalgan (*q.v.*). In 1914 revolts of Mongol *arats* (livestock breeders) broke out in various places, particularly in the region of Dolon-nor.

The events of 1921 in Outer Mongolia, which led to the establishment there of a *de facto* independent state, exerted an influence in Inner Mongolia. A Mongolian People's Revolutionary party was formed and the first session was held at Kalgan in 1925. The anti-Communist reaction in China in 1927 resulted in the execution of two leaders of this party, known as To Sung-nien and Li Yu-chih, and the party went underground.

When the Japanese seized Manchuria in 1931 and in the next year organized there the puppet state of Manchoukuo, they also exploited the anti-Chinese sentiments of the Mongolian princes. In 1939 they created in the western part of Manchoukuo a Mongolian "state" headed by Prince Teh (Teh Wang) and in 1943 they included in it other Mongol-populated parts of northeast China and called it the Sinan or Khingan autonomous province of Manchoukuo.

The Japanese defeat in 1945 was followed by a Chinese civil war and the conquest of all continental China by the Communists. In Nov. 1945 a meeting of people's delegates from western Inner Mongolia, held at Kalgan, set up a committee to work for the autonomy of Inner Mongolia. In Jan. 1946 a meeting of people's representatives of eastern Inner Mongolia took place at Gegen Sume, 25 mi. E. of Ulanhot (Wangyehmiao) and organized the autonomous government of Eastern Mongolia. A joint conference of representatives of eastern and western Inner Mongolia, held in March–April 1946 at Ch'eng-te (Jehol), set up the joint committee of the autonomy movement of Inner Mongolia under the veteran Communist Ulanfu (Yun Tse). In May 1946 the autonomous government of Eastern Mongolia was disbanded by the people's representatives of that state, meeting in extraordinary session at Ulanhot, and a Khingan provincial democratic government was set up. A joint meeting of the people's representatives of Inner Mongolia, held from April 23 to May 2, 1947, at Ulanhot, proclaimed the autonomy of the Mongolian districts of northeast China and Inner Mongolia within the boundaries of a free democratic China, under the title of Inner Mongolia. The autonomous democratic government of Inner Mongolia was formed on May 1, 1947, and Ulanfu was elected president. In July 1947 a provincial committee of the Communist party of China in Inner Mongolia was established with Ulanfu as its president.

At first the autonomous region comprised the lands that were formerly part of Heilungkiang, Liaohsi, Jehol and Chahar provinces, with a population (1951 est.) of 2,322,500. In June 1954, as a result of changes in the administrative organization of the Chinese People's Republic, the province of Suiyüan (*q.v.*) was included in the Mongolian autonomous region, with an additional population of 2,670,000 (1951 est.). The area of the enlarged autonomous region thus amounted to 454,633 sq.mi. and its population was 7,338,000 in 1953 and estimated to be 9,200,000 in 1957. According to a 1954 estimate, however, there were in China only 1,462,956 Mongols, mostly in the Mongolian autonomous region and in the former Ningsia (*q.v.*) province. This figure suggested that the proportion of Mongols in the Mongolian autonomous region was no more than 23%. In 1954 the capital of the autonomous region was moved from Ulanhot to Huhehot (formerly Kuei-sui), till then the chief town of Suiyüan. *See* also Mongolia; Mongolian People's Republic; Mongol; China.

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**MONGOLIA, OUTER:** *see* Mongolian People's Republic.

**MONGOLIAN LANGUAGE.** The Mongolian language consists of a group of dialects, spoken in various parts of Central Asia, which are related to other Altaic languages, such as Turkic (Turkish, Uzbek, Kazakh), Manchu-Tungus (Manchu, Goldi, Evenki), and Korean. Mongolian languages are divided into two main groups: western Mongolian, or Oirat, particularly Kalmyk, and eastern Mongolian, which includes Ordos, Kharchin, Chakhar, Buryat and Khalkha. Between World Wars I and II about 3,500,000 Mongols were living in various parts of Asia. At mid-century there were approximately 1,500,000 Mongols in Inner Mongolia. Buryat Mongolian is spoken by about 300,000 persons around Lake Baikal. Mogol, which is spoken in Afghanistan, Monguor, which is spoken in Kansu province, and Dagur, which is spoken in Manchuria, contain many archaic features. About 1,500,000 persons understand Khalkha Mongolian easily.

The pronunciation of Mongolian is comparatively simple. A characteristic feature is the existence of both long vowels and short vowels, *i.e.*, *der* ("pillow") and *deer* ("above"), *tara* ("butter") and *tooso* ("dust"), *khana* ("wall") and *khaanaa?* ("where?"). Another basic feature is called vowel harmony, the essence of which is that a single word may contain either back vowels only (*a, o, u*) or front vowels only (*e, ö, ü*). Initial accent is a common feature in the pronunciation of most words.

Mongolian is an agglutinative language group: the use to which a word is put is indicated by means of suffixes. Verbs have about 30 possible formative suffixes, and nouns have seven regular declensional suffixes. In declensions the suffixes are the same for all nouns, modified only by the requirements of vowel harmony. Note the following example: *gar* (nominative "hand"), *garin* ("of the hand"), *garta* ("in the hand"), *garig* (accusative "hand"), *garaas* ("from the hand"), *garaar* ("by means of the hand"), *gartay* ("along with the hand"). Each suffix has only one function, *e.g.*, Khalkha *akhnartan* ("to his elder brother"), *akha* ("elder brother"), *-nar* (a plural suffix), *-ta* (dative suffix), and *-n* (possessive ending "his"). There are no prepositions but only postpositions, *e.g.*, *uula deer* ("on the mountain"), *uula* ("mountain") and *deer* ("on"), *usan dotora* ("in the water"), *usan* ("water") and *dotora* ("in"), *tiinii orondo* ("instead of you"), *tiinii* (genitive "of you") and *orondo* ("instead"). Mongolian has no grammatical gender, and there is little distinction in form between the use of words as nouns or adjectives.

The syntax is characterized by a strict word order. The verb is the last element in a sentence or clause. Note the following

sentences: *aawa namaig surguulid yawuulawa* ("father sent me to school"), *aawa* ("father"), *namaig* ("me"), *surguuli* ("school"), *-d* (dative suffix), *yaw-* ("to go"), *-uul* (causative suffix), and *-awa* (past tense suffix); *tŝi yawawal bi haniladž yawayii* ("if you go, I'll go with you"), *tŝi* ("you"), *yawa-* ("to go"), *-wal* (conditional suffix), *bi* ("I"), *hanila-* ("to accompany"), *-dž* (auxiliary verb suffix), *yawa-* ("to go"), and *-yii* (voluntative suffix); *Ulaan Baatart suusaar önöödör tawan džil boldž baina* ("it is now five years since he has been living in Ulan Bator"), *Ulaan Baatar* ("Ulan Bator"), *-t* (dative suffix), *suu-* ("to reside"), *-saar* (subsequent time suffix), *önöödör* ("today"), *tawan* ("five"), *džil* ("year"), *bol-* ("to become"), *-dž* (auxiliary verb suffix), *bai* ("to be"), and *-na* (present tense suffix).

The Mongolian alphabet was received from the Uigurs, a Turkic people, in the 13th century. The latter took it from the Sogdians, an Iranian people. The Sogdian alphabet was an adaptation of a Semitic alphabet (Aramaic). The Mongolian alphabet was written vertically downward. After 1941 the Cyrillic alphabet was introduced into the Mongolian People's Republic (Outer Mongolia). It contains additional letters to indicate the front vowel sounds ü and ö. It is now the official alphabet in the Mongolian People's Republic.

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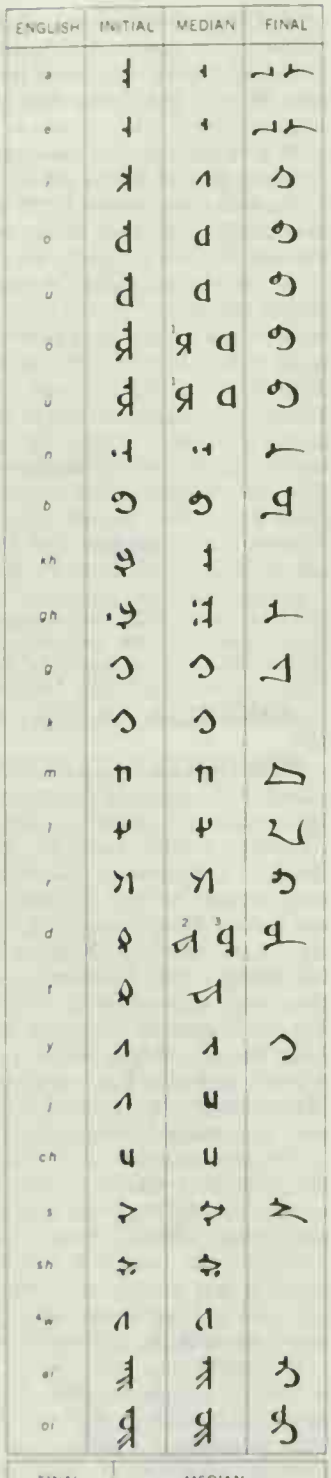
(F. H. Bx.)

**MONGOLIAN LITERATURE** begins with the *Secret History of the Mongols*, an imperial chronicle dealing with the life and times of Genghis Khan and his successors, written A.D. 1240.

*Uligers*, orally transmitted epic stories in verse, form the bulk of native literary expression. Highly stylized, they relate adventures of legendary heroes and villains. In spite of their great length (sometimes more than 20,000 lines), they are recited from memory by bards. Like the *Iliad*, the *Aeneid* and other epics, they are genuine artistic creations. The verses alliterate in couplets or quatrains, are seven or eight syllables long and are characterized by parallelism. Much phraseology is common to many epic poems. Besides Genghis Khan, there are heroes such as Erintsen Mergen, Engke Bolod Khan and Geser Khan (the last of Tibetan origin). The villain of the epics is the many-headed monster, the *manggus*, whom the hero always defeats.




MONGOLIAN ALPHABET. [1]USED ONLY IN FIRST SYLLABLE. [2]USED BEFORE VOWELS. [3]USED BEFORE CONSONANTS. [4]USED ONLY IN FOREIGN WORDS

Historical chronicles represent another important form of indigenous literature. Usually beginning with the creation of the world from primordial elements, they attempt to link the Indian and Tibetan rulers into the house of Genghis Khan. Such are the *Altan Tobchi* ("The Golden Button"), composed about 1604 and giving a world history down to Ligdan Khan (1604–34), and another *Altan Tobchi* of about 100 years later. The *Erdeni-yin Tobchi* ("The Jeweled Button") became known in the west as early as 1829 when a Russian savant, I. J. Schmidt, published it in Mongolian with a German translation and commentary. It is by Sagang Sechen.

Mongolian literature was profoundly influenced by the introduction of Buddhism around the end of the 1500s. Earlier surviving works (on stone or paper) are mostly official documents. No oral epics were written down until the late 1880s. The advent of Buddhism evoked translations of its sacred writings and related works. A Buddhist canonical collection, the *Kanjur* (comprising the *sūtras* and *vinaya* of the Tripiṭaka), was translated and printed in 1635 in 108 volumes; the *Tanjur*, containing canonical commentary and noncanonical works in its 225 volumes, followed in 1741. Two especially well-known sermons (*sūtras*) of Buddha are the "Golden Beam" (*Altan Gerel*) and the "White Lotus" (*Chagan Lingqua*), best called by their Sanskrit names, *Suvarnaprabhāsa* and *Saddharmapuṇḍarika*. However, none of these works is indigenous.

The religious but nondogmatic birth stories (Sanskrit *Jātaka*) deal with Buddha's meritorious deeds, and like the parables of Christianity illustrate religious truths. Best known is the *Uligerün dalai* ("The Sea of Stories"). Translations of other Indian fables are the "Tales of the Vampire" (*Siddhi Kür*) and the "Saga of King Vikramāditya" (Mongolian *Bigarmijid*).

In the 18th and 19th centuries Chinese traders brought from China many Mongolian translations of Chinese novels of enchantment and romance, including the *San-kuo chih* and others.

In the early 20th century T. Zhamtsarano, a Russian-educated Buriat writer and intellectual, founded the short-lived Mongolian newspaper *Shine Toli* ("The New Mirror"). He also translated the works of some western authors, such as Edgar Allan Poe, Jules Verne and H. G. Wells. The outstanding modern writer is Damdin Surun. After the establishment of the Mongolian People's Republic in 1924, a body of realistic literature patterned on Soviet models emerged, and the old tales were rapidly forgotten.

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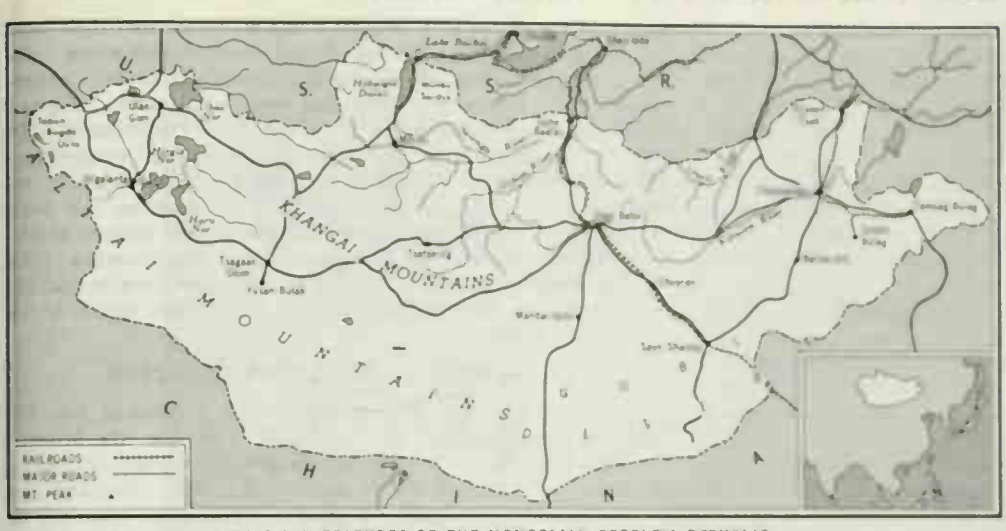
(J. Kr.)

**MONGOLIAN PEOPLE'S REPUBLIC** (BÜGEDE NAYRAMDAH MONGOL ARAD ÜLAS), formerly known as Outer Mongolia, is an independent state in eastern central Asia bounded on the north by the Russian Soviet Federated Socialist Republic, U.S.S.R., and on the east, south and southwest by the People's Republic of China. Area 592,664 sq mi. Pop. (1963) 1,019,000. For physical geography and early history *see* MONGOLIA; for the people *see* MONGOL; *see* also CHINA.

**Mongolian Autonomy Proclaimed.**—In the endeavour to transform the greater part of Mongolia into a buffer state between Russia and China, the Russian tsarist diplomacy traditionally backed the autonomist tendencies of Mongolian princes and lamas. This policy succeeded because the Mongols feared Chinese colonization of their lands. The new Mongol nationalism looked abroad for support and found that only Russia was interested in giving




PHYSICAL FEATURES OF THE MONGOLIAN PEOPLE'S REPUBLIC

it. On Aug. 4, 1911 (new style), the tsarist government decided "to play an active part in the Mongolian question." Early in November the general commanding the Irkutsk military district delivered 15,000 rifles, 7,000,000 cartridges and 15,000 sabres to Mongolian princes. On Nov. 18, three months before the abdication of the emperor of China and the proclamation of the Chinese republic, the Living Buddha of Urga (Ulan Bator) was proclaimed *bogdo khan* of Outer Mongolia. A government was set up and a military force of 20,000 was trained by Russian officers and noncommissioned officers of Russian Mongol (or Buryat) nationality. Tsarist Russia, however, did its best to prevent the Mongolian state from having diplomatic relations with any foreign power and to circumscribe Mongolian territorial aspirations toward Inner Mongolia, Barga in Manchuria, or Urianghai (Tannu Tuva), a region whose Turkic-speaking population was under Russian protection.

In the summer of 1912 Ivan Korostovetz, former Russian minister to Peking, was sent to Urga to negotiate a Russo-Mongolian treaty. On Nov. 3 (N.S.) he signed a treaty with Sain Noyan Khan, the Mongolian prime minister, which proclaimed that "the old relations between Mongolia and China were at an end," but did not recognize the full independence of Mongolia. For all practical purposes the treaty created a *de facto* Russian protectorate in Outer Mongolia.

**Autonomy Abolished.**—The fall of the tsarist régime in 1917 caused the temporary abolition by China of Mongolian autonomy. As soon as it learned of the success of the Communist revolution in Russia, the Mongolian government closed the Russo-Mongolian frontier and refused to receive a Soviet representative in Urga. In Oct. 1919 Gen. Hsü Shu-tseng, formal representative of the central Chinese government but actually an agent of the pro-Japanese Anfu party then in power in northern China, arrived at Urga. With 6,000 Chinese soldiers at his disposal he presented the Mongolian government with a 36-hour ultimatum demanding the abolition of autonomy. The government accepted, and a petition to restore the old relations was signed, though not by the Living Buddha. On Nov. 22, the president of the Chinese republic accepted the petition, agreeing to preserve the dignity of *bogdo khan*, the title assumed by the Living Buddha eight years before, but declaring all treaties concluded between Russia and Mongolia null and void. The Mongolian army was disarmed.

The Chinese success was, however, of short duration. In Oct. 1920 Mongolia was invaded by a White Russian force of 5,000 horsemen (Russian and Buryat) commanded by Baron Roman von Ungern-Sternberg, a soldier of fortune who declared himself for the idea of Pan-Mongolism. He occupied Urga on Feb. 3, 1921, but not for long. Since the end of 1919 there had existed in Urga two secret Mongolian groups plotting for independence and a new social order: one led by Sühe Baator (1893–1923) and Danzan Khorlo, officers of the first national Mongolian force, and the other by Khorloghiyin Choybalsan (1895–1952), a Communist sympathizer. On Soviet advice the two groups merged in 1920 to form a Mongolian People's party. On March 13, 1921, the new party established a revolutionary provisional government in Kyakhta, on the Russian side of the frontier. In June a Soviet army, with Mongolian units under Sühe Baator, defeated Ungern-Sternberg and on July 6 entered Urga. A national government headed by Lama Bodo was formed, while the Living Buddha was invited to limit his activities to religious affairs.

**Autonomy Restored.**—On Nov. 5, 1921, Lama Bodo and G. V. Chicherin, the Soviet people's commissar for foreign affairs, signed a Soviet-Mongolian treaty of friendship in Moscow. This recognized Outer Mongolia as an independent state and omitted all mention of its relations with China. At the same time a northwestern corner of Outer Mongolia, the Urianghai, was proclaimed the independent republic of Tannu Tuva under Soviet protection. In April 1922 the Soviet political police claimed to have discovered that the head of the Mongolian government was a "Chinese spy"; Bodo was arrested and shot (Aug. 30) with 15 other "pro-Chinese plotters."

Events in Mongolia, however, did not divert the Soviet leadership from their concern with developments in China, and from 1921 they made every effort to increase their influence there. On May 31, 1924, a Soviet-Chinese agreement, signed by L. Karakhan, Soviet ambassador, and Wellington Koo, Chinese foreign minister, recognized China's sovereignty over Outer Mongolia and promised the withdrawal of Soviet troops. "We recognize the Mongolian People's Republic as part of the Chinese republic," commented Chicherin, "but we recognize also its autonomy in so far-reaching a sense that we regard it not only as independent of China in its internal affairs, but also as capable of pursuing its foreign policy independently."

Meanwhile, on May 20, 1924, the Living Buddha had died in Urga, and no new incarnation was permitted. On Aug. 4 the third congress of the Mongolian People's party opened in Urga, at which Danzan Khorlo, the commander in chief of the Mongolian army, made an "anti-Russian" speech. He was arrested, sentenced to death and shot as a "Japanese spy." (His friend Sühe Baator had died on Feb. 22, 1923, believed poisoned by the "enemies of the people.") The third congress prepared a draft of a new Mongolian constitution and changed the name of the party to the Mongolian People's Revolutionary party. On Nov. 26, 1924, the great people's khural (parliament) voted the new constitution and changed the name of Urga into Ulan Bator (*q.v.*), meaning Red Hero. At the beginning of 1925 Soviet troops were withdrawn from Mongolia.

**Soviet-Mongolian Alliance.**—China was too absorbed by its internal troubles to do anything about its theoretically recovered sovereignty over Outer Mongolia. In 1931 an entirely new situation was created by the Japanese invasion of Manchuria. In the same year Choybalsan joined the Mongolian government as foreign minister. On Nov. 27, 1934, Gendung, the prime minister, and Choybalsan concluded an agreement with M. M. Litvinov, the Soviet people's commissar for foreign affairs, which amounted, though not explicitly, to a Soviet-Mongolian military alliance. Soon afterward Gendung was killed as a "Japanese spy" and Choybalsan became prime minister. On March 17, 1936, a formal treaty of alliance was signed at Ulan Bator between the U.S.S.R. and Mongolia, and Soviet armed forces reoccupied the territory of the sister republic. On July 7, 1937, Japan began the invasion of China and in the following month General Demid, commander in chief of the Mongolian army, died from poisoning in the train on his way to Moscow. He was succeeded by Choy-

balsan, who was made general and later marshal.

The Soviet-Mongolian alliance was implemented by the Soviet forces in the summer of 1939 when a Japanese army under Lieut. Gen. Kamatsubara attempted to invade eastern Mongolia. On the Soviet-Mongolian side Gen. G. K. Zhukov had at his disposal a stronger force, and the principal battle was fought (Aug. 20–31) on the Khalkhin gol (river). The Soviet-Mongolian forces lost 9,824 dead while the Japanese losses (according to Soviet sources) were about 25,000 killed. Hostilities ended on Sept. 15 and four days later a mixed commission was set up to define the frontier between Mongolia and Manchuria.

**Independence Proclaimed.**—Henceforward the U.S.S.R. was firmly established in Mongolia. The situation was recognized (in a secret agreement disclosed on March 24, 1947) not only by Great Britain and the United States at Yalta (Feb. 11, 1945) but also by Nationalist China (Aug. 14, 1945), with the face-saving formula of a plebiscite. This took place on Oct. 20, 1945. The world was told that 487,409 citizens of the Mongolian People's Republic, *i.e.*, 98.4% of those entitled to vote, had gone to the polls and not a single vote was cast against independence. On Jan. 5, 1946 Nationalist China officially recognized the independence of the Mongolian People's Republic and on Feb. 27 a new Soviet-Mongolian treaty of alliance was signed. In 1946 the government applied for admission to the United Nations (*q.v.*) but was rejected the following year because it had not exchanged diplomatic representatives with other UN members except the U.S.S.R. Only in April 1950 was Mongolia permitted to establish diplomatic relations with other people's republics. On Sept. 28, 1952, Yumzhaghiyin Tsedenbal, chairman of the Mongolian council of ministers, arrived in Peking. The following day Mao Tse-tung (who in 1936 had expressed his hope of seeing Outer Mongolia as a part of the Chinese federation) received the head of the Mongolian government, the first to visit the Chinese capital officially. On July 31, 1954, Chou En-lai, the prime minister of the Chinese People's Republic, visited Ulan Bator. This, too, was the first visit of a Chinese statesman to Outer Mongolia since it had ceased to be part of China.

Sandwiched between two great powers, the Mongols were successful in establishing their independence. Confronted by deteriorating relations between the Soviet Union and Communist China, Mongolia maintained its traditional alliance with the U.S.S.R. The Mongolian People's Republic, paired with Mauritania (formerly French West Africa), was admitted to the UN in Oct. 1961.

## POPULATION

About 90% of the inhabitants of the Mongolian People's Republic are Mongols. Two-thirds of them speak the Khalkha-Mongolian language, while the Oirat-Mongolian dialect is used in the western provinces. In the west also there are Turkic-speaking minorities (Kazakhs and Uighurs). A certain number of Russians, mainly advisers, technicians and skilled workers, and about 20,000 Chinese, mostly workers, live in the towns. In 1925 the total population was estimated at 651,700 and in 1956 at 845,500. The 1963 census recorded a total population of 1,019,000. Before 1921 the Mongolian population was slowly dying out. Its increase within the frontiers of the Mongolian People's Republic is explained by the improvement of health measures and a decrease in venereal diseases, which were formerly widespread. In 1960 the natural increase of population was said to be 31.2 per 1,000, while in 1955 it had been only 15.1 per 1,000.

Urbanization of the country has progressed. Ulan Bator, the capital, had 204,000 inhabitants in 1963. In 1959 the town of Choybalsan had 10,900, Jirgalanta (Hobdo) 5,800, Tsetserlig 9,000 and Sühe Baatar 12,000.

**Religion.**—Tibetan Buddhism (*q.v.*), influenced by and in competition with native shamanism (*q.v.*), was until the revolution the state religion in Mongolia. The Living Buddha of Urga, sometimes described as Khutukhtu (saint), was both religious head and national leader and was recognized as such by the Mongolian princes, although this was resented by the Manchu dynasty. The Living Buddha had the largest number of *shabinar* or serfs. At the beginning of the 20th century it was estimated that their total number was 150,000. This meant that together with about 150,000 lamas (including 40,000 living permanently in 747 monasteries), about half of the population was directly under religious jurisdiction. After the death of the last Living Buddha in 1924 this situation began to change. Officially, freedom of religion prevails, but by the mid-20th century Buddhism was subject to restriction and control. The majority of monasteries had been destroyed or turned to secular uses. A few former temples of historic and artistic value had been transformed into museums. The Ganden monastery in Ulan Bator and four other temples had re-established their religious function, and the Mongol capital had a few dozen lamas.

## GOVERNMENT AND ADMINISTRATION

The first constitution of 1924 was replaced by that of June 30, 1940, slightly amended in 1949 and 1952. By this, "the Mongolian People's Republic is an independent state of *arats* (livestock breeders), workers and intelligentsia, who have abolished the imperialist and feudal yoke, ensuring a noncapitalist approach to the development of the country to pave the way to the Socialism of the future." All the land and its natural resources belong to the people and private ownership of them is forbidden, but the right of citizens to private ownership of livestock, agricultural implements, houses, yurts (tents), incomes and savings, as well as the right of inheritance of private property, "is protected by law."

The republic consists of 17 *aymags* (regions) subdivided into *somons* (districts). The capital city of Ulan Bator is an independent administrative unit. (*See* Table.)

The highest organ of state authority is the great people's khural composed of deputies elected for three years on the basis of one for every 2,500 of the population, with universal franchise from the age of 18. The first general election took place on June 10, 1951. There were 295 constituencies in which 489,031 citizens recorded their votes (99.9% of the electorate); 487,358 voted for official candidates.

*Administrative Aymags (Regions) of the Mongolian People's Republic (1963)*

| *Aymags* | Chief cities |
|---|---|
| Töb (Tub) or Central | Dzuo-modo |
| Hentey (Kentei) | Öndör Haan (Undur-Khan) |
| Doronod (Choybalsan) | Choybalsan (Choibalsan) |
| Sühe Baator (Sukhe-Bator) | Barun-Urt |
| Dorono Gobi or East Gobi | Savn Shanda (Sain-Shanda) |
| Dunda Gobi or Middle Gobi | Mandal-Gobi |
| Ömönö Gobi (Umnu) or South Gobi | Dalan Dzadagad |
| Ara Hangay (Ara Khangai) | Tsetserlig (Tselserlik) |
| Bayan Hongor (Bayan-Khongor) | Bayan Hongor |
| Gobi Altay (Gobi-Altai) | Yusan-Bulak |
| Hobdo (Kobdo) | Jirgalanta |
| Bayan Ölögey (Bayan-Ulegei) | Ölögey (Ulegei) |
| Ubsa Nur (Ubsu Ilur) | Ulaan Goom (Ulan-Gom) |
| Dzabhan (Dzabkhan) | Jibhalanta (Ulyassutai) |
| Hövsögöl (Khubsugul) | Mörön (Muren) |
| Bulagan (Bulgan) | Bulagan (Bulgan) |
| Öbör Hangay (Ubur Khangai) | Arbay Heere (Arbai Khere) |
| Selenge | Sühe Baatar |

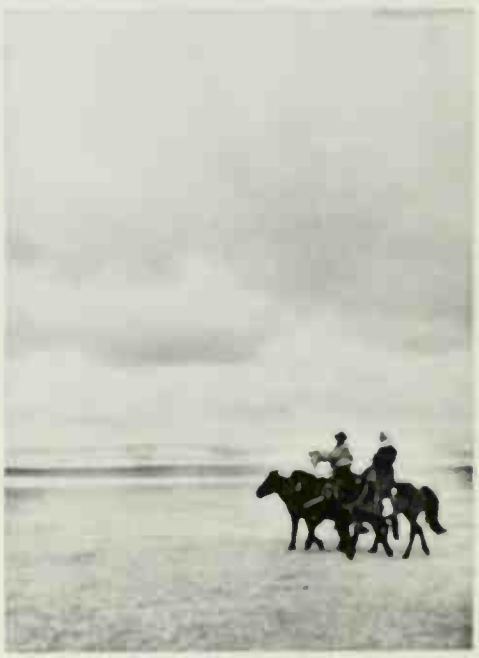
Regular sessions of the great people's khural are convened once a year. Between the sessions the presidium of the khural assumes the function of the highest state authority. The great khural appoints the council of ministers. There are local khurals in the city of Ulan Bator and in every *aymag* and *somon*. Justice is administered by the supreme court of the republic, by the city court of Ulan Bator and by the *aymag* courts.

There is only one political party, the Mongolian People's Revolutionary (Communist) party. From 1940 Tsedenbal was the party's first secretary, combining this post with that of chairman of the council of ministers (premier) from 1952, when Choybalsan died (Jan. 26). In April 1954 he was succeeded as the party's first secretary by Dashiyin Damba, but in Nov. 1958 he again assumed the first secretaryship without abandoning the premiership. In March 1959, Damba, accused of conservatism, was dismissed from the party's politburo, together with five other members of this body.

**Education.**—Great strides have been made in combating illiteracy. In 1921 there existed in the entire country only one

Bulagan, the capital of Bulagan Aymag (region) in northern Outer Mongolia, at the foot of the Khangai mountain range

A street scene in Ulan Bator, the capital of the Mongolian People's Republic. Behind the city are the hills of the Choybalsan-Uly range



Horses still are favoured by Mongolians for transportation over the vast steppes of their country

Walls of the Erdeni-Dzuu monastery, built in 1586. It stands on the ruins of the Mongol capital erected during the reign of Ogadai Khan on the banks of the Orhon river in central Mongolia

A village of yurts, Mongolian tents, near Ulan Bator. Many Mongolians live in yurts, which are easily folded and transported to new locations

VIEWS OF MONGOLIAN PEOPLE'S REPUBLIC

PHOTOGRAPHS: [illegible]

# MONGOLIAN PEOPLE'S REPUBLIC

A Mongolian wrestler instructing children. Now the national sport, wrestling once was a discipline required of all Mongolian warriors

Mobile refreshment stands serve horsemen gathered outside Ulan Bator. The occasion is National day, July 11, when visitors from all parts of the country customarily journey to the capital to attend festivities

## PEOPLE OF MONGOLIAN PEOPLE'S REPUBLIC

A meeting of farm workers. Such meetings are part of the government's drive to develop agriculture

Harvesting grain on the Batorsumbul state farm in northern Mongolia. State farms mainly grow wheat, oats and vegetables

Woman textile workers at an Ulan Bator textile factory. Such processing industries, based on animal products, are most highly developed in Outer Mongolia

PHOTOGRAPHS: (TOP LEFT) SHARMA—CAMERA PRESS—PIX FROM PUBLIX; (TOP RIGHT) P. N. SHARMA—PIX FROM PUBLIX; (CENTRE RIGHT) ERIC LANDAU FROM RAPHO GUILLUMETTE; (BOTTOM LEFT) SHARMA PRESS—PIX FROM PUBLIX; (BOTTOM RIGHT) SHARMA—ID FROM THOSE LIONS

school with 40 pupils (excluding, of course, the lamaistic schools in the monasteries). By 1960 there were 419 public schools for general education with 131,046 pupils, the great majority being four-year schools, compulsory and free of charge for all children between the ages of 8 and 12. In the towns there were about 30 seven-year and 24 ten-year schools, 15 vocational schools and 7 institutions of higher education, including the Mongolian State university which was opened in 1942 and had 1,767 students in 1960. In that year, a total of 4,982 students were enrolled in higher schools. Between 1935 and 1956 literacy increased from 5.8% of the population to 72.2%. In 1941 the government of the republic replaced the old Mongolian alphabet by one based on the Cyrillic, and the old Mongolian numerals by Arabic. (K. SM.)

## ECONOMY

Pastoral pursuits still formed the livelihood of more than 80% of the population into the second half of the 20th century, while from 70%–80% of the commodity production and more than 80% of the total exports derived from animal products. The total number of domestic stock in 1918 was only 12,700,000. This had risen to 27,500,000 in 1941. However, evidences of deteriorated ranges indicated that perhaps this number resulted in overcrowding of the grasslands. Efforts to increase numbers further have been unsuccessful, partly because of heavy annual stock losses from wolf attacks, diseases, droughts and severe winters. The winters of 1941–42 and 1944–45 resulted in such losses that total livestock numbers in 1947 were only 21,000,000. In the 1960s the number generally ranged between about 22,800,000 and 25,000,000. No other land on earth has so high a number of livestock per capita—approximately 24 for each person.

Most Mongols are *arats* or private owners of flocks and herds who follow their animals from one pasture land to another. The practice of providing fodder for winter feeding has been extensively introduced by the Russians. By the 1960s an estimated total of 1,700,000 tons of hay was reported to have been gathered annually for winter use.

Cultivation is severely limited by low rainfall and a short growing season. The Mongols traditionally have abhorred agriculture and have generally left it to be carried on by Chinese and Russians. Approximately 175,000 ac. were under cultivation in 1912 but with decreased Chinese influence in the 1920s and 1930s this total fell to between 25,000 and 50,000 ac. Russian pressure during World War II resulted in the cultivation by 1944 of over 197,000 ac. distributed as follows among the major crops: wheat and rye, 87,450 ac.; oats, 43,960 ac.; barley, 40,500 ac.; millet, 18,280 ac.; and legumes and garden products, 8,150 ac. With the end of the war the total acreage declined and by 1947 was less than half the 1944 total. Thereafter Soviet prodding brought the total up to more than 2,000,000 ac. by 1960. Most of this land is state operated and is concentrated in the valleys of the Selenga, Orhon and Onon rivers. Some of the crop land is irrigated.

Minerals found in the Mongolian People's Republic include non-coking brown coal extracted from the mines in the Nalaikha coalfields (*see* also MONGOLIA). Coal is carried by rail to Ulan Bator where it is used for heat, electric power and light. Other coal deposits are being exploited near Choybalsan and at four other localities. Another source at Tawan-Tolgoi on the Trans-Mongolian railroad in the eastern Gobi also gave promise of future importance. Total annual coal production for the country, under 350,000 tons in the mid-1950s, exceeded 750,000 tons by 1960.

Oil fields were found in the Sayn Shanda region in the eastern Gobi district and were said to supply a significant part of Mongol oil requirements. Other important minerals were copper, lead, zinc, silver, gold, manganese, antimony, tungsten, tin, mercury, graphite and sulfur. Salt was extracted and limestone processed for cement and lime. A Soviet-Mongol agency had charge of all mineral development until 1957 when control and investments were turned over to the Mongol state on condition that the latter was to amortize its debt to the Soviet Union in 30 years.

Industry, mining, transport, trade and professions (excluding the armed forces) employ an estimated 90,000 persons, the bulk of these being Mongols. Industries are primarily concerned with animal products such as meat, fur and butter. Some 500 food-processing enterprises are said to produce about 45% of the country's industrial output.

Before 1921, Chinese merchants monopolized most of Mongolia's trade. By 1931 a Soviet trade agency, Stormong, had taken over the monopoly. External trade was later monopolized by Mongol state agencies. In internal trade, however, some 53% was handled by Mongol co-operatives, while state agencies handled 40%. Wool and live animals each comprised 30% of the exports. The north-south railroad through the capital was opened in Jan. 1956, connecting Peking with Siberia. A spur line runs south to Choybalsan from the Trans-Siberian railroad near the Manchurian border. Motor highways run roughly east-west through the middle of the country from Man-chu-li to the Soviet border at Kusch Agatsch, as well as north-south through the capital from the Soviet border to Dalan Dzadagad. A network of telephone and telegraph lines connects important places and there are also radio stations and airfields. (H. J. WS.)

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**MONGOLOID,** a term used to designate one of the hypothetical major racial stocks or ethnic divisions of mankind, the others being Caucasoid (*q.v.*) and Negroid (*see* NEGRO). Mongoloids are supposed to resemble, in one way or another, the Mongols (*q.v.*). The use of the word as a racial designation implies that such resemblances are of a biological, hereditary nature rather than linguistic or cultural. In the narrower sense the name Mongoloid is applied only to those peoples who, like the Chinese, Japanese and their neighbours, are most like the Mongols. By extension, however, it has been applied to other populations which are supposed to be related to them. Such populations include the American Indians and the Indonesians or Malayans. Even such groups as the Lapps and Polynesians are thought by many authorities to be partially Mongoloid in ancestry.

**Physical Characteristics.**—It has long been apparent that differences exist in the typical appearance of members of different tribes and nations. The extent to which these differences are due to genetic rather than environmental causes has been much debated, but the fact that there are differences in appearance is obvious. Almost all natives of the countries of eastern Asia, for instance, have dark eyes, very dark coarse straight hair, and skin which, being less florid than that of Europeans, ranges in shade from pale ivory to deep yellow-brown. Their facial features are molded more smoothly than those of Europeans or Africans, and facial hair is scanty in both sexes, so that the difference between men and women in this respect is minimized. The cheekbones jut forward, neither the chin nor the brow ridges are prominent, and the bridge of the nose is rather low. In a large majority of individuals the eye appears to slant because a fold of skin covers the inner edge of the eyelid. The body tends to be stocky, with relatively short legs, and body hair is almost absent even among men, while among women the breasts are usually rather small.

In southeast Asia, and even more in Indonesia, the inhabitants tend to be shorter and slighter in build. The average skin colour is darker, the lips fuller, the nose broader. Men, at least, are less likely to have the epicanthic eye fold; women are more likely to have larger breasts. Wavy hair is less uncommon. The resemblance to the Chinese and Japanese is, however, quite obvious. Among American Indians, in contrast, a great range of intertribal variation is found. Typically, women have a closer resemblance to the peoples of eastern Asia than do men, for the latter, among many tribes, have high-bridged noses, prominent brow ridges and

marked angularity in features generally. Facial and body hair is very scant, but baldness and even graying of hair with age are rare. The skin colour may be pale but is commonly even darker than among the peoples of Indonesia. A closer examination shows that American Indians resemble the peoples of eastern Asia, but differ from most other peoples, in the high frequency among them of shovel-shaped incisor teeth, a counterclockwise lambdoidal hair whorl, the Inca bone at the back of the skull and arches rather than whorls in the fingerprints. It is probable that these characters, like hair and eye pigmentation and hair quantity, are altered very little by environmental effects, which makes them much more useful as criteria of ancestral relationship. Indeed, since races are populations which differ in the relative frequencies of genes, there would be no assurance that the Mongoloids are a racial stock unless it could be demonstrated that their similarities, and the ways in which they differ from other ethnic groups, are genetically based. (*See* also FACE; HAIR.)

**Blood Types and Biochemistry.**—Knowledge of the mode of inheritance of human characteristics is most inadequate, but enough has been learned, especially in the field of serology, to make it possible to say that Mongoloid populations, whether in America or Asia, have a very low frequency of the allele for bloodtype $A_2$ in the ABO series, of the alleles for the blood types known as $R^o$, $D^u$, and negative in the Rh series, and lack the alleles for the abnormal hemoglobins which lead to sicklemia or thalassemia. These same populations have a rather low to very low frequency of the alleles for blood types N and Duffy negative, for red-green colour blindness and for absence of the palmaris longus muscle (in the forearm), as contrasted with other human populations. Only among Mongoloid populations has the allele for the blood factor Diego been demonstrated to exist. Studies of characters of which the mode of inheritance is known are in general agreement with previous studies and serve to define more precisely the characteristics which unite Mongoloid populations.

Such studies have also served to define the differences between various populations of Mongoloid origin. American Indians, for instance, apparently lack the alleles for blood types B, $A_2$ and Rh negative completely; and even $A_1$, with the exception of a few tribes, is a rare allele. Very few tribes seem to possess the allele for type $R^o$, but many possess an especially high frequency of $R^2$, in the Rh series. Japanese, as contrasted with Chinese, have a lower frequency of B and of $R^o$ alleles, but a higher frequency of the allele for the peroneus tertius, one of the anterior muscles of the lower leg. The greater frequency of hair on the lower legs of the Japanese as contrasted with the Chinese suggest further genetic differences between these two populations. These are, however, minor as compared to the differences between the Asian Mongoloid and the American Indian populations.

**Ecology.**—Ecological adaptation would appear to offer the most plausible explanation for some, but by no means all, of the features which distinguish Mongoloid from non-Mongoloid populations. Stocky build, short limbs, facial hairlessness and the general conformation of the face should provide advantages to a well-clothed arctic hunter; and it is true that these characteristics are found most frequently among those populations, such as the Eskimo and the Tungus, which inhabit the coldest areas of Siberia and North America. Adaptation to a lack of iodine in central Asia has been advanced as an explanation of the type and distribution of hair and of the high frequency of roundheadedness. There certainly seems to be a high correlation between average weight and climate, and some correlation between nose breadth and climate, among the various Mongoloid populations. Pedomorphism, or the retention into adult life of youthful characteristics, has been suggested as an explanation for such traits of the Asian Mongoloids as their short legs, lack of hirsuteness, lack of facial angularity and the small size of the female breast. It should be noted that none of these conjectures are mutually exclusive.

**Archaeology.**—It must also be noted that paucity of archaeological evidence prevents us from knowing for how long a period the characteristics of Mongoloids have been distinctive. The earliest skeletal remains from the Americas resemble those of the Indians of historic times, but they are not very early. *Sinanthropus*, who lived in north China during the second interglacial period, had shovel-shaped incisors, but he was anything but pedomorphic and is not even regarded as a member of the species *Homo sapiens*, to which all living races belong. Among a group of much later inhabitants of this same locality, one only, a female, resembles a typical Mongoloid. The earliest skulls from Japan, more recent in date, bear some resemblance to those of modern Japanese; and by the time of the Neolithic period, skeletal remains from China appear to be those of Chinese. In Indonesia, crania like those of the modern inhabitants seem to be relatively recent.

About one-third of the living inhabitants of the world are members of one or another of the Mongoloid populations. At the time of the discovery of America by the Europeans the proportion was probably greater. Historical and archaeological evidence both indicate that there has been a continuous drift of peoples from the general area of northern China to the south for thousands of years, as well as sporadic movements to the west and into the Pacific. Archaeological and genetic evidence indicate that the movement of tribes or bands into America took place much earlier, and for the most part before the Asian Mongoloids had evolved all of their present characteristics.

*See* ANTHROPOLOGY: *Physical;* RACES OF MANKIND; *see* also references under "Mongoloid" in the Index.

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**MONGOOSE,** any of the small carnivorous mammals of the subfamily Herpestinae of the civet family (Viverridae). Many different kinds are found throughout Asia and Africa, one of the African species extending into southern Spain. The common mongooses (*Herpestes* species) are characterized by a sharp snout, small ears, short legs and a long tail; their general colouring is grayish-brown, in a "pepper-and-salt" pattern, some species having darker or lighter markings on the head, throat or tail. When angry or excited, they erect their long hair, especially that on the tail.

Among the common mongooses are the African ichneumon (*H. ichneumon*) and the Indian mongoose (*H. edwardsii*), the "Rikki-tikki-tavi" of Kipling's famous story in *The Jungle Book* (1894). The ichneumon is the largest of the group, attaining about 40 in., half of which is bushy tail; dwarf mongooses (*Helogale*) are about half that size. Africa has many other forms, including the marsh (*Atilax*), striped (*Mungos*) and white-tailed (*Ichneumia*) mongooses.

All mongooses are active, bold predators, seeking their prey on the ground and rarely climbing trees; they feed on small mammals, birds, reptiles, insects, eggs and occasionally fruit. Mongooses live in burrows that they excavate themselves, and are often found in small parties, perhaps families. It is well known that a mongoose will attack and kill poisonous snakes, darting upon the head of the snake and cracking the skull with a powerful bite. It is not immune to the snake's poison, nor does it seek and eat a herbal remedy if bitten, but avoids the snake's fangs by its amazing quickness in dodging when the snake strikes. A mongoose is easily tamed and makes a good pet; but the Indian mongooses introduced into Jamaica to kill the rats destroying sugar cane have worked havoc upon the native fauna of the island.

*See* also CARNIVORE. (L. H. M.)

**MONISM:** *see* PLURALISM AND MONISM.

**MONITOR, NAVAL,** a type of warship designed originally for use in shallow harbours and rivers for the blockade of the Confederate states, 1861–65. A minimum draft was essential and protection against gunfire from enemy artillery or fixed fortifications was necessary. The need for pointing guns at a target when the ship could not be maneuvered led to the revolving turret.

John Ericsson designed a vessel that met the essential specifications and suggested the name "Monitor." The dramatic battle between the "Monitor" and the "Merrimack" on March 9, 1862, caught the attention of the world and resulted in the building of many similar vessels for the U.S. navy. Unfortunately many

errors were made in evaluating the genuine merits, capabilities and limitations of the monitor type. (*See* "MONITOR" AND "MERRIMACK," BATTLE OF.)

The original "Monitor" conformed to the essential specifications, as noted above, but the ship was not seaworthy. While enroute from New York to Chesapeake bay for her famous battle, the "Monitor" almost sank on two occasions. She went to sea again in Dec. 1862, in tow of the "Rhode Island," and sank off Cape Hatteras with a loss of 4 officers and 12 men.

It is not strange that a new type should have serious defects; that is the rule and not the exception in engineering and shipbuilding developments. But the qualities and capabilities of the "Monitor" became an untouchable subject with the secretary of the navy, Gideon Welles, and the assistant secretary, G. V. Fox. Suggestions for modifications and improvements in the monitor type were suppressed; the officers recommending alterations were rebuked and accused of opposition to progress. Welles convinced himself that he had an invincible weapon in the monitor type and considered that any contrary opinion was disloyalty to the Union.

The climax was the attempt to capture Charleston, S.C., with a squadron of monitors. Adm. Samuel Francis du Pont made the effort against his better judgment and was replaced in the command by Adm. John Dahlgren, who also failed. The Union squadron was saved from destruction only because the Confederates handled the defenses badly. Before du Pont attacked Charleston with nine monitors, John Ericsson wrote to Fox a letter of warning and protest in which he said, "A single shot will sink a ship, while 100 rounds will not silence a fort. . . ." Naval officers had been saying that the monitors were never designed to fight against forts. In fact, no naval vessels ever were designed for such a purpose.

Many vessels of the monitor type of various sizes were begun soon after the battle of March 9, 1862, and a number of these vessels were used successfully in the blockade of Confederate ports and related naval operations. Along with the building of these successful monitors, however, about 20 others were built which were found to be almost completely lacking in buoyancy when completed. These 20 monitors were useless. One consequence of the controversies over the monitor type was that no other navy built monitors until World War I, and those built at that time for the British, as well as for other navies, were designed for a different purpose. For many years after the Civil War the U.S. navy retained monitors of that period. Six monitors with two turrets each were built and placed in commission between 1891 and 1896. These ships displaced 4,000 to 6,000 tons and carried four 10-in. or 12-in. guns. Four later monitors were commissioned in 1902 and 1903, each carrying two 12-in. guns, with a displacement of 3,356 tons, and with a speed of 12 knots. These vessels "Ozark," "Tonopah," "Tallahassee," and "Cheyenne," were the last monitors of the U.S. navy. Before and during World War I they served as submarine tenders. They were scrapped in 1922.

In 1915 and 1916 British monitors of 6,000 and 8,000 tons, mounting 15-in. and 18-in. guns, were built for use along the Belgian coast, in the Dardanelles, in the Suez canal and in the Adriatic. The larger vessels of this type were 405 ft. long, had an 88-ft. beam and an 11-ft. draft. There were about 20 small monitors, of 400 tons, with draft of 6 ft. The British navy built monitors for World War II use, "Roberts," completed in 1941, and "Abercrombie," in 1943. They mounted two 15-in. guns each, and displaced about 8,000 tons. In 1957 the Russian and Rumanian navies employed monitors designed for river use; they were small vessels with a draft of 6 ft.

The development of the monitor type by the U.S. navy was one of the most significant factors in the defeat of the Confederacy. The Union monitors were important for what they did between 1862 and 1865; they were even more important for what they could have done if any European power had attempted to break the blockade of the Southern ports.

Monitors are classed as powerful seagoing river gunboats. River gunboats have a shallow draft and relatively heavy guns for use against troops, artillery, towns or other gunboats. The river gunboats of the Union navy in the American Civil War were especially useful and effective. For many years squadrons of gunboats were maintained on the Yangtze river, China, by the Royal and U.S. navies for the protection of their citizens and national vessels. *See* FLEET, NAVAL.

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**"MONITOR" AND "MERRIMACK," BATTLE OF,** a naval engagement notable as the first duel between ironclad men of war and chiefly memorable in the annals of the American Civil War because of the dramatic contrast between the news of the spectacular successes of the "Merrimack" on March 8, 1862, and her failure to defeat the little "Monitor" next day. The events of the first day thrilled the South, and appeared to mean that the blockade of the Confederacy would be broken if not destroyed; while the conflict between the ironclads was generally interpreted as a victory for the "Monitor" and produced feelings of combined relief and exultation in the North. The battle on March 9, 1862, was in fact indecisive, and had little or no influence on the course of the war, but it is difficult to exaggerate the profound effect on morale that was produced in both sections. The secretary of war, Edwin M. Stanton, was almost hysterical on March 9 before the battle, and he sent telegrams to governors of Northern states and mayors of seaport cities urging them to prepare defenses against the "Merrimack." He did his best to create a feeling of panic, even though some of his messages quoted the opinion of naval officers that the "Merrimack" would not venture outside the Chesapeake capes. Thus Stanton's efforts greatly increased the importance of the "Monitor's" achievements, and helped to establish her as an invincible engine of war.

In undertaking to create a navy, Confederate officers agreed that they required a number of ironclads to break the blockade proclaimed by the federal government on April 19, 1861, five days after the surrender of Ft. Sumter. The Union navy had abandoned the Norfolk navy yard, Portsmouth, Va., on April 20, and burned a number of vessels, including the steam frigate "Merrimack." This vessel was raised from the Elizabeth river and hauled into drydock on May 30, where inspection disclosed that she had suffered relatively little damage, except to her upper decks. Soon afterward the Confederates faced the fact that they lacked the facilities to build engines for the ironclads wanted, and a plan was made for converting the "Merrimack." On July 25, the Confederates were still engaged in repairing fire damage in the navy yard, but work on the ship began soon after that date.

The "Merrimack" had been built at the Boston navy yard, where she was first commissioned on Feb. 20, 1856, and named for the river which flows from central New Hampshire, through northern Massachusetts, into the Atlantic. Her length was 275 ft., beam, 38½ ft.; draft, 23 ft.; displacement 4,636 tons when built. Authentic records of the conversion of the "Merrimack" were lost when the yard was burned again, and men's memories differed as to details, but she was cut down to the water line, and a casemate with rounded ends was constructed on her hull to house ten guns. The casemate was 175 ft. long, with sides sloping at an angle of 45 degrees extending about 2 ft. below the water line. The flat top of the casemate was covered with an iron grating to admit light and air. A cast-iron ram was fitted 2 ft. below the water line, projecting 24 in. from the bow. Sides of the casemate were built up of pine, 20 in. thick, covered with 4 in. of oak, and sheathed with two layers of 2-in. iron plates. A Brooke 7-in. rifle on a pivot was in each end, and there were two Brooke 32-pounder rifles, as well as six Dahlgren 9-in. smooth-bore guns in the broadsides.

John Ericsson designed, built and named an ironclad for the Union, the "Monitor," and abundant publicity attended her progress as well as the work of converting the "Merrimack." The "Monitor" displaced 987 tons; mounted two 11-in. shell guns in her revolving turret. Her length was 172 ft.; beam, 41½ ft.;

draft, 10½ ft. She left New York harbour on March 6, commanded by Lieut. John L. Worden with Lieut. Samuel D. Greene as executive officer, accompanied by two steamers, under tow of a tug.

Renamed the "Virginia," the Confederate ironclad left the navy yard for a trial trip after noon on March 8 with two gunboats, under the command of Capt. Franklin Buchanan, whose executive officer was Lieut. Catesby ap R. Jones. The "Virginia" headed for Newport News, where the Union sailing frigate "Congress," and the newer sailing sloop "Cumberland" lay at anchor. After raking the "Cumberland," the "Virginia" rammed her, and was joined by three Confederate vessels from the James river. Buchanan attacked the "Congress" with his guns, killed her captain, set her on fire and sent his gunboats to receive her surrender, while Union guns on shore at Newport News joined the combat and injured him among others. In trying to join in the battle, the Union steam frigate "Minnesota" ran aground about one mile away, but Buchanan's attempts to secure the surrender of the two sailing ships delayed him, and prevented him from attacking her because of darkness and the falling tide. The "Virginia" anchored off Sewell's Point; Buchanan and 20 other Confederate wounded or dead were sent to Norfolk. That night, the "Monitor" arrived at Hampton Roads and went alongside the "Minnesota."

Crowds of Union soldiers occupied every vantage point along the northern shores of Hampton Roads, on Sunday morning, March 9, 1862, to see the naval battle. Decks of the Federal ships were crowded, and it was known in the fleet that the "Monitor" had arrived. Norfolk and Portsmouth thought of the "Virginia" as their own ship. Huge crowds on shore, and all who could find standing room on floating craft turned out to see the blockading vessels destroyed. Soon after 8 A.M. the "Virginia" opened fire on the "Minnesota," and the "Monitor" appeared. They passed on opposite courses; turned, and passed again. Both crews lacked training; shooting was ineffective. The "Monitor" could fire only once in seven or eight minutes but she was faster and able to turn more quickly than her larger opponent. In two hours she had exhausted the ammunition in her turret and ran into shallow water to renew it. In the interlude, the "Virginia" pounded the "Minnesota" vigorously. When the "Monitor" intervened again, the "Virginia" grounded, and was slow in freeing herself. Jones then tried to ram his opponent, but the "Virginia" turned so slowly that she struck only a glancing blow, and did little damage because her ram had been broken off in the "Cumberland." Jones made the "Monitor's" pilothouse the target; a hit drove iron splinters into Worden's eyes. The "Monitor" sheered into shallow water while Greene was called to the pilothouse to take over the command from Worden. Jones concluded she was disabled, and he turned again to the "Minnesota." His officers reported ammunition low, a leak in the bow, difficulty in keeping up steam and that it would be necessary to cross the Elizabeth river bar soon or to wait 24 hours. At about 12.30 P.M. the "Virginia" headed for the navy yard. The battle was over.

The "Virginia" was in dry dock until April 4. Efforts were made to complete her armour as planned, a new ram was installed and Commodore Josiah Tattnall took command on March 26. Delayed by engine repairs, the "Virginia" appeared in Hampton Roads on April 11, and offered battle. Neither the "Monitor" nor any other Union vessel interfered as the Southerners seized three army transports. The "Virginia" remained at Sewell's Point until April 21; and returned May 8 on news that the "Monitor" with other Union ships was shelling the batteries at Sewell's Point; whereupon the Union vessels withdrew. After the Confederates evacuated Norfolk, Tattnall destroyed the "Virginia" ("Merrimack") May 11, 1862.

*See* also AMERICAN CIVIL WAR: *The Navies and the Blockade*; MONITOR, NAVAL. (J. B. HN.)

**MONK,** a member of a community of men living a life under vows of religious observance; the term is properly confined to a member of a Christian community but is sometimes applied to members of Buddhist brotherhoods. The Greek and Latin name was first used of the hermits but was early widened to embrace the cenobites. *See* MONASTICISM.

**MONKEY,** a term of uncertain origin, possibly derived from the Latin diminutive *homunculus*, "a little man" or "mannikin." In the broad sense, as used today, a monkey is any subhuman member of the mammalian order Primates, with the exception of the lemurs and their allies (often collectively designated half-apes) and the large tailless apes (the anthropoid apes of English writers). Other tailless species, such as the Barbary (ape) macaque as well as the baboons, are included among the monkeys. In the restricted sense, as defined by the English naturalist John Ray (1627–1705), the term includes all tailed apes other than the baboon, the tailless forms being called simply apes.

Under the broad definition, monkeys are arranged into two main groups: those of the old world tropics, the Catarrhini, with two families, Cercopithecidae (monkeys with cheek pouches) and Colobidae (leaf monkeys); and those of the new world tropics, the Platyrrhini, also with two families, Hapalidae (or Callithricidae; marmosets) and Cebidae.

Monkeys live in tropical forests where they progress by using all four limbs. Except for the largest, such as the baboons and drills, monkeys are predominantly arboreal, leaping from limb to limb in their travels. On the ground they walk in plantigrade fashion (the entire sole of the foot touching the ground); but they are capable of sitting upright and sometimes standing erect, consequently their hands are freed for many manipulative tasks. Most have a short, relatively flat face without great prominence of the muzzle (excepting the baboons and drills). The hands and feet are prehensile with typically five digits on each, the first (thumb and big toe) being divergent from the others. Commonly the digits have flattened nails, but those of marmosets have claw-like structures on all but the big toe.

Except for the night-roaming douroucouli of tropical America, monkeys are active during the day, moving frequently in bands in search of vegetation, birds' eggs, smaller animals or insects to eat. The socially organized clans, headed by an old male, are rigidly defined in forms such as the howlers and baboons (*see* SOCIOLOGY, ANIMAL: *Organization of Animal Groups: Dominance-Subordinance; Mammalian Dominance Orders*).

As in all primates the brain is comparatively large. This feature, combined with the freeing of the hands and a well-developed vision, allows monkeys a great latitude of activity; their actions are often amusingly manlike. Among the smaller new world forms that have endeared themselves to man because of their ingratiating antics and their tameability are the alert marmosets, often plumed and colourfully arrayed, the inquisitive squirrel and woolly monkeys and the capuchins, or organ grinder's monkeys, all of which exhibit in marked degree the curiosity and cleverness ascribed to monkeys generally (*see* PSYCHOLOGY, COMPARATIVE: *Psychological Superiority of Mammals; Intelligent Behaviour*). Other interesting kinds are the acrobatic spider monkeys and the noisy howlers. The old world monkeys include many that are popular in zoos, especially the beautifully coloured African guenons (green, mona, diana, white-nosed, vervet and grivet monkeys), long-maned guerezas, mangabeys and the chiefly Asiatic macaques. The macaques include the Barbary ape of the rock of Gibraltar—the only macaque outside of Asia and the only monkey inhabiting any part of Europe today—and the rhesus monkey of India, which has found considerable use in medical research. The graceful Asiatic langurs include the hanuman or sacred monkey of India. Among the more unusual monkeys are the grotesque and strikingly coloured African drills and mandrills, large ground-dwelling monkeys, and the proboscis monkey of Borneo and the related snub-nosed monkeys of western China.

New world monkeys, or platyrrhines, have broad noses, with a wide septum separating the outwardly directed nostrils; each side in both jaws has three premolar teeth. Platyrrhines lack a bony ear passage, and the arrangement of some cranial bones differs from that in old world monkeys. Usually long tailed, a few have prehensile tails with specialized naked skin on the under surface. Old world monkeys or catarrhines, have narrow noses and a thin septum, the nostrils being directed downward. Only two premolar teeth are present above and below on each side of each jaw, but the skull is provided with a bony auditory passage. In

none is the tail prehensile; it may be long, short or lacking. All old world monkeys have hard patches of naked skin on the buttocks (ischial callosities). In this they differ not only from the Platyrrhini but also from the great apes.

Monkeys differ from the lemurs (*q.v.*) in that there is no restricted breeding season. After sexual maturity males are at all times potent and nonpregnant females undergo regular monthly cycles termed menstrual cycles. The phases of each cycle may, as in many platyrrhines, scarcely be recognizable, except by behaviour, but in some platyrrhines and all catarrhines a sanguinous discharge appears at one stage. This is accompanied in many species by gross swelling of the external genitalia and neighbouring skin. Gestation varies from four and a half months in marmosets to nearly seven months in some old world monkeys. A single young, occasionally twins, are produced and are nursed by the mother. The placenta, instead of being diffuse as in lemurs, takes the form of a double disc, the umbilical cord being connected with one (primary) disc, but sometimes (normally in howler monkeys) the disc is single as in the anthropoid apes and man.

*See* PRIMATES; *see* also references under "Monkey" in the Index.

*See* I. T. Sanderson, *The Monkey Kingdom* (1957); W. C. O. Hill, *Primates*, vol. 1–5 (1953–62). (W. C. O. H.)

**MONKEY PUZZLE** (*Araucaria araucana*), a Chilean pine, an evergreen timber tree of the Cordilleras, often 150 ft. tall. Rigid, overlapping, needle-pointed leaves, one to two inches long and half as wide, cover the stiff branches, which form a tangled, prickly network that thwarts monkeys and other animals attempting to climb the tree. The oblong cones, five to seven inches long, fall apart at maturity; each scale bears one edible seed. It is cultivated widely in warm temperate zones as a striking ornamental. *See* ARAUCARIA. (I. L. W.; X.)

**MON-KHMER LANGUAGES:** *see* AUSTROASIATIC LANGUAGES.

**MONLUC, BLAISE DE LASSERAN-MASSENCÔME, SEIGNEUR DE** (*c.* 1500–1577), French soldier and memorialist, was born in Armagnac, probably at St. Puy, the eldest son of an impoverished branch of the great family of Montesquiou. Brought up as a page at the court of Lorraine, he served as an archer in northern Italy in 1521–22, became an ensign of infantry in Gascony (1523) and was with King Francis I at Pavia (1525). In Italy again (1527–28), he broke his arm but refused amputation. As lieutenant of a company, he played a brilliant part in the relief of Marseilles from Charles V's siege (1536). He commanded a company of the dauphin Henry's guards in the northeast in 1537. Disguised as a kitchen hand with an embassy, he spied on the Spanish fortifications of Perpignan in 1538. In Italy again from 1543, he was chiefly responsible for the great victory at Ceresole (April 1544) before going to serve as *maître de camp* against the English in northeastern France. After being governor of Moncalieri in Piedmont for Henry II of France (1548–50), he consolidated his fame in the campaigns of 1551–53 and defended Siena from July 1554 to April 1555 despite illness and inadequate support. In May–July 1558 he was temporary colonel general of the French infantry.

When the French wars of religion began, Monluc was a partisan of the house of Guise (*q.v.*). His victory at Vergt (Oct. 9, 1562) broke the Huguenot power in Guienne, and he was the mainstay of the league of Catholic nobles of the southwest. As king's lieutenant for half of Guienne, with his seat at Agen, he had difficulty in reconciling his military efficiency with the royal court's devious policy. Finally Henry III made him a marshal of France (Sept. 1574). Monluc died at Condom on Aug. 26, 1577.

Monluc's *Commentaires*, probably begun in 1570, combine autobiography with reflections on the art of war. He records his successes with Gascon frankness but does not conceal his mistakes or his furious impatience whenever his hopes of recognition were disappointed. Huguenot propaganda gave him a reputation for barbarity which he scarcely deserved. Militarily he stood for the use of mobile infantry (notably arquebusiers) against heavy cavalry. The best editions of the *Commentaires* (first published in 1592) are those by A. de Ruble (1864–72) and by P. Courteault (1911–25); an English translation by C. Cotton appeared in 1674 and selections in English by A. W. Evans in 1913.

**MONMOUTH, JAMES SCOTT, DUKE OF** (1649–1685), pretender to the English throne and leader of the rebellion against James II in 1685, was born at Rotterdam, Neth., on April 9, 1649, the son of Lucy Walter, mistress of Charles II. Shortly before the death of his mother in 1658, he was entrusted to the care of William, Lord Crofts, by whose name he was for some time known. Under the direction of Thomas Ross he was brought up in the Protestant religion but on the whole his early education appears to have been neglected. In the summer of 1662 he was brought to England and received by the king with the utmost favour, a marriage being almost immediately arranged between him and one of the wealthiest of Scottish heiresses, Anne Scott, countess of Buccleuch in her own right. With this marriage in view he abandoned the name of Crofts, was knighted as Sir James Scott, and on Feb. 14, 1663, was created duke of Monmouth. The marriage itself, which took place on April 20 of the same year, was marked by the granting of further honours, including the Garter and the title of duke of Buccleuch in the Scottish peerage.

From an early stage the possibility was entertained that Monmouth might succeed Charles on the throne, and as it became increasingly apparent that Queen Catherine was unlikely to have children this possibility was taken more and more seriously. As he grew into manhood Monmouth developed into the very ideal of an English ruler. Extremely handsome, yet without the least suggestion of effeminacy in his appearance, he was an adept at all manly exercises, a good enough soldier to win praise from the great marshal Henri, vicomte de Turenne, generous, affable and capable of making himself at home in any company, male or female. That he was deficient both in intelligence and in resolution was not immediately apparent, and did little to detract from his popularity. By contrast, James, duke of York (afterward James II), the king's brother and heir presumptive, having gained a high reputation by his activity and public spirit at the beginning of the reign, was declining in general esteem, mainly because of his inclination toward Roman Catholicism, which culminated in his failure to take the tests required by the Test act and by his marriage to the Catholic Mary of Modena in 1673.

Thus an inevitable rivalry developed between the two dukes, in which York, being excluded from office by the Test act, was at a serious disadvantage compared with Monmouth, on whom the king, with injudicious partiality, conferred one important office after another. Captain of the king's own troop of guards in 1668, he was admitted to the English privy council on April 29, 1670, and to the Scottish privy council on May 18, 1674. During the second Dutch War of the reign he was given command of the British forces operating in conjunction with the French on the continent. He took the duke of Buckingham's place as master of the horse on April 14, 1674, and on the king's recommendation was elected chancellor of the University of Cambridge on July 14 of the same year. He was appointed captain general of all the armed forces in England in April 1678, and on being given a similar appointment in Scotland gained a great reputation not so much by his defeat of the Covenanting army at Bothwell bridge on June 22, 1679, as by the clemency he showed to the rebels thereafter.

When it came to the point, however, and the frenzy roused by the revelations of Titus Oates (*q.v.*) made the succession to the throne an immediate and serious issue, the king refused to desert his brother. Charles made a solemn declaration in council on March 3, 1679, that he had never been married to Monmouth's mother, and although three successive parliaments endeavoured to deprive the duke of York of his right to the throne he firmly refused to accept their policy of exclusion. Unfortunately Monmouth by this time had fallen under the influence of the earl of Shaftesbury and other irreconcilable enemies of York, and at least partly in the belief that the interests of his country and religion were vitally concerned, refused to accept the king's decision. He was thereupon ordered abroad and, returning without permission, was deprived of most of his offices. Refusing to leave the country again, he embarked on a series of progresses in the southwest and later in the northwest, in the course of which he assumed almost royal state and was everywhere hailed with enthusiasm as the

Protestant duke. In the confused conspiracy vaguely called the Rye House plot he was deeply involved, though precisely how deeply it is impossible to say. For this he was pardoned; but on his failure to make a full and explicit confession he was forbidden the court, and took refuge in the Netherlands early in 1684. Any prospect he had of restoration to favour was cut short by the death of Charles II on Feb. 6, 1685.

At this point Monmouth would gladly have abandoned his pretensions and resigned himself to a private life; but neither his pretended friends nor his very real enemies were at all inclined to leave him in peace, and he was thus induced to embark on his disastrous expedition to England in the summer of 1685. Landing at Lyme Regis, Dorset, with 82 followers on June 11, he received considerable support from the populace of the surrounding district, and experienced little serious opposition from the militia hastily embodied to bar his progress. The gentry, however, held aloof, and it was partly in the mistaken hope of bringing them over to his side that on June 20, after his entry into Taunton, he abandoned his earlier undertaking to leave to a free parliament the decision of his title to the crown and had himself formally proclaimed king. Unfortunately for himself if not for his country, the moment he had chosen for his enterprise was the worst possible, when James II had had sufficient time to seat himself firmly on the throne but insufficient to antagonize any considerable section of his subjects, and responsible men were thus unwilling to throw in their lot with a movement which seemed to them both hopeless and unnecessary.

Moreover Monmouth was not the man for the task he had undertaken. A regular soldier by training, he showed little capacity for handling the untrained forces then under his command, and failed to grasp the need for pushing on at all costs. Too late in his advance on Bristol, where he found the forces of the regular army closing in upon him, he fell back on Bridgwater. After much hesitation he determined to stake everything on the hazardous expedient of a night attack on the royal army, which he could see carelessly encamped before him on the plain of Sedgemoor. There in the early hours of July 6 he just failed to bring off a complete surprise; but the flight of his small body of cavalry and the failure of his foot soldiers to press home their attack over the deep ditch that covered the royalist front left his men at the mercy of a combined onslaught from horse, foot and guns, of which there could be only one outcome. He fled from the battlefield but he was captured a few days later. After having endeavoured to purchase his life from James by a slavish submission and an offer to turn Roman Catholic, Monmouth met his end on the scaffold with courage and dignity at the Tower of London on July 15, 1685.

BIBLIOGRAPHY—Monmouth was not a ready writer, and his surviving letters and papers are few, badly put together and worse spelled. The most reliable account of his career is still that of George Roberts, *The Life, Progresses and Rebellion of James, Duke of Monmouth*, 2 vol. (1844). There are also several more recent works, of which the most useful are Allan Fea, *King Monmouth* (1902) and *The Loyal Wentworths* (1928), Elizabeth D'Oyley, *James, Duke of Monmouth* (1938), and Lord George Scott, *Lucy Walter, Wife or Mistress* (1947). The crisis and final stage of Monmouth's life are exhaustively examined in William R. Emerson, *Monmouth's Rebellion* (1951). (A. Bg.)

**MONMOUTH, ROBERT CAREY,** 1st EARL OF (*c.* 1560–1639), chamberlain and cousin to Queen Elizabeth I, the first to bring news of her death to her successor James VI (James I of Great Britain) in Edinburgh, was the youngest son of Henry Carey, 1st Baron Hunsdon. He joined in the attempt to relieve Sluys (1587), served against the Spanish Armada (1588) and commanded a regiment in the expedition to Normandy (1591) led by the earl of Essex, who knighted him. Carey sat in the parliaments of 1586, 1588, 1593, 1597–98, 1601 and 1620. From 1593 to 1603 he was employed on the Scottish border and was warden of the eastern marches (1597–98) and warden of the middle marches (1598–1603). He witnessed Queen Elizabeth's last illness in March 1603, apprised James of the imminence of her death and had horses waiting for him along the entire route to Scotland. Upon the queen's death early on March 24 he set out within a few hours and reached Edinburgh late on March 26. He was, however, little rewarded by King James, although his wife Elizabeth became governess of Prince Charles. Carey became master of the prince's household (1605), his master of the robes (1611) and was his chamberlain from 1617 to 1625. He followed Prince Charles and the duke of Buckingham on their visit to Spain in 1623. Created Baron Carey of Leppington in 1622, he was made earl of Monmouth in 1626. He died at Moor Park, Hertfordshire, on April 12, 1639.

See *Memoirs of the Life of Robert Carey, Written by Himself*, ed. by John earl of Corke and Orrery (1759), by Sir Walter Scott (1808) and by G. H. Powell (1905).

**MONMOUTH,** a market town and municipal borough, and until 1939 the county town of Monmouthshire (*q.v.*), lies 24 mi. N.E. of Newport, the county administrative headquarters. Pop. (1961) 5,505. Almost surrounded by wooded hills, it is at the confluence of the Monnow with the Wye and on the western edge of the Forest of Dean. The Norman castle, below which the town grew up, was built about 1070 by William FitzOsbern, earl of Hereford, on a high ridge above the Monnow. It was captured in 1264 by Simon de Montfort; in 1387 Henry V (Harry of Monmouth) was born there; it was taken by Owen Glendower in 1404 and sacked by the Parliamentarians in 1646. The 12th-century Great tower and part of the 13th-century Great hall are all that remain. Nearby is Great Castle house, built in 1673, and over the Monnow is Castle field, the site of the battle of Monmouth in 1233. The original market place is now Agincourt square with a statue (1792) of Henry V on the Shire hall (1724) where John Frost and the Chartist leaders were tried after the Newport riots. The Nelson museum contains a fine collection of relics of the admiral, presented in the 1920s and since added to, and a room devoted to local history. The parish church of St. Mary (largely rebuilt in 1881) belonged to an 11th-century Benedictine priory, the only remains of which is Geoffrey's window (15th-century), named after Geoffrey of Monmouth. Near Wye bridge (1617) is Monmouth school for boys founded in 1614 by William Jones, a benefactor of the town. Two miles over the bridge, on Kymin hill, stands the Naval temple (now National trust) put up in 1800 by the Beauforts to honour distinguished admirals of the second half of the 18th century, and visited by Nelson in 1802. On Monnow bridge is a unique 13th-century gateway, not part of the walled town but probably an outer defense.

Monmouth received its first royal charter in 1256, but its first recorded royal grant of communitas was in 1447. It is the centre of a rich agricultural area and has weekly and fortnightly produce and cattle markets and an annual May fair. There are also food-processing factories and engineering works and a flourishing tourist industry.

**MONMOUTH COURT HOUSE, BATTLE OF.** This engagement of the American Revolution was fought on June 28, 1778, between the Americans under Washington and the British under Sir Henry Clinton. Having evacuated Philadelphia on June 18 the British were marching through New Jersey to Sandy Hook. Washington decided to strike a vigorous blow, if possible, at the retreating enemy even at the risk of bringing on a general engagement. He therefore ordered Charles Lee with the advance guard to attack the British rear, doubtless planning to support him with the main body of the army if the attack should precipitate such an engagement. Lee, a former officer of the British army who had seen much service in the Seven Years' War, believed the Continental troops to be no match for British regulars in the field and thought it unwise to risk a pitched battle which, in case of defeat, would jeopardize the advantage gained by the recent French alliance.

After a 40 hours' halt at Monmouth Court House (now Freehold), Clinton made an early start on June 28. His baggage train of 1,500 wagons led the way under escort of Knyphausen's German division, and Cornwallis' British division formed the rear guard. When Lee approached Monmouth he found only a small covering force there. He was executing an elaborate maneuver to envelop it when Cornwallis' division appeared. Clinton had ordered Cornwallis to turn back and strike hard at the attacking force to prevent any attempt to harass his train. Rather than risk fighting a delaying action on terrain from which it would be difficult to withdraw in case of defeat, Lee ordered a retreat. He planned to make a stand at a hill commanding a ravine over which

the British would have to pass to reach him, but was tardy in giving Washington notice that he was retiring. When the commander in chief came up he was surprised and indignant to find Lee's forces retreating in much disorder. He hastened to form a line of battle with the divisions of Greene and Alexander on the right and left, while part of Lee's force rallied under Wayne and checked the British advance. Cornwallis brought up his infantry and endeavoured to dislodge Washington, but without success. Toward evening Cornwallis fell back. Washington sent forward three brigades to renew the battle, but darkness forestalled them. During the night Cornwallis withdrew, undetected by the American outposts, and overtook Knyphausen near Middletown, where the high ground secured them from further attack. Finding the enemy gone, Washington attempted no pursuit and presently marched to the Hudson to join General Gates, while Clinton's army was conveyed by transports from Sandy Hook to New York. Thus, the combatants resumed the positions held two years before.

Washington and Clinton, having about equal forces, each claimed to have won a victory; but, since the latter's losses were apparently not much more than Washington's and he successfully completed his march without further serious molestation, his claim seems the more valid. A court-martial suspended Lee from any command in the American armies for 12 months. He was later dismissed from the service after he wrote an insulting letter to congress. In 1860 a letter from Lee to General Howe, written when Lee was a prisoner in British hands, suggesting a plan of campaign for Howe's forces, came to light. To the charge of incompetence and insubordination against Lee, later writers have added that of deliberate treachery at Monmouth, but no evidence has been found to support the graver charge.

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**MONMOUTHSHIRE** (SIR FYNWY), a county on the border of England and Wales. For three centuries after 1536 its legal and fiscal links were with England, but it is now grouped administratively with the Welsh counties (see *Population and Administration* below). It is bounded west by Glamorgan, north and northwest by Brecknockshire, northeast by Herefordshire, east by Gloucestershire and the Wye and south by the Severn estuary. Area 541.8 sq mi.

**Physical Features.**—The county includes five widely differing areas: in the northwest, the eastern quarter of the south Wales coalfield lies within the county. Its plateau tops rise to more than 1,800 ft. and are deeply trenched by the Rhymney, Sirhowy, Ebbw and Llwyd rivers, which run roughly north–south. Their narrow valleys tap iron and coal seams and since the mid-18th century ribbons of houses, chapels, shops, roads, railways and pits have accumulated in them. On the upper hillsides and gritstone plateau tops, pastoral farms survive from the preindustrial period. At the heads of the valleys, from Rhymney to Blaenavon, lie the former centres of the iron industry. The coalfield presents a high limestone rim to the surrounding lowlands and beyond the Blorenge (1,834 ft.), the highest point in this rim, lie the fine Vale of Usk and the Black mountains. The northwestern scarp of the Black mountains lies in Brecknockshire, but Monmouthshire includes the deep Vale of Ewyas and its bounding Fwddog and Hatteral ridges. Like the outlying Sugar Loaf (1,955 ft.) and Skirrid peaks, the Black mountains are of Old Red Sandstone. The Honddu, flowing down the Vale of Ewyas and diverted by a moraine 150 ft. high at Llanfihangel Crucorney, joins the Monnow, which forms the boundary with Herefordshire.

Monmouthshire is drained mainly by the Usk, whose lower reaches occupy the centre of the county where there are rolling Devonian lowlands, well farmed and well wooded, with, on the whole, well-drained soils. North of the town of Usk the river cuts through glacial gravel terraces. Around this town older Silurian shales rise, often sharply, above the alluvial plain. East of the Usk lowlands lie the red sandstone ridges of Wentwood and Trelleck and, between them, Carboniferous limestone hills trenched by the meandering Wye. From Monmouth to Chepstow this formerly busy waterway flows through splendid tree-clad gorges. On the Severn shores of the county lie the Wentloog and Caldicot levels. These are polders lying behind seawalls initiated by the Romans and since frequently breached and strengthened. The reclaimed marine alluvium of these levels supports good fattening pastures. Newport lies partly on reclaimed land, but much of the town is set on Old Red Sandstone slopes capped with gravels.

The Brecon Beacons National park (515 sq mi.), designated in 1957, includes 47 sq mi of north Monmouthshire, chiefly in the picturesque Black mountains. In 1961 the National trust owned 2,374 ac. and protected a further 725 ac. in the county; of this 2,130 ac. lie around the Sugar Loaf peak, northwest of Abergavenny. The Blackcliff and Wyndcliff woods (200 ac.) in the Wye valley are a forest reserve of the Nature conservancy.

**History.**—Before 400 B.C. Monmouthshire, fronted by mud flats and heavily forested, attracted fewer settlers than Glamorgan. Small groups seem to have come mainly by sea and to have settled on the lighter windswept soils between Chepstow and Portskewett, where one of their long barrows survives. Settlers also came inland up the Usk and Wye, and a few of the Bronze Age dead were buried on hilltop cairns overlooking these rivers. Iron axes were more effective against the forests and a number of Iron Age forts harboured groups of Silures, both in the coastlands and in the Usk basin. They include some large hill forts such as Llanmelin, overlooking Caerwent, and the multivallate promontory fort at Sudbrook, above the Severn tunnel. Contacts with the Somerset shores of the Severn estuary were maintained in the Iron Age, as they were throughout the history of Monmouthshire.

The Roman conquest of Monmouthshire was completed *c.* A.D. 75 and a legionary fortress was set up at Isca, now Caerleon (*q.v.*). Outside the 50-ac. fortress was a civil settlement with shops, amphitheatre, baths and warehouses. To contain the tribal groups auxiliary forts and roads were gradually laid out. In Monmouthshire such forts include Usk (perhaps Burrium), Monmouth (Blestium) and Abergavenny (Gobannium). To attract the local Silures the Romans founded Venta Silurum (Caerwent), a town of 44 ac. still surrounded by the lower parts of its wall. Late in the 4th century the Romans abandoned Caerwent and their forts, and the tribes of Monmouthshire may have reverted to pastoralism, moving between winter homesteads in the lowlands and summer shielings and pastures on the ridgetops. The tribes were separated from Mercia by Offa's dike, which runs above the east side of the Wye gorge. From the 9th to the 11th century they were harried by Scandinavian raiders who, even after the Norman conquest, despoiled St. Gwynllyw's church in Newport. Monmouthshire—the native kingdom of Gwent—was conquered by Harold II in 1065 and annexed to his earldom of Hereford, with which it is grouped in Domesday Book. The Normans advanced from Chepstow and set up administrative centres there and at Caerleon. From these and later fortresses they controlled the Marcher lordships and stamped the English manorial pattern on the lowlands of Monmouthshire. Many traces of the medieval open-field system could be seen in south Monmouthshire until the mid-19th century.

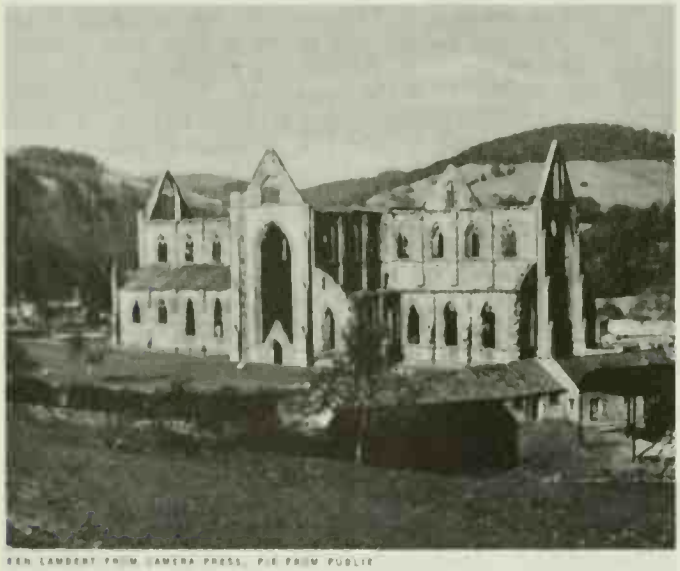
Medieval Monmouthshire was less frequently ravaged by the Welsh princes than Glamorgan. Its lordships passed to the crown and to powerful English families such as Neville, Buckingham and Herbert. The latter family acquired Tintern abbey (*q.v.*) and its granges after the suppression of the monasteries. By the Act of Union of 1536, the Marcher lordships were grouped into shires. In Gwent the lordship of Monmouth gave its name to the county and the personal rule of the Marcher lord was replaced by representation by county, hundred and parish. After 1536 many of the great families consolidated their positions and built fine manor houses. In 1606 the whole of the Wentloog and Caldicot levels were flooded and devastated by a great storm which breached the seawalls. Flood marks may still be seen on church towers there. In the 17th century the great houses of Monmouthshire sheltered many Catholic priests and laymen. Nonconformity also flourished; the first independent church in Wales was established at Llanfaches in 1639. A different revolt was the Chartist march on

Newport under John Frost in 1839. (*See* CHARTISM.)

From the pre-Norman period, when Christianity was brought to Monmouthshire by Celtic missionary saints, until 1921, most of the county was in the diocese of Llandaff (Monmouth was in the diocese of Hereford until 1836). In 1921 the diocese of Monmouth, centring on St. Woolos' (Gwynllyw's) church in Newport, was created.

**Architectural Features.**—Many Marcher lords' castles adorn the county. At Chepstow (*q.v.*) the castle wards are aligned on a narrow ridge by the Wye; Caldicot, protected by marshes, has an unusual round keep and fine gatehouse. At Newport (*q.v.*) the medieval castle commands the busy bridge, and at Abergavenny (*q.v.*) the red sandstone shell of the castle keep dominates the town. Grosmont, Skenfrith and White castle, in the northeast of the county, form an interesting triangle of castles formerly held by the duchy of Lancaster. Raglan castle shows the transition from grim stronghold to residence; building began in the 16th century, but after the Civil War, when it was a royalist stronghold, the great castle was slighted. Many Norman mottes adjoin the churches of the county. A number of the castles became Tudor or, later, manor houses. Of these Pencoed, Penhow, Mathern palace, Moynes court and St. Pierre are outstanding. Llanfihangel Crucorney court and Trostrey court are Tudor houses and Tredegar park has a handsome 17th-century house.

In the remote Vale of Ewyas, William de Lacy established Augustinian canons at Llanthony priory about 1100. The ruins of their great transitional Norman church dominate the surviving buildings. The best-known abbey ruins in Monmouthshire are



KEN LAMBERT FROM W. AMERA PRESS, P.I.B. FROM PUBLIC

TINTERN ABBEY, A FAMOUS CISTERCIAN RUIN DATING FROM THE 13TH CENTURY, LOCATED IN THE WYE VALLEY, MONMOUTHSHIRE

those of 13th-century Tintern, superbly placed by the Cistercians in the Wye valley (*see* TINTERN ABBEY). Although many parish churches were heavily restored in the 19th century, much of interest remains. The Benedictine priory church of St. Mary in Chepstow has a fine Norman east front. Abergavenny church has a notable series of altar tombs and effigies. Caerleon has beautiful altar cloths and Llangattock Lingoed part of a well-carved rood screen. The cathedral church of St. Woolos at Newport has a great Norman doorway and several later building phases are represented there.

**Population and Administration.**—The area of the administrative county is 529.8 sq mi and of Newport county borough 12.0 sq mi. Their populations in 1961 totaled 335,582 and 108,107, respectively. The headquarters of the county council are at Newport. The two municipal boroughs, Abergavenny and Monmouth (*qq.v.*), had 9,625 and 5,505 inhabitants, respectively, in 1961. Cwmbran New Town, with a projected population of 55,000, had 30,043 in 1961. The parliamentary divisions Abertillery, Bedwellty, Ebbw Vale, Monmouth and Pontypool, like Newport, each return one member. Assizes are held alternatively at Newport and Monmouth, and from the time of Charles II Monmouthshire has been included in the Oxford circuit. The Welsh language was the common tongue of Monmouthshire until the 18th century, when it began to recede northwestward, until by 1931 only 6%, and by 1961 only 3.4%, of the people spoke Welsh. They live mainly in the hills bordering Brecknockshire.

Administratively the county is part of Wales and is included in all official reports relating to Wales, for although the Act of Union (1536) grouped Monmouthshire with England for legal purposes it did not state that the county was to be severed from Wales, and the legal features that distinguished it from the undoubtedly Welsh counties lapsed in 1830. However, its relationship to Wales and England is not yet clearly defined and some regard it as an English county. The county motto is "Faithful to Both."

**Agriculture.**—Farming patterns vary and include sheep rearing and milk production on the poor soils of the coalfield, mixed farming with an emphasis on milk production on the undulating lowlands, rearing and forestry on the eastern ridges and milk production and summer fattening of cattle and sheep on the Wentloog and Caldicot levels. On the average, holdings are smaller than in England, but those exceeding 150 ac. are more common than in most Welsh counties. Monmouthshire has a larger acreage under wheat than any Welsh county, and it has productive market gardens, especially around Newport and Abergavenny. Of the total agricultural area, which is about two-thirds of the county, approximately one-quarter is in arable and temporary grass and over half in permanent grass. Cattle, pigs and poultry are the chief livestock. The largest agricultural institute in Wales is at Usk as is also one of the six artificial insemination centres.

The Forestry commission has considerable holdings in the county, notably in the valleys of the Ebbw and its tributaries, where pit props are produced above the mines that use them; in Wentwood, replanted after wartime felling; and between Chepstow and Monmouth, where old-established deciduous woodlands are replanted, where necessary, with oak and beech on the lower slopes and conifers on the higher slopes. The woodlands stretching northward from Chepstow park to Trelleck common are included in the Dean forest and Wye Valley National Forest park. Private woodlands cover a smaller acreage and are mainly in the hills overlooking the Usk and Monnow rivers.

**Industry.**—The mineral wealth of Monmouthshire includes lead, coal and iron. Lead was worked by the Romans in the lower Rhymney valley; ironstone was the basis of the county's prosperity from 1750 to 1850; coal mining is still the major industry; Tudor metal manufacture centred on the water-driven wireworks at Tintern and on small iron forges such as that of Capel Hanbury at Pontypool. From the mid-18th century English ironmasters and immigrant workers established ironworks along the north crop of the coalfield. The main ironworks were at Rhymney, Tredegar, Ebbw Vale, Brynmawr, Blaenavon and Pontypool. All decayed in the late 19th and 20th centuries, when the industry moved to the coast, bringing unemployment and migration. Ebbw Vale integrated steelworks, restarted in 1938, is part of the old distribution pattern. Examples of the newer locations are Newport's steelworks and the great strip mill between Llanwern and Bishton, which is near Newport docks and the South Wales railway. The steel and tinplate works between Pontypool and Pontymister, like Ebbw Vale, are nearer to their Midlands market than other south Welsh centres of the industry. Since 1934 a greater variety of industry has been brought to south Wales and Monmouthshire. The new Monmouthshire factories manufacture textiles (notably nylon near Pontypool), clothing, glass, foodstuffs, electrical goods, chemicals, aluminum, metals and other goods, and are mainly found in Newport, Rogerstone, Cwmbran, Pontypool, the Blackwood area in the heart of the coalfield, and in the old iron towns. Though primarily market towns, Abergavenny, Monmouth and Chepstow have engineering works, and factories which process farm and forest products. Sudbrook has a hardwood pulp mill and Severn Tunnel Junction is a railway engineering centre.

Coal, worked in the 18th century where it is exposed on the coalfield rim, was soon won from deeper pits farther south. Since World War II the coalfield rim has had many opencast workings. In the 19th century deeper sinkings also tapped the bituminous coal of the Monmouthshire valleys. Many of the earlier pits have been abandoned and the industry is concentrated on a smaller number of pits. Though mechanization is increasing, a dozen of these pits each employ 1,000–2,000 men. Modern mining projects include pits interlinked by underground roadways, such as Hafod-yr-ynys near Pontypool.

**Communications.**—Newport is now one of the major south Wales seaports and the only shipbuilding centre. Since medieval times Newport, Caerleon and Chepstow have traded across the Severn sea with Bristol, Somerset and Devon. Newport became paramount after 1812 when the canal between Newport and Brecon was completed. A fine stretch of this canal survives along the hillsides north of Pontypool. Like its branch up the Ebbw valley to Crumlin it now has no commercial traffic but, with its contributory tramways, it facilitated the development of the Monmouthshire iron and steel industry. Roads were poor for centuries, but from the turnpikes a good modern road network has evolved. Roughly parallel with the major roads are the South Wales railway from Chepstow to Cardiff (opened in 1850), the Newport to Hereford line (dating from 1854) and, up the mining valleys, lines which were formerly used by horse-drawn trams. The Severn tunnel was opened in 1886 and the foundation stone of the Severn bridge, designed to replace the Beachley-Aust car ferry, was laid in 1961.

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(M. D.)

**MONNET, JEAN** (1888– ), French economist and diplomat who after World War II initiated comprehensive economic planning in France and western Europe, was born at Cognac, Charente, on Nov. 9, 1888. He was the French representative on the Interallied Maritime commission during World War I and deputy secretary general of the League of Nations from 1919 to 1923. Then, after reorganizing the family brandy business, he became the European partner of a New York investment bank in 1925. From 1932 to 1938 he was financial adviser to many countries. At the start of World War II he was made chairman of the Franco-British Economic Co-ordination committee. In June 1940 it was he who suggested Franco-British union to Winston Churchill. After the Franco-German armistice Monnet left for Washington, where he was appointed to the British Supply council. Early in 1943 he moved to Algiers, where in May he became a member of the French Committee of National Liberation. In April 1944 Gen. Charles de Gaulle appointed him commissioner on special mission in the United States. After the liberation of France he headed a committee to prepare a comprehensive plan for the reconstruction and modernization of the French economy. On Jan. 11, 1947, the plan was adopted by the French government and Monnet himself was appointed its commissioner general.

On May 9, 1950, when the French government launched the plan for establishing the European Coal and Steel community, Monnet, who had played an outstanding part in its formulation, was appointed leader of the French delegation to prepare the community's statute. From 1952 to 1955 he was the first president of the E.C.S.C.'s high authority. In Jan. 1956 he organized and assumed the presidency of the Action Committee for the United States of Europe.

**MONO** or MONACHI, two Shoshonean-speaking Indian groups of central California, of the same dialectic division as the northern Paiute of Nevada and the Bannock of Idaho. The western Mono, in the pine belt of the Sierra Nevada, are acculturated to the nearby Yokuts; the eastern branch, of Mono and Owens valley across the crest, locally called Paiute, are more similar to their congeners of the Great Basin. There were an estimated 500 Mono in the state in the 1960s.

*See* A. H. Gayton, *Yokuts and Western Mono Ethnography* (1948); United States Department of the Interior, *United States Indian Population and Land* (1961).

**MONOCHORD**, an instrument of musical science employed by ancient Greek and later theorists for measuring musical intervals. It consisted of a single string stretched over a calibrated sound box with a movable bridge. In the middle ages it was also developed as a musical instrument called the manichord (later clavichord), by the addition of further strings and eventually, a keyboard mechanism for striking them. (A. C. Ba.)

**MONOCOTYLEDONS**, plants of the Monocotyledonae (Monocotyledones), the smaller of the two great groups (the larger is the Dicotyledonae) of the flowering plants, or angiosperms. Lilies, orchids, palms and grasses are included in this assemblage. All monocots are distinguished by, among other things, the presence of only one seed leaf, or cotyledon, in the embryo contained in the seed. *See* ANGIOSPERMS; SEED: *Structure*. *See also* PLANTS AND PLANT SCIENCE.

**MONOD, ADOLPHE THÉODORE** (1802–1856), the foremost Protestant preacher in 19th-century France, was born at Copenhagen, Den., on Jan. 21, 1802. He came of a Swiss bourgeois family from Geneva, many of whose members were celebrated Protestant ministers. His grandfather, Gaspard Joel (1717–83), was successively pastor in Geneva, Guadeloupe and England. His father, Jean (1765–1836), was pastor in Copenhagen and Paris, where he was president of the Reformed consistory. Adolphe Monod studied theology at Geneva (1820–24) and, after a religious crisis, began to emphasize long-neglected doctrines. He became minister of the French church at Naples in 1826 and then at Lyons in 1827. His insistence on the older teaching of the Reformed Church of France was disliked and he was dismissed from the state-recognized church there. He founded a Free Evangelical church at Lyons in 1833. In 1836 he became professor in the theological college of the Reformed Church of France at Montauban and in 1847 succeeded his brother Frédéric as minister of the Reformed church of the Oratoire in Paris. He died in Paris on April 6, 1856.

FRÉDÉRIC MONOD (1794–1863), Adolphe's brother, spent most of his ministerial life in Paris, where, after he had become doubtful of the orthodoxy of the Reformed Church, he resigned from the Oratoire and founded, with Count Gasparin, in 1849 the Union of Evangelical Churches of France. WILFRID MONOD (1867–1943), grandson of Frédéric, was prominent in the reunion of the French Reformed churches and in the ecumenical movement.

*See* A. Monod, *Souvenirs de la vie, choix de lettres*, 2 vol. (1885–1902); *Pages choisies* (1950). (B. H.)

**MONODY** (MONOPHONY), a musical term that in England is often used to describe music for a single melodic line, though in the U.S. monophony is preferred for this meaning. The term monody is also used for the accompanied solo song style that came to the fore about 1600, particularly in Italy, as a counterblast to the contrapuntal style of the 16th-century madrigal and motet, and as an answer to the appeal of Greek ideals. The words should be of prime importance, according to Vincenzo Galilei (d. 1591), and this goal could only be achieved by abandoning counterpoint. The recitative-like style of G. Caccini's *Le Nuove Musiche* of 1602 with its figured bass demanding plain chords exemplified the new ideas, which are also represented in early Italian operas and oratorios. (G. Rt.)

**MONOGRAM**, originally a cipher consisting of a single letter, now a design or mark consisting of two or more letters interwoven. The letters thus interlaced may be either all the letters of a name or the initial letters of the Christian name and surname of a person for use upon note paper, seals or elsewhere. Many of the early Greek and Roman coins bear the monograms of rulers for whom, or the towns in which, they were struck. The late Latin and Greek words were first applied to the signatures, which took this form, of the emperors of the eastern empire. The signatures of the Frankish kings also were of a monogram.

The most famous of monograms is that known as the sacred monogram, formed by the conjunction of the two initial letters of Χριστος, Christ. The most usual form of this is the symbol

☧ and sometimes the α (alpha) and ω (omega) of the Apocalypse were placed on each side of it. The symbol was incorporated in the labarum (*q.v.*) when the imperial standard was christianized. The interlaced I H.S. (also called the sacred monogram) apparently possesses no great antiquity; it is said to have been the creation of St. Bernard of Siena in the mid-15th century.

Monograms or ciphers were often used by the early printers as devices and are of importance in fixing the identity of early printed books. Similar devices have been used by painters and engravers. The middle ages were, indeed, extremely prolific in the invention of ciphers for ecclesiastical, artistic and commercial use alike. As the merchant had as a rule neither right nor authority to employ heraldic emblems, he, therefore, fell back upon plain simple letters arranged very much in monogram form. These "merchants' marks" generally took the form of a monogram of the owner's initials together with a private device. They nearly always contained a cross, either as a protection against storms or other catastrophes, or as a Christian mark to distinguish their goods from Muslim traders in the east.

**MONOLOGUE,** a passage in a drama in which a personage speaks unconsciously aloud, either alone on the stage or with others keeping silent. The tragedies of the 17th and 18th centuries greatly affected the monologue, which has always, however, been liable to ridicule. There is something of a lyrical character about the monologue in verse; and many of the examples in the tragedies of Corneille are nothing more or less than odes or cantatas. The monologues of Shakespeare and Racine have a more dramatic character. The French critics record as striking examples that of Figaro in Beaumarchais's *Le Mariage de Figaro* and the 160 lines of Charles V in Victor Hugo's *Hernani*. In the Elizabethan drama, the popularity of Kyd's *Spanish Tragedy*, in which Hieronymo spouts interminably, set a fashion for ranting monologues, which occur frequently in Marlowe and others. After 1600 the practice was much reduced, but it returned in exaggerated form after the Reformation, to fall once more into deserved contempt. In the 19th century it was revived in lyric poetry by Robert Browning in such poems as *Andrea del Sarto*, and by Tennyson in *Ulysses* and *Rizpah*. In the 20th century it has been employed in plays such as Eugene O'Neill's *Strange Interlude*, and in poetry; T. S. Eliot used it with great subtlety in "Prufrock" and "Portrait of a Lady."

By means of the "interior monologue," which is an extension of the stage soliloquy, Marcel Proust and James Joyce revolutionized the novel. (G. W. A.; X.)

**MONOMETALLISM:** *see* BIMETALLISM; MONEY.

**MONOMOTAPA** (MANAMOTAPA, BENAMOTAPA) was reported by Portuguese sailors at the beginning of the 16th century as being a mighty emperor living inland from Sofala (Mozambique); the name was applied also to the country that he controlled.

In the second quarter of the 15th century a Karanga chief, Mutota, living south of the Umfuli river, conquered northward as far as the Zambezi. He vanquished Tongas and Tavaras who, according to D. P. Abraham (see *Bibliography*), called him Mwene-mutapa, "master of the ravaged lands." The conqueror adopted this as a praise name. He established his head kraal (village) on the slopes of Chitako hill, at the foot of the escarpment 105 mi. N. of modern Salisbury; surrounded by a dry stone wall, which still stands, it was called *Zimbabwe*, "the big house."

The Portuguese founded a settlement at Sofala to exploit the gold trade of Monomotapa, but the "empire," which at its greatest extent had been bordered by the Sabi and Zambezi rivers and the sea, was already disintegrating. An official in 1506 recorded that about 1490 one monomotapa had been killed by a usurper, Changamire, who had ruled for four years before being himself killed by a son of the murdered chief; since then the country had been rent by revolt. The first European to visit Monomotapa was Antônio Fernandes, about 1511. Portuguese traders, supplanting Arabs, followed, traveling, as the century wore on, from Sena and Tete on the Zambezi. In 1561 a Jesuit, Gonçalo da Silveira, baptized the paramount chief, only to be put to death a few weeks later. A military expedition under Francisco Barreto, sent ostensibly to avenge Silveira's death, failed to reach the Karanga. Traders continued their peaceful penetration and before the end of the 16th century there were three Portuguese *feiras* (trading posts) in Karanga lands. Portuguese help enabled the monomotapa Gatsi Rusere to subdue his enemies, and in 1607 he presented all mines of gold and silver and other metals in his kingdom to the king of Portugal for as long as Portugal maintained him in power.

The Portuguese deposed one unco-operative monomotapa and in 1629 appointed a relative, Mavura. Dominicans baptized Mavura and built a church at his *Zimbabwe*, near Chitako. Other monomotapas were also baptized, but all lived and died as pagans. A garrison protected and dominated the paramount chiefs who were made and unmade by the Portuguese. Traders opened more *feiras*, but conquistadores and miners failed to exploit the mineral wealth of the country. An immigration plan, with agricultural labourers and artisans from Europe, planned in 1635, fell through, and another in 1677 met with little success. Traders acquired vast estates and maltreated subjects of the monomotapa; and the monomotapa in 1693 invited another Changamire to expel the Portuguese. Changamire's clan, the Rozvi, rose to pre-eminence, and in the 18th century the monomotapa's influence became restricted to lands bordering the Zambezi and often not beyond the range of the garrison's muskets.

Descendants by various lines live in Mozambique territory; but the mhondoro ("lion-spirit") of Mutota, custodian of the traditions of Monomotapa, was found in 1958 to be living between the *Zimbabwes* of Mavura and Mutota.

*See* G. M. Theal, *Records of South-Eastern Africa*, 10 vol. (1898–1903); D. P. Abraham, "The Monomotapa Dynasty," *Native Affairs Department Annual*, vol. 36 (Salisbury, 1959). (E. V. Ax.)

**MONONGAHELA,** a river of southwestern Pennsylvania and northern West Virginia, and a major headwater of the Ohio river (*q.v.*), whose source is the confluence of the Allegheny and Monongahela rivers at Pittsburgh, Pa. The headwaters of the Monongahela are the Tygart and West Fork rivers, which join at Fairmont, W.Va. The river flows in a northerly direction in a very sinuous course. Its total length is 128 mi., and it drains about 7,390 sq.mi. The principal tributaries are the Cheat and Youghiogheny rivers. The most important cities along the course of the Monongahela are Fairmont and Morgantown, W.Va., and Brownsville, Charleroi, Monessen, Donora and McKeesport, Pa. In its upper reaches the river has a swift current and furnishes hydroelectric power to several cities. The river has been made navigable for 106 mi. The Monongahela flows through some of the richest coal fields of the United States and is a major artery of transportation carrying such commodities as coal, coke, iron and steel. (E. W. MI.)

**MONONUCLEOSIS, INFECTIOUS:** *see* INFECTIOUS MONONUCLEOSIS.

**MONOPHYSITES,** Christians who teach (or are accused of teaching) that in the person of Jesus Christ there was only one nature rather than two natures, divine and human, as asserted at the Council of Chalcedon in 451.

In the development of the doctrine of the person of Christ during the 4th, 5th and 6th centuries (*see* JESUS CHRIST), Chalcedon managed simultaneously to harmonize several divergent traditions and to alienate some of the adherents of those traditions. It adopted a decree declaring that Christ was to be "acknowledged in two natures, without being mixed, transmuted, divided or separated." This formulation was directed in part against the Nestorian doctrine that the two natures in Christ had remained separate and that they were in effect two persons (*see* NESTORIUS); and in part against the theologically unsophisticated position of the monk Eutyches (*q.v.*), who had been condemned at Constantinople in 448 on the accusation of teaching that after the incarnation Christ had only one nature and that therefore the humanity of the incarnate Christ was not of the same substance as that of other men. Not only theology but political and ecclesiastical rivalries played a role in the decision of Chalcedon to depose and excommunicate the patriarch of Alexandria, Dioscorus (d. 454). The church that supported Dioscorus and insisted that his

teaching was consistent with the unassailably orthodox doctrine of St. Cyril (*q.v.*) of Alexandria was labeled Monophysite. Actually, the label was attached to various theologians and groups. For example, some held that the incarnation had rendered the human body of Jesus incapable of corruption (Julian of Halicarnassus). Others said—in a liturgical formula employed also by some who supported Chalcedon—that "one [person] of the Trinity was crucified," hence that the Godhead had suffered in the crucifixion and death of the one-natured Christ; this position was called Theopaschitism and is associated with the name of Johannes Maxentius. Although still others who were dubbed Monophysite, notably Severus of Antioch (d. 538), did repudiate the terminology of Chalcedon as self-contradictory, most modern scholars are agreed that Severus, as well as Dioscorus himself, probably diverged from what was defined as orthodoxy more in their emphasis upon the intimacy of the union between God and man in Christ than in any denial that the humanity of Christ and that of mankind are consubstantial.

What was true of Dioscorus and Severus would appear to be true also of the Eastern Churches usually classified as Monophysite: the Coptic, the Syrian and the Armenian (*see* ANTIOCH, SYRIAN ORTHODOX PATRIARCHATE OF; ARMENIAN CHURCH; COPTIC CHURCH). They affirm that Christ was perfect God and perfect man, God the Son being really incarnate in him. Christ's manhood, they teach, was not only real and perfect but also dynamic. As man, he was fully like us, with the only exception that he was sinless. Born of the Virgin, he underwent all human experiences of happiness and sorrow, joy and suffering, life and death, with the same reality as any human being. Recovery of communication between these churches and the churches of Roman Catholic, Eastern Orthodox and Protestant Christendom has led to the breakdown of some of the traditional barriers, with the result that most responsible spokesmen for these latter communions would acknowledge the essential orthodoxy of the "Monophysite" churches.

*See* also references under "Monophysites" in the Index.

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**MONOPLACOPHORA,** a class of marine invertebrate animals belonging to the phylum Mollusca (*see* MOLLUSK) and characterized by having a single, cap-shaped shell and bilateral symmetry. They are represented in modern seas by two rare and small species (up to 15 mm. in length) found in waters as deep as 19,200 ft. They are distributed in deep-sea trenches off the coasts of Central and South America. Monoplacophorans have an exceedingly peculiar geologic distribution: they are first known in Lower Cambrian deposits of Newfoundland (about 500,000,000 years old) and are completely unknown in the fossil record after the Lower Devonian (about 320,000,000 years old). One of the most exciting finds in the biological sciences occurred in 1952, when, during the Danish deep-sea expedition "Galathea," a research vessel, dredged up about 12 live monoplacophorans from a depth of 11,400 ft. off the coast of Costa Rica.

Monoplacophorans are unusual and important because of the combination of primitive characters they possess. These characters provide one of the few known instances where a group of animals help bridge the morphologic gap between several animal phyla. In addition to the single, cap-shaped shell, they have paired organs that may be multiple (*e.g.*, several elements of gills and kidneys), reflecting at least partial segmentation (metamerism). Gill structures and the type of metamerism suggest a much closer affinity of the mollusks with the annelid worms than was previously known and also may provide a means of associating the mollusks with the arthropods.

Within the Mollusca, the Monoplacophora stand as a very primitive group. They are similar to the class Amphineura (*q.v.*), which differ in having eight articulated plates (requiring a complex musculature) instead of the single, cap-shaped shell. Amphineura, however, do not show metamerism. Monoplacophorans, because of their single, partly coiled shells, were thought to be members of the class Gastropoda (snails, *q.v.*; whelks, etc.) until paleontologists showed them to possess bilateral symmetry. Gastropods generally lack one of a paired set of organs, thus are asymmetrical, and are not metamerized. The gastropods are fundamentally different from the Monoplacophora in being torted, *i.e.*, early in the growth of gastropods the gastrointestinal tract, along with other features, twists or torts into a figure eight so that the anus is brought near the mouth.

*See* J. Brookes Knight, "Primitive Fossil Gastropods and Their Bearing on Gastropod Classification," *Smithsonian Miscellaneous Collections*, vol. 117, no. 13, publication 4092 (1952). (R. L. BS.)

**MONOPOLIES COMMISSION,** a government body set up in the United Kingdom in 1949 as the Monopolies and Restrictive Practices commission under the Monopolies and Restrictive Practices (Inquiry and Control) act, 1948 (11, 12 Geo. VI, c. 66). It was enlarged by the Monopolies and Restrictive Practices Commission act, 1953 (1, 2 Eliz. II, c. 51), and was reconstituted in 1956 on a reduced scale as the Monopolies commission under the Restrictive Trade Practices act of that year (4, 5 Eliz. II, c. 68). It consists of not less than four nor more than ten persons appointed by the president of the board of trade. Its chairman serves on a full-time basis but the other members serve only part time and include businessmen, a trade union official, an economist and an accountant. The commission is an independent statutory body with its own officers and staff.

The work of the commission (independent of that of the Restrictive Practices court, set up in 1956) is to inquire into the existence and effect on the public interest of monopolies in the supply, processing and export of goods and of certain restrictive practices not dealt with by the court. The term monopoly is used here to indicate the control by one supplier, a group of interconnected bodies corporate or a number of concerns that act together in such a way as to restrict competition, of at least one-third of the supply of specific goods either in the U.K. as a whole or in some specified area of the U.K. If these conditions exist only by virtue of a restrictive agreement falling within the jurisdiction of the Restrictive Practices court, the commission has no power to investigate the supply or processing of the goods concerned; it may investigate conditions arising as a result of agreements relating solely to exports because such agreements cannot be brought before the court. The powers of the commission do not extend to the supply of services or labour.

The commission cannot itself initiate an inquiry. It inquires only into matters referred to it by the board of trade. When an inquiry is made into the supply or processing of goods the commission may be asked merely to report on the facts, but usually it is also directed to consider and report whether the existence of the monopoly conditions or any of the things done by a monopolist as a result of, or in order to maintain, its monopoly, operate or may be expected to operate against the public interest. If it does so find, it is invited, but is not bound, to recommend remedies. Unlike the Restrictive Practices court, the commission, while it must take into account some matters mentioned in the act of 1948, has a fairly wide discretion in interpreting the public interest.

The commission can also be required to report on the general effect on the public interest of a specified class of restrictive practices. It was a general report of this kind, on "Collective Discrimination," 1955 (Cmd. 9504), which led to the legislation of 1956. Where the commission has reported on an industry it may be asked to make a further report showing whether, and to what extent, any recommendations made in or as a result of the earlier report have been carried out by the industry concerned.

The commission has wide powers to obtain the evidence of witnesses and the production of documents. In the absence of any direction by the board of trade it has power to determine its own procedure. The proceedings fall naturally into two parts, the establishment of the facts and considerations of the public interest.

Much evidence is taken in writing and this is supplemented by oral hearings of witnesses. The final stage in the factual part of the inquiry is a "clarification hearing" at which any doubtful points are discussed with the monopolist. After the hearing, a "public interest letter" is sent to the monopolist setting out the matters relating to the public interest that the commission believes may require consideration. This is followed by a "public interest hearing" at which the monopolist is usually represented by counsel and at which the public interest issues are argued.

The commission is not an executive body; it can only report and recommend. Its reports are made to the board of trade who are responsible for laying them before parliament and for publishing them subject to any excisions that the board consider should be made in the public interest or to protect certain trade secrets. It is then for the government to decide what action, if any, should be taken upon them. If the commission has reported that either the existence of monopoly conditions or something done by the monopolist is against the public interest, the minister primarily concerned with the industry has power in certain cases to issue orders to remedy the situation. Any such order must be laid in draft before each house of parliament and approved by resolution of each house. The reports of the commission and the action taken on them are summarized in the board of trade's annual reports on the working of the Monopolies and Restrictive Practices acts. *See* also MONOPOLY: *Legal Aspects: England.*

*See* O.E.E.C., *Guide to Legislation on Restrictive Business Practices: Europe and North America*, 3 vol. (1960). (A. S. GI.)

**MONOPOLY,** a term used in law and economics to denote exclusive control of the supply of a commodity or service in a given market, or the exclusive privilege of buying or selling in a given market. A monopoly may be granted by the state for certain purposes or may be acquired through the normal processes of business competition. This article considers the subject under three headings: History, Legal Aspects and Economic Theory.

## HISTORY

Monopolies are probably as old as commercial civilization. Corners and combinations were prohibited by the most ancient laws of China, Babylonia and India, and specific monopolies are mentioned in classical literature. Aristotle (384–322 B.C.) tells in the *Politics* that Thales hired all the olive presses in Miletus during the winter and was able to lease them profitably when a plentiful harvest came. Aristotle treats the maneuver as a commonplace; all Thales did, he says, was to create a monopoly, just as cities do in order to raise revenues. In Egypt, this method of public finance was carried to an extreme when the Ptolemies (323–30 B.C.) took over from the temples the control of all manufactures, and required merchants to sell materials at fixed prices to the royal monopolies, which enjoyed exclusive rights to the services of craftsmen and were the only sellers of papyrus, oil and cloth. In Rome such practices were less common, though the Flavian and Antonine emperors in the 1st century A.D. established some monopolies of corn so that by manipulating its supply they could control their subjects, while Alexander Severus and Aurelian in the 3rd century A.D. created monopolies to rent them to private contractors. Complaints recorded by Pliny the Younger and a prohibition passed during the reign of Tiberius show that unauthorized monopolies often sprang up during the 1st century A.D.; an edict of Zeno, issued in 483 and perpetuated in the Code of Justinian, gives evidence that combinations had by then become frequent, especially among builders, who agreed that none would complete a house begun by another. By the 5th century, all the fundamental varieties of monopoly were known and its basic principle understood, although many forms and uses were devised later.

**Medieval Monopolies.**—An important innovation was made during the middle ages, when governments began to bring economic life under their domination and adapted to this end privileged institutions that had arisen for other purposes. They based their control over foodstuffs partly on powers that lords of manors traditionally exercised over markets, powers they successfully defended in royal courts as early as the 12th century and which precluded anyone from trading outside the official stalls and hours, or from holding any other market within a certain distance. As part of their effort to keep prices low and stable by law, governments reinforced these monopolies by imposing punishments sometimes as severe as death on those who evaded the markets and the fixed prices. A statute for the "assize of bread and ale," passed in 1266 by Henry III of England, provided that bakers or brewers who charged more than the law permitted would be fined, or "corrected" by pillory and tumbrel. Like many similar laws of the next 500 years it prohibited interference with the established prices by forestallers, engrossers, regrators, and, in short, all speculators or wholesale traders.

Other institutions were empowered by royal authority to establish control over manufactures and commerce. The most important were the guilds, which, originating as private associations of townsmen, grew by the 12th century to be organizations of particular crafts, armed by charter with considerable monopolistic powers. The guilds fixed conditions of membership, set limits to the number of employees as well as to the hours and conditions of work, and were able to uphold the joint monopoly of the handful of masters by the power of search and seizure. (*See* GUILD.) During the 16th century, for instance, no Londoner could lawfully work in precious metal unless he belonged to the Goldsmiths company, which had power to assay and stamp all gold and silverware made nearby, to destroy any that fell below their standards and to punish the makers. Although the guilds often paid annual fees and made large occasional gifts to the crown, the income they gave the treasury was not considered a more important contribution to the public good than the order they imposed on trade. Foreign commerce was often regulated in the same manner by companies of merchants privileged to trade with certain parts of the world, and some of the great mercantile companies that grew up in the 17th century accepted in addition responsibility for supporting armed forces and their nations' ambassadors abroad. They were thus pressed into public service and, like the guilds, became in effect administrative agencies of the government. (*See* EAST INDIA COMPANY.)

**Monopolies by Grant and Patent.**—Special privileges were created also in order to encourage new trades, and were granted with special liberality to enterprises that needed large sums of capital. In 1538, Duke George of Saxony gave Michel Puffer, a merchant of Leipzig, a three-year monopoly to sell all the tin produced by several mines, in return for which Puffer provided capital for the working of the mines and paid a set price for the product. In 1549, Emperor Ferdinand I granted similar powers over Bohemian tin to a merchant of Augsburg, who was required in turn to extend a large loan to the emperor and to pay royalties on his profits. But the monopoly was threatened by the competition of tin from Saxony, even though the emperor forbade its importation and ordered special vigilance against smuggling, and despite further concessions the monopolist sustained great losses. Industries depending on rare skills were encouraged by the same means. In 1467, a monopoly of papermaking was granted by Berne; two years later a monopoly of printing was given by Venice; and in 1507, another Venetian was given a monopoly of mirror making. In England during the 16th century, patents were given to induce foreign craftsmen—Italian glassworkers, French iron founders, German armourers and Dutch drainage engineers—to settle there.

But such grants were not always disinterested. The privilege granted John Peeche in 1373 to be the sole retailer of sweet wine in London, despite the general rule that sweet wine should not be sold at retail, recompensed him for having made loans or gifts to John of Gaunt, the king's son. To grant monopolies as rewards for faithful service or to sell them to the highest bidder remained an only occasional practice until Elizabeth I made it a frequent if not characteristic exercise of prerogative. Beginning in 1561, patents were regularly issued for the sale of common commodities, so that by 1590 paper, glass, vinegar, salt, starch, oil and even playing cards were sold exclusively by patentees. Parliament resented the powers of patentees to search private houses and order arrests, regarded the whole system as an abuse of royal power, and attacked it with such energy that Elizabeth promised in 1601 to forego it. Although her successors during the rest of

the century alternately issued and revoked similar patents, the Statute of Monopolies of 1624 established the broad principle that patents must be awarded by parliament for a limited term to inventors, the principle on which modern patent law is erected.

The Statute of Monopolies, however, was neither the climax of a long development of antimonopoly law nor the end of the system of public control by private privilege. Legislation against monopolistic behaviour was common enough throughout Europe long before the 17th century, and indeed there have probably been antimonopoly laws for almost as long as there have been private monopolies. Capitularies of Charlemagne prohibited combinations from raising the price of food; a municipal law of Viterbo, Italy, adopted in 1251, penalized merchants who associated to buy or sell fish; and Wenceslaus II of Bohemia toward the beginning of the 14th century condemned combinations to raise the price of ore. Similar rules were contained in the municipal statutes of Florence, Nürnberg and Cologne during the 14th and 15th centuries and in ordinances of French kings, as well as in the acts of England. But these laws were less broad than they seemed at first sight; almost invariably they were directed against unauthorized efforts to raise the price of foods and basic raw materials such as wool, ore and hides; they did not question the validity of established and authorized monopolies. The city councilors who prohibited combinations of food sellers were often themselves representatives of guilds, and kings who vigorously enforced laws against engrossers were often simultaneously setting up patent monopolies. Even as late as the 17th century, the Statute of Monopolies itself, while strictly limiting the issue of new patents, expressly exempted all prescriptive and statutory privileges of guilds, companies and municipal corporations. Many statutory monopolies were never abolished, but decayed as the governments, more or less dedicated to free trade or democracy, withdrew their support. Unauthorized monopolies continued in many places to be prohibited by law, but after the 18th century they became more liable to be prosecuted for interfering with competition than with government control of the economy.

**Industrial Monopolies.**—After the early 19th century, the most noticeable feature in the history of monopoly was the apparent increase in the number of private monopolies, often national and sometimes international in scope, and the efforts of promoters to organize them in legally and economically stable forms. As increasing ease of transportation extended the area of markets, the scale of monopolies grew accordingly, and with it the difficulty of organizing combinations, since as the number of associated firms grew greater it became simpler for any one of them to undercut prices secretly or to exceed its quota. As a result of this, many U.S. combinations during the second half of the 19th century collapsed. Also, it was usually impossible to enforce agreements among members, since the courts continued to uphold the common law rules against contracts and combinations in restraint of trade. Moreover, because U.S. corporations generally lacked power to own stock in other corporations, it was difficult to devise any lawful arrangement to give a monopolistic combination legal permanence. But in 1882 the Standard Oil company combination reorganized as a trust; the stockholders of each corporation participating in the combination turned over their shares to a small group of managers, who became the trustees of the former owners and by holding all the stock were able to operate the separate legal entities as a single economic unit. The scheme seemed to answer the purpose so well that it was widely copied, and by 1890 a number of important national monopolies had organized as trusts, particularly in the oil, sugar and distilling industries. The device was soon attacked, however, on the principle that by joining trusts the corporations had exceeded their powers; and it was readily abandoned after 1890 when a number of states altered their laws so as to allow one corporation to own another, as a result of which the more tightly knit monopolies organized as holding companies or simply as consolidated corporations.

The apparently sudden growth of great industrial combinations that took place in the U.S. and gave rise there to the antitrust laws was paralleled in England, where no legal obstacles were interposed until after World War II, and in Germany, where government neither prohibited nor ignored the cartels but established public agencies to regulate them. (*See* CARTEL.) In these countries during the 20th century, as elsewhere in the past, monopolies and large firms that were assumed to be monopolistic were always being formed and always fading or vanishing. In the latter 1950s the impression was very widespread that monopolies controlled a much larger fraction of economic life than they had in the past, even though investigators did not agree that close statistical study substantiated this conclusion. The longer history of monopolies, based as it must be, on less precise and complete evidence, makes it clear that hosts of private monopolies existed even though they were prohibited, but that none of them survived very long unless it was protected by the positive intervention of the state.

(W. L. L.)

## LEGAL ASPECTS

The extent to which competition should be encouraged or restricted by law has been an important issue in Anglo-American countries for hundreds of years. In the 20th century the subject has received much attention in Europe, especially after World War II when provisions against restraint of competition were embodied in a number of national laws and international treaties. The English common law and ancient statutes forbade certain activities known as "forestalling," "engrossing" and "regrating" that were deemed prejudicial to the functioning of the public markets because they resulted in cutting off or "cornering" the supply of a commodity destined for the market. The common law of contracts evolved a doctrine of "unreasonable restraint of trade" pursuant to which the courts invalidated certain restrictive agreements. The courts, for example, invalidated contracts by which the seller of a business bound himself not to compete with the buyer, or an apprentice or employee bound himself not to compete with his employer, if the scope of the restraint exceeded the fair requirements of the buyer or employer. The common law of conspiracy constitutes another antecedent of the antitrust laws; this vaguely defined cause of action covers any combination of persons to oppress or wrong others or to injure them in their trade or profession. Still another ingredient of the antitrust tradition was the hostility to royal grants of exclusive trading privileges that was crystallized in the Statute of Monopolies of 1624.

**United States.**—The United States in the 19th century, especially after the Civil War, saw a spectacular growth of great private corporations. The new transcontinental railroads levied heavy tolls on farmers and other shippers and could decree economic life or death to individual firms or whole communities by discriminating against them in rates or services. Producers of basic commodities such as steel, sugar or petroleum entered into agreements or combinations to keep up prices or drive undesired rivals from the field by depriving them of access to raw materials or cheap transportation. The monopoly tactics of John D. Rockefeller's Standard Oil company became an important political issue. State legislation having proved ineffective to regulate these activities, two federal laws were finally enacted: the Interstate Commerce act of 1887, setting up the Interstate Commerce commission to control rates and practices of interstate railroads, and the Sherman Anti-Trust act of 1890.

Section 1 of the Sherman act declared illegal "every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations." Section 2 forbade any person to monopolize or to attempt, combine or conspire to monopolize such trade. Violation was made punishable by fine and imprisonment up to one year. Federal prosecutors were directed to seek injunctions to prevent and restrain violations; and private parties injured by violations were permitted to sue for treble damages.

In the early years of its history, administration of the Sherman act was severely restricted by narrow judicial interpretation of the words "trade or commerce among the several States, or with foreign nations." The famous Sugar Trust case (*U.S. v. E. C. Knight Co.*, 156 U.S. 1 (1895)) held that a monopolistic combination of sugar refiners did not violate the Sherman act since the

combination related solely to local production, even though the raw materials were imported and the finished product was distributed in interstate commerce. But such views gradually gave way to a more expansive conception of federal concern for interstate commerce as epitomized in Justice Jackson's remark in *U.S. v. Women's Sportswear Manufacturers Association*, 336 U.S. 460 (1949): "If it is interstate commerce that feels the pinch, it does not matter how local the operation which applies the squeeze." So also earlier doubts whether "trade or commerce" embraced professional or financial activities, and services as distinct from commodities, have been laid to rest.

A more enduring controversy rages over what kind of behaviour the antitrust laws condemn; *i.e.*, what constitutes unlawful restraint or monopoly. In the landmark decision that upheld a decree against the Standard Oil company, the supreme court declared that the first section of the act could not be read literally to outlaw every restraint, for many normal and useful business contracts necessarily restrict the freedom of the parties to some extent. Accordingly the section was to be read in the light of the common law as prohibiting only unreasonable restraint. This famous declaration of the "rule of reason" is the mainstay of those who favour considerable latitude for collaboration by businessmen. On the other hand, the courts from the very beginning held that certain agreements were illegal "per se"; *i.e.*, without regard to the good reasons which might be advanced in justification. Preeminently illegal per se are agreements to fix, regulate or influence prices. Collective boycotts and agreements allocating shares of the market among the contracting parties are likewise illegal per se.

The basis of the per se rules is the courts' conviction that certain trade freedoms are essential if trade is to be regulated by competition rather than private planning. Moreover, the courts are understandably reluctant to have legality turn on whether a price fixed by agreement is fair or unreasonable. The answer depends too much on philosophic, moral and political preferences. Also, a price that is reasonable one day may become unreasonable the next day as a result of changed conditions; to keep up with such changes the courts would have to be constantly reassessing the reasonableness of innumerable prices, an administrative task for which they are not equipped.

Certain restrictive business arrangements, not illegal per se, came to be so readily justified despite their adverse effect on competition that congress undertook in the Clayton Antitrust act of 1914 to tighten the prohibitions against them. Section 2 of the Clayton act, strengthened in 1936 by an amendment known as the Robinson-Patman act, relates to price and other forms of discrimination among customers. Section 3 relates to sales of goods "on condition, agreement or understanding" that the buyer will not deal in goods of the seller's competitor. Section 7, fortified by the Celler-Kefauver amendment of 1950, relates to mergers. Section 8 deals with interlocking officers and directors. The Clayton act forbids such transactions where the effect "may be to substantially lessen competition," phraseology designed to focus consideration upon three elements: (1) upon effect, without regard to good business intentions; (2) upon competition, rather than broader questions of desirability of the restraint; and (3) upon potential rather than demonstrable actual injury to competition. The courts have nevertheless occasionally interpreted the Clayton act with a latitude reflecting the "rule of reason" developed under the Sherman act. Violations of the Clayton act are not punishable as crimes, but subject the offender to civil action for injunction and treble damages.

Concurrently with the Clayton act, congress enacted the Federal Trade Commission act declaring in section 5 that "unfair methods of competition" are unlawful, and setting up a commission to interpret and enforce this prohibition. The commission issues cease and desist orders against practices that incipiently threaten competition, even though they may not yet have reached the stage of violating the antitrust laws.

Interesting examples of the application of U.S. antitrust laws have to do with the efforts of trade associations to standardize trade practices, exchange information among competitors, or hamper the operation of "unethical" firms. It has been held that a trade association violates the Sherman act if it publishes statistics and forecasts of production, inventory, shipments, prices and costs, in combination with warnings against overproduction, urging members to resist price-cutting pressures, and requiring participants to supply detailed information as to their operations and prices. The U.S. supreme court viewed this action as a combination to maintain or raise prices, notwithstanding that membership in the plan was voluntary and there was no limitation on the freedom of any member to produce as much as he liked and sell at whatever price he chose. (*American Column & Lumber Co. v. U.S.*, 257 U.S. 377 [1921].) Trade associations and their members have also run into antitrust difficulties by sponsoring a rule that each member will publish a schedule of prices and will adhere to his own schedule until he publishes an amendment (*i.e.*, to refrain from secret price concessions).

There is an elaborate body of antitrust law in the United States relating to "vertical integration" by merger or contract. Vertical integration denotes the unification of control over several successive stages of production or distribution. Thus a producer of rolled steel may buy the assets or stock of a firm engaged in fabricating or distributing steel products. The acquired firm is no longer free to buy unfinished steel from rival producers, thus circumscribing their ability to compete with the acquiring firm. Such an acquisition was upheld in *U.S. v. Columbia Steel Co.*, 334 U.S. 495 (1948); but expansive interpretations of Section 7 of the Clayton act have put stronger checks on vertical acquisitions; *U.S. v. Brown Shoe Co.*, 370 U.S. 294 (1962); *cf. U.S. v. DuPont Co.*, 353 U.S. 586 (1957).

A similar result would follow from a long-term contract between a producer and a distributor requiring the latter to handle only the goods of the former. In the case of *Standard Oil Co. of California v. U.S.*, 337 U.S. 293 (1949), the petroleum company was held to have violated section 3 of the Clayton act by making one-year renewable "requirements contracts" with independent retail gasoline dealers. This form of contract obligated the dealer to purchase all his requirements of gasoline from the Standard Oil company. The effect was to preclude the dealer from switching to another supplier during the contract year, although the contract terms did not literally violate the prohibition of "condition, agreement or understanding" that the buyer would not "use or deal in" goods of another seller. The supreme court, by vote of 5–4, held that there was sufficient likelihood that this arrangement would impair the vigour of competition in the sale of gasoline, since Standard Oil was the leading seller in the market. The court also observed that other leading companies followed a similar distribution plan, with the result that a new company seeking to invade the market would encounter difficulties in finding distributors free to handle its product. Dissenting justices believed that vertical integration served to make rivalry more effective between the integrated suppliers, and regarded the majority opinion as resting unjustifiably upon the mere quantity of sales covered by the contracts.

With regard to the monopoly branch of antitrust law, represented principally by section 2 of the Sherman act and section 7 of the Clayton act, the following observations may be made. A firm need not control 100% of the market to be an illegal monopoly, but it has been said that one-third would be insufficient and two-thirds doubtful. On the other hand, this striking tolerance for dominant position loses much of its significance when it is recalled that a firm may violate section 2 merely by attempting to monopolize, even if it has at present only a small position in the market. Intent is crucial, at least under the Sherman act. Even 100% control would not be illegal if monopoly were thrust upon the firm; *e.g.*, by retirement of other rivals from the field as a result merely of effective but fair competition. A convicted monopolist may be broken up into smaller firms, as was the original Standard Oil company, but the courts have been notably reluctant to employ this remedy.

There are a number of important exemptions from the antitrust laws. Section 6 of the Clayton act, supplemented by later legislation, provided that the antitrust laws should not apply to labour

unions or agricultural co-operatives "lawfully carrying out the legitimate objects thereof," although such organizations may still be guilty if they aid employers or others to commit violations. The Webb-Pomerene Export Trade act authorized U.S. firms to collaborate in noncompetitive associations for export. The McGuire act, reinforcing a provision first passed in 1937, exempted arrangements whereby a producer or distributor of a trade-marked commodity fixes the resale price of the commodity, if such arrangements are lawful in the state where the resale takes place. (*See* FAIR TRADE LAWS.) The Interstate Commerce act and other regulatory statutes explicitly exempt from the antitrust laws mergers and other arrangements approved by the regulatory agency as consistent with the public interest. The courts have also been compelled to reconcile the general mandate of the antitrust laws with the explicit authorization of limited monopolies under the patent and copyright laws. (L. B. S.)

**England.**—Although the Sherman act, in the contemplation both of the U.S. congress and of the courts, was declaratory of the common law, the English legal approach to combinations in restraint of trade has differed markedly from the U.S. approach. No body of English antitrust law has grown up which is comparable to that comprised in U.S. cases.

English judges have consistently refused to equate the narrowly defined concept of "public policy" to a particular economic theory. Whereas numerous U.S. dicta are to be found which express the view that the intention of the common law is affirmatively to foster freedom of trade or freedom of competition, English judges say no more than that it is contrary to public policy that the course of trade should be subject to unreasonable restraint or that a man should be restrained from employing his capital or talents as best he may. It is moreover entirely consistent with public policy, in the English judicial view, that reputable businessmen should be free to enter into such contracts as seem necessary or desirable to advance their interests and that they should be obliged to honour these agreements.

During the economic depression of the 1930s, when the New Deal produced in the United States violent attacks on all practices tending to monopoly, restrictive agreements between competitors in England, often encouraged by the government as "rationalization," became widespread. Numerous associations of manufacturers or wholesalers were formed, in addition, having stringent powers of imposing extralegal sanctions on those who infringed their rules, and the exercise of these powers was upheld by the courts. After World War II a succession of government committees and a government commission sat to inquire into the effect on the public welfare of this complex of agreements and associations which had grown up under the joint influence of legal rule and economic circumstance. The commission's reports, in general but not without reservation, were adversely critical.

In 1948, accordingly, the Monopolies and Restrictive Practices (Inquiry and Control) act was passed into law. This act set up a commission known as the Monopolies commission whose duty is to investigate, on a reference by the board of trade, monopolistic or restrictive practices or conditions considered to exist in particular trades or industries. Sitting in private, but with wide powers of calling witnesses, it produces reports, which are published for the board of trade, determining whether the alleged practices or conditions exist and, if so, whether they are detrimental to the public interest.

Although various government departments have statutory power to make orders bringing such agreements to an end, this power had by 1961 been used in one instance only. The board of trade normally relies on moral suasion to induce parties to abandon obnoxious agreements or arrangements and this method has been widely effective. Many persons and associations have given undertakings to the board of trade to abandon the practices or conditions concerning which complaint has been made and such undertakings, whether the result of a finding by the Monopolies commission or of proceedings or the threat of proceedings before the restrictive practices court, are of the greatest importance in the day-to-day operation of the English law.

In 1956 the Restrictive Trade Practices act was passed. The purpose of this original and ingenious statute is to lay down a legal test as to those agreements or arrangements which are contrary to the "public interest," a concept distinct from the "public policy" of the common law, and to provide judicial machinery for their abrogation. By contrast with U.S. legislation, criminal sanctions are absent from the English statute save for those which are ancillary to its major purpose. The act brought into existence two mechanisms to give effect to its intentions. First, it created a registrar of restrictive trading agreements who is charged with the duties of compiling and maintaining a register of agreements and of taking proceedings in respect of them. Second, it constituted a new superior court of record called the restrictive practices court, consisting of five judges and of up to ten other persons who are qualified by virtue of their knowledge of or experience in industry, commerce or public affairs.

With certain exceptions, it is obligatory to register with the registrar any agreement made between two or more persons carrying on business within the United Kingdom in the production or supply of goods, or in the application to goods of any process of manufacture, under which the parties accept restrictions as to prices, conditions of supply, quantities to be produced, the processes of manufacture or the persons or classes of persons or areas concerned in the supply or acquisition of goods.

The registrar enjoys twofold powers in the event of failure to register such an agreement. First, he may serve a notice on a person requiring him to furnish the necessary particulars. Omission to comply with the notice or deliberate falsehood in the particulars supplied is a criminal offense punishable by fine. Secondly, he may make an application to the high court of justice, and if the court is satisfied that there has been a wilful failure to register an agreement, it may exercise forthwith all the powers conferred by the act on the restrictive practices court in the case of agreements found to be contrary to the public interest.

The court is empowered to determine whether or not restrictions brought before it by the registrar are or are not contrary to the public interest. A restriction satisfying the requirements for registration is presumed to be contrary to the public interest unless the parties can displace the presumption by proving affirmatively any of the matters set out in section 21 of the act. An agreement so found is void, and the court may grant an injunction restraining the parties from giving effect to it or from entering into any similar agreement.

Section 21 of the act provides that the presumption may be displaced if the court is satisfied as to one or more of seven specific circumstances: (1) that the restriction is reasonably necessary to protect the public from injury in connection with the consumption, installation or use of goods; (2) that the removal of the restriction would deny to the public specific and substantial benefits; (3) that the restriction is reasonably necessary to counteract measures taken by one person not a party to the agreement with a view to restricting competition; (4) that the restriction is reasonably necessary to enable parties to it to negotiate fair terms with one person not a party thereto who controls a preponderant part of the market; (5) that the removal of the restriction would be likely to have a persistent and adverse effect on the level of employment in a given area; (6) that its removal would be likely to cause a reduction in the volume or earnings in the export trade; (7) that the restriction is reasonably required for the maintenance of another restrictive agreement which has been found to be not contrary to the public interest.

In practice a very large number of offending restrictions contained in registered agreements have been abandoned by the parties without recourse to the court. In a considerable number of other cases the court has made a declaration by agreement between the parties and the registrar. A small number only have been contested. An injunction is rarely granted. Instead the parties give an undertaking not to give effect to the agreement and not to enter into any similar agreement.

The elaborate machinery whereby the trade association enforced its restrictions is abolished. Section 24 provides that it shall be unlawful to make any agreement or arrangement whereby persons collectively undertake to withhold supplies from dealers or to

discriminate between dealers who have resold goods in breach of a condition as to price; and likewise to make any arrangement authorizing the recovery of penalties, whether by way of domestic proceedings or otherwise, as a means of enforcing resale conditions.

The act, on the other hand, institutes a new cause of action thereby obviating one of the matters for which the trade association was formed. For whereas in common law a supplier who sells goods subject to a condition as to the price at which they shall be resold may not enforce the condition against a dealer who sells in breach of it if not a party to the contracts, by section 25 of the act he may, by injunction, restrain a dealer who threatens to disregard the condition, even though not a party to the agreement, provided he had notice of it. (E. A. Mo.)

## ECONOMIC THEORY

**Pricing and Allocation of Resources.**—The theory of monopoly price is most exact where the entire market for a commodity or service is occupied by a single firm which also controls all entry into its field. Such a firm will of necessity consider the effect of changes in its output on the resulting price and on its total receipts. Consequently, in deciding whether to utilize another unit of productive services purchased in a competitive market, it will compare the cost of such a unit with the amount the resulting product will add to its receipts, taking account of the fact that the additional output will lower the price of its total output. And if the firm is also the principal purchaser of the productive services, it will also take account of the effect its purchases have on the prices of these services. This behaviour is in marked contrast with that of competitive firms (*see* COMPETITION, ECONOMIC), which take the market price as given and adjust their output to the point where the cost of an additional unit is just equal to its price. This difference in behaviour results in a misallocation of productive resources when monopoly is prevalent. The output of a monopolized industry is smaller than it would be under competition; and the price of the commodity or service is higher. Whether misallocation of productive resources results also from the fact that monopolies are less efficient than competitive enterprises, or contribute to greater instability in the economy, is a matter of dispute.

The same type of analysis, with slight modification, is applicable to the industry in which there are a great number of firms that remain as independent entities, but combine for the purpose of deciding on price and output. The general direction of the result is the same as that for the single firm, a smaller output and a higher price than result from competition. But since the participating firms are independent, they will endeavour to enlarge their scale of operations in order to increase their individual claims to the higher profits prevailing in the industry. Similarly, new firms will be tempted to enter the industry in order to get a share of the higher profits, and will have to be given a share in total output if the collective action is to be continued. In this way the amount of productive resources attached to the industry is greater, although the total output is smaller, than it would have been under competition. Ultimately the rate of return to productive resources will be reduced to the competitive level, but the productive resources attached to the industry are not utilized efficiently. One difference between the two types of monopoly is that in the single firm type the misallocation of resources is the result of having too small an amount in the industry, while in the association type it is the result of having too large an amount. Another difference is that in the single firm type the rate of profit is higher than it is under competition, while in the association type it is the same.

**Formation and Maintenance.**—Monopoly may be inevitable. It may be due to the fact that cost of production is smaller for a single firm than it would be for several smaller firms because of economies of scale. Industries characterized by such cost conditions are usually designated as natural monopolies; e.g., public utilities. Because competition is impossible, such industries are generally subjected to some form of state regulation over prices and the scale of operations. While generally associated with public utilities, economies of scale may also be a characteristic of other industries. Whether such cost conditions are prevalent in other industries cannot be readily determined. Conclusions must be based on such factors as the length of time during which a single relatively large firm continues to thrive, and the extent to which smaller firms survive. On the other hand, an industry characterized as a natural monopoly at one time need not always remain one. Railroads may still be subject to economies of scale, but the advent of alternative forms of transportation—trucks and airplanes—has probably eliminated the monopoly element from railroads.

All monopolies are temporary except those based on economics of scale or exclusive grants from the state. The prices and profits of monopolized industries will attract new firms whose entry will in time destroy the monopolies. The most general method of establishing such temporary monopolies is that of purchasing existing firms or merging with them into a single relatively large firm. Or a temporary monopoly may be established by creating a single association to replace the individual decisions of the independent firms over price and output with a collective decision. It is frequently suggested that temporary monopolies can also be established through coercive methods such as general or local price-cutting, exclusive dealing with or without rebates, tie-in sales or licensing under patents, price discrimination and price maintenance. (*See* FAIR TRADE LAWS.) But these policies can be utilized only when some monopoly power already exists. A competing firm has no advantage in price-cutting not available to other competing firms. A buyer with adequate alternative sources of supply will not accept imposed conditions of exclusive dealing or tie-in sales unless he is paid for such conditions by offsetting rebates. The payment of such rebates does not establish any advantages for the seller not available to other competing sellers. A producer will not enforce price maintenance at the distribution level except where peculiar conditions of marketing make this an advantageous procedure, unless the distributors already have sufficient power to exact such enforcement. A competitive seller will not continue to accept lower prices from some buyers when he can divert his output to other buyers.

If effective at all, coercive methods or predatory practices can be utilized only if some firm already has some monopoly power obtained in other ways. The alternative functions of such practices is said to be that of increasing the monopoly power obtained in other ways, or maintaining a given degree of power by discouraging potential competition. The effectiveness of such methods for this purpose is also subject to significant limitations. The cutting of prices on a local or general basis imposes the same costs per unit on the firm initiating such reductions in order to destroy a rival or a newcomer as it imposes on the rival or the newcomer. The evidence of price-cutting can usually be interpreted as the result of the expansion of rivals or the entry of new firms rather than as a practice to keep such rivals from expanding or to prevent new firms from entering the industry. Even a complete monopoly is not unlimited in its power. Once a monopoly has imposed a monopoly price it has exhausted its market power. Thus it cannot both charge a monopoly price and impose exclusive dealing on its purchasers. If it does the latter, it must make some concessions from the monopoly price. Such a practice, therefore, involves some cost, and unless the cost assumed is less than the cost imposed on rival firms, the method cannot be effective as a device to increase or maintain a given degree of monopoly. There are special circumstances which may make the costs of exclusive dealing smaller for the firm with some monopoly power than for the firms without such power. This would be the case where the firm with monopoly power has a greater variety of the product than all the other firms, and where such variety is economically important to the distributor. In the general case, as when the product is standardized, the costs are the same to both the firm with monopoly power and the other firms, and exclusive dealing is not an effective method of preventing other firms from expanding or entering. Beyond this, exclusive dealing or its equivalent—ownership of the channels of distribution—may impede the expansion of existing firms, or the entry of new ones, because it increases the capital required for entry or expansion. Increased capital requirements may impede expan-

sion or entry either because of the difficulties of obtaining capital or because of the greater risks attached to entry and expansion on a large scale than on a small scale.

Tie-in sales, when the sale or licence of the monopoly product or machine is made conditional on the purchase of some complementary unpatented product, are commonly found in connection with patented machines or products. As in the case of exclusive dealing, setting a monopoly price exhausts market power. The monopolist cannot both set a monopoly price and impose other coercive conditions. Hence in the usual case he cannot increase his monopoly profit by attempting to monopolize another product. In many instances, it is difficult to make certain that the practice of tie-in sales is in fact coercive. It may result from the advantage of selling the two products in a single transaction and the disadvantage of offering them separately. In other cases the practice may be an indirect method of charging different prices for the monopoly product to different buyers. The sale of the unpatented complementary product may be the most effective means of making such a differentiation in price. Thus a firm which has a patented machine could not ordinarily sell it at different prices. Resale would promptly establish a uniform price. And yet different prices might result in maximum profits. By setting appropriate prices for the machines and for the materials used in the machines, the firm may collect higher prices for the machines from those who use large quantities of the materials than from those who use small quantities of the materials. Price discrimination may indeed be a characteristic of monopoly whenever a given market can be separated into two or more parts, and the customers in each have different demand conditions. But such discrimination is a method of maximizing the profits from a monopoly and not one of increasing the degree of monopoly. In fact, insofar as price discrimination increases the profits of monopoly, it increases the incentive for expansion of other firms and entry of new ones. The interpretation of price discrimination as a method of extending monopoly is in part at least based on failure to distinguish between nominal prices and prices which reflect other conditions of selling. In part the interpretation is based on a failure to separate sporadic price discrimination, which may be a characteristic of competition, from systematic price discrimination, which is a characteristic of monopoly conditions.

**Oligopoly and Monopolistic Competition.**—Monopolies of the single firm type are quite rare except for natural monopolies and those based on exclusive grants from the state. The commoner phenomenon is that of markets in which a few firms account for the bulk of the industry output. These monopolies also may be based on economies of scale so that the cost of production of three or four firms is significantly less than that of many smaller firms. Or monopolies may arise from the purchase by three or four firms of many of the other firms in the industry, or the merger of competitive firms into three or four relatively large firms. The behaviour of such oligopoly industries cannot be predicted with the same confidence that the behaviour of a single monopoly firm can be predicted. In general, if the firms can work out a satisfactory scheme for sharing in the advantages of monopoly, they can be expected to approximate the prices set by a single-firm monopoly. The smaller the number of firms the more likely is such a result to follow. But the difficulties of arriving at a satisfactory division of the market may make the behaviour of an oligopoly industry approximate that of competition rather than that of monopoly.

*See* CARTEL; COMPETITION, ECONOMIC; MARKET; *Economic Theory* and references under "Monopoly" in the Index.

(AN. D.)

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**MONORAIL,** a type of material-handling or passenger-carrying equipment which employs trolleys or cars travelling on overhead tracks. (*See also* MATERIAL HANDLING.)

The use of the monorail principle of a single overhead track for passenger trains is exemplified by the Wuppertal (Ger.) Schwebebahn ("suspension railway"), conceived by Eugen Langen and put into operation in 1901. In 1956 a 670-ft. pilot line was opened in Houston, Tex., to show the possibilities of such a system for urban transportation and another line, about 1½ mi. long, was built in Seattle, Wash., for the World's fair held there in 1962. The term monorail is also sometimes confusingly applied to track systems like conventional ones except that only one rail is used. Such a system was the Ballybunion railway in Ireland (1882–94); another such, the "Alweg," was demonstrated near Cologne, Ger., in 1952.

Monorails for material handling differ from trolley conveyors in that the load carriers are not connected by chain or cable. The free monorail carrier is pushed or pulled along its track by an operator walking along the floor, whereas power-driven monorail carriers have independent electric motors to provide locomotion. Loads are moved intermittently over a fixed path and in an elevated position. The overhead trackage may consist of a pipe, flat bar or structural rail, attached to the overhead structure of the building, or to special structural supports, by hanger rods, structural angles, side-strain brackets and clamps.

Pipe or tubing tracks have been widely used in the garment industry. The pipe or tubing can be bent during installation to form curves, and the sections are welded together to form a complete system. Hooks, wire hangers or small-wheeled trolleys may be employed to guide on the pipe rails.

Flat-bar rails are used largely in the meat industry. The track consists of straight and curved sections of steel flats which are butt-welded during installation. Special mounting hangers support the bar rail from one side, and the load is supported on hangers which extend from the trolley wheels on the other side of the rail. Single pulley-type trolley wheels are employed to ride on the top edge of the bar rails.

Structural rail systems are by far the most common and are used in all types of industry. The tracks must be sufficiently strong to withstand heavy loads and they must be designed to provide flat and wear-resistant surfaces to support the trolley wheels. The rail sections may be modified I- or T-beams, or they may consist of specially constructed steel truss assemblies, slotted rectangular tubing or twin-track sections bolted back to back. In most of these rail systems, the trolley wheels are employed in pairs riding on each flange of the beam. These pairs of wheels are mounted into yokes which in turn support the load directly beneath the centreline of the rail. An individual load carrier may be supported on two, four or eight trolley wheels. Where slotted rectangular tubing track is employed, the smaller trolley wheels ride inside the tubing on the bottom flanges and the load is supported on hangers which extend through the slot in the bottom of the rails. For all monorail systems, the track is installed parallel to the floor at one selected elevation. Elevating sections may be employed to raise or lower one section of the rail to other elevations or to tracks at other levels. Such elevating sections employ man-

ual, electric or pneumatic hoists. Coupled with a powerized carrier, a completely automatic carrier system can be designed to provide a repeating cycle of lifting, carrying and lowering operations.

As with a model railroad, switches and cross tracks can be provided to connect intersecting track sections. Turntables may also be provided to rotate the carrier and its load for spraying, cleaning or inspection operations. As has been indicated, the individual carriers may be powerized with an electric motor drive, which is supplied current from an electric feed rail that runs parallel to the trolley-support rail. Rubber-tired traction wheels bear on the monorail track to provide locomotion. The powerized carrier is usually operated from the floor, although in some installations the operator rides overhead with the carriers in a cab supported on the monorail.

*See* D. Oliphant Haynes, *Materials Handling Equipment* (1957).

(H. H. Yg.)

**MONOTHELITES,** in church history, the name given to those who, in the 7th century, while otherwise orthodox, maintained that Christ had only one will. Their theory was an attempt to effect some kind of solution of the vital unity of Christ's person on the basis of the now firmly established doctrine of the two natures (for the two natures, *see* JESUS CHRIST; *The Dogma of Christ in the Ancient Councils;* COUNCIL: *From Ephesus [431] to Chalcedon [451]* and *Council of Chalcedon [451]*). The controversy had its origin in the efforts of the emperor Heraclius (*q.v.*) to win back for the church and the empire the excommunicated and persecuted Monophysites (*q.v.*) or Eutychians of Egypt and Syria. In Egypt especially the Monophysite movement had assumed a nationalistic, patriotic character.

It was in Armenia in 622, in an interview with the head of the Severian Monophysites, that Heraclius first broached the doctrine that the divine and human natures in Christ, while quite distinct in his one person, had but one will (*thelema*) and one operation (*energeia*). Sergius, patriarch of Constantinople, was a strong upholder of the doctrine and was the emperor's adviser on the whole question. In 638 Heraclius issued his *Ecthesis* ("statement of faith"), which formulated the position. This led to such intense and widely spread controversy that Heraclius' successor, Constans II, issued an edict in 648 forbidding all discussion of the question. This secured silence, notwithstanding the protest of the Western church at the Lateran council of 649. But with the accession of Constantine IV in 668 the controversy once more revived, and the new emperor resolved to summon a general council. It met at Constantinople in 680 (*see* COUNCIL), having been preceded in 679 by a brilliant synod under Pope Agatho at Rome. The will, Agatho said, is a property of the nature, so that as there are two natures there are two wills; but the human will determines itself ever conformably to the divine and almighty will. The Council of Constantinople condemned Monothelitism and asserted two wills and two operations.

**MONOTREME,** a member of the most primitive order of mammals, the Monotremata, which includes only the duck-billed platypus, or simply duckbill, of Australia and the echidnas or spiny anteaters of Australia and New Guinea. They share several important features with other mammals (*q.v.*); they have hair, nurse their young and are warm-blooded. They differ, however, in laying eggs, in having their right and left oviducts separate and not united to form a uterus but opening into a single chamber, or cloaca, in common with the ducts from the bladder and digestive tract. The genital ducts of the male also open into the cloaca, which has a single external orifice or vent. This last feature, unique among mammals, is shared with birds and reptiles, and gives the order its name, Monotremata ("one opening").

The platypus (*q.v.*) is adapted for semiaquatic life, with webbed feet, smooth sleek fur, beaverlike tail and a sensitive, ducklike bill used for finding food in the submerged mud of streams. A facial furrow shuts the eye and ear during submergence. The echidna (*q.v.*), found in dry country, is covered with quills and coarse hair. Unlike the platypus, in which juvenile teeth are replaced by horny plates, the echidna has a toothless bill and a long, extensile tongue, posteriorly furnished with horny serrations that grind its diet of ants against the hard palate.

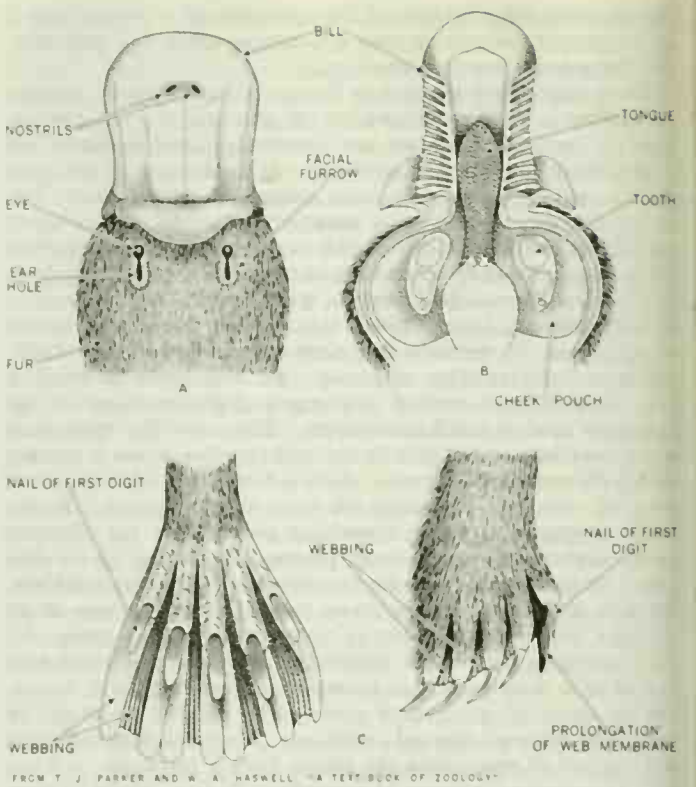


FIG. 1.—PLATYPUS (ORNITHORHYNCHUS): (A) EXTERNAL FEATURES OF HEAD SEEN FROM ABOVE; (B) LOWER JAW SEEN FROM ABOVE; (C, LEFT) LEFT FOREFOOT SEEN FROM ABOVE SHOWING PROLONGATION OF WEBBING BEYOND THE NAILS; (C, RIGHT) RIGHT HIND FOOT SEEN FROM ABOVE. THE PROLONGATION BENEATH THE FIRST DIGIT IS NOT THE POISON SPUR, WHICH IS ON THE ANKLE

In 1792 G. Shaw and F. P. Nodder described and drew the spiny anteater of New South Wales; thinking it was related to the South American anteater, they named it *Myrmecophaga aculeata.* It was soon found to be distinct, and G. Cuvier in 1798 proposed the name *Echidna.* This latter name, however, was already in use for another animal (a fish); the Australian echidna was then designated *Tachyglossus,* and the larger New Guinean echidna was named *Zaglossus.* In 1799 Shaw and Nodder published the first description and figures of the duckbill, naming it *Platypus anatinus* and noting its aquatic modifications. In 1800 Johann F. Blumenbach received a stuffed specimen collected by Sir Joseph Banks, which he described under the name *Ornithorhynchus paradoxus,* referring it to the order Edentata (*q.v.*). The generic name *Platypus* of Shaw and Nodder was in use for another animal (a beetle), so the platypus was named *Ornithorhynchus anatinus.*

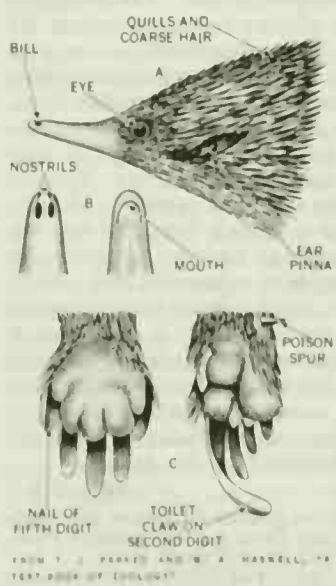


FIG. 2.—ECHIDNA (TACHYGLOSSUS): (A) EXTERNAL FEATURES OF HEAD SEEN FROM SIDE; (B) BILL (LEFT) SEEN FROM ABOVE, (RIGHT) SEEN FROM BELOW; (C, LEFT) LEFT HAND OF FEMALE SEEN FROM BELOW; (C, RIGHT) RIGHT FOOT OF MALE SEEN FROM BELOW

In 1802 E. Home published a description of the anatomy of two preserved specimens of the platypus, in which he noted that "the structure of the female organs is unlike anything hitherto met with in quadrupeds . . ." He was led to examine the corresponding parts in birds and reptiles and found most resemblance to the organs of ovoviviparous lizards. Later in the same year Home ex-

amined the anatomy of the spiny anteater. He at once recognized its affinity to the platypus and included it in the same genus. Home also concluded that *Ornithorhynchus* represented a new tribe of quadrupeds, "so that it may be considered as an intermediate link between the classes Mammalia, Aves and Amphibia. . . . Between it and the bird, no link of importance seems to be wanting." Thus arose the misleading and still widely prevalent notion that the platypus is a link between mammals and birds, whereas its true position is more that of a link between mammals and reptiles.

In 1803 Étienne Geoffroy Sainte-Hilaire, a colleague of Cuvier, established a new order, Monotremata, characterized by: "Digits clawed, no true teeth; a common cloaca opening to the exterior by a single orifice." In 1809 Lamarck added a class, Prototheria, for the platypus and echidna, deciding that they were not mammals, for they had no mammary glands and were probably oviparous; they were not birds, for their lungs differed, and they had no wings; and they were not reptiles, for they possessed a four-chambered heart. Then followed a long argument whether the monotremes were to be classed as mammals. Finally in 1834 Henri de Blainville arranged the mammals under three subclasses: (1) Ornithodelphia (birdlike uteri); including the monotremes; (2) Didelphia (double uteri), including the marsupials; (3) Monodelphia (single uteri) including the placental mammals. In 1884 W. H. Caldwell obtained evidence enabling him to cable to the British Association meeting at Montreal, "Monotremes oviparous, ovum meroblastic." In 1891 Richard Semon secured monotreme material in Queensland including newly laid eggs and a series of embryos of the echidna. He deduced that the egg of echidna, unlike the eggs of reptiles or birds, grows within its shell by receiving nutriment through the shell from the uterine tissues of the mother. Later H. Burrell, working under Launcelot Harrison, gave accurate descriptions of the underground tunnels dug by the platypus, and of the carefully constructed nests of leaves and grass in which their eggs are laid.

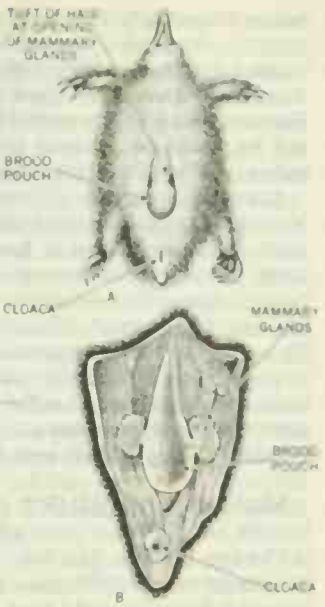


FIG. 3.—ECHIDNA (A) LOWER SURFACE OF BROODING FEMALE (B) DISSECTION SHOWING REVERSE SIDE OF SKIN OF ABDOMEN

According to J. T. Wilson and J. P. Hill, the ovum of the platypus at the time of fertilization is about 0.1 in. in diameter, after fertilization it becomes surrounded by an exceedingly thin layer of albumin, and outside this by a thin translucent horny shell. It grows to a length of 0.6 to 0.7 in. before oviposition. The eggs, which resemble those of certain lizards, are usually laid in pairs that stick together. Burrell infers that when the eggs are laid the animal is sitting curled up and receives them in its forepaws, by which they are placed between the curled-in tail and the abdomen, where they are brooded. For some time after the young are hatched no milk is secreted; the young when born have a very short bill with "lips." There are no teats but the young lick and suck the milk from the surface of the mammary field. In the platypus there is no pouch but in the echidna a "brood pouch" is developed.

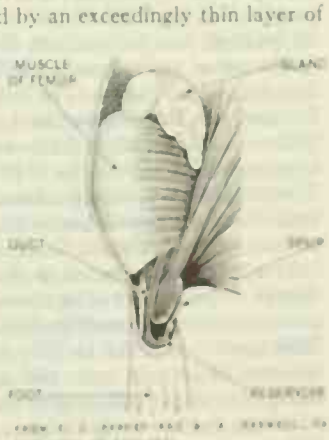


FIG. 4.—POISON APPARATUS IN THE PLATYPUS, WHICH IS FOUND ONLY IN THE MALE. A SPUR LIES ON THE INNER ASPECT OF EACH HIND LEG

While the platypus and the echidna differ widely in habits, external appearance and in skeletal and anatomical characters connected with the difference in their habits, they have many important features in common. For instance, both possess a peculiar venom-secreting apparatus, in some ways analogous with those of poisonous snakes. The fang in the platypus represented by a large horny spur attached to each ankle of the male, is far better developed in the platypus than in the echidna. The sharp tip of the spur is perforated by a canal leading to a duct running up the leg to a large gland beneath the skin on the upper surface of the femur. The albuminous secretion is poisonous but not fatal to other mammals. The spurs may be used in fighting between the males during the breeding season.

There are two main theories of monotreme evolution: one that monotremes have evolved independently from a very early point in mammalian history, perhaps even from the ancestors of the reptiles; the other that they are derived from the ancestors of the marsupials and have retained some ancient characters and have acquired other specialized features. Since monotremes differ so widely from marsupials and placentals, especially in the extreme specializations of the poison gland and tarsal spur, they are generally excluded from the ancestry of these mammals. Nevertheless, some features of the monotreme brain and skeleton are shared with the marsupials.

*See* F. W. Jones, *The Mammals of South Australia*, part 1 (1918); W. K. Gregory, "The Monotremes and the Palimpsest Theory," *Bull. Amer. Mus. Nat. Hist.*, 88 (1947). (J. E. B.)

**MONOTYPES,** in art, are unique impressions on paper. (For a discussion of the typesetting machine called Monotype *see* TYPESETTING: *Mechanical Composition*.) A monotype is printed from a drawing which has been painted on a hard surface (glass, metal, wood, etc.) in printers' ink or thinned oil paint. While the pigment is still wet the impression is taken by passing it through a press or by rubbing, as in the printing of a woodcut. The monotype produces an effect unlike any other print-making process: on the paper it has no raised quality like the line engraving (*see* ENGRAVING, LINE) or acid-bitten etching (*q.v.*); although flat, like a lithograph (*q.v.*), it has much more of the spontaneity and directness of a water colour or wash drawing. Sometimes additional impressions are made from the same plate, but these, of course, are much duller and fainter.

The earliest appearance of the monotype as a printmaking medium is in the work of Benedetto Castiglione (1616–70), who produced about 20 prints of this kind. The process seems forgotten in the 18th century until William Blake (1757–1827) made use of it for several subjects. During the latter half of the 19th century the monotype enjoyed increasing popularity and was practised by artists as varied in their expression as Whistler, Gauguin, Toulouse-Lautrec, Carrière, Renoir, Fantin, Steinlen, Pissarro and Ensor. Its greatest exponent was Edgar Degas (1834–1917), who made original and compelling use of the medium. His monotypes present many new aspects of this great artist's flair for experimentation and his ability to extend tradition into new forms. The experimental possibilities and freedom of the monotype medium have made it very popular. (H. Es.)

**MONREALE,** a town and seat of an archdiocese in Sicily, Italy, province of Palermo, 3 km. (1.8 mi.) inland from the city of Palermo. Pop. (1961) 24,350 (commune). Monreale lies on the slope of Monte Caputo, overlooking the valley of the Conca d'Oro ("Golden Shell"), a rich citrus fruit and olive region for which Monreale is a trade centre.

The town grew up around an important Benedictine (Cluniac) monastery, first chartered in 1174 and richly endowed by its founder, King William II of Sicily. Its abbot held episcopal and, after 1183, archiepiscopal rights. Little now remains of the monastic buildings (which were surrounded by a massive wall with 12 towers) except parts of the dormitory and frater and the splendid cloister (with 216 marble columns), a part of which was completed in the 13th century.

The cathedral, dedicated to the Assumption of the Virgin, was

begun between 1172 and 1174 and, in the main, completed by 1189, the date of William's death. Norman, Byzantine, Italian and Saracen styles combine to make it one of the richest in Italy. Its ground plan incorporates a basilican western and a centralized eastern part, the latter based on the Byzantine cross-in-square type of church, with an elevated central space and transepts but lacking a dome and vaults. The nave is wide with narrow aisles. Monolithic columns of gray oriental granite (except one of *cipollino*), with Corinthian capitals, support eight pointed arches on each side. The roofs throughout are of open woodwork, the only vaulted parts being the three apses and the presbyteries. At the west end are two projecting towers with an entrance hall between them. A large open atrium, which once existed at the west, has been replaced by a Renaissance portico. The exterior is decorated with intersecting arches and other ornaments inlaid in marble.

The mosaic decoration, restored in the 16th, the late 17th and the 19th centuries, one of the largest in existence, is the homogeneous product of a Byzantium-trained workshop and seems to have been completed within less than a decade, before 1189. The nave contains an Old Testament cycle (from the creation to Jacob's wrestling with the angel); the mosaics of the aisles illustrate the miracles of Christ; the central square and the transept contain a cycle on the life of Christ. The side chapels show the lives of SS. Peter and Paul (whose enormous figures fill the side apses), and the main apse is dominated by a huge bust of Christ the All-Ruler (Pantocrator), with the Virgin, angels, the apostles and saints below. In the central square, on the left side, is the king's throne, on the right that of the abbot-archbishop; both are topped by dedicatory mosaics. The church was for a few decades the burial place of the Hauteville dynasty and contains several royal tombs. The leaves of the main door were cast in bronze by Bonanno of Pisa in 1186; the reliefs show scenes from the Old and New Testaments and figures of prophets. The north door, a work of Barisanus of Trani, of approximately the same date, is decorated with reliefs cast from molds which the artist had used before, in the doors of Trani (1175) and of Ravello (1179).

Two baroque chapels, of the 17th and 18th centuries, are accessible from the aisles.

*See* O. Demus, *The Mosaics of Norman Sicily* (1950); E. Kitzinger, *The Mosaics of Monreale* (1960). (O. DE.)

**MONRO,** the family name of three Scottish physicians—father, son and grandson—who lifted Edinburgh university to international prominence as a centre of medical teaching in the 18th and 19th centuries. The Monros, all named Alexander and differentiated as *primus*, *secundus* and *tertius*, held the chair of anatomy at Edinburgh for 126 years (1720–1846) without interruption. They exerted a great influence on medicine by contributing to the education of physicians and surgeons throughout the world besides making important additions to scientific knowledge.

ALEXANDER *primus* (1697–1767), who established the triumvirate, was born in London on Sept. 8, 1697, the son of an army surgeon who later moved to Edinburgh, where Alexander received the M.D. degree. He then studied in Paris and Leiden before returning in the fall of 1719 to Edinburgh. There he was appointed professor of anatomy and surgery, beginning his lectures in the winter of 1720. He was not formally inducted into the professorship, however, until 1725. Alexander *primus* came to be known as an interesting lecturer who never used notes. In his lifetime he published two books and 53 separate papers; his writings were collected in one volume as *Works* (1781) by Alexander *secundus*. His anatomical preparations were outstanding. Though not a surgeon, he was greatly interested in surgery and advanced many new ideas in surgical instruments and dressings. Of his eight children, four of whom died when young, Donald and Alexander *secundus* entered medicine. Alexander *primus* resigned his professorship in 1764 and died in Edinburgh on July 10, 1767.

ALEXANDER *secundus* (1733–1817) was born in Edinburgh on May 22, 1733. In 1753, when in his second year of medical study at Edinburgh, he began giving the evening lectures for his father. On July 12, 1755, he was appointed coadjutor to his father. In that same year he received his M.D. degree and then continued his education in London, Paris, Leiden and Berlin for two years before returning to Edinburgh, where he was appointed professor in 1758. Alexander *secundus* lectured from 1759 to 1807, being assisted by his son from 1800 to 1807. Of the three Monros, Alexander *secundus* is judged the greatest teacher and anatomist. His classes were well attended by students from all over the world and his researches covered pathology and physiology as well as anatomy. He died in Edinburgh on Oct. 2, 1817.

ALEXANDER *tertius* (1773–1859) was born in Edinburgh on Nov. 5, 1773, and received the M.D. degree from Edinburgh in 1797. He then studied in London and Paris, returned to Edinburgh in 1800 and in that year was appointed conjointly with his father. Alexander *tertius* gave the entire course beginning in 1808 because of his father's illness and became sole professor in 1817. He resigned in 1846. Alexander *tertius* did not rank with his father or grandfather as a teacher or scientific investigator, choosing to make use of the notes handed down to him and adding only imperfect observations. None of his works was of permanent value. He died in Craiglockhart near Edinburgh on March 10, 1859.

(S. W. S.)

**MONROE, HARRIET** (1860–1936), U.S. poet and editor, founder and for many years editor of *Poetry* magazine, was born in Chicago, Ill., Dec. 23, 1860. Educated at the Visitation convent in Georgetown (Washington, D.C.), she was early ambitious to become a dramatist and a poet. Fame arrived when she was commissioned to write the ode for the dedication of the World's Columbian exposition. Though none of her plays was performed professionally, *Valeria* was published in 1892 (*Valeria and Other Poems*) and a collection of short verse plays in 1903 (*The Passing Show*). Meanwhile Miss Monroe served as art or drama critic on various newspapers. Elated by Chicago's artistic renascence, she resolved that poetry, the one neglected art, should have a journal of its own. After guarantors had been found, she solicited work from more than 50 poets. Their response was enthusiastic. *Poetry: a Magazine of Verse* (first issue, Oct. 1912) soon became the leading journal of its kind. A list of its contributors, beginning with Pound, Yeats, Frost, Eliot, Stevens, Lindsay, Masters and Sandburg, became an index to contemporary poetry. Miss Monroe was an ideal editor. Though her own verse was rhapsodic and her editorials romantic and reformist, her contributors rightly trusted her open-mindedness. Her later publications include two volumes of verse, *You and I* (1914) and *The Difference* (1924). A collection of essays, *Poets and Their Art* (1926), contains some of her editorials. In 1917 she co-edited the influential *The New Poetry, an Anthology of Twentieth-Century Verse in English* (revised 1923 and 1932). Miss Monroe died on Sept. 26, 1936.

Indispensable to a knowledge of Miss Monroe's career is her posthumously published autobiography, *A Poet's Life, Seventy Years in a Changing World* (1938). Her books and correspondence files are in The University of Chicago library. (W. T.)

**MONROE, JAMES** (1758–1831), fifth president of the United States, was born on Monroe's creek, in Westmoreland county, Va., on April 28, 1758. His father, Spence Monroe, was of Scottish, and his mother, Elizabeth Jones, of Welsh descent. At the age of 16 he entered the College of William and Mary, Williamsburg, Va., but in 1776 left college to fight in the American Revolution. He took part in the battles of Harlem Heights, White Plains, Trenton (where he was wounded), Brandywine, Germantown and Monmouth. In 1780 he began the study of law under Thomas Jefferson, then governor of Virginia, and between the two men there developed an intimacy and a sympathy that had a powerful influence upon Monroe's later career.

In 1782 he was elected to the Virginia house of delegates, and though only 24 years of age he was chosen a member of the governor's council. He served in the congress under the Articles of Confederation from 1783 to 1786 and was conspicuous there for his vigorous insistence upon the right of the United States to the navigation of the Mississippi river, and for his attempt, in 1785, to secure for the weak congress the power to regulate commerce and thus remove one of the great defects in the existing central government. On retiring from congress he began the practice of law at Fredericksburg, Va. He was chosen a member of the Virginia house of delegates in 1787 and in 1788 was a member of the

state convention at which Virginia ratified the federal constitution. In 1790 he was elected to the U.S. senate where he vigorously opposed Washington's administration, but Washington nevertheless in 1794 nominated him as minister to France.

**Minister to France.**—It was the hope of the administration that Monroe's well-known French sympathies would secure for him a favourable reception, and that his appointment would also conciliate the friends of France in the United States. His warm reception in France and his enthusiastic republicanism displeased the Federalists at home; he did nothing, moreover, to reconcile the French people to the Jay treaty (*q.v.*), which they regarded, without real justification, as a violation of the French treaty of commerce and amity of 1778 and as a possible *casus belli*. Monroe led the French government to believe that the Jay treaty would never be ratified by the United States, that the administration of George Washington would be overthrown as a result of the obnoxious treaty and that better things might be expected after the election of 1796 when a new president, perhaps Thomas Jefferson, should take office. Washington did not know of this intrigue, but he sensed that Monroe was unable to represent his government properly and late in 1796 recalled him.

Monroe returned to America in the spring of 1797, and in the following December published a defense of his course in a pamphlet of 500 pages entitled *A View of the Conduct of the Executive, in the Foreign Affairs of the United States*. Washington seems never to have forgiven Monroe for this, though Monroe's opinion of Washington and Jay underwent a change in his later years. In 1799 Monroe was chosen governor of Virginia and was twice re-elected, serving until 1802.

At this time there was much uneasiness in the United States as a result of Spain's restoration of Louisiana to France by the secret treaty of San Ildefonso, in Oct. 1800. The subsequent withdrawal of the "right of deposit" at New Orleans by the Spanish intendant greatly increased this feeling and led to much talk of war. Resolved upon peaceful measures, President Jefferson in Jan. 1803 appointed Monroe envoy extraordinary and minister plenipotentiary to France to aid Robert R. Livingston, the resident minister, in obtaining by purchase the territory at the mouth of the Mississippi, including the island of New Orleans, and at the same time authorized him to co-operate with Charles Pinckney, the minister at Madrid, in securing from Spain the cession of East and West Florida. On April 18 Monroe was further commissioned as the regular minister to Great Britain.

President Jefferson harboured some rather impractical thoughts of forming an alliance with the British against France if Napoleon Bonaparte would not come to terms with the United States on the free navigation of the Mississippi. Monroe joined Livingston in Paris on April 12, after the latter's negotiations were well under way; and the two ministers, on finding Napoleon willing to dispose of the entire province of Louisiana, decided to exceed their instructions and effect its purchase. Accordingly, on May 2 (antedated to April 30) they signed a treaty and two conventions whereby France sold Louisiana to the United States. (*See* LOUISIANA PURCHASE.) The fact that Monroe signed the treaty along with Livingston did not hurt his political career at home, although he is not entitled to much credit for the diplomatic achievement.

**Further Diplomatic Service.**—In July 1803 Monroe left Paris and entered upon his duties in London; and in the autumn of 1804 he proceeded to Madrid to assist Pinckney in his efforts to define the Louisiana boundaries and acquire the Floridas. After negotiating until May 1805, without success, Monroe returned to London and resumed his negotiations concerning the impressment of American seamen and the seizure of American vessels. As the British ministry was reluctant to discuss these vexing questions, little progress was made, and in May 1806 Jefferson ordered William Pinkney of Maryland to assist Monroe. The British government appointed Lords Auckland and Holland as negotiators, and the result of the deliberations was a treaty signed on Dec. 31, 1806, which contained no provision against impressments and provided no indemnity for the seizure of goods and vessels. Accompanying its signature was a British reservation maintaining freedom of action to retaliate against imminent Napoleonic maritime decrees. In passing over these matters Monroe and Pinkney had disregarded their instructions, and Jefferson was so displeased with the treaty that he returned it to England for revision. Just as the negotiations were reopened, however, the questions were further complicated and their settlement delayed by the attack of the British ship "Leopard" upon the American frigate "Chesapeake."

Monroe returned to the United States in Dec. 1807 and was elected to the Virginia house of delegates in the spring of 1810. In the following winter he was again chosen governor, serving from Jan. to Nov. 1811, and resigning to become secretary of state under James Madison, a position he held until March 3, 1817. The direction of foreign affairs in the troubled period immediately preceding and during the second war with Great Britain thus devolved upon him. On Sept. 27, 1814, after the capture of Washington, D.C., by the British, he was appointed secretary of war, and discharged the duties of this office, in addition to those of the department of state, until March 1815.

**Election as President.**—In 1816 Monroe was chosen president of the United States, he received 183 electoral votes, and Rufus King, his Federalist opponent, 34. In 1820 he was re-elected, receiving all the electoral votes but one, which William Plumer (1759–1850) of New Hampshire cast for John Quincy Adams, the president's accomplished secretary of state. The chief events of his calm and prosperous administration, which has been called the "era of good feeling," were the Seminole War (1817–18); the acquisition of the Floridas from Spain (1819–21); the Missouri Compromise (1820), by which the first conflict over slavery under the constitution was peacefully adjusted; the veto of the Cumberland Road bill (1822) on constitutional grounds; recognition of the new Latin-American states, former Spanish colonies, in Central and South America (1822); and—most intimately connected with Monroe's name—the enunciation in the presidential message of Dec. 2, 1823, of what has since been known as the Monroe Doctrine (*q.v.*), which has profoundly influenced the foreign policy of the United States.

Not until 1852 did the phrase Monroe Doctrine come into use. The "principles of President Monroe," as the message was referred to in congress, consisted of three openly proclaimed dicta: no further European colonization in the new world, abstention of the United States from the political affairs of Europe and nonintervention of Europe in the governments of the American hemisphere. In the diplomatic correspondence preceding the proclamation of these principles in the president's message was a fourth dictum not publicly associated with the doctrine until 1869: the United States opposed the transfer of any existing European colonies from one European sovereign to another.

Much discussion as to the real authorship of the Monroe Doctrine comes to these conclusions. Secretary of State John Quincy Adams was undisputed author of the noncolonization principle; the principle of abstention from European wars and politics was common to all the fathers of American independence, inherited and expressed by the younger Adams all his professional life; in cabinet meetings Adams also urged the dictum of nonintervention —hands off the independent states of the western hemisphere. But Adams had no idea of proclaiming these dicta to the world. Monroe took responsibility for embodying them in a presidential message drafted by himself. Modern historical judgment considers the Monroe Doctrine to be appropriately named.

**Retirement.**—On the expiration of his second term Monroe retired to his home at Oak Hill, Loudoun county, Va. In 1826 he became a regent of the University of Virginia, and in 1829 was a member of the convention called to amend the state constitution. Having neglected his private affairs and incurred large expenditures during his missions to Europe, he experienced considerable pecuniary embarrassment in his later years, and was compelled to ask congress to reimburse him for his expenses in the public service. In 1826 congress finally authorized the payment to him of $30,000, and after his death appropriated a small amount for the purchase of his papers from his heirs. He died in New York city on July 4, 1831, while visiting his daughter. In 1858, the centennial year of his birth, his remains were reinterred with impressive ceremonies at Richmond, Va.

Jefferson, Madison, John Quincy Adams, John C. Calhoun, and T. H. Benton all spoke loudly in Monroe's praise; but he suffers by comparison with the greater statesmen of his time. Possessing none of their brilliance, he had, nevertheless, to use the words of John Quincy Adams, "a mind . . . sound in its ultimate judgments, and firm in its final conclusions." James Schouler points out that like Washington and Lincoln he was "conspicuous . . . for patient considerateness to all sides." Monroe was about six feet tall, but, being stoop-shouldered and rather ungainly, seemed less; his eyes, a grayish blue, were deep-set and kindly; his face was delicate, naturally refined and prematurely lined. The best-known portrait, that by John Vanderlyn, is in the New York city hall. Monroe was married in 1786 to Elizabeth Kortright (1768–1830) of New York, and at his death was survived by two daughters.

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(S. F. B.)

**MONROE,** the largest and most important city in northeastern Louisiana, U.S., is on the Ouachita river about 100 mi. E. of Shreveport and is the seat of Ouachita parish. Pop. (1960) 52,219; standard metropolitan statistical area (Ouachita parish), 101,663. (For comparative population figures *see* table in LOUISIANA: *Population.*)

Monroe was founded in 1785 when a group of French pioneers from southern Louisiana, under the leadership of Don Juan Filhiol, established a trading post on a land grant obtained from King Charles X of Spain. Until a fort was constructed and named in honour of Don Esteban Miró, Spanish governor general at New Orleans, the settlement was simply referred to as the "Post." Fort Miró was renamed Monroe in 1819 to honour the arrival of the first steamboat which had been named for Pres. James Monroe. The town was incorporated in 1820. It was shelled during the American Civil War.

Monroe, along with its smaller twin city across the Ouachita, West Monroe, is a manufacturing city and also the cultural and commercial centre for the surrounding rural parishes. The predominant manufactured items in Monroe are paper and paper products, supplemented by lumber, furniture, clothing and cottonseed products. The nearby Monroe gas field, over 400 sq.mi. in area with more than 2,000 producing wells, supports chemical and carbon black industries. Although the city has experienced steady growth, it is surrounded by rural parishes with declining populations as agriculture slowly shifts from cotton and corn to forestry and beef cattle. Northeast Louisiana State college (1931) serves the whole northeastern corner of the state. (P. K. C.)

**MONROE,** a city of southeastern Michigan, U.S., on the Raisin river 2 mi. inland from Lake Erie, 39 mi. S.W. of Detroit and 20 mi. E. of Toledo; the seat of Monroe county and Michigan's only port on Lake Erie. Monroe's diversified industries include the manufacture of paper, automotive parts, metal products and office supplies. Because of its extensive nurseries, Monroe is often called the "Floral City." The choice of Monroe as the site for the Enrico Fermi Atomic Power plant in 1956 further enhanced the city's industrial position. The city is the home of St. Mary's academy (Roman Catholic) for girls.

Monroe's formal beginnings can be traced to 1784 when a small community, largely French-Canadian, on the Raisin river was known as Frenchtown. There, on Jan. 23, 1813, Gen. James Winchester's troops were massacred by Indians allied with England. In 1817 Frenchtown was renamed Monroe in honour of Pres. James Monroe. It was incorporated as a city in 1837.

For comparative population figures *see* table in MICHIGAN: *Population.* (St. G.)

**MONROE DOCTRINE,** a policy statement enunciated by Pres. James Monroe of the United States in his message to congress on Dec. 2, 1823, which had its roots in the general principle that Europe and the Americas constitute two separate and distinct spheres of political activity and, politically speaking, should have as little to do with each other as possible. This principle had been given precise form in the farewell address of Pres. George Washington, on Sept. 19, 1796, and had been reiterated in the first inaugural address of Pres. Thomas Jefferson. It had become widely, if not universally, accepted at the time that James Monroe became president of the United States, and from it there flowed quite naturally his famous message of Dec. 2, 1823.

**Origin.**—The message itself had a dual origin. It was in part due to the pretensions of the Russian government with regard to the northwest coast of North America. In 1821, the tsar had issued a ukase by which foreign vessels were forbidden to come within 100 mi. of the shore of the territories claimed by Russia (the modern Alaska) on the American continent. This ukase was, from the first, contested by the U.S. secretary of state, John Quincy Adams, and in the course of the diplomatic negotiations that followed Adams laid down the general principle that European states could claim no right to establish colonies in the new world. Adams' principle was taken over by Monroe in the president's annual message of 1823 to the U.S. congress. It was declared therein that "the American continents, by the free and independent condition which they have assumed and maintain, are henceforth not to be considered as subject for future colonization by any European power." The president and the secretary of state had based this declaration on the thesis that every part of the American continents had been already occupied. In view of the fact that there were still many areas entirely unsettled, and others in dispute, it is doubtful whether this viewpoint accorded with the actual situation in 1823.

The second, and in the long run the more important, part of the declaration was directed against the assumed danger that the continental European powers would intervene in Central and South America to restore to Spain its revolted colonies, most of which had won their independence by this time, and a number of which had been recognized by the United States. The fear of such reconquest derived in part from the fact that, acting at the mandate of the Holy Alliance (*q.v.*), *i.e.*, Russia, Austria, Prussia and France, the last-named government had put down a revolutionary movement in Spain. In Aug. 1823 George Canning, the British foreign secretary, had approached the U.S. envoy, Richard Rush, had intimated to him that there was some danger of intervention in Central and South America, and had proposed a joint declaration on the colonial question. Rush's dispatches, transmitted to Washington, aroused the apprehensions of the U.S. cabinet, as did also the language of the Russian tsar. Long discussions took place in advance of the president's message. It was finally decided not to act with Great Britain but independently. And so, in the message of Dec. 2, 1823, Monroe declared that "we could not view any interposition for the purpose of oppressing" the former colonies, or "controlling in any other manner their destiny by any European power in any other light than as the manifestation of an unfriendly disposition toward the United States."

**Significance.**—It is now known that the danger of European intervention was virtually nonexistent. But Monroe's message was, in the face of the situation as he saw it, a bold act; it was a striking example of open diplomacy, more dramatic and less dangerous than direct representations to the European powers could have been; it took courage, also, to act alone instead of waiting on the action of Britain. Its effects, however, were for a long time overvalued and misunderstood.

In Central and South America the message was, on the whole, well received, but the new republics in most cases looked for protection more to Great Britain than to the United States; on the European continent it was received with irritation and silent contempt; in London it was applauded by the opposition, but regarded with some dislike by Canning as an effort to compete with England for the favour of the new republics. Furthermore, it was not followed by closer relations with Central and South America. When, after 1823, on four separate occasions Central and South American powers sought to secure from the United States fuller commitments looking to the carrying out of the policy enunciated in the message of 1823, such commitments were refused. In the debates in congress on the so-called Panama

congress of 1826 projected by Simón Bolívar with a view toward closer co-operation between the states of North and South America, opinion in the United States was seen to be distinctly hostile to any political understanding with the states to the south.

For some time, indeed, Monroe's message commanded little attention. The British occupation of the Falkland Islands, the French blockades of Mexico and Argentina in 1838 and the encroachments of Great Britain in Central America produced no great excitement in the United States. It was Pres. James K. Polk who drew renewed popular attention to the principles of 1823, and set them on the way to becoming doctrine in the literal sense of the word. Polk was aroused by the intrigues of the French and the British in Texas, and wished to controvert the principle laid down by François Guizot, the French premier and foreign minister, that the idea of the balance of power applied to the new world, and specifically to the question of annexing Texas to the United States. He also wished to use Monroe's declaration to bring the British to yield on the Oregon question, and he probably feared British activities in California. With these matters in mind, in his message of Dec. 2, 1845, he restated the principles of 1823, and gave them special weight in regard to North America. In 1848 he again had recourse to those principles when he declared that the United States could not acquiesce in the establishment of a British or French protectorate over the province of Yucatán, then in revolt against Mexico, and even suggested that it might be the duty of the United States to assume such a protectorate rather than to permit such action by a European power.

**Mid-19th Century Applications.**—But Polk's message, like Monroe's, produced little effect abroad, and like Monroe's, it received at the time no congressional sanction. It was in the 1850s that the famous message of 1823 was actually translated into doctrine, chiefly as the result of disputes with Great Britain over Central America. At first largely relied on by the Democrats and subjected to some partisan criticism, it was in due course adopted also by the Whigs. It was first cited as doctrine in a dispatch of 1854. Though its validity was by no means recognized by any other government, it had by 1860 become fairly well known in Europe.

Sharp challenges to the doctrine took place in the period of the American Civil War. Spain occupied the Dominican Republic, its former colony; and France, intervening in Mexico, set up there a monarchy under the Austrian archduke Maximilian. In the first of these two instances William H. Seward, the U.S. secretary of state, made formal protest, citing the famous American doctrine by name. He received a sharp rebuff from Madrid. Taught by this experience, he proceeded more cautiously in dealing with the French, alluding in general terms to the U.S. position, keeping the record straight but waiting until the end of the Civil War before becoming emphatic in opposition to the policy of Napoleon III. His increasingly strong diplomatic representations were admirably timed to take account of French difficulties in Mexico, and they played a part in producing the eventual French withdrawal, along with the gallant opposition of the Mexicans, French fiscal difficulties and popular opposition in France itself.

**Later Applications.**—By 1870 the popularity of the doctrine was unquestioned. Moreover, in the next 40 years it was more and more liberally interpreted. The first extension of its original terms was in what is usually known as the no-transfer principle. On many occasions prior to the 1870s, the United States had declared its opposition to the transfer of new-world territories from one power to another, and there had been repeated pronouncements to this effect in connection with the island of Cuba. But the link between this principle and the Monroe Doctrine was first established by Pres. Ulysses S. Grant in 1870 and reiterated in a long and able memorandum of the secretary of state, Hamilton Fish, on July 17 of the same year. In the course of the next 20 years the opposition of the United States to the cession of American territory to a European state was made clear on at least eight occasions.

A second development with regard to the doctrine came in connection with the development of an interoceanic canal. In the period before the Civil War the United States had entered into a compact with Great Britain for the joint control of such a waterway. But when the question of transisthmian communication became a matter of immediate interest, with Ferdinand de Lesseps' famous project to build a canal across the Isthmus of Panama, there was a widespread reaction among U.S. politicians. Pres. Rutherford B. Hayes, it is true, merely declared that no European power could intervene for the protection of the projected line of communication "without adopting measures on this continent which the United States would deem wholly inadmissible." He did not mention the Monroe Doctrine by name. But there were a number of persons who were more definite; in 1881 Secretary James G. Blaine, in a circular note of June 24, declared in discussing the isthmian question that "it is the long-settled conviction of this government that any extension to our shores of the political system by which the great powers have controlled and determined events in Europe would be attended with danger to the peace and welfare of this nation." The same view was expressed by Blaine's successor, Secretary Frederick T. Frelinghuysen, and by Pres. Theodore Roosevelt after the turn of the century.

A third extension of the Monroe Doctrine was made by Pres. Grover Cleveland in 1895. For many years there had been a dispute between Great Britain and Venezuela with regard to the boundary between the latter country and the British colony of British Guiana. Despite frequent appeals on the part of the Latin-American republic to the United States in the name of the doctrine, the U.S. government for some time remained quiescent. But in 1895 Secretary Richard Olney took up the cudgels for the regime at Caracas. In a remarkable dispatch of July 20, 1895, he demanded that the British arbitrate the issue. When this demand was repelled by the British, the president transmitted to congress on Dec. 17 an aggressive message in which he declared that the boundary dispute would be examined by an impartial tribunal, and that when its report was made it would be "the duty of the United States to resist by every means in its power, as a wilful aggression upon its rights and interests, the appropriation by Great Britain of any lands or the exercise of governmental jurisdiction over any territory which after investigation we have determined of right belongs to Venezuela." After a brief period of excitement, the British yielded to U.S. pressure, and the dispute was arbitrated (on terms, however, that ensured British possession of a large part of the contested territory). While the position of the United States met with much criticism abroad, and was not even generally accepted in Central and South America, it undoubtedly directed world attention to the doctrine on a scale hitherto unknown.

A fourth extension of the doctrine came with the beginning of the 20th century. During the 77 years since its enunciation, the doctrine had never been construed to prevent coercive action against an American state by a European state if the objective was merely punitive and did not involve either domination or any cession of territory. But with the rise of U.S. power, and with the increasing importance of the U.S. position in the Caribbean, popular sensitiveness with regard to the action of old-world governments began to develop on an increasing scale. This was well illustrated by the blockade of Venezuela at the end of 1902. The then ruler of that republic was an unsavory dictator, Cipriano Castro. He had committed various offenses against both Germany and Great Britain, and these two powers determined to take joint action against him. They notified the United States of their purpose, and at the time of such notification the U.S. administration made no protest of any kind. But when, in Dec. 1902, a naval blockade was instituted against Venezuela, indignation in the United States was widespread. The irritation was particularly strong against Germany, which was suspected of having various designs for establishing itself in the new world. The blockade was terminated in Feb. 1903, and the questions in dispute were arbitrated. It has frequently been stated that this settlement came about as a result of pressure from the United States, and Pres. Theodore Roosevelt later claimed that he directed an ultimatum to the government of the *Reich*. While this claim was still widely

believed in the second half of the 20th century, it is important to note that there exists not the slightest confirmation of any such episode in the archives of the United States, Great Britain or Germany.

**Roosevelt Corollary.**—The Venezuela episode of 1902–03 had important consequences. It led to the first formal recognition of the Monroe Doctrine by another state, Great Britain. It also raised the question of what should be done to forestall punitive action by European states against the republics of the new world. President Roosevelt's answer to this problem was the so-called Roosevelt corollary to the doctrine, adopted by him, in part at least, at the suggestion of Great Britain. This corollary was first stated by him in May 1904, and reiterated in his message of Dec. 6. "In the Western Hemisphere," the president stated, "the adherence of the United States to the Monroe Doctrine may force the United States, however reluctantly, in flagrant cases of such wrongdoing or impotence, to the exercise of an international police power." While his position was much criticized abroad, it was followed out in practice in the years that followed. The United States government in 1905 established customs control over the Dominican Republic, by agreement with that state; Secretary Philander C. Knox, in the administration of Pres. William H. Taft, sought to develop similar understandings with Honduras and Nicaragua, and in the latter case followed up a treaty with the landing of marines; the administration of Pres. Woodrow Wilson actually intervened forcibly in both Haiti and the Dominican Republic in the name of the principles of 1823. Wilson's secretary of state, Robert Lansing, developed the Roosevelt corollary to the fullest extent, declaring that the United States government should "aid the people of those republics (*i.e.*, the Caribbean republics) in establishing and maintaining honest and responsible governments to such extent as may be necessary in each particular case" and "should declare that it will not tolerate control over or interference with the political and financial affairs of these republics by any European power or its nationals, or permit the occupation, even temporarily, by any European power, of any territory of such republics." This statement was not made public, but the administration acted on it in repelling German and French schemes for customs control in Haiti.

A final extension of the doctrine, in the period before World War I, has sometimes been seen in the resolution of Sen. Henry Cabot Lodge of Aug. 2, 1912, which declared that "when any harbor or other place in the American continents is so situated that the occupation thereof for naval or military purposes might threaten the communications or the safety of the United States, the Government of the United States could not see without grave concern the actual or potential possession of such harbor or other place by any Government, not American, as to give that Government practical power of control for naval or military purposes." Senator Lodge himself, however, did not connect this resolution with the principles of 1823, and the rumours of purchase of land in the Magdalena bay region of Mexico by Japanese interests, rumours on which the resolution was based, appear to have been unfounded.

**Post-World War I Period.**—The Monroe Doctrine, with its various extensions, unquestionably had become a central tenet of U.S. foreign policy by the period of World War I. The importance which U.S. opinion attached to it was well demonstrated in the debates over the League of Nations covenant in 1919 and 1920. In proposing the establishing of a League of Nations which should maintain peace by collective action against an aggressor, President Wilson had at first argued that this was merely an extension of the principles of 1823. The covenant as drafted stated, however, that "nothing in this Covenant shall be deemed to affect the validity of international engagements such as treaties of arbitration or regional understandings like the Monroe Doctrine, for securing the maintenance of peace." This phraseology was regarded as unsatisfactory by President Wilson's opponents at home, who declared that the doctrine was not a regional understanding but a unilateral declaration of U.S. policy. The Lodge reservation to the treaty, adopted by the senate, declared that the doctrine was "to be interpreted by the United States alone and is hereby declared to be wholly outside the jurisdiction of said League of Nations and entirely unaffected by any provision contained in the said treaty of peace with Germany." In the same way, when the question of U.S. adherence to the protocol creating the World Court was up for discussion and again, when the Kellogg-Briand pact for the outlawry of war was before the senate, it was necessary to propitiate the friends of the doctrine, in the first instance by a reservation, in the second by a gloss on the treaty.

But if the Monroe Doctrine seemed securely established in the minds of U.S. citizens by the 1920s, it was nonetheless true that it was already undergoing an important and lasting transformation, a transformation that operated to diminish its significance. It is not necessary to consider at length a view widely disseminated at the time of World War II that the doctrine owed its force not to the power of the United States but to the British navy. Such a view was, in reality, little more than a rationalization to justify closer U.S. association with Britain itself. It is nearer to truth to say that throughout the latter part of the 19th and earlier part of the 20th century, the imperial nations of Europe were sufficiently occupied in Africa and the middle and far east to reduce to a minimum their ambitions with regard to the American continents. It is also relevant that many of the Central and South American states had now attained a consistency and solidity that made the possibility of intervention in their affairs remote. While just before the outbreak of World War I there were proposals for the control of customs in the Dominican Republic and in Haiti, and while the German naval office, contrary to the views of the German foreign office, flirted with the idea of naval bases in the new world in the first decade of the 20th century, the danger of interference on an important scale never existed after the French invasion of Mexico in the 1860s.

But what is more significant is that there developed within Central and South America a growing resentment against the doctrine as an offensive expression of U.S. hegemony in the new world. Many expressions of this resentment can be found in Central and South American literature in the period between 1902 and 1915, in the work of the eminent Nicaraguan Rubén Darío, in the writings of the Uruguayan José Rodó, in *Latin America* of the Peruvian García Calderón, and in the widely read volume of Manuel Ugarte, *The Future of Latin America*. The tone of Central and South American publicists in many instances reflected the same temper. And in the United States itself such works as that of Hiram Bingham, *The Monroe Doctrine, an Obsolete Shibboleth* (1913), gave wider circulation to the critical view of many of the statesmen to the south. In 1920, the little state of El Salvador called for a definition of the doctrine in the midst of "anarchy of opinions"; the Mexican government declared that it would not recognize the principles of 1823. These attacks had an important influence on U.S. policy. In 1923 Secretary Charles Evans Hughes, in two very able speeches, attempted to answer the critics. He denied that the doctrine conveyed any implication of overlordship or superintendence, and he sought to dissociate U.S. interventions in the Caribbean from the principles of 1823, declaring that these interventions stood upon different grounds. But the critics were not silenced; in the Pan-American conference of 1923 the policies of the United States were severely criticized; and at the next conference at Havana, in 1928, a proposal was brought forward declaring that all intervention in the domestic or external affairs of one state by another was illegal. The proposal was opposed by Hughes, the leader of the United States delegation, but it had important effects. When the senate ratified the Kellogg-Briand pact in 1929, it adopted a gloss which, while maintaining the validity of the doctrine, dissociated the principles of 1823 from the Roosevelt corollary; and in 1930 the U.S. state department published a memorandum prepared in 1928 by Undersecretary J. Reuben Clark which explicitly declared that the corollary was not "justified." New steps were to be taken in due course along the same line. At the conference of Montevideo in 1933 the United States set its signature to a protocol which followed the lines of the proposal made at Havana; at the same time, however, it reserved its rights under international law. At Buenos Aires in 1936 it went still further; again it subscribed to the nonintervention doctrine, and this time there was no reservation whatsoever. Both the protocol

of 1933 and the protocol of 1936 were ratified unanimously by the senate of the United States.

**Inter-American Consultation.**—Thus disappeared the interpretation of the doctrine most offensive to the Central and South Americans; and perhaps it is fair to say that no great and powerful nation had ever put its name to so remarkable a self-denying ordinance as did the United States at this time. But a still more remarkable development was ahead, for with the rise of Hitler's Germany, the U.S. government moved toward a series of understandings with the states of the new world that gave a new international sanction to the principles of 1823. The first step in this direction was taken at the conference of Buenos Aires and consisted of an agreement that "in the event of an international war outside America, the New World republics would consult together as to the necessary measures to be taken." At Lima in 1938 machinery to facilitate such consultation was set up. At Havana in 1940, after the fall of France, resolutions were adopted declaring that an attack against any American state was an attack against all, and a procedure was also outlined for the possible occupation and administration of French or Dutch colonies in the new world which might otherwise fall a victim to the Nazis. In 1942 the nations of the new world agreed to break off relations with the Axis powers, and in most cases this agreement was promptly honoured. In 1945 and again in 1947, at the conferences of Chapultepec and Rio de Janeiro, the principle of collective action against aggression was again accepted. These steps did not internationalize the doctrine; the United States retained the right to take action on its own initiative if it deemed such action necessary, but they gave the principles of the doctrine international validity. During this period, moreover, the doctrine was extended to Canada and Greenland.

**Post-World War II Period.**—In a sense, however, there were fundamental developments in the World War II and postwar periods that altered the place of Monroe's great pronouncement in the scheme of things. U.S. citizens discovered that constant reference to that pronouncement was likely to rasp the susceptibilities of their Central and South American friends; and, as a consequence, there was a striking decline in the number of such references. In the second place, the danger of a direct physical attack upon the nations of the new world diminished, and the strategic significance of the nations declined with the growth of long-range nuclear weapons. The danger seemed rather to lie in the possible subversion of American governments by Communism.

The United States was bound by the protocols of Montevideo and Buenos Aires to abstain from direct intervention to overthrow a communist or protocommunist regime, and by the declaration of Bogotá (1948) international intervention was also banned. In an effort to deal with this problem, the U.S. government urged the passage of resolutions at Pan-American conferences, notably at Bogotá in 1948 and at Caracas in 1954, underlining the danger. At Caracas it was declared that "the domination or control of the political institutions of any American state by the international Communist movement, extending to this hemisphere the political system of an extracontinental power, would constitute a threat to the sovereignty and political independence of the American states, endangering the peace of America, and would call for a meeting of consultation to consider the adoption of appropriate action in accordance with existing treaties." In the same year, when it appeared that Guatemala was falling under communist control, and when that state was receiving massive shipments of arms from behind the "iron curtain," a meeting of the American states was summoned. But before any action could be determined upon, the victory of a revolutionary movement against the protocommunist regime removed the question from the area of international discussion.

Much more serious were the events that occurred in Cuba. (*See* also CUBA: *History*.) In Jan. 1959 the regime of President Batista was overthrown, and a new government constituted under the insurgent leader, Fidel Castro. Castro soon showed himself to be under the influence of Communists. He governed without elections; he confiscated U.S. properties on an increasing scale; he whipped up public feeling against the United States as an "imperialist" nation. Moreover, in 1962 he permitted the Soviet Union to take steps toward the emplacement in Cuba of long range nuclear weapons that threatened the physical security of the United States. The plan was detected by U.S. reconnaissance planes that took aerial photographs of the missile sites. On Oct. 22 Pres. John F. Kennedy, in a television address to the nation, announced a partial blockade of Cuba and demanded the withdrawal of the Soviet missiles. In the crisis that followed, the Kremlin yielded to the U.S. pressure.

What of the relation of these events to the Monroe Doctrine? It was clear that the Russian action was a challenge to the doctrine in that the physical security of the United States was directly threatened. It was not so clear, in view of the commitments of the United States to the doctrine of nonintervention, that the necessary sequel to the president's message was direct action to overthrow the Castro regime. Indeed, in its handling of the question the administration purposely avoided citation of the message of 1823 and chose to act with the collaboration of the Organization of American States.

**Influence on Public Opinion.**—In the history of the development of the Monroe Doctrine one other fact should be stressed. The doctrine is an illustration of the tendency, in a democratic diplomacy such as that of the United States, to lay down broad principles of action that can be easily understood by the mass of the people. These principles come to have great influence and undeniable force. They operate to provide strong public support for decisions in specific cases. While they are subject to modification and divergent interpretations, and while their significance alters at different epochs, they play a useful and significant role in the diplomacy of a democratic state. *See* PAN-AMERICAN CONFERENCES; AMERICAN STATES, ORGANIZATION OF; DRAGO DOCTRINE; TRUMAN DOCTRINE; EISENHOWER DOCTRINE; *see also* references under "Monroe Doctrine" in the Index.

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**MONROVIA,** on the west African coast, capital of Liberia and the country's largest city. Pop. (1956) 41,829. Monrovia was founded in 1822, during the administration of U.S. Pres. James Monroe (for whom it is named), by the American Colonization society as a home for freed slaves. The population is chiefly descended from former slave emigrants from the United States and the British West Indies, most of whom arrived between 1830 and 1871. Largely cut off from contact with the U.S. since 1871, Monrovians preserve a charm and dignity, even an architecture, reminiscent of the plantation south but mixed with a colour and exuberance distinctly west African. Monrovia (lying on Bushrod Island on the north and Cape Mesurado peninsula on the southeast) is shaped like a bent arm about 14 mi. long and ¾ mi. wide. Bushrod Island contains the 507-ac. free port (the only one in west Africa) of Monrovia, a lend-lease project completed in 1948. Transhipping for liquid latex and iron ore are among the excellent facilities provided; six ships of 28-ft. draft can be accommodated at a time. A seat of government and commerce, Monrovia has little industry. Public services remain inadequate, though most streets are paved. After 1952 much European capital was invested in construction. Southeast of the main city are tin-roofed mud huts of detribalized Africans, living sometimes in appalling poverty. Beyond lie fine homes, the capitol (built in 1958) and the expanding University of Liberia. Monrovia is the educational centre of Liberia, with, in addition to the university (founded 1862, given university status in 1951), the College of West Africa (operated by the Methodist Church of America), Monrovia college (Baptist)

and St. Patrick's Catholic college. For history, *see* also LIBERIA.
(P. W. Po.)

**MONROVIA,** a residential city of Los Angeles county, Calif., U.S., 18 mi. E. of Los Angeles in the foothills of the Sierra Madre mountains at the eastern end of the San Gabriel valley. Its townsite was once part of Ranchos Santa Anita and Azusa de Duarte. Incorporated in 1887, Monrovia was developed by Los Angeles realtors and speculators William N. Monroe and Edward P. Spence among others who planned to make their boom town a tropical paradise with palm and pepper trees lining the streets, and groves of citrus trees surrounding the site. After the wild speculation of the 1880s Monrovia settled down to be a rural town of citrus growers and retired people from the eastern U.S. While the rural atmosphere of earlier decades remained, the city had a considerable increase in population after 1940, and in the 1960s had more than 50 light industries. Monrovia has a council-manager form of government, in effect since 1949. For comparative population figures *see* table in CALIFORNIA: *Population*. (J. A. Sz.)

**MONS** (Flem. BERGEN), the capital of Hainaut province, Belgium, is situated between the Trouille and Haine rivers, 32 mi. S.W. of Brussels. Pop. (1961) 26,973. The town probably owes its origin to a camp of Roman legionaries who remained as frontier guards in the 3rd century; in 640 A.D. the settlement was designated Castrilocus by St. Aubert, bishop of Cambrai. About 804 Charlemagne recognized it as the capital of Hainaut. At first the counts occupied the castle of Hornu, leaving Mons to the abbey and the church of St. Waudru. Regnier V moved to Mons at the beginning of the 11th century, and his only child, a daughter, Richilde, married Baldwin VI of Flanders. The two countdoms were again divided between Richilde's sons. Between the 14th and 16th centuries Mons prospered as a cloth- and serge-weaving town and the count transferred his principal fortress there from Valenciennes. When the Hainaut title became merged in the duchy of Burgundy, Mons was a stronghold near the French frontier. Its capture, defense and surrender by Louis of Nassau in 1572 and its many sieges in the 17th and 18th centuries attest its troubled history. Mons was converted into an open town in 1862.

The late-Gothic cathedral of St. Waudru, named after the first countess, was built 1450–1621 and contains some fine stained-glass windows as well as a few paintings by Theodor van Thulden. The *hôtel de ville* (townhall) dates from the mid-15th century; the tower was added in 1718. There is also a belfry (297 ft. high) with a fine carillon of 47 bells. The modern town has a flourishing trade in cloth, lace, sugar, etc.; but its chief importance is derived from its proximity to the Borinage ("place of boring") coal-mining district. There is a polytechnic college. The annual procession of the Car d'Or (Golden car) takes place on Trinity Sunday, followed by the *Lumeçon* fight between St. George and the dragon. Not far from Mons are the battlefields of Malplaquet (1709) and Jemappes (1792).

**Battle of Mons, 1914.**—This, the first battle of the British expeditionary force in World War I, took place on Aug. 23, 1914, and next day the heavily outnumbered British army began the historic retreat which, marked by the battle of Le Cateau (*q.v.*), ended on the Marne (*q.v.*), where the Franco-British counter-offensive turned the invasion. The well-known legend recounts how the retreat was suddenly stopped by the intervention of angels who made their appearance in the sky as fighting bowmen. Mons has many World War I memorials dedicated to British and Canadian regiments, war museums and military cemeteries.

**MONSIEUR,** the French equivalent both of "sir" (in addressing a man directly) and of "Mr." Etymologically it means "my lord" (*mon sieur*), as also does the far more exalted *Monseigneur*. Used very liberally in French speech, Monsieur is followed by the definite article when it precedes reference to a man's title or office, as in *Monsieur le Président* ("Mr. President"). Marshals of France are addressed as *Monsieur le Maréchal*, but other army officers do not receive *Monsieur:* a general, for example, is *Mon général* to men, *Général* to women. Under the first republic, the Convention by a decree of Oct. 9, 1792, imposed *Citoyen* ("Citizen") instead of *Monsieur*, but this usage lapsed with the end of the first republic.

Under the *ancien régime*, *Monsieur*, by itself, came to be the specific designation of the French king's eldest brother. The origin of this usage is obscure. François, duc d'Alençon and duc d'Anjou, Henry III's last surviving brother, was frequently, but not invariably, so designated. The first prince to have himself so designated consistently was Louis XIII's brother Gaston, duc d'Orléans. The example was followed by Louis XIV's brother Philippe, later also duc d'Orléans; by Louis XVI's brother the comte de Provence till he became king as Louis XVIII; and finally by the comte d'Artois, last surviving brother of Louis XVI and Louis XVIII, till he became king as Charles X. For Monsieur le Prince and Monsieur le Duc *see* CONDÉ, PRINCES DE.

**MONSIGNOR** (Italian *monsignore*, "my lord") is a title of honour in the Roman Catholic Church, borne by persons of ecclesiastic rank and implying a distinction bestowed by the pope, either in conjunction with an office or merely titular. All those who bear the title of monsignor belong to the "papal family" and are entitled to be present in the Cappella Pontificia (when the pope celebrates solemn Mass) and to participate in all public religious and social celebrations, wearing the robes corresponding to their respective offices. The ecclesiastics who have a right to the title of monsignor are (1) patriarchs, archbishops and bishops, who are addressed as "most reverend monsignor"; (2) apostolic protonotaries and domestic prelates, who are addressed as "right reverend monsignor"; and (3) private chamberlains, who are addressed as "very reverend monsignor" and lose their honorific title at the death of the pope. (P. Lt.)

**MONSON, SIR WILLIAM** (1568–1643), English naval officer best known for his *Naval Tracts*, was the son of Sir John Monson of Lincolnshire. He entered Balliol college, Oxford, in 1581, but four years later ran away to sea; however, he took his degree in 1594. In the Armada campaign he served as volunteer in the "Charles" pinnace and afterward accompanied the earl of Cumberland on three voyages to the West Indies. In 1596 he was flag captain to the earl of Essex at the capture of Cadiz, and in 1602 was vice admiral of the last fleet to be sent against Spain, when the great carrack "St. Valentine" was taken. From 1604 to 1616 he was Admiral of the Narrow Seas, being chiefly engaged against pirates. He was dismissed partly for accepting bribes from Spain and partly on account of his supposed connection with the murder of Sir Thomas Overbury. Monson's last service at sea was in command of the ship-money fleet of 1635. During his retirement he composed his *Naval Tracts*, which were first printed in abbreviated form in 1682, then in full in 1704, a definitive edition in five volumes being edited by M. Oppenheim for the Navy Records society in 1902–14. It is to these writings that Monson owes his fame, since, besides being the first account by a naval officer of a war in which he himself served, they provide a valuable commentary on the Elizabethan war with Spain and conditions at sea during that period. Monson died at Kinnersley, Surrey, in Feb. 1643. (C. C. L.)

**MONSOON,** originally the name given by the Arabs to those seasonal winds of the Arabian sea which blow for approximately six months from the northeast and six months from the southwest. The name (Arabic *mausim*, "season") is applied to all wind systems on a continental scale that seasonally reverse their direction. Southeast Asia, from the Arabian sea to China, is the most prominent instance; other examples are the Gulf coast of the United States and northern Australia. The primary cause of the monsoon lies in the difference of the annual temperature trends over land and sea. Changes are large over land, small over the oceans. The monsoon blows from cold toward warm regions: from sea toward land in summer, from land toward sea in winter. Atmospheric pressure is high in the cold regions and low in the warm regions, permitting the air movement to take place. Beyond these facts, a complete explanation of the monsoon has not been offered.

At the poleward limit of the monsoon the winds shift sharply. In India, for instance, the monsoon blows from the southwest in July–August, and north of India winds are from the east. Over northern Australia the monsoon comes from northwest in January–February, and at the southern limit winds again become easterly. Along the line where monsoon winds and easterlies meet, much

convergence of mass and ascent occurs; because of the condensation of water vapour during ascent the monsoon is one of the most important rain-producing currents of the globe. Unfortunately, its intensity and duration are not uniform from year to year, for unknown reasons. A heavy season with floods may be followed by several seasons with below average rainfall, failure of crops and famine. *See* also references under "Monsoon" in the Index.

(H. RL.)

**MONSTER,** an animal or plant departing greatly from the normal appearance of its kind. The marvel of the processes of development is that so few disruptions occur to produce malformed organisms; but those monsters that infrequently appear in any population can often shed light on normal development. The science of teratology—a branch of morphology or embryology—is concerned with the study of these structural deviations from the normal, whether in animals or plants.

## ANIMAL MALFORMATIONS

Among the newborn young and embryos of man and most other species of animals are found occasional individuals who are malformed in whole or in part. The most grossly abnormal of these have been referred to from ancient times as monsters, probably because the birth of one was thought to signify something monstrous or portentous; the less severely malformed are usually known as abnormalities or anomalies.

Monsters have been regarded by primitive peoples as of supernatural origin. The birth of a human monster was often attributed, before the rise of modern science, to intercourse between human beings and devils or animals. The mythical beings that appear in the folklore of many peoples—races of dwarfs and giants, of sirens, mermaids and men with a single median eye (cyclops) or leg (skiapods)—were probably suggested by observations of actual human monsters. Giants and dwarfs are often classed as monsters, probably because of the prominent places they occupy in mythology (*see* DWARFISM AND GIGANTISM).

The objective study of monsters began with William Harvey (1651), who correctly attributed them to deviations from the normal course of embryonic development. Systematic scientific study, however, had to await the pioneer work of the French anatomists Étienne and Isidore Geoffroy Saint-Hilaire. Their *Traité de Teratologie* (1836), which laid the basis for the science of teratology, still remains a valuable source of information. Recent improvements in understanding have been due to the application of experimental analytical methods and of ideas from genetics.

According to form, two main classes of monsters may be recognized: those with defective or excessive growth in a single body, and those with partial or complete doubling of the body on one of its axes.

### REPETITION OR DEFICIENCY OF PARTS

**Somatic Characters.**—Repetition or deficiency of single parts such as fingers or toes (polydactyly, hypodactyly, brachydactyly) are frequent anomalies in man and other mammals. In many analyzed cases they have been shown to result from the inheritance of an abnormal gene that produces a localized disturbance of a growth process in the embryo. In the rabbit a recessive gene for brachydactyly (short digits) causes a localized breakdown of circulation in the developing limb bud of the embryo followed by necrosis and healing (O. R. Inman, 1941).

Absence or abnormality of whole limbs is less common, and includes, besides club foot, the so-called congenital amputations once thought to be due to strangulation of a limb by a fold of embryonic membrane (amnion). It is probable that endogenous abnormalities of the bone are more frequent causes of such amputations than are strangulations. Cases are recorded of human identical twins in which both members have the same type of limb abnormality, suggesting a hereditary predisposition to this type of malformation.

In addition to monsters with rudimentary limbs (phocomelus, having "seallike limbs"), others are known with incomplete or underdeveloped extremities (hemimelus, micromelus, ectromelus).

A rare type of monster, but one that has always attracted special interest, has the lower extremities more or less united, as in the mythical figures of sirens or mermaids. Such sirenoid monsters may have a single foot (uromelus), or limbs fused throughout their length with no separate feet (sirenomelus or symmelus).

Absence of the brain at birth (anencephaly), abnormally small brain and head (microcephaly), enlargement of the brain and head, sometimes to prodigious dimensions due to dilatation of the ventricles by fluid (hydrocephaly) are frequent congenital defects in man. In some cases they have been traced to defective genes (L. C. Dunn, 1950), although they may also arise from accidental or traumatic processes during embryogeny (*see* also EMBRYOLOGY, EXPERIMENTAL). Occasional monsters are found in which a part of the brain protrudes through the cranium as an encephalocoele. An extreme along this line is pseudencephaly, in which the whole brain is everted and rests upon the top of the cranium like a wig.

Cyclopean monsters with a single median eye occur rarely in man and other animals, taking their name from Cyclops, the race of one-eyed giants in Greek mythology. Less striking but more frequent anomalies are anophthalmia (absence of eyes) and microphthalmia (abnormally small eyes), both occasionally the result of abnormal heredity.

Defective closure of lines of junction in the embryo produces monstrosities such as harelip and cleft palate, in which the ventral laminae of the palate have failed to fuse. A frequent abnormality in human infants is spina bifida, in which the spine fails to close over and a gap is left in the vertebral column. Both conditions are inherited, albeit somewhat irregularly, in man.

**Sexual Anomalies.**—In man and other vertebrates male and female individuals usually have distinctive characters in addition to the primary one of producing either sperm or eggs. Individuals with both male and female functions are known as hermaphrodites (*q.v.*). While this is the normal condition in some lower animals and in many flowering plants, it is so rare in mammals and man as to be regarded as anomalous or monstrous. Individuals with mixtures of male and female characters (usually sterile) are known as intersexes. In man there occur two rare conditions that, according to recent evidence, represent partial sex reversal. Individuals with Klinefelter's syndrome are apparent males who produce no sperm. Several cases have been shown to have two X chromosomes (the usual state determining femaleness) with an additional Y chromosome (which carries genetic factors for maleness). Individuals with Turner's syndrome are apparent females without functional ovaries. The cases analyzed have only one X chromosome (like the normal male with one X and one Y chromosome). These anomalies are clearly due to disturbances in the hereditary mechanism for sex determination (*see* GENETICS, HUMAN).

**Complex Syndromes.**—A remarkable feature of monsters in vertebrates including man is the association of multiple abnormalities in complex syndromes. Thus in man harelip, spina bifida, hydrocephalus and polydactyly may be found in the same monster; acrocephalosyndactyly (an egg- or dome-shaped skull and partial or complete fusion of digits in both hands and feet) often occurs with harelip, contractures, spina bifida and mental abnormalities.

In man, individuals afflicted with mongolism, also known as Down's syndrome (*see* MENTAL DEFICIENCY), have facial and bodily characters that permit diagnosis at or even before birth. Mongols have 47 instead of the normal 46 chromosomes. The extra chromosome is apparently responsible for the abnormal syndrome.

### DOUBLE MONSTERS

**Siamese Twins.**—Individuals partially or wholly double, but joined together, are represented by the rare occurrence in man of Siamese twins. This type of monster, so called from a famous Siamese pair exhibited for many years in the 19th century, consists of identical twins joined by a bridge of tissue through which the circulatory systems communicate. They probably arise by the incomplete separation of a single fertilized egg into two parts. The experimental production of such double monsters in newts was accomplished by Hans Spemann by constricting the egg in the two-cell stage with a hair loop. (*See* also MULTIPLE BIRTHS.)

**Doubling of Parts.**—In man partially double symmetrical

monsters are found. They vary from those with a single head but with neck, trunk and limbs doubled, through those with two heads and single trunk, to others with head, shoulders and arms doubled, but with one trunk and one pair of legs. Such double monsters probably arise following the less complete separation of the halves of the early embryo or partial separation at later stages. A rare type is one in which there is a Janus head, two faces on a single head and body. Janus monsters have been produced experimentally by a variety of treatments of amphibian embryos in early stages. A group of cases in which the hinder end of the body was doubled from the sacrum back has been found in one strain of mice and appears to be due to abnormal heredity. Doubling of whole limbs in amphibia has been produced experimentally by injuring the limb rudiment at an early sensitive stage (*see* EMBRYOLOGY, EXPERIMENTAL).

Unequal double monsters consist of two parts, one of which is usually well formed while the other is small, vestigial or abnormal, occurring as a "parasite" upon the more normal partner. Thus a young man of Genoa, Lazarus Colloredo, born in 1716, who was drawn as a child by Fortunias Licetus and later by Caspar Thomeson Bartholinus, bore at the lower end of his breast bone a living child as a parasite. In other cases such parasites have been attached to the head or to other parts of the trunk. The parasite often shows the same types of monstrosities that in single monsters have been attributed to delayed development. Rarely the parasite is included within the abdominal cavity of the larger partner as a *foetus in foetu*.

### THE ORIGIN OF MONSTERS

In general, abnormalities in the newborn trace to deviations from the normal course of development, often in very early embryonic stages. Such deviations may be due to abnormal (mutant) genes, to environmental conditions and perhaps most frequently to interactions between these two sets of causes. A general interpretation proposed by Charles R. Stockard (1921) is that a primary factor in all cases is inhibition of the rate of development, the kind and degree of deformity depending upon the stage at which the inhibition occurs. This interpretation is supported by the results of descriptive studies of monsters and anomalies, and especially by evidence from experimental teratology.

As an example of descriptive study, S. Wright and K. Wagner (1934) showed that an extensive series of monsters found in one inbred family of guinea pigs could be arranged in a graded order of increasing defectiveness, from those with a single tooth missing, through reduction and absence of the lower jaw (agnathia), fusions of ears (otocephaly), reduction and fusion of eyes (microphthalmia, cyclopia) and finally absence of all head structures (acrania). This order was interpreted as corresponding to degrees of inhibition of early development due to abnormal heredity acting together with a chance assortment of minor environmental factors.

In man certain gross defects in babies at birth have been shown to be associated with effects acting through the mother in early pregnancy: gross defects of eyes and ears due to infection of the mother with rubella (German measles); microcephalic idiocy with diagnostic use of X-rays on the mother. Both of these observations have been confirmed by animal experimentation. It has been established that higher rates of congenital malformations occur in areas of higher natural radioactivity. The same effect may follow from increases in radiation due to fallout from atomic explosions.

The teratogenic action of certain drugs was tragically dramatized in the late 1950s and early 1960s. The appearance of an alarming number of phocomelic infants, especially in Germany, was traced to the ingestion by pregnant women of the sedative thalidomide (known under many trade names). This drug adversely influences the developing fetus; it appears to interfere with development only in the first seven weeks of pregnancy.

### EXPERIMENTAL TERATOLOGY

Knowledge of the origins of monsters has continually expanded through the systematic application of chemical and physical agents to the study of development. By chemical treatment of eggs and early embryos of the fowl, for example, it has been possible to produce at will most of the types of monsters previously described. The form produced depends on the intensity of treatment, the stage treated, the genetic constitution and to a lesser degree on the specific substance used. When analyzed in terms of these variables, the genesis of monsters is seen to involve deflection of certain metabolic reactions such as oxidations, the effect on later development depending on the position occupied by the reaction in the normal sequence. Similar effects have been observed to follow the treatment of mammalian embryos with X-rays, the most important factor here being the stage treated; certain periods of development appear to be more radiosensitive than others. Interpretation of chemical and physical effects as causing aberrations of biochemical functions like those due to abnormal genes is currently attracting much interest in biochemistry and genetics.

(L. C. D.)

## PLANT MALFORMATIONS

Monstrosities, freaks and other malformations have interested botanists for many years. There are numerous categories of such growth abnormalities in plants and these are often related only loosely or not at all to one another.

**Exaggerated Growth.**—Sometimes divergence from the normal represents merely a quantitative change, which is evidenced by a harmonious but exaggerated manifestation of the normal developmental processes. This is well illustrated in the so-called *bakanae*, or foolish seedling disease, of rice. The *bakanae* disease is caused by the fungus *Gibberella fujikuroi*. Diseased plants are often conspicuous in a field because of their extreme height and pale, spindly appearance. This exaggerated growth response was found to be due to specific substances, known as gibberellins, that were produced by the fungus. Evidence is now available to indicate that gibberellins, also produced by higher plant species, participate directly as an essential growth-regulating system in all higher plant species. The gibberellins of either fungal or higher plant origin stimulate the normal development of certain genetic dwarfs of maize and peas, which cannot themselves produce the gibberellins in amounts sufficient for their normal development.

A common deformity of tobacco, called frenching, occurs in most tobacco-growing regions of the world. The advanced stage of this condition is characterized by a cessation of terminal bud and stem growth. When dominance of the stem tips is lost, the buds in the axils of the leaves develop and unusually large numbers of leaves (as many as 300) appear on a plant. The leaves are characteristically sword- or string-shaped because of the failure of the leaf blades to develop. Such plants have the appearance of a rosette. Although the cause of frenching has not yet been unequivocally established, it is thought to be due to a toxic substance produced by the nonpathogenic soil bacterium *Bacillus cereus*.

**Alteration of Floral Parts.**—Under the stimulus of pathogenic organisms of the most diverse kinds the sepals, petals, stamens or pistils of a flower may be transformed into structures that are very different in appearance from those found normally. In the United States there are at least three different viruses that produce gigantism in the sepals and calyxes of certain solanaceous plants—the aster-yellows virus, the cranberry false-blossom virus and the tomato big-bud virus. The tomato big-bud virus appears to affect the sepals of the tomato flower rather specifically. These structures enlarge greatly under the influence of the virus and fuse to form huge bladderlike structures that may be ten times or more the normal size. Viruses of this type do not cause gigantism in the sepals of certain other plant species. In the Madagascar periwinkle (*Vinca rosea*), for example, viruses of this type bring about a green colouring in the petals, stamens and styles; normally the petals are pink and the stamens and styles whitish. There is in this instance a retrograde development of floral parts into foliage leaves. Findings such as these are of interest to the morphologist because they support the contention that the flower should be regarded as a modified leafy branch.

**Translocation of Organs.**—Plant organs may arise in unusual places as a result of the infection by certain types of pathogenic agents. The carrot-yellows virus from Texas, for example, stimulates production of aerial tubers in the axils of the leaves of potato

plants. Large numbers of adventitious roots (arising in abnormal places) appear on the stems of tomato plants infected with the bacteria *Pseudomonas solanacearum* and *Agrobacterium tumefaciens* as well as the *Fusarium* wilt fungus and the cranberry false-blossom virus.

An extreme example of adventitious shoot formation is found in *Begonia phyllomanica* after shock. In this instance small plantlets develop spontaneously in incredible numbers from the superficial cell layers of the leaf blades, petioles and stems. The adventitious shoots do not arise from preformed buds but develop from cells at the base of hairs and especially from certain glands present in great numbers in young stems and leaves of this species. Although these plantlets develop a vascular system of their own, the vast majority never succeed in connecting that system with the vascular system of the host. They must therefore be regarded not as branches but rather as independent organisms.

**Witches'-Brooms.**—Witches'-brooms, or hexenbesens, are closely grouped, many-branched structures commonly found on a number of species of trees and shrubs. Witches'-brooms caused by certain specific fungi live a more or less independent existence despite the fact that they are derived from the tissues of the host. In accordance with their independence, the witches'-brooms tend to break away from the normal correlations of the parent plant. Instead of branching out horizontally, the brooms stand as more or less erect clusters of branches. Witches'-brooms do not as a rule flower and the vegetative buds may open several weeks earlier in the spring than do those present on healthy branches, indicating further the independence of these structures from normal morphogenetic controls.

Similar structures occur in certain plant species after virus infection. These appear to result from the excessive stimulation and development of secondary shoots. The witches'-broom virus in potato, for example, causes the infected plant to produce numerous buds at the nodes of the aboveground stems of potato plants. Long slender stolons resembling aerial roots that are covered with hairs develop from these adventitious buds.

**Fasciation.**—This condition is best placed in that category of teratological abnormalities known as monstrosities. Fasciation is a morphological term that has been used to describe a series of abnormal growth phenomena resulting from many different causes, all of which result in flattening of the main axis of the plant. Although a ribbonlike expansion of the stem is often the most striking feature of this condition, all parts of the plant may be affected. As fasciation develops, the growing point of the plant becomes broader; the unregulated tissue growth results in significant increases in the weight and volume of the plant. The apical growing point becomes linear and comblike in some instances or develops numerous growing points, producing a witches'-broom effect. In still other instances, the growing points may be coiled and resemble a ram's horn or they may be fused and highly distorted into a grotesque tangle of coils. Fasciations found in plants such as the common cockscomb (*Celosia argentea cristata*), as well as the cristae in cacti, are highly prized by gardeners.

There seems little doubt that nutritional changes due to disturbances in the growth-hormone relationships in a plant play an important role in fasciation. It has been suggested that a proximate cause of these abnormalities is the maldistribution of growth hormones in the plant. (A. C. BR.)

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**MONSTRANCE** (Latin *monstrare*, "to show"; also called *Ostensorium* (*ostendere*, also "to show"), a vessel in which the eucharistic Host is carried for exposition at Benediction and also in processions. The 14th-century popular devotion to the Blessed Sacrament produced monstrances modeled after pyxes or reliquaries—sacred vessels for transporting the Host or relics. The addition of small openings and the invention of the lunette, a lunar-shaped instrument holding the Host, made exposition practicable. In the 16th century the present monstrance took shape, viz. a crystal or glass circular disk set in a cross or surrounded with metal rays. (C. J. H.)

**MONSTRELET, ENGUERRAND DE** (*c.* 1390–1453), French chronicler and a member of a noble family of Picardy. If a document issued in 1424 by Henry VI of England refers to him, he was then commanding the castle of Frevent (or Frevenche) for the count of St. Pol. He took service with John of Luxemburg and, though he did not see Joan of Arc captured, witnessed her subsequent interview with Philip the Good, duke of Burgundy. His chronicle, continuing Froissart's, is in two books covering the years 1400 to 1444, when, according to Mathieu d'Escouchy, who continued it to 1465, he ceased to write. A diffuse writer, Monstrelet was harshly judged by Rabelais; but he is well informed and exact, and his chronicle is valuable for the final stages of the Hundred Years' War because of the many authentic documents and credibly accurate reported speeches it records.

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**MONTAGNA, BARTOLOMMEO** (*c.* 1450–1523), Italian painter, the most eminent master of the school of Vicenza, was born in Brescia about 1450. G. Vasari classes him among the pupils of Andrea Mantegna, but although there can be little doubt of the influence of the great Paduan master on his style, he more probably studied at Venice (where he was living in 1499) under the influence of Alvise Vivarini and Giovanni Bellini. His first datable work, of 1487, shows the influence of Vivarini. He interpreted his favourite subject, "The Virgin and Child," either alone or attended by saints, with a solemn, quiet grandeur. Montagna is first heard of at Vicenza in 1474; he also worked at Praglia near Padua and at Verona (1504–07), where he painted a fresco in the oratory of S. Biagio in the church of SS. Nazaro and Celso, as well as an altarpiece for the church of S. Sebastiano now in the Venice academy.

His most important work is probably the great altarpiece for S. Michele at Vicenza dated 1499, now in the Brera gallery, Milan. Here the stateliness of the composition, staged under a lofty vault, the nobility of the enthroned Madonna, the dignity of the attendant saints and the charm of the angels making music at the foot of the throne are profoundly impressive. It would be impossible here to enumerate the many works of Montagna in Vicenza and in many public and private collections. One of his last pictures is the altarpiece, dated 1522, in the cathedral at Cologna Veneta. He died at Vicenza on Oct. 11, 1523. Bartolommeo founded a school of painting at Vicenza, which influenced Giovanni Speranza and partly also Giovanni Buoconsiglio and Francesco da Ponte, the father of Jacopo da Bassano.

His son, BENEDETTO MONTAGNA (1481–1558), imitated the style of his father in his paintings. He was a distinguished engraver.

See T. Borenius, *The Painters of Vicenza* (1909). (P. J. MV.)

**MONTAGNAIS AND NASKAPI,** the most northeasterly Indian tribes of the Algonkian linguistic family, they occupy a vast area on the Labrador peninsula in eastern Canada. Originally they lived in the interior, their traditional enemy, the Eskimo,

occupied the seacoast. The name Montagnais is of French origin, and these people were encountered by Samuel de Champlain in 1603 north of the St. Lawrence river. The Naskapi are close relatives, the Indian name apparently referring to their crude, northern or frontier characteristics. These unwarlike peoples had little influence on the French colonies, but their own northward movement seems to have been in part caused by the Iroquois wars. (*See* ALGONKIAN TRIBES.)

The Montagnais-Naskapi territory is huge, while the native population is small. The Canadian census of 1924 gave a combined population totaling 4,684; the best (unofficial) estimate in the 1960s is still about 4,700. They continue to live in shifting bands of varying composition; the southern bands had definite fur-trapping and hunting territories imposed by the European fur trade. The northern Naskapi territories were much larger and more loosely defined.

The loose native political organization is limited to voluntary attachment to successful leaders; family organization is bilateral, without clans. Economy is based on fish and game, with agriculture totally absent. The caribou is the basic food in the north and the Caribou god is a vague, supreme being among the Naskapi. Tribal religion also includes the manito (*q.v.*) concept, culture heroes, tricksters, animal characters and, especially, dream fulfillment. In general, families and bands spend the winter hunting and trapping in the interior. They come to the coast trading stations and missions in summer.

Aboriginal dwellings are of birch bark or caribou skin. Canoes furnish transportation in summer, while sleds and snowshoes are used in winter. Dog traction is a fairly recent borrowing from the Eskimo. The Naskapi were famous for their distinctive painted skin coats. The introduction of air transport, railroads, pulpwood manufacture, mining and other rapidly expanding industrial activities in Labrador has vastly accelerated changes in cultural patterns. *See* also CANADA: *Native Peoples;* LABRADOR-UNGAVA.

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**MONTAGU,** the family name of the later medieval English earls of Salisbury. DROGO OF MONTAIGU (or MONTAGUD), the ancestor of the Montagus, appears in Domesday Book as one of the chief landholders in Somerset. His descendant, SIMON DE MONTAGU (d. 1316), summoned to parliament as a baron in 1299, was the first of the family to achieve prominence. Simon's son, WILLIAM (d. 1319), steward of the royal household (1317–18), became one of Edward II's favourites and was afterward seneschal of Gascony.

The career of his heir, WILLIAM (d. 1344), raised this west country baronial family to magnate status. At Nottingham castle in Oct. 1330, William de Montagu was responsible for the success of the conspiracy which overthrew Roger Mortimer, earl of March, and Queen Isabella, and made Edward III the real ruler of England. His rewards included grants of land worth more than £1,000 a year; he was created earl of Salisbury in 1337 and in 1338 was made marshal of England. Montagu served in the Scottish and French wars and was frequently employed by Edward III on diplomatic missions. In 1333, he had been given the Isle of Man (to which his grandfather, Simon, is reputed to have acquired a claim), after its conquest from the Scots. His elder son WILLIAM (1328–1397), the 2nd earl, fought at Crécy (1346), was one of the founder members of the Order of the Garter and had joint command of the rear guard at the battle of Poitiers (1356). A large part of the estates granted to the first earl was lost by his heir, including the valuable lordship of Denbigh, which was recovered in 1354 by Roger Mortimer (d. 1360), 2nd earl of March, and in 1392 the Isle of Man was sold to William Scrope of Bolton, afterward earl of Wiltshire. Earl William II's only son WILLIAM was killed in a tournament in 1382 and he was succeeded in 1397 by his nephew, JOHN MONTAGU (*c.* 1350–1400), 3rd earl, who inherited the barony of Monthermer from his mother, Margaret (d. 1395). His early Lollard sympathies seem to have been short-lived and he was apparently orthodox in his beliefs soon after 1387. Unpopular as one of Richard II's courtiers, Salisbury lost his life in a plot against Henry IV in Jan. 1400.

The last of the Montagu earls of Salisbury, THOMAS (1388–1428), was a notable soldier. Despite his father's attainder, he had livery of his lands in 1409 and was summoned to parliament as earl. For his services in Henry V's conquest of Normandy, he was granted the county of Perche in 1419 and he was appointed lieutenant general in Normandy and Maine in the following year. He died of injuries received at the siege of Orléans on Nov. 3, 1428. His only legitimate child was his daughter, ALICE (d. 1462), who had married Sir Richard Neville, a younger son of Ralph Neville, first earl of Westmorland. Neville became earl of Salisbury in the right of his wife, and their eldest son was Richard Neville (d. 1471), earl of Warwick, "the Kingmaker."

*See* R. Douch, *The Career, Lands and Family of William Montague, Earl of Salisbury, 1301–44* (Master's thesis, University of London; 1950); G. A. Holmes, *The Estates of the Higher Nobility in Fourteenth-Century England* (1957). (T. B. P.)

**MONTAGU, EDWIN SAMUEL** (1879–1924), British politician, played an important part in introducing the Government of India act of 1919, a measure that marked a decisive stage in India's constitutional development. The second son of the 1st Lord Swaythling (*see* SWAYTHLING, SAMUEL MONTAGU, 1st Baron), he was born in London on Feb. 6, 1879, and educated at Clifton college, at the City of London school and at Trinity college, Cambridge. He entered parliament as a Liberal in 1906 and became secretary to H. H. Asquith. As parliamentary undersecretary to the India office from 1910 to 1914, under Lord Morley and Lord Crewe, he had the task of explaining their constitutional reforms to the house of commons. He visited India in 1912.

During the first years of World War I, Montagu held a number of minor posts, entering the cabinet in 1915 as chancellor of the duchy of Lancaster. As financial secretary to the treasury, he helped to popularize the first war loans and to set up voluntary war-savings organizations. Although he resigned with other supporters of Asquith when Lloyd George took office in 1916, he became secretary of state for India in 1917 and began work on a declaration of British policy toward India, made in August, and then on measures to provide the "progressive realization of responsible government" which it promised.

As head of a delegation to the Indian provinces in the winter of 1917–18, he collaborated with Lord Chelmsford, the viceroy, in the preparation of the Montagu-Chelmsford report. Its main recommendations were embodied in the Government of India act, 1919, by which, for the first time, control over some aspects of provincial government passed to Indian ministers responsible to an Indian electorate (*see* INDIA-PAKISTAN, SUBCONTINENT OF: *History*). Montagu's personal diary of the tour, edited by his wife, was published in 1930, and paid much attention to the personalities behind the report. His emphasis upon the Indian objections to Lloyd George's Turkish policy, which offended opinion among Muslims in India, led to friction with his colleagues, culminating in March 1922 when he authorized publication of the government of India's protest against the proposed treaty of Sèvres (*q.v.*) without consulting the cabinet. Lloyd George demanded his resignation and his political career ended when he lost his seat at the general election in that year. He went into business, and died in London on Nov. 15, 1924.

*See An Indian Diary* (1930), ed. by Venetia Montagu. (KE. A. B.)

**MONTAGU, ELIZABETH ROBINSON** (1720–1800), English leader of intellectual society and first of the "bluestockings," was born at York, Oct. 2, 1720. In 1742 she married Edward Montagu, grandson of the first earl of Sandwich. She made his Mayfair house the social centre of intellectual society in London. Lord Lyttleton, Horace Walpole, Dr. Johnson and Sir Joshua Reynolds, who painted her portrait, being among her regular visitors. The term "bluestocking" was applied for the first time to her assemblies.

In 1760 she contributed to Lyttleton's *Dialogues of the Dead* and in 1769 published an *Essay on the Writings and Genius of Shakespeare*. Her husband, who died in 1775, left her a considerable fortune and large estates, including Sandleford Priory, which she enlarged. In 1781 she built Montagu house, new 22 Portman square, London, where she died, Aug. 25, 1800.

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**MONTAGU, LADY MARY WORTLEY** (1689–1762), English writer, remembered chiefly for her letters, was one of the most colourful Englishwomen of her day, distinguishing herself also as a traveler, medical pioneer, poet, feminist, periodical essayist and eccentric. She was born in London and baptized at St. Paul's church, Covent Garden, on May 26, 1689, the first child of Evelyn Pierrepont, who was created duke of Kingston in 1715, and Lady Mary Fielding, a cousin of Henry Fielding, the novelist. As a girl she scribbled verse, read widely in French and English literature, and taught herself Latin. While her father tried to arrange a marriage for her she eloped, in Aug. 1712, with Edward Wortley Montagu (1678–1761), a member of parliament and a friend of Addison and Steele.

When the Whigs came into power on the accession of George I in 1714, Wortley Montagu was rewarded with a treasury post and then with the embassy to Turkey. He left on his mission in Aug. 1716 accompanied by Lady Mary and their son Edward (1713–1776). After visiting Vienna they went by way of Adrianople to Constantinople, where they arrived in May 1717. Observing the practice of inoculation against smallpox, Lady Mary had it performed on her son. She later introduced it in England, and her daughter Mary (b. 1718), who later became Lady Bute, was among the first to be inoculated. She stayed in Constantinople until July 1718 when, Wortley Montagu having been recalled, they sailed for Italy and home. Her actual letters written on her travels have not survived, but she later compiled a series of 52 letters based on them in which she keenly and sympathetically set down what she saw.

In England she resumed her friendship with Alexander Pope, who in 1715 had helped her write her "town eclogues" (*Court Poems* [1716]), witty urban imitations of Virgil's bucolic poems, and who had sent letters of strained gallantry to her on her travels. But their friendship cooled in the 1720s, and, beginning with the 1728 *Dunciad*, he frequently attacked her in his satires. With the aid of her friend Lord Hervey (*q.v.*), she retaliated with the vigorous *Verses Address'd to the Imitator of the First Satire of the Second Book of Horace* (1733), and then gave up poetic warfare, though she continued to write occasional clever *vers de société*. She also acted as a literary patroness to Edward Young and Henry Fielding, advising them about their plays. Her versatility embraced yet another genre, the periodical essay. In Dec. 1737, after Sir Robert Walpole's ministry had been harried by the opposition paper *Common Sense*, a new paper appeared, derisively called *The Nonsense of Common-Sense*. Written anonymously by Lady Mary, it ran to only nine issues. Its crisp essays dealt obliquely with politics and directly with feminism and the moral cynicism of the time.

In the spring of 1736 Lady Mary met Francesco Algarotti (1712–64), a cosmopolitan Italian writer who had come to England to further his career. By the time he left in September Lady Mary was infatuated with him, and soon suggested that they should live together in Venice. To her husband and friends she pretended to be traveling for her health when, in July 1739, she sailed from Dover for what she called her "Elysium."

In Venice she was pleased by the informal social life among the patrician families and distinguished visitors. But instead of joining her, Algarotti went to Berlin in June 1740, having been summoned by Frederick II, from whom he could expect greater rewards. Lady Mary then visited her friend Lady Pomfret in Florence, there meeting Horace Walpole, who drew her portrait in acid in his letters. She went on to Rome, Naples, Leghorn, Genoa and to Turin, where she saw Algarotti in March 1741, but their meeting proved a disagreeable disappointment to her.

After brief visits to Geneva and Chambery, in 1742 she settled in the papal state of Avignon. Except for occasional excursions into France she remained there in pleasant retirement until 1746, when she returned to Italy escorted by a young Brescian, Count Ugolino Palazzi. For the next ten years she lived in the province of Brescia. She was frequently swindled by Palazzi, and later drew up a memorial of their transactions as though she intended to bring legal action. Several times she suffered severe, almost fatal illness. But her life in the beautiful lake country was otherwise full of felicities; she tended her garden, sailed on the lakes and joined in the simple pleasures of her neighbours. In her ample philosophical letters to her daughter, Lady Bute, she described her life with affectionate detail, and she also gave her pungent opinion of the new novels sent by Lady Bute. Her remarks on Richardson and Fielding, notable as literary criticism, and her advice on the education of her granddaughters, reveal the unimpaired power of her intellect.

In 1756 she moved to Venice where she enjoyed new and old friends, including Algarotti, who had retired to Bologna. She tried a new kind of writing—historical memoirs of the courts of Queen Anne and George I—of which only two provocative fragments survive. In Jan. 1761 Wortley Montagu died, leaving his immense riches to Lady Bute. His wayward son Edward was disinherited, though he had become a member of parliament for Huntingdon in 1747 and served as a secretary at the congress of Aix-la-Chapelle (1748); he had become notorious by his dissolute life, much of which was spent traveling, particularly in the middle east. Lady Mary set out for England in September, and while detained in Holland she presented her manuscript of the Embassy Letters to an English clergyman with instructions to publish them. She was discontented with life in London and would have returned to Italy had she not been ill of a cancer. She died in London on Aug. 21, 1762, at the age of 73.

Although the censorious Lady Bute retrieved the Embassy Letters from the clergyman, they were published in 1763 from an unauthorized copy, and were immediately acclaimed throughout Europe, winning the admiration of readers as diverse as Voltaire, Johnson, Gibbon and Walpole. With the successive publication of her other, private letters Lady Mary took her place as a uniquely talented woman and one of the great English letter writers.

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**MONTAGU, RALPH MONTAGU,** 1st Duke of (1638–1709), English politician who held a variety of court appointments under Charles II and achieved his dukedom under Queen Anne, after a career that justified Jonathan Swift's opinion that he was "as arrant a knave as any in his time." The second son of Edward (1616–84), 2nd Baron Montagu of Boughton, he was born in London where he was baptized on Dec. 24, 1638, and was educated at Westminster school under Richard Busby. He soon acquired a reputation for gallantry and his early appointments—as master of the horse to the duchess of York and, on the death of his elder brother, master of the horse to Queen Catherine—were attributed to female influence. These places, and his appointment as ambassador to France in 1666 and 1669, he found insufficiently lucrative to gratify his ambitions and he sought vainly for a post at the treasury. His purchase of the mastership of the wardrobe in 1671 strained his resources, which were only relieved in 1673 by the first of his profitable marriages. His wife Elizabeth Wriothesley, the daughter of the late lord treasurer and widow of the earl of Northumberland, was alleged to be worth £6,000 a year.

Montagu became a privy councillor in 1672, and in 1676 again served as ambassador in France. Here he conducted simultaneous

intrigues with the duchess of Cleveland and her cloistered daughter, the countess of Sussex. Denounced to Charles by the outraged mother, Montagu was dismissed from his posts in July 1678. His revenge for this and other disappointments was directed against the lord treasurer, the earl of Danby (afterward duke of Leeds), whose secret negotiations with Louis XIV he revealed to the house of commons after he had secured a seat in parliament. He thus precipitated the impeachment of Danby, the dissolution of parliament and a major political crisis which was soon enveloped in the "popish plot." Bribed by the French, at his own suggestion he fished in these troubled waters as a supporter of the duke of Monmouth's claims to replace the duke of York in succession to the throne, but he was never given the full confidence of such exclusionists as the earl of Shaftesbury. For some time he moved on the fringe of the group which included the marquess of Halifax and the earl of Sunderland, and he maintained a useful contact with William of Orange, but nothing came of these intrigues.

After a period of voluntary exile in France, he succeeded his father as Lord Montagu of Boughton in Jan. 1684, but although he later made overtures to James II, he was not given office. He turned readily to William III in 1688, again seeking honours and office. He was made earl of Montagu in 1689 and privy councilor. Again, in 1692, he married well, two years after the death of his first wife. His second wife was Elizabeth, daughter of the duke of Newcastle, widow of the 2nd duke of Albemarle. Allegedly mad, she had sworn to marry only a crowned head, but Montagu's wooing in the guise of the emperor of China was successful. The marriage of his son, John, to a daughter of the duke of Marlborough in 1705 was soon followed by his own elevation as marquess of Monthermer and duke of Montagu. He died in London on March 9, 1709.

However shabby his public and private morals, Montagu had the merit of building nobly, both at Boughton, Northamptonshire, and in London. Montagu house, in Bloomsbury, was built in 1675–80 to the designs of Robert Hooke and contained some of Antonio Verrio's finest frescoes. It was burned down in 1686 but immediately rebuilt on the original plan with some French embellishments. It was bought by the government in 1753 to hold the national collection of antiquities and its site became the home of the British museum.

Montagu's titles became extinct after the death of his son, John, in 1749. (H. G. Ro.)

**MONTAGU, RICHARD** (1577–1641), English bishop, scholar and theological controversialist who was threatened with impeachment by parliament for Arminianism, was born at Dorney, Buckinghamshire, and educated at King's college, Cambridge. He became dean of Hereford in 1616, canon of Windsor in 1617 and rector of Petworth, Sussex. He was also chaplain to James I. Like William Laud, he upheld the catholicity of the English church, disapproving of the extremes of Calvinism and Romanism. About 1619 he came into conflict with some Roman Catholics in his parish and Matthew Kellison attacked him in a pamphlet entitled *The Gagge of the Reformed Gospell* (1623). Montagu replied with *A Gagg for the New Gospell? No. A New Gagg for an Old Goose* (1624). The publication of the *Immediate Addresse Unto God Alone* (1624) incensed the Puritans, who appealed to the house of commons, but Montagu was protected by the king. After the appearance of his famous *Appello Caesarem* (1625), in which he vindicated himself from the divergent charges of Arminianism and popery, his case frequently came before parliament and conferences of bishops, but his influence at court and with Laud saved him. He became bishop of Chichester in 1628 and of Norwich in 1638. He died on April 13, 1641.

*See* J. R. Tanner, *English Constitutional Conflicts of the XVII Century* (1928). (G. Hu.)

**MONTAGUE, CHARLES EDWARD** (1867–1928), English journalist and man of letters whose long association with the *Manchester Guardian*, and essays, novels and short stories, give him a permanent place in literary history. Born at Ealing, Middlesex, on Jan. 1, 1867, of Irish parents, he was educated at the City of London school and at Balliol college, Oxford. In 1890 he joined the *Manchester Guardian*, under the editorship of C. P. Scott (*q.v.*), and in 1898 became Scott's chief assistant. His liberal views, moral courage and high standard of political morality matched those of his paper, and he became known for vigorous leading articles and penetrating dramatic criticisms, collected in *Dramatic Values* (1911). In 1914 he joined the Royal Fusiliers, and, after being invalided in 1916, served in the intelligence and as press officer. Experience of war matured his writing: his pre-war novel, *A Hind Let Loose* (1910), is a lighthearted satirical fantasy of journalistic life, but in *Disenchantment* (1922), an essay based on wartime diaries and articles, expressing the bitterness of the survivors, and in *Fiery Particles* (1913), comic and tragic stories of life in the trenches, he developed both a carefully wrought style and new depth of feeling.

In Dec. 1925 Montague retired from the *Manchester Guardian* to Burford, Oxfordshire, and in 1926 he published *Rough Justice*, a novel containing much personal feeling and experience, written in lyrical prose at its best in minute description of natural sights and sounds. *Right Off the Map* (1927), a satiric antimilitarist tragedy, reveals in its description of mountains his lifelong enthusiasm for rock-climbing. His last book, *Action* (1927), stories about picaresque characters, excels in realistic dialogue and evocation of atmosphere. He died on May 28, 1928, at Manchester.

The outstanding characteristics of Montague's work are his sense of values, concern for good style (see *A Writer's Notes on His Trade*, 1930), humour, love of life and of the English landscape (shown in essays on holidays in *The Right Place*, 1924), and a capacity for righteous anger. He represents a valuable element in the liberal, traditionalist literature of the early 20th century.

*See* Oliver Elton, *C. E. Montague: a Memoir* (1929).

**MONTAIGNE, MICHEL (EYQUEM) DE** (1533–1592), French writer who by the exploration of his own nature held up a mirror to mankind and created a new literary form: the essay (*q.v.*). He was born at the château of Montaigne, between Bordeaux and Périgueux, on Feb. 28, 1533. His father, Pierre Eyquem, came from a line of Bordeaux merchants who had grown rich and purchased the *seigneurie* of Montaigne with its title of nobility. His mother, Antoinette de Louppes (Lopez), belonged to a family of Spanish-Jewish origin, long converted to Catholicism, which had representatives in Antwerp as well as in Spain. His brother Thomas de Beauregard and his sister Jeanne became Protestants; his niece Jeanne de Lestonnac (1556–1640), a Catholic prioress, was canonized in 1949.

Much care was devoted to Montaigne's education. His father employed a German tutor who knew no French and the boy learned to speak Latin as his native tongue. At the age of six he was sent to the Collège de Guyenne at Bordeaux, where two of the greatest humanists of the time, George Buchanan and M. A. de Muret, were masters. He then studied law, probably at Toulouse (1546–50); and in 1557 he became *conseiller* at the *parlement* of Bordeaux. There he met another lawyer, Étienne de La Boëtie, and formed a friendship, the outstanding emotional event of his life, movingly described in the essay "De l'amitié." La Boëtie's death in 1563 greatly affected Montaigne, who published his friend's works in 1571. In 1565 he married Françoise de La Chassaigne: all but one child of the marriage (a daughter, Léonor, born in 1571) died in infancy. In 1569 appeared his translation of the *Theologia naturalis* of Raimond Sebond (Sabunde; d. 1432), made at his father's behest. His father died in 1568; in 1570 he resigned his judicial office, and in the following year retired to Montaigne, where he installed his library in the famous tower. He began the *Essais*, the fruit of his reading, in 1572 and went on writing, though not continuously, until his death.

However, his retirement was far from complete and in spite of a chronic and painful illness (the stone) he made several incursions into the world of affairs. In particular he acted as an intermediary between Henry of Navarre (who made him a gentleman of his chamber in 1577) and the court party, a task for which his position as a moderate Catholic and advocate of toleration fitted him well. From Sept. 1580 to Nov. 1581 he made the great journey through Germany and Italy described in the *Journal du voyage*. From 1581 to 1585 he was mayor of Bordeaux in a troubled

period (his father also had held the office). In 1588, visiting Paris to supervise the publication of the new edition of the *Essais*, he was arrested by the Ligueurs as a suspected agent of Henry of Navarre (*see* FRANCE: *History: The Reformation*), but released after a few hours in the Bastille. Both the Spanish and the English ambassadors report his arrival in Paris as an event of some political significance. His last years were cheered by the devotion of Marie de Gournay (1565–1645), whom he adopted as his *fille d'alliance* and who edited his works and defended his memory. He died at Montaigne, accepting all the rites of the Catholic Church, on Sept. 12, 1592.

**Works.**—*Journal du Voyage.*—Of his minor writings the most important is the *Journal du voyage*, published in 1774 from a manuscript discovered at Montaigne. The manuscript has since disappeared and it is therefore possible to question the authenticity of the *Journal*. However, an examination of the internal evidence leaves little room for doubt. It is a diary of the journey, written partly by a secretary at Montaigne's dictation, partly by Montaigne himself, at first in French and then in Italian as an exercise in the language. Some readers have expressed disappointment, but the *Journal* is of considerable intrinsic interest as a record of life, people and places (especially watering places) and of great value for the sources of many incidents and reflections in the *Essais*.

*The Essays: Editions.*—However, Montaigne is essentially a man of one book, the *Essais*, alike in matter and form one of the great seminal works of modern literature. The first edition (Bordeaux, 1580, reprinted with corrections in 1582) contains the first two books; that of 1588 (Paris) adds the third book, written from about 1586 to 1588, together with numerous interpolations in the first two. Between 1588 and 1592 Montaigne made many more additions in the margins of his copy of the 1588 edition, and after his death Marie de Gournay and Pierre de Brach used it (and perhaps another similar copy, now lost) to prepare a new edition, published in 1595. This edition, with all its faults, was followed by nearly all editors until about 1900. Montaigne's own copy (in the Bibliothèque Municipale of Bordeaux and known as the Bordeaux copy) was used sporadically by J. A. Naigeon (1802) and subsequent editors, but it was not until the Édition Municipale (1906–33) that a genuine critical edition was based on it. Because Montaigne's thought is dynamic, fluid, ever-changing, it is all but essential to read him in an edition which distinguishes the three principal phases of the text: 1580, 1588, and the marginalia of the Bordeaux copy.

*Meaning of the Title.*—The modern meaning of the word "essay" derives from Montaigne: he is the creator of a new literary genre (though there were forerunners in the letters of antiquity, in the *adagia* and *leçons* of the Renaissance). However, he does not himself apply the word *essai* to the separate chapters. There has been much discussion about the exact meaning from which he starts, but examples in the text show clearly enough that he is "testing" or "trying out" his judgment and opinions (*cf.* English "assay").

*Range and Development of Thought.*—The *Essais* themselves are a series of chapters (107 in all), differing widely in length, from sketches of a page or two to the elaborate and extended "Apologie de Raimond Sebond," and differing also in the ostensible topic discussed (for the title is by no means always a reliable guide to the subject of an essay: thus "Coustume de l'isle de Cea" is about suicide, "Sur des vers de Virgile" about love, "Des coches" about many things of which coaches are the least). The work of Pierre Villey, editor of the critical edition (see *Bibliography*), established an approximate chronology, showing an evolution from the essays written in 1572, little more than strings of examples drawn from classical authors or Renaissance compilers, to the gradual unfolding of Montaigne's personality and the rich maturity of the third book, culminating in "De l'expérience" (1587–88). The early essays (especially "Que philosopher c'est apprendre à mourir") reveal a Stoicism derived from the prevailing interest in Stoic philosophy and from the reading of Seneca. In Book II emerges what is usually regarded as Montaigne's characteristic attitude: Pyrrhonism or skepticism, condensed in the device "*Que sçay-je?*" and developed at length in the "Apologie," with its emphasis on doubt and the contradictory nature of truth. The third book is more confident and balanced, attaining a doctrine of acceptance of nature, perfectly expressed at the end of the last essay of all: "C'est une absolue perfection, et comme divine, de sçavoir jouyr loyallement de son estre" (Bk. iii, ch. 13). In fact Villey's system (of which this is a simplified account) fails to do justice to the continuity and complexity of Montaigne's thought, for Stoicism and Pyrrhonism never disappear, but it makes a useful framework.

*Intellectual Position.*—After the earliest essays Montaigne displays an openness of mind and a receptivity to the most audacious ideas, probing to the roots of accepted customs and values. He is often called a conservative, but his conservatism is pragmatic only. Intellectually he may well be considered a revolutionary. Thus "Des cannibales" compares European civilization with the newly discovered societies of America to the disadvantage of the former and ends with an implied justification of political and economic equality. The cumbersome processes of law are subjected to keen scrutiny; cruel punishments, torture and the persecution of witches are condemned, especially in "Des boyteux" by persuasive and reasonable irony; tolerance is conveyed as a positive ideal by the exposure of the absurdities of intolerance. Montaigne's religion is a complicated question, much debated; briefly, he was a practising and probably believing Catholic, but no dogma was secure from the play of his mind as he sat in his library surrounded by the pagan authors of antiquity. To Montaigne can be traced nearly all the ideas which transformed European thought in the 17th and 18th centuries. He belongs to the Renaissance by his learning and respect for antiquity, but he introduces a new spirit of criticism and even disillusionment. From this point of view it is instructive to compare the dithyrambic enthusiasm of Gargantua's letter in Rabelais with the opening of the "Apologie" and its sober comment on humane letters: "Mov, je les aime bien, mais je ne les adore pas" (Bk. ii, ch. 12). In the essays on books and education ("De l'institution des enfants") he stresses always the primacy of judgment against the mere accumulation of book learning.

*Method and Influence.*—These ideas are presented in glancing fashion, almost never systematically, and the greatness of Montaigne resides only partly in them. In the brief preface of 1580 he writes "je suis moy-mesmes la matiere de mon livre," and in fact he offers us a complete portrait of himself, physical, emotional, intellectual. This had probably never been done before, but it is not unique, as the example of Rousseau shows. Montaigne goes further and in the third book extends his self-portrait to a point where every reader can recognize himself ("chaque homme porte la forme entière de l'humaine condition"). His thought is concrete, immersed in the business of living, so that we see as nowhere else what it means, for example, to think to the accompaniment of excruciating physical pain. Moreover it is thought in movement ("Je ne peints pas l'estre. Je peints le passage"), thought as it wells up from its source, before it is frozen in the formal arrangements of systematic thinkers. In this way the innermost recesses of the mind can be explored:

> C'est une espineuse entreprinse, et plus qu'il ne semble, de suyvre une alleure si vagabonde que celle de nostre esprit; de penetrer les profondeurs opaques de ses replis internes, de choisir et arrester tant de menues airs de ses agitations. (Bk. ii, ch. 6.) ("It is a thorny undertaking, and more so than it seems, to follow such a wandering motion as that of our mind; to penetrate the dark depths of its innermost recesses; to choose and fix all the faint stirrings of its movements.")

This enterprise is scarcely undertaken again with success before Joyce and Proust (who shares much with Montaigne, especially his realisation of the variability of human character and personality). The study of style is particularly important for the appreciation of Montaigne's method, which works by association of words and flexible syntax rather than by formal logic, as well as of the concrete vocabulary which gives substance to his thought.

His influence is clearly marked in 17th-century writers: in Descartes, who starts from his position of universal doubt; in Pascal, on whom he acts as a powerful irritant, and in the libertins. Through them, and also directly, his ideas passed to Bayle and the

18th-century *philosophes*. At the end of the 19th century he inspired Nietzsche and Gide in their search for new moral values. In England John Florio's translation became a classic in its own right, and through him Montaigne influenced Shakespeare (there is an unmistakable borrowing from "Des cannibales" in *The Tempest*). Above all he is the immediate progenitor of Francis Bacon and through him of the long line of English essayists.

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(R. A. Sa.)

**MONTALE, EUGENIO** (1896– ), Italian poet, a leader of the "Hermetic" movement in Italian poetry (*see* ITALIAN LITERATURE), was born at Genoa, Oct. 12, 1896. He fought in World War I but was never a nationalist, and opposed Fascism from its beginning. He was director of the Gabinetto Vieusseux, a literary society and library in Florence, from 1929 to 1938, and later became literary editor of the Milan daily *Corriere della sera*.

Montale's first book of poems, *Ossi di seppia* (1925), expressed the bitter pessimism of the postwar period. In form it reacted against the D'Annunzian and futurist poetry of the preceding decade, and sought to express by means of symbols the poet's inner self. The rocky landscape of Liguria, the sea and a tragic vision of the world as a dry, barren, hostile wilderness (not unlike T. S. Eliot's *Waste Land*) inspired Montale's best poems. In *Le occasioni* (1939) and *La bufera* (1956) he was inspired mainly by his memories and his efforts to recapture the atmosphere of the past are singularly moving.

Twenty of Montale's poems are translated in *The Penguin Book of Italian Verse*, edited by G. Kay (1958).

*See* R. Lunardi, *E. Montale e la nuova poesia* (1948).

(F. Di.)

**MONTALEMBERT, CHARLES FORBES RENÉ DE** (1810–1870), French orator, politician and historian; a leading opponent of absolutism in church and state during the 19th century. He was born in London, April 15, 1810, during the exile of his father, Marc René, comte de Montalembert. Educated in England until the age of eight, and then at the Lycée Bourbon and the Collège Sainte-Barbe, he later accompanied his father on ambassadorial tours (Sweden, Germany), and visited Ireland where he was the guest of Daniel O'Connell. He began his political career with the newspaper *L'Avenir*, founded by Lamennais (*q.v.*) in 1830, and the associated *Agence générale pour la défense de la liberté religieuse*. In 1831 he helped to found a Catholic school as a protest against the state monopoly of education which excluded religious orders from teaching. The police closed it and brought proceedings against the teachers. Having succeeded his father in 1831, Montalembert was able to claim the right of trial by his peers, and although he lost the case, only the minimum penalty was imposed and his eloquent pleading put him in the forefront of Catholic resistance to the state.

This resistance was not unanimous. The hostility of those bishops with strong Gallican leanings caused Lamennais and his group to suspend publication of *L'Avenir* in 1831. They decided to plead their cause in Rome where Gregory XVI's decision went against them (Encyclical *Mirari vos*, 1832). Montalembert submitted, but to fill the gap left by the suspension of *L'Avenir* he raised *L'Univers religieux*, founded by the abbé Migne in 1833, to a commanding position in French Catholic journalism.

As deputy for the Doubs after the 1848 revolution Montalembert brought the Catholic party strongly behind Louis Napoleon, an act he was later to call "the great mistake of my life." Fearing that the Paris riots of June 1849 heralded socialism and mob rule, he voted for restriction of the freedom of the press, but was alienated from the regime by Louis Napoleon's expropriation of the exiled house of Orléans and the dictatorial measures that followed the 1851 *coup d'état*. He tried to use the Académie Française, to which he was elected in 1851, and the review *Le Correspondant* (revived to oppose *L'Univers*, which had turned against him) as rallying points for liberal views against the second empire. He attacked the emperor's Italian policy, but in spite of his impassioned defense of the pope's temporal power, his insistence that the church should encourage civil and religious liberties brought him into conflict with Rome, particularly after his eloquent proclamation of "a free church in a free state" at the Congress of Belgian Catholics at Malines in 1863. His later years were saddened by the feeling that the political direction of the church he had so ardently championed was being given over, like his own country, to the absolutists. Consequently he regarded the definition of papal infallibility as inopportune, but said he was prepared to submit to the Vatican council's decree of 1870. He died in Paris on March 13, 1870.

His last great intellectual labour was *Les Moines d'Occident* (1863–77), a study of the growth of western monasticism, parts of which can still be read with interest, as can his *Des Intérêts catholiques au XIX^e siècle* (1852) and *De l'Avenir politique de l'Angleterre* (1856). He welcomed the victory of the North in the American Civil War in "La victoire du Nord aux États-Unis" (an article in *Le Correspondant*, May 25, 1865). His links with England were always close and he took a keen interest in the Oxford movement (*q.v.*) and the Gothic revival.

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(L. Al.)

**MONTALEMBERT, MARC RENÉ,** MARQUIS DE (1714–1800), French military engineer and writer who developed a new system of field fortification, was born at Angoulême on July 16, 1714, and entered the French army in 1732. He fought in the War of the Polish Succession on the Rhine (1733–34), and in the War of the Austrian Succession made the campaigns of 1742 in Bohemia and Italy. In the years preceding the Seven Years' War, Montalembert devoted his energies to the science of fortification, to which Vauban's *Traité de l'attaque* attracted him, and founded the arsenal at Ruelle, near his birthplace. On the outbreak of war he became French commissioner with the allied army of Sweden, with the rank of brigadier general. He constructed the field fortifications of Anklam and Stralsund. In 1761 he was promoted *maréchal de camp*, and began the works on which his fame rests. Montalembert's fortress has been aptly described by an English author as an "immense battery." The intricacies of trace by which Vauban and Louis de Cormontaigne sought to minimize the power of the attack were abandoned in favour of a simple tenaille plan giving the defenders an overwhelming fire power.

The "polygonal" method of fortification was the direct outcome of Montalembert's systems. In his own country the caste spirit of the engineer corps was roused to defend Vauban, and though Montalembert was allowed to construct some successful works at Aix-en-Provence and Ile d'Oléron, he was forbidden to publish his method, and given but little opportunity for actual building.

After 15 years of secrecy he published in Paris (1776–78) the first edition of *La Fortification perpendiculaire*. At the time of the Revolution he emigrated for a time. After his return Lazare Carnot often called him into consultation on military affairs, and in 1792 promoted him general of division. He died in Paris on March 29, 1800.

**MONTANA,** popularly known as the "Treasure state" because of its rich mineral resources, is located in the Rocky mountain region of the United States, athwart the continental divide. It is bounded on the north by Canada, on the east by North Dakota and South Dakota, on the south by Wyoming and Idaho and on the west by Idaho. In area it ranks fourth among the states of the union (after Alaska, Texas and California) having 145,736 sq.mi. of land area and 1,402 sq.mi. of water, a total area of 147,138 sq.mi. It averages 535 mi. in length and 275 mi. in width. Its population in 1960 was 674,767, giving it 41st rank among the states.

Montana became a territory on May 26, 1864, and was admitted to the union as the 41st state on Nov. 8, 1889. Its name, proposed by James M. Ashley, sponsor of the bill for its territorial organization, is derived from the Spanish *montaña*, meaning "mountainous region." The state capital, Helena, traces its origin to a mining camp of the 1860s known as Last Chance Gulch. The official state bird is the western meadowlark, the state flower, bitterroot; state tree, Ponderosa or western yellow pine. The state motto, *Oro y Plata* ("Gold and Silver"), appears on both the state flag and state seal.

## PHYSICAL GEOGRAPHY

**Physical Features.**—Montana lies between 44° 23′ and 49° N. latitude, and 104° 2′ and 116° 3′ W. longitude. The eastern three-fifths of the state is in the Great Plains and is characterized by vast stretches of range land and dry-farming areas sharply cut by many small streams leading to the larger rivers. Near the centre of the state distinctive isolated mountains, known as mountains of the plains, rise abruptly. These mountains cause sufficient precipitation to promote the growth of grass and trees and provide irrigation water for adjacent communities. The alternating ranges and valleys of the Rocky mountains occupy the western two-fifths of the state. The continental divide follows the boundary line between Montana and Idaho west and northwest of Yellowstone National park (*q.v.*) to Ravalli county; it turns eastward through Deer Lodge and Silver Bow counties, then northward to Lewis and Clark county, and from there extends north-northwest to Glacier National park and Canada.

The area west of the continental divide is made up of fertile valleys of rare beauty. The Bitterroot valley merges into the broad Missoula valley, and to the north Flathead lake and its adjacent timber and ranch lands are bounded on the east by the majestic Mission range. To the east of the Bitterroot valley the high mountain valleys of Flint creek and Deer Lodge lie at the headwaters of the Clark Fork of the Columbia river. The Clark Fork rises near Butte and is joined by the Little and Big Blackfoot rivers from the east, the Bitterroot from the south and the Flathead from the north. The Kootenay river has carved a beautiful valley in the extreme northwest corner of the state. Here, near Troy, is the lowest point in the state, 1,800 ft. above sea level.

Crossing the continental divide just south of the Canadian border is Glacier National park. It was created in 1910 and contains 1,013,129 ac. of towering mountains and long, narrow mountain lakes. The Glacier watershed drains into the Pacific, the Atlantic and Hudson bay. Nearly all of Yellowstone National park lies in Wyoming, but the park has three entrances from Montana. Just north of Yellowstone park lie the Absaroka and Snowy ranges, and to the east the Beartooth range contains Granite peak (12,799 ft.), the highest point in the state. The Great Plains slope from about 4,000 ft. above the sea at the foothills of the mountains to 2,000 ft. in northeastern Montana. As noted above, several isolated mountain groups such as the Highwoods, Bear Paws, Little Rockies and Sweet Grass hills modify the character of the plains in mid Montana.

Montana has an exceptionally good river system. The two main rivers east of the continental divide are the Missouri and the Yellowstone. The Missouri is formed by a union at Three Forks of the Jefferson, Madison and Gallatin. Farther north the Missouri is joined by the Smith river from the south, and from the west by the Sun, the Teton and the Marias. After making a big bend to the east it is joined from the south by the Judith and the Musselshell rivers, and on the north by the Milk and Poplar.

The Yellowstone river rises in Yellowstone park and has only one minor tributary from the north, the Shields river. From the several mountain groups to the south, however, it is joined by the Clark Fork, Bighorn, Rosebud, Tongue and Powder rivers. The Yellowstone joins the Missouri just across the state's eastern border.

The average altitude of Montana is 3,400 ft., with more than half the state lying under 3,000 ft. This low average, much lower than that of any other Rocky mountain state, to some extent offsets its northern position and tempers its climate. Montana's mountains contain a number of low passes that provide favourable routes for railroads and highways. The largest of the state's many natural lakes is Flathead lake in the northwestern section. There are in addition numerous man-made water storage reservoirs that have been developed as recreation areas.

**Climate.**—Montana has a varied and generally favourable climate. The average mean temperature for the state is about 43° F. (about 6° C.). It ranges from 46° F. in the lower Yellowstone valley to 35° F. in the higher mountain valleys, but extremely low temperatures are occasionally recorded in the winter. The mean precipitation is 15.45 in. Nearly half the rainfall comes during the growing season from May to August. Northern Montana lies in the chinook belt where frequent warm winter winds remove the snow cover. The growing season varies from 87 frost-free days at Philipsburg to 141 at Roundup. Ninety frost-free days are considered necessary for most of Montana's crops.

**Vegetation.**—Plant life in Montana has developed around three distinctive natural groupings according to geographic location: subalpine or high mountains, montane and plains.

The Great Plains are covered for the most part with forage grasses of the bunch types, particularly blue grama and wheat grasses. These mature quickly and by mid-July are highly nutritious and take on a dry, brown appearance. Generous patches of sagebrush, cedar and low pine trees characterize the broken terrain of eastern Montana, with willows and cottonwood on the bottom lands. The mountains of western Montana are densely covered with forests below the timber line. Important commercial trees include Ponderosa or western yellow pine, Douglas fir, western larch and Engelmann spruce.

**Animal Life.**—The American buffalo or bison, which formerly ranged the plains in great herds, was almost exterminated by early hunters and settlers, but protective measures in the 20th century have rescued the buffalo from extinction. Three herds are maintained, one at the National Bison range near Moiese, another on the Crow Indian reservation and a third in adjacent Yellowstone park. Favourite game animals in Montana include deer, elk, moose and antelope. Controlled herds of antelope increased greatly during the 1950s. Fur-bearing animals found in Montana include beaver, mink, muskrat and weasel. Geese, ducks, pheasants and grouse are numerous. Most popular among the 60 species of fish are the cutthroat trout, rainbow trout, grayling trout and sockeye salmon. Lakes, rivers and mountain streams are restocked regularly by state and federal fish hatcheries.

## HISTORY AND GOVERNMENT

**Early Exploration and Settlement.**—Eastern Montana was probably reached in 1742 by French traders from Canada, the Verendrye brothers, François, titled the Chevalier, and Louis Joseph. Fur traders reached the area occasionally during the next 50 years but the first major expedition of record is that of Lewis and Clark, who reached the state in April 1805. This expedition opened the way for traders and settlers. Manuel Lisa appears to have built the first trading post in Montana at the mouth of the Bighorn river in 1807. In the same year, John Colter, while securing Indian trade, discovered the future Yellowstone park

area. Lisa's Missouri Fur company operated on the Yellowstone for 20 years. David Thompson of the Canadian North West company explored and mapped the Columbia basin and established the second trading post in Montana in 1808 by sending Finan McDonald to trade near the present town of Jennings. McDonald built Salish House near the present Thompson falls on Clark Fork river in the northwestern part of the state. From 1820 to 1840 the Hudson's Bay company sent annual brigades up the Columbia and its branches, and many of its best traders were in the Montana area.

The American Fur company dominated the fur business east of the mountains, largely through its important posts, Ft. Union, which was established in 1829 by Kenneth McKenzie near the junction of the Missouri and Yellowstone rivers, and Ft. Benton, which was built by Alexander Culbertson in 1846 at the head of navigation on the Missouri river.

Indian affairs on the west slope were aided substantially by the work of the Belgian Jesuit missionary, Pierre Jean DeSmet, who established St. Mary's mission in the Bitterroot valley in 1841. He was joined in 1845 by Father Anthony Ravalli, an Italian Jesuit. The mission of St. Ignatius in the Flathead area in the northwestern section of the state was established in 1854.

Gold discoveries brought the first population boom to Montana. The first discovery of gold is credited to François Finlay in 1852 in the lower Deer Lodge valley, but it aroused no great interest. Six years later James and Granville Stuart publicized their discoveries on Gold creek in the same area. Following 1860, when the Mullan road leading from Ft. Benton to Ft. Walla Walla was built past the small settlement, prospectors fanned out to discover some of the richest placer deposits in the world. Discoveries were made at Bannack in 1862; Alder Gulch, where one of the greatest gold discoveries was made in 1863, soon grew into Virginia City; Last Chance Gulch became Helena, the future capital city, in July 1864; and the Confederate Gulch discovery was made in December of the same year, taking the name of Diamond City. These boom mining camps created markets for the farms that appeared in the valleys of the Bitterroot, Deer Lodge, Madison and Gallatin rivers.

**Territorial Status.**—The growth of population in the territory led to a demand for independent political status. The region had been under various administrations during the preceding half century. The area east of the mountains had been included in the Louisiana Purchase of 1803 and its subsequent government. The western section had been a part of the Oregon country following the treaty with Great Britain establishing the boundary at the 49th parallel in 1846. The Territory of Idaho, created in 1863, included the Montana area but access to the capital at Lewiston was difficult. The rise of a large band of thieving road agents caused the organization of the Vigilantes of Montana, an extragovernmental law enforcement agency. To provide more adequate government services for the area the Territory of Montana was created May 26, 1864, with Sidney Edgerton as the first governor. The first territorial legislature met at Bannack but the following year the capital was moved to Virginia City, and in 1875 to Helena.

There was continued development of mining, which went from placer gold to quartz gold veins, to silver (in the 1870s) and then to copper (in the 1880s). Combined with mining was a thriving agriculture and a growing range cattle industry, all of which led to a movement for the building of railroads. The growth of the territory also created urgent pressures to obtain possession of the lands held by the Indians and rights of travel over such natural highways as the Bozeman road and the Northern Overland road to Minnesota.

The most dramatic episode in the movement to deal with the Indian problem took place in June 1876, on the Little Bighorn when George A. Custer and over 200 of his men were annihilated by the Sioux and Cheyennes. The spectacular march through Montana in 1877 of the Nez Percés in protest to reservation conditions in Idaho further emphasized the Indian problem. A series of new forts and new treaties led the Indians to withdraw reluctantly to reduced reservations and white men expanded into their lands.

The stockmen profited most from the withdrawal of the Indians. The beginning of cattle raising in Montana may be traced to the year 1833 when a few milk cattle had been driven down the Bighorn to Ft. Union. Both cattle and sheep were brought into the western valleys by the missionaries in the 1850s and by stockmen in the early 1860s. The first drive of cattle from Texas to the Montana ranges was made in 1866 by Nelson Story of Bozeman. Eight years later a herd of Montana cattle was driven to Ogden, Utah, and from there shipped east on the Union Pacific railway. After the Indians were quieted in 1877 most of the herds were driven to Cheyenne, Wyo., for shipment. The completion of the Northern Pacific railway through the state in the early 1880s further stimulated the cattle industry but the drought and severe winter of 1886–87 killed thousands of cattle and caused withdrawal of much of the foreign capital intent on huge profits.

Sheep raising, which developed in Montana along with the cattle industry, was not as dependent upon transportation. Large quantities of wool were shipped by flatboat down the Missouri and Mississippi rivers to New Orleans and thence by steamer to Boston. Sheep increased in number from about 4,000 in 1870 to 250,000 by 1880 and to more than 6,000,000 in 1900, when the wool clip of Montana exceeded that of any other state.

**Statehood.**—As the territory grew in population during the 1880s it took steps to acquire statehood, beginning in 1884 with a constitutional convention which congress ignored. In 1889 a convention drafted a state constitution which was approved by popular vote and by congress. After 25 years as a territory, Montana was admitted to the union on Nov. 8, 1889, as the 41st state. The capital was at Helena and the first governor was Joseph K. Toole. (See *Government* below.)

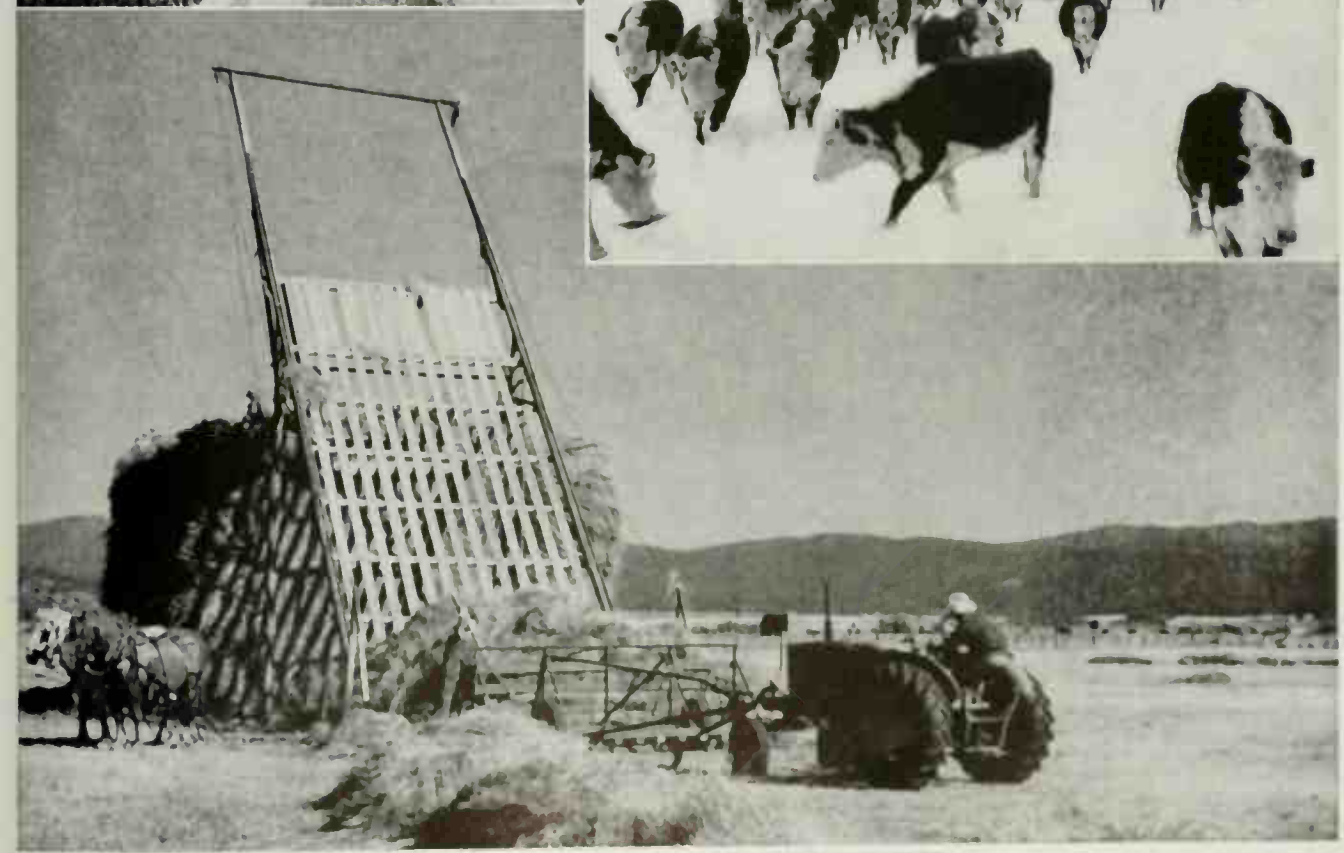
The decade 1895–1905 was also characterized by the bitter "war of the copper kings," William A. Clark, Marcus Daly and F. Augustus Heinze. Their feud affected such diverse problems as methods of mining, manipulation of copper prices on international exchanges, control of the courts, the organization of labour, the location of the state capital and whether Clark should be U.S. senator.

During the first quarter of the 20th century Montana gained new industries with the discovery of natural gas and oil. Petroleum refineries were built in 16 Montana communities during the 1920s, including Great Falls, Billings, Shelby and Sunburst, and pipelines to distribute the products of Montana wells spread throughout the state. In 1951 wells in the Williston basin began to pump oil in quantities far surpassing the output of earlier wells.

One of the most notable figures in Montana's political history during the first three decades of the 20th century was Thomas J. Walsh (*q.v.*). First elected to the U.S. senate from Montana in 1912, he was re-elected in 1918 and 1924. He won wide recognition as a skilled and energetic senate investigator. Another Montanan prominent in politics was Burton K. Wheeler, who was elected to the U.S. senate from Montana in 1923 and who served continuously until 1947. He was the Progressive party's candidate for vice-president in the election of 1924.

Montana was hard hit during the 1930s by the nationwide depression and by severe droughts. Mines closed and lumbering operations came to a virtual standstill. Farmers not only reaped poor harvests but also received low prices for their products. The federal government initiated large projects for irrigation, soil conservation, rural electrification and control of insects such as the grasshopper. One of the most important projects of this era was construction of Fort Peck dam on the Missouri river; it was completed in 1940 and was the largest earth filled dam in the world. Meanwhile, in 1935, the state capital, Helena, was hit by an earthquake that caused property damage amounting to several million dollars.

During the 1940s more abundant rainfall brought a revival of Montana's agriculture while the wartime demand for copper, lead, zinc and other minerals stimulated the mining industry. An important air force base was constructed near Great Falls during World War II and continued in service in the postwar years. Construction of additional dams for flood control, irrigation and production of electric power continued through the 1950s. Hungry Horse dam on the Flathead river was completed in 1952 and made



BY COURTESY OF [TOP LEFT, TOP RIGHT, BOTTOM] MONTANA DEPARTMENT [illegible], PHOTOGRAPH; [CENTRE RIGHT] UNITED STATES FOREST SERVICE

## SCENES IN MONTANA

*Top left:* Hungry Horse dam, 564 ft. high, across the South fork of the Flathead river. A highway crosses the top of the dam

*Top right:* White birches lining a back country road with mountains in the background

*Centre right:* Hereford cattle wintering at Big Hole valley in southwestern Montana

*Bottom:* Ranchers making hay in late summer for winter feed

# MONTANA

BY COURTESY OF (TOP LEFT, CENTRE) MONTANA HIGHWAY COMMISSION, (TOP RIGHT) INTERNATIONAL HARVESTER CO. FROM "HARVESTER WORLD", PHOTOGRAPHS, (BOTTOM LEFT) JEANNE MILLER, (BOTTOM RIGHT) ERNST PETERSEN

## VIEWS OF MONTANA

*Top left*: The Garden Wall, a terraced rock formation towering above the lesser peaks at Logan pass on the continental divide near the Canadian border

*Top right*: Members of the Hutterite sect harvesting one of Montana's extensive wheat fields

*Centre*: Copper mines near Butte which account for about 50% of the state's total metal output

*Bottom left*: Herding sheep in the Bitterroot valley. Sheep raising is carried on extensively in the western part of the state

*Bottom right*: Virginia City, old territorial capital of the gold rush days, was restored to preserve most of the buildings in their original state

possible increased industrial expansion in the northwestern part of the state. An even larger hydroelectric project, Noxon Rapids dam on the Clark Fork river, was completed in 1960.

**Government.**—The state is governed under a constitution adopted in 1889. To amend this constitution an affirmative vote of two-thirds of the members of each house of the legislature is required, followed by an affirmative vote of a majority of the electors voting thereon at the next general election; or, as an alternative method, by a like vote of each house of the legislature and of the electorate, a convention may be called to revise or amend it. A revision or amendment in this manner requires the ratification of the electorate not less than two months nor more than six months after the adjournment of the convention.

The officers of the executive department are the governor, lieutenant governor, secretary of state, attorney general, treasurer, auditor and superintendent of public instruction, each of whom is elected for a term of four years. The governor, with the advice and consent of the senate, appoints various administrative officers such as the state engineer, state forester, the commissioner of agriculture, and numerous boards including the State Board of Equalization and the State Highway commission. He may veto any bill passed by the assembly, or in the case of a bill making appropriations of money he may veto any item of it, and no bill or item of an appropriation which he vetoes within five days (Sunday excepted) after it has been presented to him can become a law or a part of a law unless passed over his veto in each house by a two-thirds vote of the members present.

The legislature consists of a senate and a house of representatives, meeting regularly on the first Monday of January in odd-numbered years only. Senators are elected, one from each county, for a term of four years; representatives are elected, one or more from each county according to population, for a term of two years. The senators number 56, and the representatives 94. The action of the legislature is much restricted by the constitution, a long list of cases being named in which that body is prohibited from passing any local or special laws.

The administration of justice is entrusted to a supreme court, 18 district courts and at least two justices' courts in each organized township, besides police and municipal courts. The supreme court is composed of a chief justice and four associate justices elected for a term of six years. It holds four sessions a year at Helena and has limited original and plenary appellate jurisdiction. For most district courts there is only one judge, but for the more populous districts there are two judges; they are all elected for four years.

In addition to two U.S. senators, Montana has two representatives in the house of representatives, elected from two separate districts. The state thus has 4 votes in the electoral college. Montana adopted the initiative and referendum in 1906 and extended the right to vote to women in 1914. Two years later Montana elected Jeannette Rankin to the U.S. house of representatives, the first woman to be elected to that body. Voters in Montana must be 21 years of age and citizens of the United States; they must have resided in the state for one year and in the county for 30 days preceding an election.

## ECONOMIC AND SOCIAL CONDITIONS

**Population.**—The population of Montana in its first census in 1870 was 20,595; by 1890 it was 142,924. In 1940 it was 559,456 and an increase in the following two decades made the 1960 population 674,767. The population per square mile in 1960 was 4.6, as compared with 49.6 for the U.S. as a whole. In 1960 the population of Montana was 92.0% native white; 4.4% foreign-born white; and 3.6% nonwhite, including 18,739 Indians and 1,460 Negroes. Of the total number of employed males, 22.7% were engaged in agriculture, 25.8% in transportation and trade, 13% in manufacturing, 8.9% in construction and 4.0% in mining.

**Finance.**—The largest item in the state's bonded indebtedness in the years following World War II was the veterans' bonus, which was being rapidly retired by a two cents per package tax on cigarettes. Among the major tax sources, property taxes yielded the largest single sum. In 1955 the gasoline tax was raised to seven cents per gallon; 75% of this amount was allocated to highways. The state university system was permitted in 1948 to levy six mills on property valuations. As early as 1923 the Montana legislature passed a low but effective inheritance tax. The following year a controversy of long standing was settled when a metal mines tax was passed graduated from 0.25% to 1% of the gross product. Since the repeal of national prohibition in 1933 a state monopoly on liquor sales has been another important source of revenue.

*Montana: Places of 5,000 or More Population (1960 Census)**

| Place | Population | | | | |
|---|---|---|---|---|---|
| | 1960 | 1950 | 1940 | 1930 | 1920 |
| Total state | 674,767 | 591,024 | 559,456 | 537,606 | 548,889 |
| Anaconda | 12,494 | 12,518 | 12,668 | 12,668 | 10,719 |
| Billings | 52,851 | 31,834 | 21,961 | 15,100 | 11,178 |
| Bozeman | 13,361 | 11,107 | 8,607 | 6,181 | 5,376 |
| Butte | 27,955 | 24,841 | 37,081 | 41,611 | 39,165 |
| Great Falls | 60,091 | 39,214 | 29,808 | 28,427 | 14,930 |
| Havre | 10,740 | 9,986 | 9,427 | 5,829 | 5,011 |
| Helena | 20,227 | 11,803 | 11,106 | 12,037 | 10,770 |
| Kalispell | 10,233 | 9,715 | 6,245 | 5,541 | 3,726 |
| Lewistown | 7,408 | 6,874 | 5,674 | 6,150 | 5,806 |
| Livingston | 6,229 | 7,654 | 6,965 | 6,311 | 5,778 |
| Miles City | 8,665 | 6,249 | 7,215 | 7,917 | 5,538 |
| Missoula | 27,090 | 22,643 | 14,649 | 12,668 | 8,491 |

*Populations are reported as constituted at date of each census.
Note: Dash indicates place did not exist during reported census, or data not available.

**Education.**—Under the state's consolidation program the number of school districts was reduced from more than 1,300 at the end of World War II to fewer than 1,000 by 1960. Total annual expenditures amounted to about $64,000,000. The districts bore somewhat more than 75% of the total cost of the schools, the state bore about 20% and the federal government about 5%. The school lands totaled over 5,000,000 ac., income from which amounted to more than $4,000,000. The state also had a permanent school fund of over $30,000,000. The rapid increase in enrollments is indicated by comparing the enrollment just after World War II (1945–46) of about 63,000 elementary pupils and 25,000 high school pupils with the enrollment of more than 100,000 elementary pupils and 30,000 high school students by the 1960s.

The University of Montana, chartered in 1893, operates under the direction of a state board of education—ex officio regents, and consists of six institutions: Montana State university at Missoula; Montana State college at Bozeman; Montana School of Mines at Butte; Western Montana College of Education at Dillon; Eastern Montana College of Education at Billings; and Northern Montana college at Havre. Private colleges include Carroll college at Helena, founded in 1909, and the College of Great Falls, established in 1932, both Roman Catholic; and Rocky Mountain college of Billings supported by three denominations—Congregational, Methodist and Presbyterian. It has continued since 1947 the work of the Protestant college movement which began as the College of Montana in 1883.

**Agriculture and Livestock.**—Over the years, agriculture has been Montana's main economic activity. It began in the western mountain valleys close to the markets in the mining camps. The colonization activities of the railroads led to enthusiasm for dry-land farming in the 1890s. By the middle of the 20th century dry lands produced 92% of the state's wheat, 75% of its barley and 65% of its oats.

Irrigation began in the western valleys in the 1860s. With federal assistance the state had, nearly a century later, a total of 1,890,671 ac. of irrigated cropland, representing 17.6% of the state's total harvested cropland. Montana thus ranked 9th in the nation in irrigated lands.

By the middle of the 20th century Montana's agricultural income exceeded $363,000,000 annually, of which crops represented 37% and livestock 48%. The total acreage of farm land rose from approximately 13,300,000 ac. in 1910 to 35,000,000 ac. after World War I and to more than 60,000,000 ac. at mid-20th century. During the same span of time the number of farms decreased from approximately 57,000 to about 33,000. Farm size meanwhile increased from approximately 600 ac. to more than 1,800 ac., reflecting large gains in livestock raising and farm mechanization.

Of farm operators the great majority were full or part owners; only 14.5% were tenants.

Wheat is Montana's most valuable agricultural crop, normally amounting to more than 75,000,000 bu. annually and making Montana one of the largest wheat-producing states in the nation. Hay is the next most important crop. Barley showed striking increase from 4,582,000 bu. in 1939 to 41,370,000 bu. in the late 1950s to take third place in crop value. Sugar beets, corn, oats and potatoes, in this order, are also important.

Beef is Montana's second most valuable agricultural product. Annual sales amount to more than 800,000,000 lbs. valued at over $100,000,000. Sheep and lamb production, wool, dairy products, poultry and swine are also important.

**Mining.**—Next in importance to agriculture and livestock is the mining industry. By the late 1950s mining, metal processing and petroleum refining employed 18,200 workers or 11% of all nonagricultural workers in Montana. The value of the state's mineral production exceeded $190,000,000 annually and included chromite concentrates, manganese ore, silver, zinc, copper and lead.

Copper is Montana's leading metal, representing about 40% of the value of the state's total metal production. Annual production normally exceeds 95,000 tons. From the early 1880s to mid-20th century, the small Butte district produced 18% of the nation's copper output.

In 1916 an electrolytic process was devised whereby zinc ores, formerly an impediment in refining copper, could be reduced profitably. The Anaconda company (formerly Anaconda Copper Mining company) operates plants at Anaconda and Great Falls, with a subsidiary lead and zinc plant at East Helena. This company also opened an aluminum plant in Columbia Falls in 1955.

Production of gold, once the most valuable of Montana's metals, amounted in the 1960s to only about 33,000 troy ounces valued at about $1,000,000. Among other mineral resources is a body of high-grade manganese ore found just west of the Butte copper district. Large phosphate deposits are used for the manufacturing of fertilizers, and a plant near Butte manufactures elemental phosphorus.

Coal is found throughout the state. The resources are estimated by the U.S. geological survey to contain 389,114,000,000 tons or 11% of the nation's total reserves. Of the total deposits, 315,000,000,000 tons are lignite.

Natural gas was discovered near Glendive in 1913 and petroleum was discovered in commercial quantities at Elk basin in 1915. The leading oil fields for many years were Elk basin, Kevin-Sunburst and Cut Bank. In 1951 the Williston Basin fields were developed in eastern Montana, with natural gas as an important associated product. Other significant mineral products include vermiculite, sand and gravel, gypsum and sapphires.

**Lumbering.**—In 1949 the first field-based estimate of the timber stand in Montana placed its total at 55,960,000,000 bd.ft. of which more than 98% was softwood. Of this stand, 65% was in federal forests; 5% was in state forests; and 30% was in privately owned forests. Forest lands equal one-fourth of Montana's area for a total of 22,400,000 ac. Commercial forests total 15,800,000 ac.

Annual production of lumber by mid-20th century was 800,000,000 bd.ft. valued at $69,000,000. The most important commercial trees are western yellow pine, Douglas fir, larch and western white pine. Pulpwood, fuelwood, poles, posts, mine timbers and Christmas trees are additional products of importance. Montana has 11 national forests—Beaverhead, Bitterroot, Custer, Deer Lodge, Flathead, Gallatin, Helena, Kaniksu, Kootenay, Lewis and Clark, and Lolo. Of Montana's eight state forests the largest is Stillwater state forest near the town of Stillwater.

**Manufactures.**—By the second half of the 20th century, the state had more than 800 manufacturing establishments. Value added to the product by manufacturing exceeded $140,000,000, representing a substantial gain over earlier years. The number of employees in manufacturing in the 1960s totaled about 20,000 with a total annual wage of almost $100,000,000. Lumber and timber products, primary metals and food products were the three highest areas of manufacturing employment. Increases in electrical power from huge hydroelectric projects assisted the growth of manufactures. Power production in the 1960s amounted to more than 7,000,000,000 kw.hr. in over 20 private plants and four large government plants.

**Transportation.**—Montana is served by three transcontinental railways: the Great Northern traversing the northern portion of the state; the Chicago, Milwaukee, St. Paul and Pacific in central Montana; and the Northern Pacific traversing the southern portion. At Butte, the Oregon Short Line from Utah connects with all three, and at Billings, the Burlington makes a connection from Wyoming. Six major highways cross the state. By mid-20th century the state had a total of almost 25,000 mi. of surfaced roads. Major airlines serve the state. The Montana aeronautics commission, established in 1946, co-ordinates the state's more than 100 airports and sets standards for pilots.

**Tourist Trade.**—The tourist trade ranks close behind agriculture and mining as a source of revenue. Montana's game and natural wonders attracted visitors of international note as early as 1850. In 1890 the tourist trade produced $250,000 revenue. Dude ranches attracted visitors as early as 1920. By 1935 an income of over $25,000,000 was obtained from 1,295,000 tourists. By 1960 the number of tourists exceeded 3,500,000, with proportional increase in expenditures. The state's chief attractions include Glacier National park and Yellowstone National park.

*See* also references under "Montana" in the Index.

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**MONTAÑÉS, JUAN MARTÍNEZ** (1568–1649), who has been called the greatest Spanish sculptor, was born at Alcalá la Real, in Jaén province on March 16, 1568. He studied at Granada (*c.* 1579–82) under Pablo de Rojas and about 1587 went to Seville. There he was admitted as a master in 1588 and stayed until his death on June 18, 1649. Like his contemporary, Gregorio Hernández, at Valladolid, Montañés accomplished the transition from mannerism to an increasingly realistic baroque. He achieved admirable aristocratic dignity, idealized to some degree, and the spiritual life expressed by his statues was understood by persons in all walks of life. Called "god of wood carving," he specialized in wooden altars and altar figures covered with polished gold and colour. These objects may be seen in Seville at the museum and several churches, and at Lima, Peru. His statues of Christ on the cross, looking at the beholder, of the child Christ and of the Immaculate Conception (all at Seville cathedral) set a style. The church in Santiponce near Seville contains his finest altar (1610–13), while his largest one is at San Miguel in Jerez de la Frontera (1617–45). As sculptor of images and as an architect of altarpieces, his influence was paramount not only on the sculptors and altar makers of Spain and Latin America but also on the Spanish painters of his century.

*See* J. H. Díaz, *Juan Martínez Montañés* (1949); George Kubler and Martin Soria, *The Art and Architecture of Spain and Portugal and Their*

*American Dominions 1500–1800* (1959). [M. S. S.]

**MONTANISM,** also known as the Cataphrygian heresy and the "New Prophecy," was a movement founded by the prophet Montanus which arose in the Christian church in Asia Minor in the 2nd century. Primitive Montanism grew up especially in central Phrygia; western Montanism flourished principally in Carthage under the leadership of Tertullian.

The Montanist writings have perished except for the brief oracles or sayings preserved by ecclesiastical writers. The chief sources are the *Ecclesiastical History* of Eusebius, who cites or records the views of the martyrs of Lyons, the bishops of Asia and the anti-Montanist writers of the late 2nd century, the writings of Tertullian and Epiphanius; and inscriptions, particularly those of central Phrygia. There, in the latter half of the 2nd century, Montanus, a recent convert, appeared at Ardabau, a little village on the border of Mysia. According to one tradition, which may be a later invention, he had been a priest of Cybele. At all events his movement was to spread far and wide in Phrygia, the home of the ecstatic cult of Cybele. In the year when Gratus was proconsul of Asia, Montanus fell into a trance and began to "prophesy under the influence of the Spirit." Which year Gratus was proconsul is not known; Eusebius gives the year 172 while Epiphanius in one place assigns 156 for the rise of the new prophecy, and the matter has been disputed. The earlier date fits better with the known development of the movement and is generally regarded as the more probable.

Montanus was soon joined by two women, Prisca or Priscilla and Maximilla, who likewise began to "prophesy in the power of the Paraclete." The movement spread throughout Asia Minor and reached as far as Thrace, but it was in Phrygia that the new prophecy found its chief strength. Inscriptions from Asia Minor have shown that many towns went over almost completely to Montanism but that after the first enthusiasm had waned the followers of Montanus were found mainly in the rural districts, where the movement lasted for several centuries.

The essential principle of Montanism was that the Paraclete, the spirit of truth, whom Jesus had promised in the Gospel of St. John, was manifesting himself to the world through Montanus and the prophets and prophetesses associated with him. This did not seem at first to deny the doctrines of the church or to attack the authority of the bishops. Prophecy from the earliest days had been held in honour and the church acknowledged the charismatic gift of such prophets as Quadratus and Ammia of Philadelphia. But it soon became clear that this prophecy was really new. True prophets did not, as Montanus did, deliberately induce a kind of ecstatic madness and a state of passivity and then maintain that the words they spoke were the voice of the Spirit. In one of his oracles Montanus thus described the divine activity: "Behold man is as a lyre and I hover over him as a plectrum. Man sleeps and I wake; behold it is the Lord who takes away the hearts of men and gives them other hearts."

This novelty in the form of the prophecy, as well as the moral life of the prophets, provoked the earliest attacks of the Christian bishops and apologists. It also became clear that the claim of Montanus to have the final revelation of the Holy Spirit implied that something could be added to the teaching of Christ and the apostles and that now the church had to accept a fuller revelation.

Another prominent element in the new prophecy was the expectation of the second coming of Christ, which was believed to be imminent. Such a notion was not confined to Montanists, but with them it took a special form, giving their activities the character of a popular revival. They believed the heavenly Jerusalem was shortly to descend on the earth in a plain between the two villages of Pepuza and Tymion in Phrygia. The prophets and many enthusiastic followers went there; many Christian communities were almost abandoned.

The leaders thought of the movement as the last period of revelation, which would be followed by the descent of the new Jerusalem. As Maximilla said: "After me there shall be no other prophetess, but the end." To this exaltation was joined a legalistic moral rigorism. Certain fasts were prescribed and the time of fasting lengthened; it was forbidden to flee from martyrdom, second marriages were prohibited and marriage itself was at least discouraged.

It was now obvious that the Montanist doctrine was in fact an attack on the Catholic faith; even though some Christian teachers seem to have advocated treating it leniently, the bishops of Asia Minor gathered in synods and finally excommunicated the followers of Montanus, probably about the year 177, under the leadership of Apollinaris, bishop of Hierapolis in Phrygia.

Montanism now became a sect with its seat of government at Pepuza. It maintained the ordinary Christian ministry but imposed on it higher orders of patriarchs and associates who were probably the successors of the prophets. In Phrygia it seems to have had many adherents down to the end of the 4th century and enough vitality to call for refutations by Origen and Clement of Alexandria. Its destruction as a sect was tragic, for, when they were proscribed by a decree of Justinian, the Phrygian Montanists shut themselves in their churches and burned them down.

The earliest record of any knowledge of Montanism in the west is from A.D. 177, when the martyrs of Lyons wrote to Pope Eleutherius and to the brethren in Asia and Phrygia expressing their opinion of the movement. It is not known what these opinions were. Probably they joined Asian and Phrygian Christians in asking Eleutherius to condemn Montanism. Twenty-five years later there was a group of Montanists at Rome; their leader, Proclus, engaged in a dispute with the Roman presbyter Gaius. It was at Carthage in Africa, however, that the sect gained a real foothold. There it won its most illustrious convert in Tertullian (*q.v.*), who began his progress toward Montanism c. 206 and finally broke with the church in 212–213.

In the writings of Tertullian the direction of the movement was changed. Though he accepted the new prophecy and the claims of individual inspiration by the Paraclete, he inconsistently maintained that the apostles had received the fullness of the Spirit and that the bishops were the successors of the apostles. On him the ecstatic element characteristic of the eastern prophecy had little influence, and, though he expected the immediate coming of the new Jerusalem, he never said that it would descend on Pepuza.

Tertullian's genius was mainly directed to supporting the moral rigorism of the movement against what he considered the laxity of the Catholic bishops. He condemned all Christians who associated with pagans in military affairs, schools, business or public administration; he forbade flight from persecution, second marriage and the forgiveness of sins such as adultery and fornication; the soldier could not accept rewards from the emperor, the virgin must wear a veil of a certain length, the recently established fasts were to be observed. It was not his rigorism, however, which excluded Tertullian from the Christian communion. He waged a vigorous battle in defense of tradition and the Catholic rule of faith and then broke with the church because he accepted the new prophecy and its claim to private inspiration. Later Montanists were sometimes called Tertullianists in the west, but they were not especially influential there.

The history of Montanism is thus relatively clear. Not so clear is the nature of its effect on the Catholic Christianity of the late 2nd century. Some liberal Protestant scholars have argued that as the church was becoming more at home in the world and was developing a philosophical theology, a more elaborate penitential and sacramental system and a more tightly knit ministry, the Montanists arose and protested in the name of primitive enthusiasm. The Catholic Church was then created. There is little evidence, however, to support the notions either that Christianity underwent a revolution in the course of the 2nd century or that the Montanists were trying to recover a primitive ideal. From the documents it is clear that the influence of the bishops, and especially that of the bishop of Rome, was strengthened in the course of the church's struggle with charismatic anarchy; it is by no means clear that this influence then came into existence.

*See* also references under "Montanism" in the Index.

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**MONTAUBAN,** a town of southwestern France, capital of Tarn-et-Garonne, is 31 mi. N. of Toulouse by rail. Pop. (1962) 29,716. The town stands on the right bank of the Tarn at its confluence with the Tescou. A remarkable early 14th-century bridge of brick connects the town with the suburb of Villebourbon. The former *hôtel de ville*, 17th century with some older portions, on the site of a castle of the counts of Toulouse and once the residence of the bishops of Montauban, stands at the east end of the bridge. It contains a valuable library, and a museum including most of the work of the painter J. A. D. Ingres, who was born there. A square, the Place Nationale (17th century), is entered at each corner by gateways giving access to an open space surrounded by houses carried on double rows of arcades. The cathedral possesses the "Vow of Louis XIII," one of the masterpieces of Ingres, and the church of St. Jacques (13th to 15th centuries) has a handsome octagonal tower. Montauban is the seat of a bishop, a prefect and a court of assize. The commercial importance of Montauban is a result of its trade in agricultural produce, especially early vegetables, and poultry. Industries include nursery gardening, food processing, hatmaking and the manufacture of textiles and furniture. The town lies at the intersection of the Paris-Toulouse and Bordeaux-Sète railway lines, and is connected with the Garonne river by the Canal of Montech.

With the exception of Mont-de-Marsan, Montauban is the oldest of the fortified towns, or bastides, of southern France. Its foundation dates from 1144 when Alphonse Jourdain, count of Toulouse, granted it a liberal charter. The inhabitants were drawn chiefly from Montauriol, a village which had grown up around the neighbouring monastery of St. Théodard. In the 13th century the town suffered much from the ravages of the Inquisition, but by 1317 it had recovered sufficiently to be chosen by John XXII as the head of a diocese of which the basilica of St. Théodard became the cathedral. By the treaty of Brétigny (1360) it was ceded to the English; but in 1369 they were expelled by the inhabitants. In 1560 the bishops and magistrates embraced Protestantism, expelled the monks and demolished the cathedral. About ten years later it became one of the Huguenot strongholds, and formed a small independent republic. It was the headquarters of the Huguenot rebellion of 1621 and was vainly besieged by Louis XIII for 86 days; nor did it submit until after the fall of La Rochelle in 1629, when its fortifications were destroyed by Richelieu. In the same year the plague killed more than 6,000 of its inhabitants. The Protestants again suffered persecution after the repeal of the Edict of Nantes.

**MONTAUSIER, CHARLES DE SAINTE-MAURE,** Duc de (1610–1690), French army officer, man of letters and supervisor of the dauphin Louis' education, was born on Oct. 6, 1610. Educated as a Huguenot at Sedan (from 1621), he was known as the marquis de Salles until he became marquis de Montausier in succession to his brother Hector (1607–35). He fought well in the defense of Casale in Montferrat (1630–31) and appeared at the literary Hôtel de Rambouillet in Paris in 1632. He served with the army in Lorraine in 1633 and on the German front in 1634–39. It was he who sent to Julie d'Angennes (Mlle de Rambouillet) the famous *Guirlande de Julie*, a fine manuscript of poems by himself and others. Further campaigning in Germany ended with his being taken prisoner in 1643. Ransomed for 10,000 crowns in 1644, he returned to Paris, was promoted lieutenant general, became a Catholic, bought the governments of Saintonge and Angoumois and, in July 1645, married Julie d'Angennes. He served in Flanders in 1646 and upheld the royal government during the wars of the Fronde (1649–53), when he was fulfilling his functions in Angoumois. His wife was governess of Louis XIV's children from 1661 to 1664, and he received the government of Normandy in 1663 and a peerage duchy in 1664. In 1668, returning from the campaign in the Franche-Comté, he was appointed governor (tutor-in-chief) of the dauphin Louis. He brought to his new duties all his devout austerity which was supposedly derided by Molière in *Le Misanthrope*. Even so, it was Montausier who conceived the famous "Delphin" edition of classical texts for his pupil's use (from 1671). When his formal duties ended (1679), he remained attached to the dauphin's person. He died in Paris on May 17, 1690.

**MONTBELIARD,** a town of eastern France, a subprefecture of the *département* of Doubs, lies between the Vosges and Jura mountains 9 mi. (15 km.) from the Swiss border and 50 mi. (80 km.) N.E. of Besançon by road. Pop. (1962) 21,040. The town has a number of interesting old buildings, chief among them the castle of the counts of Montbéliard, with towers dating from 1422 and 1572. In adjoining buildings are a museum, the national school for customs officers and a reception hall. The museum has a well-known natural-history collection; Roman remains from a theatre near the town; and fine paintings. Other landmarks include the birthplace of the naturalist Georges Cuvier; St. Martin's church (1601–07); the town hall (1778); the Princes' house (1602); the museum of local history (18th century); the market hall (1536); the Fishmongers' slab (15th century); St. George's church (1674); Villars house (16th century); and the old hospital, with a library possessing incunabula and manuscripts. The Roman theatre, at Mandeure, 6 mi. (10 km.) S. of Montbéliard, was the largest in Gaul, seating 15,000 persons. Montbéliard has a technical school, a boys' high school, a girls' high school and a school for home economics.

Manufacturing is important in the region, its products including automobiles, bicycles, furniture, tools, clock and watch parts, electrical apparatus, typewriters and ironware; there are forges, foundries, breweries and malthouses. Food products include smoked Montbéliard sausages, mushroom pies, crayfish, trout and Gruyère cheese.

The town was in existence in the 8th century. After the invasion of the Burgundians and Franks, it was annexed to Lorraine by the treaty of Verdun in 843. The lordship of Montbéliard became a county in the 12th century and eventually passed to the younger branch of the Montfaucons. When this family died out in 1397, the county came into possession of the dukes of Württemberg, who administered it till the French Revolution. During this period it was several times occupied by French armies and suffered the usual evils of war. In 1524 Guillaume Farel preached the Reformation, and Lutheranism was established in the district, where it is still to be found. The county became a principality in 1597. The last French occupancy (1793) came to an end with a convention signed at Paris in 1796, which assured the attachment of the principality to France. (R. Lp.)

**MONT BLANC** (Ital. Monte Bianco), mountain massif and peak in the western Alps, southwest of the Rhône at Martigny. Over half the massif, including the summit, is French territory; it is there that Europe reaches its highest point outside the Caucasus, 15,771 ft. above sea level. It is this mountain that first attracted the attention of scientists, and its first ascent, on Aug. 8, 1786, was one of the most important events in the history of mountaineering (*q.v.*).

**Structure and Relief.**—The Mont Blanc massif is a remnant of the southern Hercynian mountains. In origin a batholith intruded during the Permian period, the crystalline massif was peneplained in the same period. Later covered by the sea, it was uplifted and broken into wedge-shaped slices. These are separated by mylonites, zones of crushed rocks. Both the varying resistance of the different rocks and the altitude are responsible for the present relief. The post-Permian rocks form the floor of the Chamonix valley, dark-coloured schists form the flanks of the massif and probably also the summit under its ice capping. All the major rocky peaks consist of granite, whereas the mylonites have been eroded to form cols and depressions occupied by the glaciers.

BRADFORD WASHBURN

MONT BLANC, FRENCH SIDE

Mont Blanc is literally overflowing with ice which covers more than 38.6 sq.mi. From the central ice dome, ice streams stretch down to altitudes below 4,900 ft. The largest, the Mer de Glace (*q.v.*), 9 mi. in length and the second longest in the Alps, ended in 1930 at 4,100 ft. This and others (des Bossons, d'Argentiere) present the strange spectacle of ice within the zone of cultivation. The size of the glaciers has varied greatly. At the beginning of the 17th century they advanced to the bottom of the Chamonix valley, destroying or burying cultivated land and dwellings. After a retreat lasting until the second half of the 18th century came a new advance of the glaciers, reaching its climax about 1820. In 1835 began another retreat, which, interrupted by minor advances in 1878–90 and 1908–20, later became particularly pronounced.

**Mountaineering and Tourism.**—When the first travelers came to Chamonix (*q.v.*) from the late 17th century onward, it was not to attempt an ascent but to behold the glaciers and delight in the sublime emotions they aroused. Among the first of the early visitors to relate their experiences in a published report were R. Pococke and W. Windham who had come in 1741. It was the scientists who drew attention to the fact that Mont Blanc is the highest mountain in Europe—P. Martel in 1742, J. A. Deluc in 1770 and later H. B. de Saussure—and this stirred people to climb. The summit was conquered in 1786 by Michel Gabriel Paccard, a doctor in Chamonix, together with Jacques Balmat as his porter. Paccard's achievement was overshadowed by De Saussure's ascent the year after. Worse still, through M. T. Bourrit, who out of jealousy published a biased account of the first ascent, the myth was started that all credit for the climb was due to Balmat. In addition to the mountaineers the number of visitors to Chamonix increased steadily, but until about 1870 when a proper road was opened it remained a very exclusive resort. Among the British, generally the largest group, there were in 1788 Prince Edward and Pitt the Younger, and later Byron, Ruskin, Shelley (whom Mont Blanc inspired to write a poem) and Wordsworth. Famous visitors of other nationalities were: Goethe (1779), J. P. C. Florian, T. Fontane, L. V. Delille, A. Chénier, L. de Chénedolle, Mme de Staël, Carl Ritter, Chateaubriand, Victor Hugo, Lamartine, Alexandre Dumas, George Sand, J. Michelet, T. Gautier, in 1810 Empress Josephine was hoisted to Montenvers by 68 guides and porters. The Mont Blanc region now forms the largest tourist centre of the Alps and not surprisingly the traditional pastoral economy of the region has become completely overshadowed.

Work on the road tunnel was first suggested by the French engineer G. de Lépiney in 1870 and started in Oct. 1958. The tunnel runs for 7 mi. from Barats, 4 mi. from Chamonix, to the Italian village of Entreves. The road width is 23 ft. with additional sidewalks, and lay-bys (sidings) every 330 yd.

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(K. A. S.)

**MONTCALM, LOUIS JOSEPH DE MONTCALM-GOZON,** Marquis de (1712–1759), French general chiefly noted for his service in Canada during the Seven Years War. He was born at Candiac near Nîmes, Feb. 28, 1712. His family dated back to the 12th century and many of his ancestors served in the king's armies with distinction. In the 16th century some members of the family were converted to Calvinism and were active on the Huguenot side in the religious wars. Montcalm's mother, however, was a devout Catholic and caused his father to adopt her faith. Commissioned an ensign in the Hainaut regiment at the age of 12, he became an active soldier at 15. His first war experience was in 1733 against the Austrians in the War of the Polish Succession.

In 1735 he succeeded to his father's titles and property and the following year married Angelique Louise Talon du Boulay. They had 10 children. He was wounded in 1742 at the defense of Prague during the War of the Austrian Succession and became colonel of the regiment of Auvergne the following year. In 1746 he distinguished himself at the battle of Piacenza where his regiment was decimated and he was taken prisoner after receiving five sabre wounds. He was later exchanged, promoted to brigadier and at the end of the war was in command of a cavalry regiment. The following few years he spent with his family at Candiac; then, in Jan. 1756, he was appointed to command the French regular troops in North America with the rank of major general. On May 13 he arrived at Quebec.

Montcalm's commission gave him no authority over the colonial regular troops or the militia, only over the regular troops sent from France, and he was subject to the superior authority of the governor-general of the colony, the Canadian-born Marquis de Vaudreuil. The temperaments of the two commanders were incompatible and their relations rapidly deteriorated. The planning of military strategy eventually was handicapped by their jealousy, suspicion and mutual recriminations. For the first three years, however, Montcalm was successful against the British forces. In the summer of 1756 Oswego was captured, restoring control of Lake Ontario to the French. This campaign was planned by Vaudreuil and effected largely by the Canadian forces, but Montcalm was in tactical command. The next year he captured Ft. William Henry, at the head of Lake George, with its 2,000-man garrison. This victory was marred by the slaughter of many of the prisoners by the Indian allies of the French. Although Montcalm deplored this event and risked his life to curb it, he had failed to take the precautions that would have prevented it.

Montcalm's greatest victory occurred in July 1758, when, with about 3,800 men, he held Ticonderoga against 15,000 British troops under Gen. James Abercrombie, inflicting nearly 2,000 casualties on the British and suffering only 372 in his own ranks. This success was due more to Abercrombie's stupidity than to Montcalm's tactical skill and Vaudreuil was very critical of Montcalm for not exploiting the victory. This merely served to worsen relations between the two men until they were almost as much concerned with their personal feud as with fighting the enemy. Unfortunately Montcalm was never able to rise above this squabbling. In consequence of his victory at Ticonderoga, however, he was promoted to the rank of lieutenant general and Vaudreuil was ordered by the king to defer to Montcalm in all military matters.

In 1759 the British sent an army, numbering only about 8,500 men but of excellent quality, under the command of Maj. Gen. James Wolfe (*q.v.*) and conveyed by a large fleet under Vice Adm. Charles Saunders, against Quebec. Montcalm had about 13,000 men, of varying quality, with which to defend the citadel. Taking full advantage of his entrenched position, he wisely refused to be drawn into open battle. For more than two months Wolfe was baffled, but finally effected a landing close above Quebec and by dint of taking grave risks got his army onto the Plains of Abraham. Montcalm was forced to give battle. He did so precipitately, was mortally wounded and his army defeated. He died the next day.

Sept. 14, and was buried in the Ursuline chapel.

Montcalm was a gallant, brave and attractive figure. A devoted husband and father, he possessed great charm and was popular with his immediate subordinates; but his impetuous temper and nervous impatience tended to undermine his judgment. Although an accomplished soldier, he was not a really great general. He capitalized successfully on his enemies' mistakes for a time, in the face of grave odds, but committed some serious tactical errors, and the last such proved fatal to himself and to New France.

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**MONTCEAU-LES-MINES,** a town of east-central France, in the *département* of Saône-et-Loire, is about 22 km. (14 mi.) S.S.W. of Le Creusot on the Besançon-Clermont line of the national railways. Pop. (1962) 8,201. It is the centre of the Blanzy coal basin, in the valley of the Bourbince, paralleled by the Canal du Centre, linking the Saône and Loire rivers.

The principal industry is coal mining. There are iron and copper foundries, and factories for shoes and stockings (7,000,000 nylon pairs a year), textile machinery, electrical appliances, sanitary equipment and plastic and rubber goods. (R. Pi.)

**MONT CENIS** (Ital. MONTE CENISIO or MONCENISIO), a mountain (10,892 ft.) and pass (6,834 ft.) between the Cottian and Graian Alps, is located in Savoie *département*, France. The pass, a historic invasion route, provides an important crossing of the Western or French Alps between France and Italy. Napoleon built a carriage road over it in 1803–10. The railway connection (Mont Cenis or Fréjus tunnel) from Chambéry to Turin opened in 1871, tunnels at a lower level (highest point, 4,245 ft.) about 17 mi. W. of the pass. Approaching the crossing from Chambéry the road and railway first follow the valley of the Isère river and then that of its tributary the Arc, a high mountain valley known as the Maurienne. Beyond its chief market town, St. Jean de Maurienne, the Route des Alpes comes in from south of St. Michel, descending from the Col du Galibier past Valloire. Above Modane the railway leaves the Arc valley to cross into Italy by the tunnel (nearly 8 mi. long) to Bardonnecchia and the head of the Dora Riparia valley, joining at Oulx (Ulzio) the road over the Mont Genèvre pass from Briançon, and descending past Susa to Turin. The road continues to follow the Arc valley as far as Lanslebourg where it turns off to climb the Mont Cenis pass. Beyond the pass, still in French territory, is the historic hospice of Mont Cenis, which was ceded by Italy to France under the treaty of Paris in 1947. Beyond the hamlet of La Grand Croix the road descends rapidly to Susa. The Route des Alpes keeps to the Arc valley above Lanslebourg and beyond Bonneval leads north over the Col d'Iseran (opened in 1938) to the head of the Isère valley. (AR. E. S.)

**MONTCHRESTIEN, ANTOINE DE** (*c.* 1575–1621) French dramatist and economist, who as a writer of tragedies on classical and biblical themes shared in the development of drama which led to the plays of Corneille. He was born in 1575 or 1576 at Falaise in Normandy and his life was one of action and turbulence. After a duel in which he killed his opponent he was compelled to leave France, and he took refuge first in England (1605–11), and then in Holland (1611–14). Through the influence of James I, to whom he had dedicated his tragedy *L'Écossaise* (1601), describing the conflict between Queen Elizabeth I and Mary Stuart (the only one of his plays with a contemporary subject), he was able to return to France, and settled at Ouzonne-sur-Loire, where he set up a steel foundry. In 1615 he published his *Traité de l'économie politique*, which owed much to his studies of industry and maritime commerce in England and Holland, and had considerable influence on French political economy. He joined the insurrection of the Huguenots in 1621 and was killed in a skirmish near Tourailles (Orne), on Oct. 8, 1621.

Montchrestien's six tragedies—*Sophonisbe* (1596, later recast as *La Carthaginoise*), *Les Lacènes*, *L'Écossaise*, *David*, *Aman* (published in one volume, 1601) and *Hector* (1604)—are poetic rather than dramatic, with lyrical choruses, and written in a flowing, harmonious style, but lacking in action and animation. He also wrote an early pastoral play, *Bergerie* (1601), and a poem, published with the plays, *Susane ou la Chasteté*.

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**MONTCLAIR,** a town of Essex county, N.J., U.S., is located on the east slope of Watchung mountain, whose heights command a fine view of New York city and its harbour. Founded in 1666 as part of Newark, Montclair was detached in 1812 as a part of Bloomfield and was incorporated as a township in 1868 when West Bloomfield, Speertown and Cranetown merged. It is 6 mi. N.W. of Newark and 12 mi. W. of New York, and since 1900 has been a developing suburban community of outstanding homes, schools, private schools, churches and hospitals. It is also noted for its excellent library and art museum. The city is the home of Montclair State college, established in 1908, and was the residence of George Inness, late 19th-century landscape painter. Principal manufactures include metalware, paints, chemicals and printers' supplies. A feature of historic interest is described as the smallest park in the world, consisting of a boulder bearing a plaque commemorating George Washington's visit to the area during the American Revolution.

For comparative population figures *see* table in NEW JERSEY: *Population*. (D. N. A.; M. P. M.)

**MONT-DE-MARSAN,** a town of southwestern France and capital of the *département* of Landes, lies at the confluence of the Midou and the Douze, 92 mi. S. of Bordeaux. Pop. (1962) 18,059. Mont-de-Marsan, the first of the bastides (*see* BASTIDE) of the middle ages, was founded by Pierre, vicomte de Marsan, as the capital of his territory in 1141. In the 13th century it passed to the viscounts of Béarn and was later involved in civil and religious wars. After being taken by the Calvinists it was besieged by General de Monluc in 1569 and surrendered in 1580 to the Catholic Sire de Poyanne of Baylens. On the accession of Henri de Béarn (Henry IV) in 1585, it was united to the crown of France. Most of the buildings are in the older quarter, on the peninsula between the two rivers forming the Midouze. A 14th-century keep, later used for military purposes, was built by Gaston Fébus. There are also remains of ramparts, fortifications and a postern dating from the 12th century.

The town is the seat of a prefect, court of assizes and of a tribunal of first instance. It is a supply centre for the north and east of the Landes and for the neighbouring district of Gers. There are several foundries and it has a small trade in timber, resinous products and other goods. An important food-preserving factory exports goose and duck "*foies gras des Landes*" to nearly all parts of the world. (J. CA.)

**MONTDORY, (GUILLAUME DESGILBERTS)** (1594–1651), French actor and manager, whose presentations of the works of Corneille were especially notable, was born on March 13, 1594, at Thiers in the Auvergne. He began his theatrical career in 1612 in a troupe led by Valleran le Conte, a company specializing in the tragicomedies of Alexandre Hardy. A member of the company of the Prince of Orange in 1622, Montdory gained a foothold in Paris in 1629 when he, with his associate Charles Le Noir, established a playhouse in one of the indoor tennis courts of the capital. Immediate success came with the performance of Pierre Corneille's first play *Mélite*. After opening the Marais theatre, another converted tennis court, in 1634, Montdory, who had produced all the earlier plays of Corneille, in 1636 staged *Le Cid* and played the part of Rodrigue in Corneille's masterpiece. In contrast with his predecessors Montdory never acted in farce. Among the principal tragic parts which he created were Masinisse in Jean Mairet's *La Sophonisbe*, Brutus in Georges de Scudéry's *La Mort de César*, and Jason in Corneille's *Médée*. As an actor he

was a great conveyer of passions employing very little stylization. While playing Hérode in *Marianne* by Tristan l'Hermite, he suffered a stroke which paralyzed him. He died in Dec. 1631.

(A. M. N.)

**MONTE, PHILIPPE DE** (1521–1603), an outstanding composer of the Netherlands school, was born in Mechelen in 1521. After an early period spent in Naples, he visited England in 1554–55 with the choir of Philip II of Spain, befriending the 13-year-old William Byrd. He then returned to Italy. In 1568 he became court musical director to the Habsburg emperors and held this position until his death in Prague, July 4, 1603. Though prolific, he was never perfunctory; a fluent but not experimental technician, he excelled in subtle contrasts of register and voice-grouping. His 38 masses and 319 motets stand comparison with Palestrina. He was also one of the last Netherlandish masters of the Italian madrigal, publishing more than 1,200 in 42 books.

*See* his *Opera Omnia* (1927–39); G. van Doorslaer, *La vie et les oeuvres de Philippe de Monte* (1921). (B. L. Tr.)

**MONTEAGLE, WILLIAM PARKER, 4TH BARON** (1575–1622), who revealed the Gunpowder plot to the earl of Salisbury, was the son of Edward Parker, 10th Lord Morley, and of Elizabeth, daughter and heiress of William Stanley, 3rd Lord Monteagle, and was born in 1575. Parker was known by the courtesy title of Lord Monteagle and was summoned to parliament in that title in Jan. 1604 and on his father's death in 1618 was styled Lord Morley and Monteagle.

His family, although Anglican, had strong Roman Catholic sympathies and Monteagle became a practising Catholic after his marriage to the Roman Catholic Elizabeth Tresham. He supported the earl of Essex' rebellion in Jan. 1601, for which he was imprisoned in the Tower of London and fined £8,000. He also intrigued to secure a Spanish invasion of England in 1602. On the accession in 1603 of James I, who had promised religious toleration, he supported the crown, enjoyed court favour and offered to become a Protestant. He was summoned to parliament, which was to meet on Nov. 5, 1605, and this ultimately led to the discovery of the Gunpowder plot (*q.v.*). Francis Tresham, his brother-in-law and prominent conspirator, wished to save Monteagle and sent him a warning letter. Monteagle immediately took it to the earl of Salisbury (*see* SALISBURY, ROBERT CECIL, 1st Earl of Salisbury), the secretary of state, who sent out the search parties that discovered Guy Fawkes and the barrels of gunpowder hidden under the palace of Westminster. For this display of loyalty Monteagle was given an annual pension of £500 and land worth £200 yearly.

He enjoyed court favour until his death and took part in the overseas commercial undertakings of the day. Monteagle died at his house at Great Hallingbury in Essex, on July 1, 1622.

(R. C. Jo.)

**MONTEBELLO,** a residential and industrial city of Los Angeles county, Calif., U.S., 9 mi. E. of Los Angeles on the slopes of the La Merced hills. Incorporated in 1916 with Monterey Park and formerly known as Newmark, Montebello became a separate city in 1920. Oil was discovered in 1916 on property owned by Walter P. Temple, an early settler of the area. Until World War II, Montebello was a farming region, with walnut orchards, strawberry patches, citrus groves and stock trees and shrubs for commercial nurseries. After 1945 the city became an industrial centre for automobile assembly, rubber materials, television sets and warehousing. At the eastern boundary of the city is the Whittier Narrows dam, a flood control project which is also used as a recreational park. The city has a council-manager form of government in effect since 1957. For comparative population figures *see* table in CALIFORNIA: *Population*.

(J. A. Sz.)

**MONTE CARLO,** one of the three *quartiers* (sections) in the principality of Monaco (*q.v.*), is situated on the Riviera (*q.v.*) 18 km. (11 mi.) E.N.E. of Nice, France. Pop. (1961) 9,516. It stands on an escarpment (Spélugues rocks) northeast of the port (La Condamine). One of Europe's most luxurious resorts, its social life centres around the Place du Casino with its picturesque gardens overlooked by the International Sporting club (1932) and the Théâtre de la Lumière. The casino, built in 1861 and later enlarged, is administered by a concessionaire (La Société Anonyme des Bains de Mer et du Cercle des Etrangers) whose annual grant to the principality constitutes about 5% of the state budget. Within the casino is the opera, built by Charles Garnier, and the Foyer de la Dance where most of Serge Diaghilev's Russian ballets were first performed.

Among the festive and sporting events is the Monte Carlo car rally, so called because first organized there, and the Monaco Grand Prix motor race which takes place through the streets of Monte Carlo.

**MONTE CASSINO:** *see* CASSINO.

**MONTECATINI TERME,** a mineral spa of Tuscany, Italy, in Val di Nievole, province of Pistoia, is 11½ km. (7 mi.) S.W. of the town of Pistoia and 105 ft. above sea level. Pop. (1961) 20,275.

Known since the 14th century for its health waters, Montecatini acquired importance when Leopold, grand duke of Tuscany, built the first thermae. United under government sponsorship, its hydrothermal wealth has made it Italy's foremost thermal station. There are 250 hotels and the saline waters, used by about 100,000 visitors annually, are also exported. Good communications include railway and bus services and Florence and Pisa airports.

**MONTÉCLAIR, MICHEL PIGNOLET DE** (1667–1737), French composer of operatic and instrumental works. Born at Andelot, Haute-Marne, where he was baptized on Dec. 4, 1667, he became a chorister at Langres and later entered noble service. Settling in Paris in 1700, he played the double bass at the Opéra from 1707 until 1737. His first *opéra-ballet, Les Fêtes de l'Eté*, was produced in 1716 and his most famous work, the *tragédie-lyrique, Jephté*, in 1732. Banned because of its biblical subject by the archbishop of Paris, it has a grandeur associated with Lully and had great influence on Rameau. Montéclair's *Cantates Françaises et Italiennes* (1709–17) show the duality of style in his approach to composition, and his three theoretical and pedagogic treatises are valuable on ornamentation and contemporary practices in performance. He died at St. Denis, near Paris, Sept. 27, 1737.

(B. P.)

**MONTE CORVINO, GIOVANNI DI** (1247–1328), Franciscan missionary, traveler and statesman, founder of the earliest Roman Catholic missions in India and China, and first Roman Catholic archbishop of Peking. In 1272 he was commissioned by the emperor Michael Palaeologus to Pope Gregory X to negotiate for the reunion of Greek and Latin churches. Around 1280 he began his missionary work in Armenia and Persia. In 1289 he was sent as papal legate to the Great Khan, the Il-khan of Persia, and other leading personages of the Mongol world, as well as to the "emperor of Ethiopia" or Abyssinian negus. Arriving at Tabriz, then the chief city of Mongol Persia, and indeed of all western Asia, Monte Corvino moved down to India to the Madras region, from which he wrote home in Dec. 1292 or 1293, the earliest noteworthy western account of the Coromandel coast. In 1294 he appears in Khanbaliq (Peking). His letters of Jan. 8, 1305, and Feb. 13, 1306, describe the progress of the Roman mission in the far east, in spite of Nestorian opposition; alluding to the Roman Catholic community he had founded in India, and to an appeal he had received to preach in "Ethiopia" and dealing with overland and oversea routes to "Cathay," from the Black sea and the Persian gulf respectively. In 1303 he received his first colleague, the Franciscan Arnold of Cologne; in 1307 Pope Clement V created him archbishop of Peking and patriarch of the entire orient, and dispatched seven bishops to consecrate and assist him; only three of these survived the hardships of the two-year journey to China. Three more suffragans were sent out in 1313, of whom one at least reached east Asia. A Franciscan tradition maintains that in 1311 Monte Corvino baptized the Great Khan (i.e., Khaishan Kuluk, third of the Yuen dynasty; 1307–11) and his mother. This has been disputed, but he unquestionably won remarkable successes in north and east China. Besides three mission stations in Khanbaliq, he established one near the present Amoy harbour, opposite Formosa.

At Monte Corvino's death in 1328 heathen vied with Christian in honouring him. He was apparently the only effective European

bishop in the Peking of the middle ages.

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**MONTECRISTI,** a province in the extreme northwestern part of the Dominican Republic. Pop. (1960) 59,240. Area 768 sq.mi. It occupies the western part of the fertile Cibao region and is drained by the Río Yaque del Norte, which is used extensively for irrigation. The province, established in 1879, is the nation's leading rice producer and has significant tobacco and banana production.

The port of Pepillo Salcedo was built in 1945 to export bananas from Libertador and Montecristi. The capital, San Fernando de Montecristi (pop. [1960] 5,912) was founded in 1506, destroyed in 1606 for trading illegally with pirates, and reconstructed in 1756. (D. R. D.)

**MONTE CRISTO** (Italian ISOLA DI MONTECRISTO; ancient OGLASA), an island of Italy in the Tyrrhenian sea, part of the province of Livorno, Tuscany region, 39 km. (24 mi.) S. of Elba and about midway between the Italian mainland and Corsica. Its highest point is 2,116 ft. above sea level; area about 15½ sq.km. (6 sq.mi.). The name was made famous by the novel *Le Comte de Monte-Cristo* by Alexandre Dumas *père*. The island is a hunting preserve owned by the state; it contains the ruins of a monastery abandoned in 1553. (G. KH.)

**MONTECUCCOLI, RAIMONDO** (1609–1680), Italian military genius in the service of the Austrian Habsburgs, preeminent both as a commander in the field and as a strategical and tactical theorist, was born on Feb. 21, 1609, in his family's ancestral castle and countship of Montecuccolo, near Modena. At the age of 16, during the first decade of the Thirty Years' War, he entered the service of the Holy Roman emperor Ferdinand II, with whose army he campaigned in the Netherlands and in Germany, being present at Breitenfeld (1631), Lützen (1632), Nördlingen (1634) and Wittstock (1636). A colonel of cavalry from 1635, he was taken prisoner by the Swedes at Melnik in Bohemia in 1639. In captivity at Stettin (Szczecin), he occupied himself with studying geometry, history, jurisprudence, philosophy, architecture and, especially, the theory of war. Released in 1642, he fought for Modena in the War of Castro (1642–43) and for the emperor Ferdinand III against György I Rakoczy in Hungary (1645) and against the Swedes in Silesia (which he defended by a sort of guerrilla warfare) and in Bohemia. After co-operating in the successful enterprise on Triebel in Aug. 1647, he covered the retreat of the imperial forces in 1648 under pressure from K. G. von Wrangel and Turenne and was promoted general of cavalry.

The peace of Westphalia (Oct. 1648) enabled Montecuccoli to proceed with his writings on the theory of war. At the same time, he was given high appointments in the emperor's military administration and also became a trusted agent of Ferdinand III on diplomatic missions. Promoted field marshal, he commanded the emperor Leopold I's troops against the Swedes in Poland, in Jutland and in Pomerania from 1658 to 1660, during the so-called First Northern War. Defending Austria against the Turks (1661–64), he won the decisive battle of St. Gotthard, on the Raab, on Aug. 1, 1664, for which he was hailed as the saviour of Christendom. He was generalissimo of the imperial armies (1664), director of the artillery and president of the supreme war council (1668).

In Austria's war against Louis XIV of France (*see* DUTCH WARS), Montecuccoli fought with skill and success against Turenne on the rivers Tauber, Main and Rhine in 1673 and in 1675: he finally drove the French back across the Rhine, crossed it himself and pushed forward into Alsace. This, however, was his last campaign. Thereafter he devoted himself to improving Austria's military organization, at the same time resuming his favourite studies. Probably with a Spanish princely title (1679) and on the eve of being created a prince of the Holy Roman empire, Montecuccoli died at Linz on Oct. 16, 1680.

Montecuccoli's reputation as a military theorist is based chiefly on his writings of the period 1640–70: *Delle battaglie; Trattato della guerra; Dell' arte militare;* and *Aforismi dell' arte bellica.* His chief concern was to develop a general concept of war, to formulate its guiding principles and to clarify the relationship between policy and war. With regard to strategy, he insists that the object of war must be victory; and with this in view he considers how numerical superiority, mobility, secrecy, fixity of purpose, surprise, lines of communication, the handling of reserves, the possession of a few strong fortresses, a standing army (which he held to be indispensable) and adequate finances can each be a decisive factor.

*Dell' arte militare* was first published in 1692, under the title *L'attione militare;* then the *Aforismi* were printed as *Memorie del Generale Principe di Montecuccoli* (1704); and both works were edited by Ugo Foscolo in 1807–08. An excellent edition of the *Aforismi* was produced by G. Grassi, under the title *Opere di Raimondo Montecuccoli,* in 1821; and there is an edition by G. Carboni (1939). A French translation of the *Aforismi* appeared with important commentaries by L. Turpin de Crissé in 1770. Four volumes of selected writings (*Ausgewählte Schriften . . .*), edited by A. Veltzé for the Austrian *Kriegsarchiv*, were published in 1899–1900. Numerous memoranda by Montecuccoli exist in manuscript in the *Kriegsarchiv* department of the Austrian state archives, Vienna. The first version of *Delle battaglie* is in manuscript in the Bibliotheca Estense, Modena.

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**MONTEFELTRO,** an Italian noble family which ruled Urbino (*q.v.*) and neighbouring places from the 13th to the early 16th century. Descended from the counts of Carpegna, they took their name from the mountainous region of the Montefeltro, so called after the ancient town on Mons Feretri, later known as S. Leo. They are first distinctly mentioned late in the 12th century and soon appear as rulers of S. Leo and then Urbino (1234). They were Ghibelline and certain of the family were among the most notable leaders of the Ghibelline interest in central Italy during the late 13th and early 14th centuries. GUIDO DA MONTEFELTRO (Dante, *Inferno*, xxvii) fought successfully against the papacy and the Guelphs in Romagna and Tuscany before submitting to Pope Boniface VIII in 1295; he died a Franciscan monk in 1298. No less distinguished and intransigent was his son FEDERIGO, who gave valuable support to the Holy Roman emperor Henry VII during his offensive in Italy. He ruled Urbino down to 1322, when the people were provoked to rise and kill him. His son NOFRO recaptured the city in 1323 and retained control of it down to the reconquest of it for the papacy by the cardinal de Albornoz (*q.v.*). At first Nofro managed to come to terms with Albornoz and secured legitimate title to govern Urbino and also Cagli as vicar (1355); but four years later he revolted and lost his lands.

A memorable phase in the family's history opened in 1377 when Nofro's grandson ANTONIO (d. 1403) took advantage of the War of the Eight Saints to recover power in the Montefeltro domains. Within a few years he had added also Gubbio (1388) and Cantiano (1393). Both he and his son, GUIDANTONIO (d. 1443), who succeeded him, were created vicars by the pope. Guidantonio indeed was brought into close association with the papacy by his marriage with Caterina Colonna, a relative of Pope Martin V, who extended the Montefeltro state in the direction of Tuscany (1424–26) and favoured the family against the Malatesta (*q.v.*), lords of Rimini. The rivalry of Montefeltro and Malatesta reached its climax during the reign of Guidantonio's two sons, ODDANTONIO (1426–1444) and FEDERIGO (1422–1482). Oddantonio, who was created duke of Urbino by the pope (1443), ruled little more than a year before he was put to death by the people for profligacy; Federigo, however, the illegitimate son of Guidantonio, became one of the most respected *condottieri* and statesmen of his time. For many years

his long career as mercenary captain was involved with personal conflict over territory with Sigismondo Pandolfo Malatesta, whose lasting hatred he incurred by frustrating his designs on Pesaro in 1445. Federigo captained Pope Pius II's armies which compelled Sigismondo to surrender nearly all his lands (1463); but later, fearing for his own dominions, Federigo fought against the papacy in support of Roberto Malatesta's reoccupation of Rimini in 1469. Even so, Pope Sixtus IV made him duke of Urbino in 1474. Two years earlier Federigo had been employed by Lorenzo de' Medici to suppress the revolt of Volterra. He died during the War of Ferrara in 1482. More enduring than his military activity was the monumental building and the patronage of art and letters on which Federigo spent his gains from war. Under him Urbino became a centre of Renaissance culture, with an incomparable library of manuscripts and a magnificent palace.

The last of the Montefeltro to govern Urbino was Federigo's son, GUIDOBALDO (1472–1508). He was dispossessed of his state by Cesare Borgia in 1502, but recovered it in 1503. In 1504, however, being without heirs, he adopted his nephew, Francesco Maria della Rovere, and on his death Urbino passed to the Della Rovere. His court, a centre of taste and fashionable learning, is commemorated in Baldassare Castiglione's *Cortegiano*.

*See* G. Franceschini, *Saggi di Storia montefeltresca e urbinate* (1957) and *Figure del Rinascimento urbinate* (1959). (P. J. J.)

**MONTEFIORE, CLAUDE JOSEPH GOLDSMID-** (1858–1938), English Jewish religious leader and scholar, the first Jew whose writings on the New Testament had an influence on Christian scholars, was born in London on June 6, 1858, of a notable London family. He was a grandson of Sir Isaac Lyon Goldsmid (*see* GOLDSMID), whose name he later adopted by letters patent. Montefiore studied classics at Oxford and attended a rabbinic seminary in Berlin and then, coming into a considerable inheritance, made a career of philanthropy and the pursuit of Jewish scholarship. Throughout his maturity he was devoted to Reform (called in England "Liberal") Judaism; he helped found (1902) the Jewish Religious union, and published his views on modern thought and traditional religion in his book *Liberal Judaism* (1903).

Montefiore first gained fame through the Hibbert lectures he delivered in 1892 on "The Origin and Growth of Religion as Illustrated by the Religion of the Ancient Hebrews" (later published). He was a founder and co-editor of the scholarly *Jewish Quarterly Review*. His *The Synoptic Gospels* (2 vol., 1909; 2nd ed. 1927), though reflecting the Jewish viewpoint, did so in a vein appreciative of and sympathetic to Christianity, leading to the absurd charge that he was flirting with it. Two additional studies in Christianity were the Jowett lectures of 1910 ("Some Elements of the Religious Teaching of Jesus") and the book *Judaism and St. Paul* (1914). Counterbalancing these studies in Christianity were *Rabbinic Literature and Gospel Teachings* (1930) and *A Rabbinic Anthology* (in collaboration first with Israel Abrahams and then Herbert Loewe). Montefiore died on July 9, 1938.

Montefiore, though gentle by nature, evoked sporadic storms of controversy in British Jewry by his religious liberalism, his interest in the New Testament and his opposition to Zionism. Nevertheless he was accepted as the leading British Jew of his day.

*See* Lucy Cohen, *Some Recollections of Claude Goldsmid Montefiore* (1940). (S. St.)

**MONTEFIORE, SIR MOSES HAIM** (1784–1885), Jewish philanthropist who performed exceptional services to the Jewish people, was born at Leghorn, Italy, on Oct. 24, 1784. A member of a merchant family settled in Italy since the 17th century, he emigrated to England and practised as a broker on the London stock exchange, rapidly becoming a rich man. Through marriage Montefiore established a close personal and business connection with the Rothschilds. Retiring in 1824 with a large fortune, he devoted himself thereafter to the cause of Jewish emancipation and betterment. From 1827 he was one of the United Deputies of British Jews, in whose struggle to obtain full civil and political rights he always remained active. In 1837 Montefiore was knighted while serving as sheriff of the City of London, and in 1846 he was made a baronet by Sir Robert Peel.

After 1839 Montefiore's efforts on behalf of his co-religionists were mainly concentrated in eastern Europe, the middle east and north Africa, the regions of most intense persecution. During his first pilgrimage to Jerusalem in 1827, Montefiore established his friendship with Mohammed Ali, which was of great benefit to Egyptian and Syrian Jews, notably in 1840. In 1839 he tried, without success, to promote a scheme for Jewish colonization in Syria; but in the following year triumphantly persuaded the sultan to extend to Jews throughout the Ottoman empire the maximum privileges enjoyed by aliens. In 1863 this concession was reaffirmed, at his request, by the new sultan, Abdul-Aziz. Montefiore vigilantly defended these gains, particularly in Syria, always his central interest in the middle east, as late as 1866. In 1864, with British naval escort, he effectively countered an outbreak of anti-Semitism in Morocco. His efforts were everywhere supported by lavish personal generosity.

In Europe Montefiore was equally persistent, though less successful. However, in 1847 he secured valuable assistance from Louis Philippe of France in meeting further difficulties in Syria. His relations with the tsars were excellent, and produced one major concession, despite later setbacks. In 1846 Montefiore managed to obtain the tsar Nicholas' withdrawal of the ukase of 1844, which had ordered all Jews to retire from the western frontier areas of Russia. His high standing in St. Petersburg was illustrated by the respect paid him on his last visit in 1872, but neither on this occasion nor during his mission to Rumania in 1867 were any new gains recorded. Montefiore made a final pilgrimage to the Holy Land in 1875, and retired thereafter to his house, East Cliff Lodge, near Ramsgate, where he maintained a centre of religious observance and theological research. He died there, a centenarian, on July 28, 1885.

Montefiore was a pious Jew, rigidly orthodox, who displayed great skill as a diplomat, adept at gaining access to the appropriate sovereigns, and failing only with Pope Pius IX over the Mortara case (a *cause célèbre* involving a Bolognese Jewish child, Edgar Mortara, whose Catholic nurse arranged for his secret baptism in 1858; Pius IX refused to act in the matter). Important to the English community and its advancement, Montefiore became a figure of European reputation. (A. F. T.)

**MONTELIUS, OSCAR** (1843–1921), Swedish archaeologist, who played a most prominent part in the early development of prehistoric archaeology, was born in Stockholm on Sept. 9, 1843. After initial studies, mainly in natural sciences, at the University of Uppsala, Montelius devoted his life almost entirely to research in prehistory, having been early stimulated by his reaction against opinions expressed by Sven Nilsson in Sweden and by discussions with Sophus Otto Müller (*q.v.*) in Denmark. From 1863 Montelius was attached to the Museum of National Antiquities in Stockholm and was appointed professor in 1888. He was director (*antiquarius regni*) of the museum (1907–13) and at the same time secretary of the Royal Academy of Letters, History and Antiquities. His research aimed at establishing foundations for prehistoric chronology, especially that of the Bronze Age from southern Europe to Scandinavia (*see* SCANDINAVIAN CIVILIZATION). He developed a so-called typological method for chronological purposes, calling it "the evolutionism of Darwin applied to the products of human work," but did not apply it widely in his own work. The evaluation of this method continues to be a matter of controversy. Many of his important contributions were made in lectures and published only in short summaries. Among his main works are *Om tidsbestämning inom bronsåldern* (1885), summarized in *Sur la chronologie de l'âge du bronze, spécialement dans la Scandinavie* (1885), *The Civilization of Sweden in Heathen Times* (1888), *La Civilisation primitive en Italie depuis l'introduction des métaux* (1895–1910), *Die älteren Kulturperioden im Orient und in Europa* (1903–23), *The Chronology of the British Bronze Age* (1908), *Die orientalische Chronologie Italiens* (1912), *Album préhistorique de la Suède* (1918) and *La Grèce préclassique* (1924). He died in Stockholm on Nov. 4, 1921. (C.-A. Mo.)

**MONTEMAYOR** (MONTEMOR) **JORGE** (1502–1561), Spanish novelist and poet, author of *Diana* (1559), the first Spanish pastoral novel and, through its translations into French, Eng-

lish and German, the starting point of a literary fashion. The excerpt in Barnabe Googe's *Eglogs, epytaphes and sonnettes* (1563) is an indirect source of an episode in *Two Gentlemen of Verona*. The work's popularity is attested by about 20 editions and two continuations published in the 16th century. The novel is elegant in style, with a less complicated plot than Sannazzaro's *Arcadia*, which may have inspired it. The psychology of love depicted in it derives from León Hebreo and Ausias March, whose love poems Montemayor translated.

Of Portuguese descent, he was born at Montemôr o Velho (near Coimbra) and probably came to Spain in 1543 with Philip II's first wife Mary as a musician, later entering the household of Joan, daughter-in-law of John III of Portugal. He died in unknown circumstances in Piedmont in 1561 or shortly before.

*See* H. A. Rennert, *The Spanish Pastoral Romances* (1912).

(J. Gs.)

**MONTEMEZZI, ITALO** (1875–1952), Italian opera and symphonic composer. Born at Vigasio, near Verona, on Aug. 4, 1875, he studied at the Milan conservatory and established himself as an operatic composer with *Giovanni Gallurese* (Turin, 1905). His greatest success was *L'Amore dei tre Re* (La Scala, Milan, 1913). Based on the play by Sem Benelli, it obtained its atmosphere of brooding tragedy from a fusion of Italian melody with French impressionism derived from Debussy's *Pelléas et Mélisande*. *La Nave* (1918), on a libretto after Gabriele d'Annunzio, was less successful. His symphonic works include *Paolo e Virginia* (1930) and *Italia mia, nulla fermerà il tuo canto* (1944), inspired by Italy's defeat in World War II. In 1939 Montemezzi emigrated to California, returning after World War II to his birthplace, where he died on May 15, 1952. He is portrayed as Italo in Franz Werfel's novel *Verdi; der Roman der oper* (1924).

(Dy. H.)

**MONTENEGRO** (Crna Gora) was an independent state before 1918, when it was absorbed by Serbia and so united with the South Slav areas of the former Austria-Hungary to form the kingdom of the Serbs, Croats and Slovenes, later Yugoslavia (*q.v.*). In 1945 it became one of the six constituent republics of Yugoslavia. The great majority of the population are Serbs.

Montenegro takes its name—a Venetian variant of the Italian Monte Nero—from the "Black mountain," Mt. Lovcen (5,738 ft.), its historical centre and stronghold in the centuries of struggle with the Turks. Alone of Balkan states, Montenegro was never subjugated, partly because of its inhospitable territory, partly because of the courage of its people, which became legendary.

The old Montenegro, in the southwest, is mainly a karst region of arid hills, with some cultivable areas; *e.g.*, round Cetinje, the former capital, and in the broad and gentle Zeta valley. The eastern districts, which include part of the Dinaric Alps (Mt. Durmitor, 8,274 ft.), are more fertile and have large forests and grassy uplands.

**Medieval History.**—The district of Zeta or Duklja, round Kotor and Scutari, was incorporated in the Serbian empire of Stephen Nemanja in the late 12th century. On the disruption of that empire after 1355 the Balshich family ruled in Zeta till 1421. After the great Turkish victory of Kosovo (1389) Zeta became the refuge of the most stubborn of the Serbs, who would not live under Islam. In the early 15th century Venice acquired nearly all the Dalmatian coast, including Kotor. It was as vassals of Venice that the Crnojevich family succeeded to the Balshich. When the Turks overran Albania and Hercegovina, Ivan the Black Crnojevich was forced in 1484 to establish his capital in the remote mountain village of Cetinje, where he founded a bishopric and a monastery.

**The Vladike (1516–1851).**—The last Crnojevich resigned and retired to Venice in 1516. Thereafter till 1697 the mountaineers were ruled by *vladike* (bishops) elected by popular assemblies. In 1697 the succession was restricted to the Petrovich Njegosh family and, since Orthodox bishops are celibates, it passed from uncle to nephew. For more than two more centuries the Montenegrins fought the Turks and Albanians, a task which was for them almost the whole duty of man (hence the Montenegrin's reputation for dignity, bellicosity and, also, aversion from work). In 1711 the *vladika* Danilo I started the tradition of alliance with Russia, receiving an envoy and a subsidy from Peter the Great and himself visiting St. Petersburg.

The gentle and unassuming *vladika* Sava (1735–1782) spent most of his time in retirement in a monastery. His cousin, Vasilije, maintained the struggle against the Turks; thrice visited Russia, where he arranged for the military education of some young Montenegrins; and established the office of civil governor, hereditary in the Radonich family, which at first promoted peace and order, but later became a nuisance by dividing supreme authority.

Then occurred the curious episode of the monk Stephen the Small, who appeared in 1767 and claimed (one of half a dozen such claimants) to be the Russian emperor Peter III, the murdered husband of Catherine II. The credulous Montenegrins accepted him; and he ruled with firmness, maintaining solvency by frequent raids into Turkish or Venetian territory. In 1769 Catherine II sent Prince Yuri Dolgoruki to rouse the Montenegrins against the Turks and to denounce the false emperor. Stephen was handed over to Dolgoruki, who, however, was so impressed by him that he left him in power, with the uniform of a Russian staff officer. Stephen turned the Montenegrins to the peaceful task of roadmaking. He was blinded by an explosion while supervising the blasting of rocks. He thereupon entered a monastery, where in 1773 he was murdered by a Greek servant, sent, it was said, by the pasha of Soutari. *Vladika* Sava resumed his office for eight years.

Peter I, "the Great *Vladika*," ruled from 1782 to 1830 and doubled the area of Montenegro. His successor Peter II (d. 1851) left a noble reputation as a warrior, ruler and poet. *See* Peter.

**The Principality and the Kingdom (1851–1918).**—Peter II's nephew, Danilo II, who ruled from 1851 to 1860, refused episcopal status, married and converted Montenegro into a secular principality. He too vindicated its claim to independence by successful resistance to the Turks.

When Danilo was assassinated, his nephew Nicholas I (*q.v.*) succeeded him. He was to reign for 58 years (1860–1918). He led his warriors to success in support of the Hercegovinian insurgents in 1876–77 and occupied Nikshich (Nikšić) and a stretch of the coast. The settlement at the congress of Berlin (1878) doubled the size of Montenegro and recognized its independence, but, because of Albanian resistance, agreement on the southern frontier was not reached till 1880. Montenegro eventually acquired all the plain of Podgorica and 25 mi. of coast with the little ports of Bar (Antivari) and Ulcinj (Dulcigno). But, as Austria-Hungary now administered Hercegovina, occupied the sanjak of Novi Pazar, protected the Catholic tribes of northern Albania and exercised maritime control of the Montenegrin coast, the little principality was surrounded by the power of its great neighbour. With the growth of nationalism, the Habsburg control became as insufferable to Montenegrin as to Serbian enthusiasts.

However, for 30 years Montenegro experienced unusual peace, relieved only by occasional scuffles with the Albanian tribes along the frontier. Nicholas maintained his authority by tradition, by his prestige as warlord, poet and diplomat, and by judicious distribution of parts of the large subsidies that he received from several foreign powers. But the spread of education, the return from the United States of some of the emigrants, the existence of parliamentary institutions in Serbia and the contrast between Montenegro's poverty and its ruler's wealth combined to produce dissatisfaction. In 1905 Nicholas proclaimed a parliamentary constitution. The resulting instability and violence were unedifying, and Nicholas soon paid little attention to the niceties of his constitutional law.

Features of the latter years of the reign were the growing movement to unite all Serbs and Nicholas' challenge to the Serbian dynasty for leadership. In 1907 the Serbian government was accused of complicity in a plot against Nicholas and for a year diplomatic relations were severed. Serbia had already become a kingdom in 1882, and Nicholas proclaimed himself king of Montenegro in 1910. In the Balkan War of 1912–13, however, the two co-operated against Turkey, Nicholas picturesquely firing the first gun of the war. His troops occupied much Turkish territory, and the result of the war was to extend Montenegro greatly to the

north and east and to give it a common frontier with Serbia (see BALKAN WARS). The question of Serb unity became more urgent, and in 1914 official discussions began for an economic and political union, though with the retention of the two dynasties.

Montenegro supported Serbia, as a matter of course, in World War I. But, when the Austro-Hungarian army invaded Montenegro in the winter of 1915–16, Nicholas tried in vain to negotiate for terms. He then fled with most of his family to Italy, but his second son, Prince Mirko, went to Vienna and was credited with projects for a vassal Yugoslav state under the Petrovich dynasty within the Habsburg monarchy (Mirko died in an Austrian sanatorium in 1918). In western Europe thereafter two voices claimed to speak for Montenegro—Nicholas, who moved his court to Neuilly in France and demanded his own restoration as a condition of increased Serb unity; and the Montenegrin committee at Geneva, under Andrija Radovich, whom for a time Nicholas accepted as his premier. The committee, in defiance of the king, accepted the Declaration of Corfu (July 20, 1917), which only alluded to Montenegro as destined to form part of an indivisible Yugoslav kingdom.

**Incorporation in Yugoslavia.**—When the Austro-Hungarian forces were withdrawn from Montenegro early in Nov. 1918, their place was taken by Serbian troops and irregular bands. Under this new control a "national assembly" met at Podgorica and on Nov. 26 "unanimously" resolved that Nicholas was dethroned and Montenegro was absorbed into Serbia. A Montenegrin rising followed, with demands for an Allied occupation and free elections. The movement was suppressed and in April 1919 a Serbian civil governor assumed authority.

King Nicholas' government protested to the Allied supreme council against the proceedings at Podgorica and was assured that the Montenegrin people would be afforded "an opportunity to pronounce freely on the political form of their future government." No such opportunity was afforded. Allied investigations on the spot led to the conclusion that nearly all Montenegrins desired inclusion in the new Yugoslavia, though also desiring administrative autonomy within it. The governments of Great Britain and France accordingly took the elections for the Yugoslav constituent assembly in Nov. 1920 as the free pronouncement of the Montenegrin people, and on July 13, 1922, accepted the incorporation of Montenegro into Yugoslavia.

In the politics of Yugoslavia the Montenegrins, though resenting administration by any non-Montenegrins, were ultra-Serb. It was a Montenegrin who wrecked the early hopes of Serbo-Croat unity and good will by shooting several Croat deputies in parliament in 1928. But the preoccupations of most Montenegrins were economic rather than political. Subsidies from foreign states had ceased, emigration to the United States was restricted, and the country was miserably poor. After 1918 there was some emigration to Serbia for better land or better employment, and the census of 1931 gave the population as 223,949 for an area approximately equivalent to the Montenegro of 1912, when the population had been estimated at 250,000. Yet when Montenegrins complained that they were forgotten by Belgrade, the Serbian statesmen could reply with justification that the Yugoslav government spent far more on Montenegro than they received from it.

The country's position was a little alleviated by King Alexander's reforms, when Cetinje became the administrative centre of the *banovina* of the Zeta, which included southeastern Hercegovina and southern Dalmatia (1929). But the Zeta was the most thinly populated of the nine *banovine* and had to be supported out of the taxation of the richer north. Some employment was given by the construction of two short lines of narrow-gauge railway, one from Podgorica to Lake Scutari and the other linking Nikshich with the Bosnian railway. Two ambitious schemes were constantly discussed, but not put into effect—the draining of Lake Scutari, which would have needed Albanian cooperation, and a railway from Serbia through Montenegro to the coast.

**World War II.**—In April 1941 Italian troops occupied parts of Montenegro. At Cetinje, in July, the Italians staged a quite unrepresentative "national assembly," which declared Montenegro independent, elected an executive body and requested the king of Italy to nominate a king, but rebellion broke out in the same month, and Montenegro was the scene of seldom-interrupted fighting until late in 1944. In the winter of 1941–42 Serb *četniks*, more or less under the command of Draza Mihajlovic and Tito's Communist partisans retreated from the Germans into Montenegro and there came to blows with each other. A series of confused three-cornered struggles between royalists, partisans and the Italians followed. The Italians soon retired to the coast and left the Yugoslavs to fight it out. Late in 1943 a German occupation of the south succeeded the Italian. But by the end of 1944 the Communists, with British arms and equipment, controlled most of Montenegro.

**The Communist Regime.**—Communism of a special sort, for there was virtually no industry or urban proletariat, had been prevalent since 1918. It had the prestige of representing Russia, the country's traditional ally, and of expressing the poorer peasants' hatred of a bourgeois ruling class. Montenegrin Communists had formed some of the toughest elements in Tito's partisans and provided many of his most vigorous officers and leaders. It was not surprising that by the federal constitution of the new Yugoslavia (1946) Montenegro was made one of the six nominally autonomous federated units. Yet its area, though it was increased by the addition of the *boke* (fjord) of Kotor and the Adriatic coast between the *boke* and Bar, still amounted only to 5,333 sq.mi., or 5.4% of the whole of Yugoslavia. The administrative centre was moved from Cetinje to Podgorica, which was rebuilt and renamed Titograd.

Supreme authority in Montenegro is vested in the people's assembly, elected every four years and divided into two houses, one elected by adult suffrage and the other by producers. For local government there were, until 1955, district, town and communal councils, similarly elected. But Montenegro was too primitive for all this: district and town councils were abolished and the number of communes, originally 145, was reduced to 20 by 1960. All these assemblies elect their executive authorities, who appoint their subordinates; but the central government can override the federated republics. Moreover, since the Communist party leadership directs all power, elections are mainly an occasion for official propaganda and instructing the people in their duties. Potential critics of the regime are not elected.

The census of 1953 gave the population of Montenegro as 419,625, of whom roughly 190,000 were Orthodox, 20,000 Catholics, 75,000 Muslims and 133,000 without religion (cf. 213,949, including 185,664 Orthodox Serbs, 11,868 Catholics and 16,351 Muslims, for the slightly smaller area in 1931). At the time of the 1961 census the population was 471,433. Before 1939 Montenegrins had lived by primitive agriculture; and only 0.5% of the population had been engaged in industry, chiefly lumbering. The Yugoslav government after 1945 devoted considerable sums to work to produce electrical power and to the iron and steel and nonferrous metal industries. Titograd was finally linked by narrow-gauge railway with Nikshich and with the coast at Bar. Something also was done for agriculture by irrigation and mechanical improvements. In the five-year plan for 1957–61 investment was divided as follows: 65% in industry, 2.6% in agriculture and 32.4% in transport.

*See* also references under "Montenegro" in the Index.

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(R. G. D. L.)

**MONTEREY,** a city of Monterey county, Calif., U.S., 324 mi. S. by E. of San Francisco, situated on a peninsula fronting the bay of the same name. Monterey is one of the oldest sites of Spanish civilization in California; to tour the city is to walk in the path of history of the Pacific coast. The area was sighted by Juan Rodriguez Cabrillo in 1542 and in 1602 was explored by Sebastián Vizcaíno, who named it in honour of the count of Monte

Rey, the governor of New Spain. Thereafter Spain was oblivious of the area until in 1770 an expedition headed by Gaspar de Portola, governor of Alta California, and Father Junípero Serra (*q.v.*), a Franciscan monk, arrived to establish a presidio and a chapel. It was on the Monterey peninsula that Father Serra's great career was brought to fruition. Close by the presidio for protection, yet far enough removed for agricultural pursuits, Father Serra established the Carmel mission, after which many others were patterned. It was the missions under Father Serra which helped to strengthen Spain's control of Alta California, maintained until 1822. Under Mexico, Monterey remained the capital of the Pacific empire, an area including what is now California, New Mexico, Nevada, Arizona, Utah and parts of Colorado and Wyoming. Such an extensive and undefended domain was coveted, not the least by the United States, to which it was contiguous. With the defeat of Mexico by the United States in 1846, the American flag was unfurled in front of the customhouse at Monterey, and four years later California was admitted to the union. (*See* also CALIFORNIA: *History.*)

The Monterey area is one of residences rather than of industries, and attracts many tourists, especially those interested in history. There is, however, a diversity of attractions, particularly the colourful wharves which were used commercially when the sardines were running but which are now used for restaurants, theatres and shops; plazas with flowers in blossom the year around; and a schedule of festivals reminiscent of the Spanish and Mexican eras. The Monterey peninsula has long been known as a retreat for artists, and the results of their skills may be seen in international galleries. The peninsula is also famous for its annual Bach festival.

Monterey is the hub of an extensive military establishment, to which its economy is closely related. The presidio of Monterey, the oldest remaining military establishment west of the Rocky mountains, is the home of the U.S. army language school. A few miles eastward is Fort Ord, an important training and replacement centre for the U.S. army on the west coast. The U.S. naval postgraduate school is within the city limits.

Monterey Peninsula college, a public junior college, was opened in 1947. Monterey has a council-manager form of government, in effect since 1925. For comparative population figures *see* table in CALIFORNIA: *Population.* (B. L. B.)

**MONTEREY PARK,** a city of Los Angeles county, Calif., U.S., formerly known as Ramona Acres, 5 mi. E. of Los Angeles at the southeastern end of the San Gabriel valley, in the Monterey hills. A residential city of medium priced homes, Monterey Park was developed in the 1880s by Harris Newmark, J. W. Hellman and Richard Garvey. It was incorporated in 1916. Monterey Park has a public library and a community hospital. Recreational facilities are provided in Barnes Memorial park, La Loma park and Richard Garvey Ranch park. There are two institutions of higher learning near the city: Los Angeles State College of Applied Arts and Sciences, established in 1947, and East Los Angeles City college, a junior college opened in 1945. Monterey Park has a council-manager form of government in effect since 1948. For comparative population figures *see* table in CALIFORNIA: *Population.* (J. A. Sz.)

**MONTE ROSA,** the name of a glacier-clad mountain mass (the place name is derived from an Aostan patois word *roëse*, meaning "glacier") which rises southeast of Zermatt and on the frontier between Switzerland and Italy. Ten summits in this huge mass are distinguished by name, of which four (Nordend, 15,131 ft., Zumsteinspitze, 14,964 ft., Signalkuppe or Punta Gnifetti, 14,957 ft., and Parrotspitze, 14,642 ft.) lie on the frontier. The five lower summits are on the Italian slope, the Dufourspitze, the highest (15,203 ft.), was named by the Swiss government after Gen. G. H. Dufour, the head of the survey that first fixed instrumentally the position of these points. It rises west of the frontier ridge on a buttress, and, being entirely in Switzerland, is its highest peak (not, as often stated, the Dom, 14,942 ft., in the Mischabel group). The summit of the Dufourspitze was first reached by an English party—J. G. and C. Smyth, C. Hudson, J. Birbeck and E. T. Stevenson—in 1855. The Zumsteinspitze was first climbed in 1820, the Signalkuppe (on top of which there is now a club hut) in 1842, the Nordend in 1861 and the Parrotspitze in 1863. A laboratory for nuclear research has been established on the Italian slope. (A. F. A. M.)

**MONTERREY,** third largest city of Mexico and capital of the state of Nuevo León. Pop. (1960) 596,939. On main highways, rail and air lines between Laredo, Tex. (150 mi. N.), and Mexico City (600 mi. S.), Monterrey also has good connections to coal and mineral areas to the north and west, to the grazing and agricultural areas north and east, and to its port, Tampico, on the Gulf of Mexico, though its own site lacks significant natural resources. Ranking first in metallic industries and second in manufacturing, Monterrey is the dominant city of the large zone lying between the United States border and the densely settled Central Mexican highlands. At an altitude of 1,765 ft., partly surrounded by mountains, Monterrey is on the flood plain of the eastward-flowing Santa Catarina river. On a semiarid piedmont north and east of the city there is considerable irrigated agriculture. Local rivers provide hydroelectric power, but for both irrigation and electricity Monterrey is the chief Mexican beneficiary of the great Falcón dam, jointly constructed by the United States and Mexico on the lower Rio Grande river for mutual benefit. Monterrey has a generally healthful climate, cool and wet in winter, hot and dry in summer.

It is a modern city, despite its early founding in 1579. Floods, hostile Indians, distance from Mexico City, lack of metals and poor communications kept it small and unimportant until the late 19th century; it has few notable colonial monuments. Its population in 1775 was 258. Rail connection with Laredo (1882) opened the way to large-scale smelting and heavy industrial enterprises originally financed by Americans. In 1880 Monterrey's population was 29,000; by 1930 it was 132,571, which more than doubled by 1950. The city has all the conveniences of a modern metropolis, in an area where native populations exerted negligible cultural influence. It is often called "The Pittsburgh of Mexico." Its city water has a lower bacteria count than that of many U.S. cities.

Favourable state legislation, especially in 1888, plus active and efficient local governments fostered its development into one of the most energetic and up-to-date industrial complexes in the hemisphere. In addition to its heavy industries, fabricating plants and ore processing units, Monterrey counts literally hundreds of light manufacturers which produce beer, cigarettes, pottery, glass, textiles, cement, processed foods, plastics and other products. In addition to electric power, these industries also employ natural gas for fuel, piped through a 129-mi. line opened in 1947 that delivers 60,000,000 cu.ft. daily.

The Technological Institute of Monterrey (modeled on the Massachusetts Institute of Technology), which was founded by local industrialists in 1942, provides excellent training and research facilities. (J. A. Cw.)

**MONTE SAN GIULIANO:** *see* ERICE.

**MONTE SANT'ANGELO,** a town of the Puglia region, Italy, in the province of Foggia, 17 km. (10 mi.) N. of Manfredonia by road. Pop. (1961) 20,150. It has a famous sanctuary of S. Michele, founded in 491 over a cave in which the archangel is said to have appeared to St. Laurentius, archbishop of Sipontum; the bronze doors, made in Constantinople, bear the date 1076, and the octagonal campanile dates from 1273. Also of interest are a ruined Norman castle and the Tomba di Rotari, both built in the 12th century. The town grew up around the sanctuary which, especially during the middle ages, was an object of pilgrimage. Occupations are agriculture, cattle breeding, wood industries and services to tourists and pilgrims. Olive oil and timber are among the town's products. (A. C.)

**MONTESPAN, FRANÇOISE ATHÉNAÏS DE ROCHECHOUART,** MARQUISE DE (1641–1707), mistress of Louis XIV of France, was born on Oct. 5, 1641, in the château of Tonnay-Charente, Aunis, the daughter of Gabriel de Rochechouart, marquis de Mortemart, whose marquisate was raised to a peerage duchy in 1650. Married in 1663 to Louis Henri de Pardaillan, marquis de Montespan, she was appointed lady-in-waiting to the queen of France, Marie Thérèse of Austria, in 1664. She had two

children by her husband. Ambitious and eager to exploit her striking beauty, Mme de Montespan set herself to supplant Louise Françoise de La Vallière (*q.v.*) in Louis XIV's favour, and in the spring of 1667 she became the king's mistress. Though its course was not always smooth, the liaison lasted for 13 years. A girl whom she bore to the king in 1669 died in 1672, but she had six other children by him: Louis Auguste, duc de Bourbon du Maine (*q.v.*); Louis César (1672–831, comte de Vexin; Louise Françoise (1673–1743), known as Mlle de Nantes before her marriage in 1685 to Louis III de Bourbon-Condé; Louise Marie (1676–81), known as Mlle de Tours; Françoise Marie (1677–1749), known as the second Mlle de Blois before her marriage, in 1692, to the duc de Chartres (later duc d'Orléans and regent of France); and Louis Alexandre (1678–1737), comte de Toulouse. Of these six, the first three were legitimated by the *parlement*, without mention of their mother's name, in 1673, the others in 1676 and in 1681. The marquis de Montespan, who displayed his resentment, was exiled to Guienne in 1668 and judicially separated from his wife in 1674 (he died in 1701). Mme de Montespan brought a brilliance of her own to the court of Versailles and to its splendid fêtes. Of high birth, she had the special "Mortemart wit"; and she was the patroness of Corneille, Racine and La Fontaine.

When the Affair of the Poisons (*q.v.*) came to light in 1679, Mme de Montespan's name was several times brought up by the accused. She was alleged to have been a customer of the witch La Voisin from 1667; to have resorted to magic in order to supplant La Vallière; to have had philtres administered to the king; to have taken part in black masses; and to have tried to poison the king and her young rival, Mlle de Fontanges (M. A. de Scoraille de Roussilles, 1661–81). The first of these charges is now known to be true, but the others were probably false.

Notwithstanding this affair, Mme de Montespan long remained at court, though the king transferred his affections to Mme de Maintenon (*q.v.*). Finally, however, in 1691, Mme de Montespan withdrew to the convent of St. Joseph, in Paris, of which she became the superior. On a visit to Bourbon-l'Archambault she died in the night of May 27–28, 1707.

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(G. Mo.)

**MONTESQUIEU, CHARLES LOUIS DE SECONDAT,** BARON DE LA BRÈDE ET DE (1689–1755), French man of letters and philosopher, whose treatise *De l'Esprit des lois* was a major contribution to political theory.

**Early Life and Work.**—He was born in the château La Brède, near Bordeaux, on Jan. 18, 1689. His parents were Jacques de Secondat, a soldier for whose ancestor the barony of Montesquieu had been erected, and Marie Françoise de Pesnel, a pious lady of partial English extraction, who brought to her husband a great increase in wealth in the valuable wine-producing property of La Brède. When she died in 1696 the barony of La Brède passed to Charles Louis, who was her eldest child, then aged seven. Educated first at home and then in the village, Charles Louis was sent in 1700 to the Collège de Juilly, in the diocese of Meaux. This school, then much patronized by the prominent families of Bordeaux, belonged to the priests of the Oratory, who imparted to their pupils a sound education on enlightened and modern lines.

Charles Louis left Juilly in 1705, continued his studies at the faculty of law at Bordeaux university, graduated and was admitted advocate in 1708, and soon after appears to have moved to Paris in order to obtain practical experience of law. He was called back to Bordeaux by the death of his father in 1713. Two years later he married Jeanne de Lartigue, a wealthy Protestant who brought him a dowry of 100,000 livres and in due course presented him with two daughters (from one of whom, who retained her name by marrying her cousin, the present family is descended) and a son, Jean Baptiste. Charles Louis, though he admired and took advantage of his wife's business skill, does not appear to have been either faithful or devoted to her. In 1716 an uncle, Jean Baptiste, baron de Montesquieu, died and left to his nephew his estates (notably the barony of Montesquieu, near Agen) and the office of deputy president or *président à mortier* in the *parlement* of Bordeaux. The young Montesquieu's position was now socially and financially secure, and he settled down to exercise his judicial function (engaging to this end in the minute study of Roman law), to administer his property and to advance his knowledge of the sciences, especially of geology, biology and physics, in the newly formed academy of Bordeaux.

In 1721 he surprised all but a very few close friends by publishing his *Lettres persanes*, in which he gives a brilliant satirical portrait of French and particularly Parisian civilization, supposedly seen through the eyes of two Persian travelers, Usbek and Rica. This exceedingly successful work mocks the reign of Louis XIV, pokes fun at all social classes, discusses, in its allegorical story of the Troglodytes, the theories of Hobbes relating to the state of nature, makes an original if naive contribution to the new science of demography, continually compares Islam and Christianity, reflects the controversy about the papal bull *Unigenitus*, satirizes Roman Catholic doctrine, and is infused throughout with a new spirit of vigorous, disrespectful, gay and iconoclastic criticism. The work's anonymity was very soon penetrated and Montesquieu became famous.

He now sought to reinforce his literary achievement with social success. Already acquainted through friends made at Juilly with several intellectual figures in Paris society, among them Nicolas Fréret and Bernard le Bovier de Fontenelle, he went to Paris in 1722 and was assisted to enter court circles by the duke of Berwick, whom he had known as military governor at Bordeaux. He became a prominent member of the salon of Mme de Lambert and appears to have visited the Club of the Entresol, which was frequented by the marquis d'Argenson, Andrew Michael Ramsay and Bolingbroke. He retained his interest in the academy of Bordeaux, reading to it in 1725 some fragments of a *Traité général des devoirs*, which was an earnest of future activity and his first attempt at a full-scale serious work. At the same time he indulged the lighter side of his character by publishing, for his friends at court, *Le Temple de Gnide* (1725), a mild essay in eroticism. His interest in the *parlement* of Bordeaux had dwindled, and in 1726 he sold his legal office. This move served both to re-establish his fortunes, depleted by life in the capital, and to assist him, by lending colour to his claim to be resident in Paris, in his attempt to enter the Académie Française. A vacancy there arose in Oct. 1727. Montesquieu had powerful supporters, but success seemed likely to elude him because of Cardinal Fleury's objection to certain passages in the *Lettres persanes*. He succeeded, however, in appeasing Fleury and was elected, taking his seat on Jan. 24, 1728.

He then sought to complete his education by foreign travel, and in April 1728 set off, without his wife and in the company of Lord Waldegrave, for Vienna. Tarrying there to meet Prince Eugene and to make an expedition to the mines of Hungary, he soon went to Venice, where Antonio Conti acted as his cicerone and where he met the exiled and impoverished John Law. He visited most of the large cities of Italy and met most of the savants of the day. He refers in his journals to the works of both Pietro Giannone and Giambattista Vico. From Italy he moved through Germany to Holland and thence (at the end of Oct. 1729), in the company of Lord Chesterfield, to England, where he remained until the spring of 1731. His account of his visit to England was destroyed by his grandson, but it is known that he had a wide circle of acquaintance, especially among the Tories and the dissident Whigs. He was presented at court; he attended parliamentary debates; he bought extensively for his library; he read the journals of the day, notably *The Craftsman*; and he became a freemason. His stay in England was intellectually one of the most fertile periods of his life.

On his return to France, Montesquieu hastened to La Brède and remained there for two years in order to devote himself to literary activities. Apart from a tiny treatise on *La Manière de universelle*, printed in 1731 but at once withdrawn (so that only his own copy is extant), he was occupied with an essay on the English constitution (not published until 1748, when it became part of his major

work) and with his *Considérations sur les causes de la grandeur des Romains et de leur décadence* (1734). The merit of this book, which was ill received by the learned, does not lie in its handling of evidence, which shows a surprising disregard for archaeology, or in its documentation, which, though extensive, is arbitrary and uncritical. In these respects Montesquieu was behind his times. But his comments on the history of Rome are penetrating and vigorous and his approach to the study of historical causation is particularly interesting. In the distinction which, under the influence of Malebranche and of Italian writers, he draws between cause and occasion, he finds a formula for the reconciliation of free will and historical determinism. He shows a unifying grasp of the varied aspects of civilization which few before him could rival. The hatred of despotism which characterized the *Lettres persanes* is here flanked by a devotion to liberty as the major political good. This is a mature and well-written book.

**De l'Esprit des lois.**—Montesquieu had for some time been meditating the project of a major work on law and politics. After the publication of the *Considérations* he rested for a short time and then, undismayed by failing eyesight, applied himself to this new and immense task. He undertook an extensive program of reading in law, history, economics, geography and political theory, filling with his notes a large number of volumes of which one only survives, entitled *Geographica, tome II*. He employed a succession of secretaries, sometimes as many as six simultaneously, using them as readers and as amanuenses, but not as précis-writers. By 1740 the main lines of his work were established and a great part of it was written. By 1743 the text was virtually complete, and he began the first of two thorough and detailed revisions which occupied him until Dec. 1746. Now the actual preparation for the press was set in hand. A Geneva publisher, J. Barrillot, was selected, further corrections were made, several new chapters were written and in Nov. 1748 the work appeared under the title *De l'Esprit des lois, ou du rapport que les lois doivent avoir avec la constitution de chaque gouvernement, les moeurs, le climat, la religion, le commerce, etc.* It consisted of two quarto volumes, comprising 31 books in 1,086 pages.

Few indeed of the most intimate of Montesquieu's associates had known the nature of his occupation. Fewer still had seen the text. The public, not expecting a political treatise comparable with Aristotle's *Politics*, was taken by surprise. The work was at once very successful. None of the multiplicity of subjects touched by Montesquieu remained unadorned. His treatment of three was particularly memorable. The first of these is his classification of governments. Abandoning the classical division into monarchy, aristocracy and democracy, Montesquieu produces his own analysis and assigns to each form of government an animating *principle:* the republic, based on virtue; monarchy, based on honour; despotism, based on fear. His definitions show that this classification rests, not on the location of political power, but on the government's manner of conducting policy; it involves a historical and not simply a descriptive approach.

The second of his most noted arguments, the theory of the separation of powers, is treated differently. Dividing political authority into the legislative, executive and judicial powers, he asserts that in the state which most effectively promotes liberty these three powers must be confided to different individuals or bodies acting independently. His exemplar of such a state is England, which he sees from the point of view of the Tory opposition to Walpole, as expressed in Bolingbroke's polemical writings. The chapter (book xi, chapter 6), the most famous of the entire book, in which he expresses this doctrine, had lain in his drawers, save for revision or correction, since it was penned in 1734. It at once became perhaps the most important piece of political writing of the 18th century. Though its accuracy has in more recent times been disputed, in its own century it was admired and held authoritative even in England; it inspired the Declaration of the Rights of Man and the constitution of the United States.

The third of Montesquieu's most celebrated doctrines is that of the political influence of climate. Basing his generalizations somewhat naïvely on experiments conducted at Bordeaux, he stresses the effect of climate, primarily thinking of heat and cold, on the physical frame of the individual and, as a consequence, on the intellectual outlook of society. This influence, he claims, is not, save in primitive societies, insuperable. It is the legislator's duty to counteract it. Montesquieu takes care (as his critics have not always realized) to insist that climate is but one of many factors in an assembly of secondary causes which he calls the *general spirit*. The other factors (laws, religion and maxims of government being the most important) are of a nonphysical nature, and their influence compared with that of climate grows as civilization advances.

Society for Montesquieu must be considered as a whole. Religion itself is a social phenomenon whether considered as a cause or as an effect, and the utility or harmfulness of any faith can be discussed in complete independence of the truth of its doctrines. Here and elsewhere, undogmatic observation is Montesquieu's preferred method. Sometimes the reader is beguiled by this into the belief that Montesquieu maintains that whatever exists, though it may indeed stand in need of improvement, cannot be wholly bad. It is then that a bold parenthesis or a rapid summing-up reminds one that for Montesquieu certain things are evil from their nature; despotism, slavery, intolerance. Though he never attempts an enumeration of the rights of man, and would probably have disapproved of such an attempt, he has a firm belief in human dignity.

In the final books of *L'Esprit des lois*, added at the last moment and imperfectly assimilated to the rest, he addresses himself to the history of law, seeking to explain the division of France into the two zones of written and of customary law, and makes his contribution to the much discussed controversy about the origins of the French aristocracy. Here he displays not only prudence and common sense, but also a real talent, not previously revealed in his life, for the handling of texts and the interpreting of philological evidence.

**Last Years.**—Very soon after the publication of *L'Esprit des lois* a campaign was begun against Montesquieu, and a variety of denunciatory articles and pamphlets appeared. Attacks made in the Sorbonne and in the general assembly of the French clergy were deflected, but in Rome, in spite of the intervention of the French ambassador, Montesquieu's enemies were successful, and the work was placed on the Index in 1751. This was but a momentary setback. Montesquieu had already (1750) published his *Défense de l'Esprit des lois*, the most brilliantly written of all his works, and his fame in France was assured.

Renown lay lightly on his shoulders. His affability and modesty are commented on by all who met him. He was a faithful friend, kind and helpful to young and unestablished men of letters, witty though absent-minded in society. The editors of the *Encyclopédie* wished to have his collaboration. When approached by D'Alembert, he declined to treat a political subject and proposed an article on taste. The resultant *Essai sur le goût* was his last work.

After a short illness he died at Paris on Feb. 10, 1755, leaving many literary projects unfinished.

The best edition of his *Oeuvres complètes* is by André Masson, in three volumes (1950–55). The Bibliothèque de la Pléiade has a useful edition by R. Caillois, in two volumes (1949–51), and the Association Guillaume Budé has a critical edition of *L'Esprit des lois* edited by J. Brethe de La Gressaye, in three volumes (1950–58).

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**MONTESSORI, MARIA** (1870–1952), Italian educator, originator of the method of education called the Montessori system (*q.v.*), was born at Chiaravalle near Ancona on Aug. 31, 1870. She graduated in medicine from the University of Rome in 1894, the first woman in Italy to do so. Her methods were originally devised for educating defective children, and when they proved extraordinarily successful she came to the conclusion that similar techniques might be applied to normal children of a lower age. She extended her methods to a large number of young children in certain private and public infant schools in Rome. Maria Montessori encountered opposition from advocates of orthodox methods in education, who regarded her system, which encouraged

freedom of movement in the children, as destructive of discipline. But she was warmly supported by certain enthusiastic reformers. From 1900 to 1907 Maria Montessori lectured on pedagogical anthropology at the University of Rome and in 1922 was appointed government inspector of schools in Italy.

Her ideas on education are set forth in such books as *The Montessori Method* (1912), *The Advanced Montessori Method* (1917–18), *The Secret of Childhood* (1936), *The Absorbent Mind* (1949), *Education for a New World* (1946) and *To Educate the Human Potential* (1948), some of which were translated from the Italian and went into several editions. She spent her later years in supervising training courses in Spain, India, England and the Netherlands. She died at Noordwijk, Neth., on May 6, 1952.

**MONTESSORI SYSTEM,** a system of education originated by Maria Montessori (*q.v.*). Her first book, *The Montessori Method* (Eng. trans. 1912), described experiments made with children (aged three to six) in the San Lorenzo slum quarters of Rome, in "Children's Houses" (*Case dei Bambini*), which were rooms set aside in courtyards of large tenements (part of a reformed dwelling scheme).

Dr. Montessori began her studies of educational problems with defective children in 1899. Working on lines first laid down by the French physician, É. Séguin, she achieved startling results, and children under her tutelage passed the state examination in reading and writing for normal children. Since these methods worked with defective children, she felt they might yield even better results with normal children. A year in the *Case dei Bambini* justified her hopes, and these schools became world-famous.

Before starting work with normal children, Dr. Montessori had examined the educational systems of Europe. Everywhere, she found, children were reduced to immobility in the classroom; "not disciplined," as she said, "but annihilated."

She discovered that certain simple yet exact educational materials provoked in the young child a deep interest and attention not previously believed possible. Children of between three and four would repeat an exercise with an air of concentration, indifferent to surrounding distractions. Such a period of "work" might continue from a quarter of an hour to an hour and the child did not seem tired, as after an enforced effort, but rather refreshed and tranquilized. Undisciplined children became settled through such spontaneous work.

The Montessori system is based on these discoveries. The teacher (directress) provides the necessary didactic materials and shows their use, but leaves the child to handle them for himself. Biological and mental growth are linked in the Montessori system. "Periods of sensitivity," corresponding to certain ages, exist when a child's interest and mental capacity are best suited to acquiring a certain specialized knowledge, *e.g.*, language, tidiness, textures and colours, etc. This can be applied to all school children; *e.g.*, one age is more suited to practical work than another, etc.

Children in each *casa* learned to read, write and count before the age of six; and Dr. Montessori later perfected means by which children over six could individually study grammar, geometry, arithmetical operations with large numbers, fractions, music, biology, geography and history and elementary general science. Art work including lettering and decoration were also developed, and Dr. Montessori, who was a Roman Catholic, showed how active methods could be brought into learning the catechism—methods that were widely adopted in Latin countries and by some Protestant and other denominational schools. Her last book, *The Absorbent Mind* (1949), dealt with children under three, and in a highly original work, *To Educate the Human Potential* (1948), she showed the value to the modern child's mental development of teaching him something about pre-history.

*See* also PRE-ELEMENTARY EDUCATION; PROGRESSIVE EDUCATION.

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(C. A. C.)

**MONTEVERDI, CLAUDIO** (1567–1643), Italian composer, whose *Orfeo* is a landmark in the history of opera, was born at Cremona, where he was a pupil of Marc' Antonio Ingegneri (*c.* 1545–92), *maestro di cappella* of the cathedral. After an unsuccessful attempt to obtain an appointment at Milan in 1589 he entered the service of Vincenzo I, duke of Mantua, in 1590 as a stringplayer. In this capacity he accompanied the duke on an expedition to Hungary in 1595. In 1599 he married Claudia Cattaneo, a singer, by whom he had two sons and a daughter, and in the same year he accompanied the duke on a visit to the Low Countries. In 1602 he succeeded Benedetto Pallavicino (*d.* 1601) as director of music to the court of Mantua. His wife died in 1607, and in 1612 he was dismissed from his appointment by Francesco, the new duke of Mantua, who succeeded his father in that year. In 1613 Monteverdi was appointed *maestro di cappella* at St. Mark's, Venice, in succession to Giulio Cesare Martinengo (*d.* 1613) and remained in this office until his death. In 1632 he became a priest. He died in Venice on Nov. 29, 1643, and was buried in the church of Sta. Maria dei Frari. His elder son, Francesco (b. 1601), began his career as a student of law but, after becoming a Carmelite friar in 1620, turned to music and entered the choir of St. Mark's, Venice, in 1623. Massimiliano (b. 1604), Monteverdi's younger son, studied medicine and graduated at Bologna in 1626. He was arrested by the Inquisition for heresy in 1627 but was acquitted in the following year.

By the time he was 20 Monteverdi had published three works: *Sacrae Cantiunculae*, a collection of three-part motets (1582); *Madrigali spirituali*, of which only the bass part survives (1583); and his first book of secular madrigals (1587). He subsequently published seven more collections of madrigals in 1590, 1592, 1603, 1605, 1614, 1619 and 1638 (the last being entitled *Madrigali guerrieri et amorosi*); a ninth book (*Madrigali e canzonette*) appeared posthumously in 1651. Three further collections of secular music were published in 1584, 1607 and 1632 respectively: *Canzonette* (for three voices), *Scherzi musicali* (for three voices, with instrumental refrains) and a second set of *Scherzi musicali* (miscellaneous pieces for one and two voices with accompaniment).

Monteverdi's first opera, *Orfeo*, was performed at Mantua in 1607 and published in score two years later. It was followed in 1608 by *Arianna*, also produced at Mantua. Of the remaining five operas, one, a comedy, was written in 1627 (there is no record of a performance) and the other four were performed in Venice. Only two of these four survive, both in manuscript: *Il ritorno d'Ulisse in patria* (1641) and *L'incoronazione di Poppea* (1643). In addition to the *Sacrae Cantiunculae* mentioned above, Monteverdi published two further collections of church music: a Mass and Vespers (*Vespro della Beata Virgine*) (1610) dedicated to Pope Paul V and *Selva morale e spirituale* (miscellaneous pieces, including a second Mass, 1640). A third Mass and a number of other sacred pieces appeared posthumously in 1650. A substantial number of secular and sacred works were published in anthologies in the first half of the 17th century; a few others survive in manuscript.

Monteverdi was both a conservative and a progressive composer. Not only his youthful *Sacrae Cantiunculae* but also the Mass dedicated to Paul V are grounded in the traditions of the older polyphonic writing. His opera *Orfeo* borrows the idioms of recitative first used by the Florentine composers Jacopo Peri (1561–1633) and Giulio Caccini (*c.* 1550–1618), but there is much in it that would not have been out of place in a 16th-century pastoral play with music—songs, duets, choruses and instrumental pieces for contrasted groups. The impression which it makes is due partly to its formal symmetry but even more to the very personal idiom of the recitative. For Monteverdi this style of writing was not merely an imitation of speech but a representation in musical terms of human passion. A contemporary writer relates that Arianne's lament (all that remains of the opera

*Arianna*) moved the audience to tears, and this is hardly surprising. The same intensity is found in the concluding portion of *Il ballo dell' ingrate*, a masque dealing with the fate awaiting hardhearted ladies, which was produced at Mantua in the same year as *Arianna* and published 30 years later in *Madrigali guerrieri et amorosi*. The scenic cantata *Il combattimento di Tancredi e Clorinda*, performed at Venice in 1624 and also printed in *Madrigali guerrieri et amorosi*, achieves the same poignancy; but it also aims at a realism that the composer hardly touched elsewhere. Here the string orchestra represents the prancing of Tancred's horse and the fury of the battle between the two combatants. In his late operas Monteverdi was concerned even more with human emotions, since Ulysses and Penelope seem more than figures from mythology, and the principal actors in *Poppea* are historical characters. Here too the practice of introducing frequent arias and duets, which had become popular in Rome and was now adopted at Venice, offered abundant opportunities for variety; and the flirtation between two servants which forms an interlude in *Poppea* is handled so deftly that the loss of Monteverdi's only comic opera is to be regretted.

In his madrigals he shows an increasing desire to ally himself with the new fashion for solo songs and duets with keyboard accompaniment. The earlier ones inherit the emotional intensity and contrasts of mood to be found in the works for five voices by his older contemporaries, though with a stronger feeling for dissonance than they normally admitted. These "audacities" were criticized severely by Giovanni Maria Artusi (*c.* 1540–1613) in his *Delle imperfettioni della moderna musica* (1600 and 1603). Monteverdi's reply, elaborated by his brother Giulio Cesare in a postscript to the *Scherzi musicali* of 1607, was that he was not concerned with traditional rules of harmony but aimed at a truthful interpretation of the words. In his fifth and sixth books of madrigals (1605 and 1614) he included some pieces which required a keyboard accompaniment and were therefore not madrigals in the older sense of the word. In the seventh book (1619) the break with the past is complete, while the eighth book (1638) is a kind of anthology of vocal music of every kind. The range of expression here is very wide, from the most intense emotion to a lighthearted vivacity and charm. His "modern" church music, such as the Vespers of 1610, shows the same qualities, together with a splendid awareness of the sonority to be obtained by combining chorus and orchestra. In spite of the unhappiness of his life Monteverdi was far from being a consistently serious composer. But though his lighter music sometimes achieves little more than a successful imitation of current fashions, he was unequaled in his capacity for translating human suffering into sound.

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(JA. A. W.)

**MONTEVIDEO,** the southernmost, smallest and most important department in Uruguay, has about 113,000 inhabitants (1962 est.) not including the city of Montevideo (*q.v.*) (pop. [1962 est.] 940,012). The city's growth has increasingly urbanized and industrialized the outlying department. Nevertheless, truck gardens, vineyards, dairy and poultry farms, orchards and commercial flower gardens send products to the capital.

Country homes for capital residents, common in the early 20th century, are gradually disappearing as land values in the department rise and new resorts emerge on the Atlantic. The department's territorial extension, including the capital, is 208 sq mi.

(M. I. V.)

**MONTEVIDEO,** capital of Uruguay and one of South America's great cities, is on the northern shore of the Rio de la Plata estuary, 120 mi E.S.E. of Buenos Aires. Airplane travelers land at Carrasco airport, but the best first sight of Montevideo still is from the sea, heading into the harbour, with the Cerro and its light, a famous landmark, looming up to the left. Formerly ships had to be unloaded in the harbour by lighters, but beginning in 1901 the port, a government-operated enterprise, was modernized; it can dock the largest ships, unload them and move cargo to the multistory customhouse. The harbour district opens out into the Old City, the Ciudad Vieja, which once was colonial Montevideo. The buildings there, for the most part, are old and the streets are narrow, but the Old City is still the financial and business heart of Uruguay. The stock exchange, the central Bank of the Republic, head offices of private banks, foreign bank branches, shipping firms, export-import houses and lawyers locate there. The Old City culminates in the Plaza de la Constitución, with the cathedral on one side and the *cabildo*, the colonial municipal building and for many years the home of the Uruguayan legislature, on the other. Sarandí street, a narrow shopping centre, connects the Plaza de la Constitución with the more recent Plaza de la Independencia, Montevideo's major square. The traditional gesture for distinguished foreign visitors is to place a wreath of flowers at the foot of the mounted statue of the hero of national independence, José Gervasio Artigas, in the centre of the plaza. Government house is on the right of the statue, the modernistic Victoria Plaza hotel on the left. Facing the statue is the Palacio Salvo, the city's first skyscraper. Leading off the Plaza de la Independencia is the Avenida 18 de Julio, the Fifth avenue of Montevideo. Buses, Montevideo's basic public transportation, taxis and private cars, directed by one of South America's few traffic light systems, crowd the avenue, with its shops, theatres, cafés and business houses. Part way up 18 de Julio, Agraciada street, cut diagonally through city blocks, connects with the marble legislative palace, the most lavish public building in Uruguay. Agraciada is Montevideo's modernistic showplace. Avenida 18 de Julio continues to its end, the obelisk at the entrance of Batlle y Ordóñez park, location of the football stadium.

There are many other parks in the city, as well as a line of beaches extending out to the Atlantic. Of the beach suburbs, Pocitos, with its modernistic apartment buildings, is especially noteworthy.

The climate of Montevideo, somewhat blustery in winter, is moderate, with the mean annual temperature around 62° F. Rainfall is adequate, around 44 in. a year. Montevideo is one of the few South American capitals where tap water, brought from the Santa Lucia river, is totally safe, but the city's rapid growth has outstripped expansion of the water pipe system.

Perhaps nowhere else in the world does a city predominate in a nation's political, industrial, commercial and cultural life to the extent that Montevideo does in Uruguay. The port of Montevideo handles the vast bulk of Uruguay's foreign trade. Most of the country's manufacturing industry is there too. The most striking proof of Montevideo's predominance is its population size in relation to the rest of the country. The total population of Uruguay was estimated at 2,800,924 in 1954. Of these, 810,000 live in the capital city, and 853,649, nearly one-third the total national population, live in the capital department, Montevideo. One result of Montevideo's size is that Uruguay has a metropolis with cultural and economic opportunities far exceeding those a country with such a small population otherwise could afford.

**Commerce and Industry.**—Four rail lines converge on Montevideo, bringing the products of the interior for use, processing and export. About 90% of Uruguay's exports are from its ranches, with wool increasingly dominating the economy. Numerous establishments in the capital process wool, and refrigerated packing plants in the Cerro district are equipped to prepare meats. In addition to export-oriented processing industries, Montevideo possesses the largest portion of Uruguay's internally oriented consumers' goods industries. Textile, shoe, soap, match and clothing factories are scattered throughout the city. Wines and dairy products, mostly for local consumption, are produced in Montevideo.

Uruguay's well-known state enterprises, the ANCAP (Administración Nacional de Combustibles, Alcohol y Portland) oil refineries and cement works, the railway shops and the electric power system are concentrated there. Public employees are a large segment of Montevideo's consumers. Much of the city's economy revolves around providing varied services for its large population,

which is notably spread out territorially.

**History.**—Montevideo was founded in 1726 by Bruno Mauricio de Zabala, governor of Buenos Aires, to counteract the Portuguese advance into the area from Brazil. The first families came from the Canary Islands, lured by offers of cattle, sheep and respectability in the form of the title hidalgo. During its early years, Montevideo was mostly a Spanish garrison town. Trade expanded toward the end of the colonial period and Montevideo's merchants played an important part in securing Uruguayan independence. From 1807 to 1830 Montevideo was alternately occupied by British, Spanish, Argentine, Portuguese and Brazilian forces, and its trade and population suffered. Independence, which came in 1830, did not bring stability. Uruguay was the scene of complicated interaction of local, Argentine and Brazilian influences which culminated in the nine-year great siege of Montevideo by a combined Argentine-Uruguayan army from 1843 to 1851. Montevideo defenders were assisted by French and English forces which blockaded Buenos Aires. The result, surprisingly, was that Montevideo flourished during the siege and became the major port of the Rio de la Plata. The city's population in 1843 was estimated at 31,197, of whom 15,252 were noncitizen Europeans. The end of the great siege in 1851 and the restoration of normal trade patterns disrupted Montevideo's economy. The gradual development of the Uruguayan interior, spurred by railroad building outward from Montevideo, starting in the 1870s, and the installation of modern public utilities in the city, starting about the same time, gave Montevideo new life. A speculative building boom opened new suburbs. The collapse of the boom in the 1890s thoroughly slowed the city's growth, but in the 20th century its development has been rapid, as the following population figures for the department of Montevideo indicate: 1860, 58,000; 1908, 300,000; 1941 (est.) 750,000, 1962 (est.) 1,053,012.

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**MONTEZ, LOLA** (stage name of MARIE DOLORES ELIZA ROSANNA GILBERT) (1818–1861), adventuress and "Spanish" dancer, achieved international notoriety through her association with King Louis I of Bavaria.

Daughter of a British army officer, she was born in Limerick, Ire., lived briefly in India, and was educated in England. At 19 she eloped with Capt. Thomas James; this marriage was dissolved in 1842. After superficially studying dancing, she made a disastrous debut in London in 1843. Nevertheless, her striking beauty brought her engagements in Germany, Poland and Russia. In 1844 she appeared unsuccessfully at the Paris Opéra. Late in 1846, she danced in Munich. King Louis became deeply infatuated, and under her influence inaugurated liberal and anti-Jesuit governmental policies. She was named countess of Landsfeld. In 1848, however, the animosity of the Bavarian people forced her to flee.

From 1851 to 1853, she danced and acted in America. After appearances in Australia, she lectured in America on fashion, gallantry, beautiful women and similar subjects. Lola Montez' second marriage (1849), to Lieut. George Heald, ended with his death. Her third, to Patrick Purdy Hall of San Francisco, terminated in divorce. She died in New York on Jan. 17, 1861.

*See* Isaac Goldberg, *Queen of Hearts* (1936). (I. S. MC.)

**MONTEZUMA II** (MOCTEZUMA II) (1466–1520), the last Aztec emperor of Mexico, succeeded his uncle Ahuizotl in 1502. Montezuma's great competence as a military leader and the fact that he was a priest in the temple of the war god Huitzilopochtli ensured his election over that of his brothers. In accordance with tradition, his coronation was accompanied by mass human sacrifices and festivities. His rule tended to be despotic and oppressive and was occupied with many expeditions of conquest for territory and sacrificial victims, the suppression of insurrections and the erection of temples. The empire was enlarged by armies dispatched to Honduras and Nicaragua. Montezuma's reign was also accompanied by omens unfavourable to Aztec rule, notably that of the return of Quetzalcoatl, a tribal god or hero, white in colour and bearded, whose return was believed to be imminent. As Cortés and his men were regarded as fulfilling this tradition, Montezuma did not deal with them aggressively. He was made a prisoner of Cortés in Mexico City and an uprising against the Spaniards ensued under the leadership of Cuitlahuatzin, Montezuma's brother. In an effort to divert the attack, Cortés induced Montezuma to address his people from the Spaniard's stronghold. The angry mob responded by showering him with stones and arrows. Montezuma succumbed, either from wounds inflicted by the mob or at the hands of the Spaniards. (J. L. Ty.)

**MONTFAUCON, BERNARD DE** (1655–1741), French Benedictine at St. Maur, pioneer in the study of Greek palaeography and archaeology and a distinguished patristic scholar, was born at Soulage (Aude) on Jan. 16, 1655. He joined the Benedictine order in 1676 and in 1687 was sent to Paris to work on the Church Fathers. His chief publications in this field were editions of Athanasius (3 vol., 1698) and John Chrysostom (13 vol., 1718–38). As a student of manuscripts in Paris and in Italy he carried the Maurist preoccupation with original sources into a new field; his *Palaeographia Graeca* appeared in 1708. As a student of antiquities he sought to base his conclusions on the evidence of monuments and may thus be claimed as one of the founders of modern archaeology; he published his five-volume *L'Antiquité expliquée et représentée en figures* in 1719 (Eng. trans. 1721–25). He died in Paris on Dec. 21, 1741. *See also* MAURISTS.

*See* L. de Broglie, *La Société de l'abbaye de St. Germain-des-Près au 18e siècle: Bernard de Montfaucon et les bernardins*, 2 vol. (1891); *see also* H. Leclercq in F. Cabrol (ed.), *Dictionnaire d'archéologie chrétienne et de liturgie*, vol. 11, col. 2608–31 (1934), with list of Montfaucon's publications. (C. O. BA.)

**MONTFERRAT** (MONFERRATO), a historic march or marquessate, later a duchy, of northwestern Italy. Geographically Montferrat may be understood to extend from the western end of the Ligurian Apennines northward over the Bormida and middle Tanaro valleys to the Po, thus including most of the country that separates Turin from Alessandria in the modern Italian *regione* of Piedmont; but the historic Montferrat was early split into southern and northern halves by the county of Asti and furthermore had territory north of the Po, with centres in the Vercelli district and in the Canavese (the country west of the lower Dora Baltea river). Its first dynasty, the Aleramici, had their principal seats at Chivasso and at Moncalvo, but their successors had Casale (*see* CASALE MONFERRATO) as their capital from 1435.

**The Aleramici.**—The origin of the Aleramici is obscure, but charters of the 10th century A.D. indicate that the first nucleus of their power was in the county of Vercelli; that the investiture of Count Aleram with a march was connected with the reorganization of northern Italy by Berengar of Ivrea c. 910; and that under the Holy Roman emperor Otto I (Berengar's successor in Italy) Aleram acquired lands in the geographic Montferrat. One of Aleram's sons, Odo, founded the dynasty of Montferrat. Odo's descendants consolidated their power at home and were distinguished as crusaders. William V the Old, marquess from 1191 to c. 1190, helped the emperor Frederick I Barbarossa against Milan and finally went to fight in Palestine, where his eldest son, William Longsword (d. 1177), had already in 1176 married Sibyl, heiress of the kingdom of Jerusalem. William Longsword's brother Conrad (d. 1192) likewise went to Palestine, where he married Sibyl's sister Isabella and so became king of Jerusalem. Another brother, Boniface I (d. 1207), a poet and the patron of the troubadour Raimbaud de Vaqueyras, joined the 4th crusade and became king of Thessalonica (*see* CRUSADES; GREECE: *History*). William VII the Great, Boniface I's great-grandson, marquess from 1253 to 1292, was first a leader of the Guelphs, but was later invested with an imperial vicariate and, with help from his son-in-law the Byzantine emperor Andronicus II Palaeologus, withstood a league comprising Genoa, Asti, Pavia, Milan, Cremona and Brescia. Taken prisoner by rebellious Alessandria, he died in a cage, and the direct male line of the Aleramici became extinct with his son John (d. 1305).

**The Palaeologi.**—In 1310 Theodore Palaeologus (d. 1338), second son of John's sister Violante (or Irene), by Andronicus II, was invested with Montferrat by Henry of Luxembourg (the emperor Henry VII). Subsequent troubles endangered the frontiers

till Theodore II, marquess from 1382 to 1418, achieved stability for the territory through well-timed changes of face and participation in the affairs of the Visconti and of the emperors. The male line of the Palaeologi of Montferrat died out with John George, marquess from 1530 to 1533.

**The Gonzaga.**—Federigo II Gonzaga, duke of Mantua, who had married Margaret, daughter of William IX Palaeologus, became the chief claimant to Montferrat on John George's death (*see* GONZAGA). Against him, Charles III, duke of Savoy, put forward claims based on earlier marriage contracts. On Nov. 3, 1536, the emperor Charles V gave his decision in favour of Federigo, since the Habsburg duchy of Milan, lying between Mantua and Montferrat, was less likely to be threatened by this link than by the addition of Montferrat to Savoyard Piedmont on Milan's western frontier. Disliked by its new subjects, the house of Gonzaga ruled Montferrat harshly; and when the Franco-Spanish peace of Câteau-Cambrésis (1559) was being negotiated, during Guglielmo Gonzaga's reign, envoys from Casale tried in vain to have the Gonzaga succession set aside. The defenders of civil liberties, however, whom Guglielmo treated with ever-increasing severity from 1562 to 1569, found a protector in Emmanuel Philibert of Savoy. Diplomatic antagonism between Emmanuel Philibert and Guglielmo was intensified on the emperor Maximilian II's erection of Montferrat into a duchy for Guglielmo (1575), but was resolved by pacts and dynastic alliances. Under Vincenzo I Gonzaga, duke from 1587 to 1612 and the builder of the famous citadel of Casale, discontent subsided, as he took some ministers from Montferrat into his government; but the interval of prosperity ended with the death of his successor Francesco II (Dec. 1612).

War between Savoy and Spain (to which Milan then belonged) began when Charles Emmanuel of Savoy invaded Montferrat in 1613. It lasted till 1618, when the treaty of Pavia (Oct. 1617) was enforced; but Montferrat was again invaded by the Savoyards in 1625, during the international dispute over the Valtellina. In the War of the Mantuan Succession (1628–31), Montferrat was the major battleground: the citadel of Casale, occupied by the French, withstood two Spanish sieges (1628–29 and 1630). The treaty of Cherasco (1631) secured the disputed duchies to Charles of Gonzaga-Nevers but transferred Alba and 73 other localities to Savoy. In 1637, two years after the declaration of the Franco-Spanish war of 1635–59, Duke Charles died. His daughter-in-law Maria, regent for her son Charles II, adopted a pro-Spanish policy, but a plot for delivering Casale to the Spaniards failed, and the French garrison there withstood another siege (1640). In 1652, however, the Spaniards took Casale almost without bloodshed.

Duke Ferdinand Charles secretly agreed in 1678 to sell Casale to France (*see* IRON MASK), and the transaction was concluded on Sept. 29, 1681. In 1695, during the War of the Grand Alliance, the marquis de Crenan (Pierre de Perrien), capitulating after a siege, was induced by Victor Amadeus II of Savoy to dismantle the fortifications of Casale, so that it was militarily worthless when Ferdinand Charles recovered it. Finally, in 1707, the emperor Joseph I declared that Ferdinand Charles had forfeited his duchies by taking France's side in the War of the Spanish Succession, and Montferrat was annexed to Savoyard Piedmont.

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**MONTFORT,** a family name derived from an ancient lordship in the Île-de-France (Montfort-l'Amaury, between Mantes and Rambouillet). It first became famous in French and English history through members of the family holding the lordship in the 13th century, and it was transmitted to a junior branch of the Capetian house of Dreux, which furnished dukes of Brittany in the 14th–15th centuries. In the Breton connection it is important to distinguish this ducal house of Montfort from the house of Montfort in Brittany (lords of Montfort west of Rennes), members of which were counts of Laval (*q.v.*) in the 15th–16th centuries.

Montfort-l'Amaury took its name from AMAURY or Amalric (d. *c.* 1053), the builder of the castle there, whose father William, probably a younger son of a count of Hainaut, had been invested with the lordship of the place by Hugh Capet. This Amaury's grandson, another AMAURY (d. 1137), inherited the countship of Evreux in Normandy from his mother, Agnes; but Evreux eventually had to be ceded to Philip II Augustus of France (1200).

The last-named Amaury's son SIMON (d. 1181 or later) married Amicia, ultimately the heiress of the English earldom of Leicester; and it was with their son, the crusader SIMON DE MONTFORT (d. 1218), that the family first attained real prominence. Simon set out for the fourth crusade and was at the sack of Zara (Zadar) in 1202, but went on to fight in Syria instead of sacking Constantinople. He returned to France in 1207. Thereafter his name was inseparably linked with the Albigensian crusade, or war against the heretical Cathars (*q.v.*) of Languedoc, which was proclaimed in 1208. In his ferocious prosecution of this crusade he was driven as much by ambition and greed as by religious zeal. When Raymond Roger Trencavel was despoiled of the viscounties of Béziers and Carcassonne (1209), Simon took them for himself, overriding the claims of the infant Raymond Trencavel, Raymond Roger's son. Raymond VI of Toulouse finally took up arms against the crusaders, but was defeated in the battle of Muret (*q.v.*; Sept. 1213); and Simon, having occupied Toulouse, was confirmed in his possession of most of Raymond VI's lands by the fourth Lateran council (1215). He did homage to Philip Augustus for his new territories and styled himself count of Toulouse, viscount of Béziers and Carcassonne and duke of Narbonne, but his dispossessed victims did not let him enjoy his gains in peace. Simon died on June 25, 1218, while besieging rebellious Toulouse. By his wife Alice de Montmorency he left four sons: AMAURY, who succeeded to Montfort-l'Amaury and to his father's titles in Languedoc (*see* below); SIMON, who became earl of Leicester and played a major role in English affairs (*see* MONTFORT, SIMON DE); GUY (d. 1220) de Bigorre; and ROBERT (d. 1226).

AMAURY DE MONTFORT (d. 1241) lost Simon's conquests. He failed to take Toulouse and, after the death of Raymond VI (1222), was obliged to treat with the latter's son Raymond VII. Having left Béziers and Carcassonne for Raymond Trencavel to occupy, he renounced all his rights in Languedoc to Louis VIII (conditionally in 1224, definitively in 1229) and was compensated with the office of constable of France (1231). Captured by the Muslims in the holy land (1239) he was released in 1241 but died at Otranto in Apulia on his way home.

GUY (d. 1228), lord of La Ferté-Alais, a brother of the crusading Simon, with whom he was at Zara and in Syria, also took a large part in the Albigensian crusade, receiving the fiefs of Rabastens and St. Antonin. He ceded his rights in Languedoc to the French crown in 1226.

JOHN DE MONTFORT (d. 1249), Amaury's son and successor, left only a daughter, BEATRICE (d. 1312), who was married in 1259 to Count Robert IV of Dreux. Their daughter YOLANDE (d. 1322) was married first, in 1285, to Alexander III of Scotland, and second, in 1294, to Arthur II of Brittany, to whom she brought the Montfort lands. Their son JOHN DE MONTFORT (d. 1345), whose elder half brothers accorded him only the Montfort title, contested the duchy of Brittany with Charles (*q.v.*) of Blois; and his son was recognized duke of Brittany, as JOHN IV (*q.v.*), by the treaty of Guérande (1365). Thenceforward he and his descendants JOHN V (*q.v.*), FRANCIS I (d. 1450), PETER II (d. 1457), ARTHUR III (*q.v.*) and FRANCIS II (*q.v.*) constituted the house of Montfort as dukes of Brittany; but Francis II left only an heiress, Anne (*q.v.*). Her marriages to Charles VIII and to Louis XII of France were followed by that of Claude, her daughter by Louis, to Francis I, which union secured the Montfort possessions to the French crown.

Montfort-l'Amaury was ceded by Louis XIV to Charles Honoré d'Albert, duc de Chevreuse, in exchange for the greater part of the

duchy of Chevreuse (arrangements of the 1650s confirmed in 1692). Thereafter the title duc de Montfort was sometimes assumed as a variant of duc de Chevreuse.

**MONTFORT, SAINT LOUIS MARIE GRIGNION DE** (1673–1716), French priest, founder of two religious congregations and apostle of devotion to the Blessed Virgin Mary, was born the son of Jean Baptiste Grignion at Montfort-sur-Meu, Brittany, Jan. 31, 1673. After eight years as a student at the Jesuit college at Rennes, and two years of clerical studies, he entered the Seminary of St. Sulpice, Paris, where he was ordained a priest in 1700. He went to Nantes as a rural preacher, and then to Poitiers, where he reorganized a hospital for the poor and began the Congregation of the Daughters of Wisdom. Named (1706) apostolic missionary for France by Pope Clement XI, he spent the rest of his life zealously preaching parish missions in western France. In 1705 he founded the Company of Mary (Montfort Fathers), a missionary congregation, to continue his work.

Montfort died at the age of 43 at St. Laurent-sur-Sèvre, on April 28, 1716, and was canonized July 20, 1947. His feast day is April 28.

Although primarily a parish missioner, Montfort is best known as the author of *True Devotion to the Blessed Virgin*, whose doctrine is that true devotion to Mary is the best means to the love and possession of Wisdom Incarnate, Christ crucified, the supreme goal of life. The teaching of this book is fully understood only in the context of another of his books, *The Love of Eternal Wisdom*, the synthesis of his whole spirituality.

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**MONTFORT, SIMON DE** (c. 1208–1265), earl of Leicester, leader of the baronial revolt against Henry III of England, was the third son of Simon de Montfort l'Amaury, leader of the Albigensian crusade, and of Alice de Montmorency. Born about 1208 at Montfort in the Île-de-France, Simon was wholly French by birth and education. On coming of age, he renounced to his eldest brother Amaury his claims on the family lands in return for the sole right to revive the Montfort claim to the English earldom of Leicester. This claim derived from his father's mother, Amicia, sister of Robert IV (d. 1204), the last Beaumont earl of Leicester, whose lands had been divided between Amicia and her younger sister Margaret, countess of Winchester. King John had recognized Simon's father as earl (c. 1205) but had deprived him as a French subject (1207), and the Montfort claim had then lapsed.

Simon came to England in 1229 and, helped by his cousin Ranulf, earl of Chester, the tenant of the confiscated estates, obtained the honour of Leicester and did homage to Henry III in 1231, though he was not formally styled earl of Leicester until Oct. 1236. He speedily became one of Henry's favourites, receiving an annual fee of 500 marks to compensate for the divided inheritance, and exercising the hereditary stewardship at Queen Eleanor's coronation (1236). Henry arranged for his sister Eleanor, widow of William Marshal II (d. 1231), earl of Pembroke, to marry Simon on Jan. 7, 1238, thus breaking Eleanor's earlier vow of chastity and offending the English magnates, who were not consulted. Henry's brother, Richard, earl of Cornwall, led an angry baronial protest, and Henry, alarmed, turned against Simon and Eleanor, driving them from England (Aug. 1239). Simon went on crusade (1240–42) with Richard, with whom he was now reconciled, and won great opinions among the magnates of the Latin kingdom of Jerusalem, who asked their absentee king, the emperor Frederick II, to appoint Simon as his viceroy there. Simon, returning, joined Henry's disastrous Poitevin campaign (1242), winning distinction by covering Henry's escape after his defeat at Saintes. Reconciled with Henry, and accepting an unfavourable settlement of Countess Eleanor's dower claims, Simon now made Kenilworth castle (a royal grant) his headquarters. He cultivated the friendship of the radical reformer Robert Grosseteste, bishop of Lincoln, and took Robert's friend, the Oxford Franciscan Adam de Marisco, as spiritual director. Although regarded as a king's man, Simon was one of the committee of 12 appointed to handle the acute crisis of 1244 between Henry and his angry barons. He also took part in many important embassies to the French, papal and imperial courts, winning golden opinions and making good friends.

In 1248 Henry asked Simon to pacify the duchy of Gascony, where his dual authority had collapsed. Simon, eager to join Louis IX's crusade, accepted reluctantly, stipulating for full powers as regent for seven years, without fear of recall, and with full refund of expenses incurred. Treating the conscienceless Gascon nobles as faithless rebels outside the law, he ruthlessly crushed the revolt and restored order; the Gascons, unused to firm treatment, appealed to Henry, accusing Simon of illegal procedure and oppression and threatening to renew their revolt. The matter was complicated by Simon's personal contest with Gaston de Foix, viscount of Béarn, the leading rebel, who had sought to deprive Simon's great-nephew Esquivat de Chabannais of the county of Bigorre, of which Simon had been nominated guardian. Henry, frightened, recalled Simon for trial on the rebels' charges; the English magnates acquitted him (1252), and he returned to Gascony to suppress the renewed revolt, but Henry now terminated his lieutenancy. Simon, accepting a partial financial settlement, withdrew to France, though Henry had to implore his help in his own campaign against the rebels in 1253. Such was Simon's international reputation that when Louis IX's mother, Blanche of Castile, died (Nov. 1252) while Louis was still on crusade, the French magnates invited Simon to succeed her as regent.

Henry's behaviour over Gascony, though not wholly unjustified, finally convinced Simon that Henry was unfit to rule, and the king's disastrous undertaking, at Pope Innocent IV's behest, to conquer Sicily for his son Edmund, strengthened this conviction. Discussions with Grosseteste, De Marisco and other Franciscan intellectuals had fired Simon's mind with visions of a new order in both church and state, and he joined the other leading English barons in forcing upon Henry the revolutionary Provisions of Oxford (*q.v.*; June 1258). The reformers began well, but by Oct. 1259 divisions appeared between the conservative wing, led by Richard de Clare, earl of Gloucester (d. 1261), that sought only to limit abuses of royal power, and the radical element, led by Simon, that sought to bind the entire baronage to observe the reforms forced upon the king and his officers. Simon exacerbated the quarrel by his arrogant vehemence, and put himself in the wrong by attempting to use Henry's subordination to secure settlement of his own and his wife's justifiable personal claims on Henry. Henry, allying with the Gloucester faction, shattered baronial unity early in 1260, and Simon emerged leading the extremist defenders of the reforms. By Oct. 1261 Henry had isolated Simon, who went abroad, but the king's annulment of the Provisions, after he had received papal absolution from his oath to observe them, revived general disaffection (1262) and Simon returned (April 1263) to lead a rebellion which restored the Provisions (July 1263). But baronial unity had vanished, and despite passionate support from the lesser barons, the county knights, the men of London and the Cinque Ports, and many clergy, Simon was forced to accept arbitration by Louis IX (Dec. 1263). By the Mise of Amiens (Jan. 1264) Louis totally annulled the Provisions and all consequent reforms. Simon rejected the award and, after unsuccessfully attempting direct negotiations, defeated Henry at Lewes (May 14, 1264), capturing Henry, his son the Lord Edward, his brother King Richard and Richard's son Henry of Almain.

Simon now governed England by military dictatorship, striving unsuccessfully for a legal basis of consent, both by negotiations with Henry's supporters and by calling representatives of both shires and boroughs to parliament (1265) to counterbalance his lack of baronial support. But his monopolization of power alienated his chief ally, the young Gilbert de Clare, earl of Gloucester, who joined the royalist Marcher lords and secured the Lord Edward's escape at Hereford (May 1265). By rapid and skilful manoeuvring Edward isolated Simon behind the Severn, destroyed at Kenilworth (Aug. 1) the large army coming to his rescue, and trapped Simon's little force at Evesham (Aug. 4, 1265), slaying Simon and most of his followers.

The Pope quashed the popular attempt to canonize Simon, but for all his faults he is remembered as a devoted champion of justice and of radical reform, the first advocate of a limited monarchy ruling through elected councilors and responsible officials, the deliberate fosterer of parliaments including county knights and burgesses, and a brave and resolute commander.

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**MONTGELAS DE GARNERIN, MAXIMILIAN JOSEPH,** GRAF VON (1759–1838), the statesman who founded modern Bavaria, was born in Munich on Sept. 10, 1759, the son of a Savoyard nobleman in the Bavarian service. Educated at Nancy, at Strasbourg and at Ingolstadt, he was appointed censor of books for Bavaria in 1779, but had to leave Munich in 1785 because of his association with the Illuminati (*q.v.*). Having entered the service of Charles II Augustus, duke of Zweibrücken, he was from 1795 closely attached to the latter's successor, Maximilian Joseph, who on becoming elector of Bavaria in 1799 kept him as his prime minister. (*See* MAXIMILIAN I Joseph, king of Bavaria.)

Montgelas wanted to set Bavaria up as an independent and effective power between Austria and France. The house of Wittelsbach, with possessions scattered across Germany, had previously sought to strengthen its holding on the lower Rhine instead of challenging Austria in the east. Montgelas reversed this policy. The Napoleonic Wars (*q.v.*) gave him his opportunity, and he brought Bavaria to France's side in 1805. For the degree of success that he achieved in the consolidation of territory round the old Bavaria, with the creation of the kingdom in 1806, *see* BAVARIA: *History*. Bavaria's enforced membership of the Confederation of the Rhine made complete independence impossible; yet by obstructing the confederation Montgelas kept a large measure of freedom. But the post-Napoleonic settlement with Austria by the treaties of 1814–16 and Bavaria's entry against his will into the German confederation (1815) meant the failure of his project for an effective buffer state.

For internal affairs, Montgelas from 1785 had been producing schemes for the development of his backward country. In the spirit of the Enlightenment, he took no account of traditional institutions. He not only dissolved the Bavarian estates (1804) but also proceeded to secularize the lands of the church and the monasteries, which comprised two-thirds of the area of old Bavaria. This secularization ought to have been the prelude to a thorough reform of the Bavarian finances, but the shortage of ready money caused it to degenerate into mere pillage and squandering; and though he was finance minister from 1803 to 1817 Montgelas could never put the finances in order. Minister of the interior also from 1807, Montgelas in 1808 produced a written constitution for Bavaria—the first ever for a German state. This set up the council of state as the supreme court of appeal for all citizens, abolished serfdom and the nobility's exemption from taxes and proclaimed the principle of equality before the law. It also envisaged representative assemblies (as did a project drafted in 1814 for another constitution). In practice, however, it was never wholly applied. Montgelas considered Bavaria not yet ready for representative assemblies: his ideal was a bureaucracy controlled by law. Meanwhile his "Organic edicts" (up to 1814) helped to build up a strictly centralized administration.

At a moment when Montgelas was negotiating with the Austrian foreign minister Metternich for a territorial link between Bavaria and the newly acquired Palatinate lands, the crown prince Louis procured his dismissal from office (Feb. 2, 1817). Seeing his lifework brought to nothing, Montgelas took no further part in politics. He died in Munich on June 14, 1838. Editions of his memoirs were published in 1887 and 1908.

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**MONTGOLFIER, JOSEPH MICHEL** (1740–1810) and **JACQUES ETIENNE** (1745–1799), brothers, French inventors who developed the first balloon that carried man aloft. Born at Annonay, both brothers had the benefit of a sound scientific education. They carried on their father's paper manufacturing business at Annonay, but maintained their interest in scientific experimentation. In 1782 they discovered that heated air, when collected inside a large lightweight paper or fabric bag, caused the bag to rise into the air. The Montgolfiers made the first public demonstration of this discovery on June 5, 1783, at the market place in Annonay. They filled the balloon with heated air by burning straw and wool under an opening at the bottom of the bag. The balloon rose into the air about 1,500 ft., remained there some 10 minutes and then settled to the ground about 7,500 ft. from where it rose. The Montgolfiers traveled to Paris and then at Versailles repeated the experiment with a larger balloon on Sept. 19, 1783, sending a sheep, a rooster and a duck aloft as passengers. On Nov. 21, 1783, the first manned free flight took place in a Montgolfier balloon with Pilâtre de Rozier and the marquis d'Arlandes as passengers. The balloon sailed over Paris for 5½ mi. in 25 minutes.

The two brothers were honoured by the French Académie des Sciences for their work. They published several books on aeronautics and continued their scientific careers. Joseph invented a calorimeter and the hydraulic ram, and Jacques developed a process for manufacturing vellum. Jacques died at Serrières on Aug. 2, 1799, and Joseph died at Balaruc-les-Bains on June 28, 1810. *See* BALLOON.

**MONTGOMERIE, ALEXANDER** (*c.* 1545–*c.* 1611), Scottish poet, one of the last of the "makaris" (poets writing in Scots) of the 16th century, was the son of John Montgomerie, laird of Hessilheid in Ayrshire. He enjoyed the favour of James VI, and was awarded a pension of 500 marks in 1583 but a lengthy and unprofitable lawsuit arose over payment. Montgomerie's pro-Catholic political intrigues brought about his disgrace when he was implicated in the Ladyland plot of 1597. He was abroad from 1586 to 1591, perhaps on the king's service, and suffered imprisonment, for which he blamed the king in some bitter verses.

Montgomerie's contemporary reputation was high, and during the 17th and 18th centuries his best-known poem, *The Cherrie and the Slae*, was reprinted many times. This poem, first printed in 1597 and later enlarged, is an allegory in the medieval manner, fresh in its descriptions but conventional in its May morning setting and in such figures as Danger, Dreid, Reason, Curage and Dispaire whose intricate and tedious debate fills the larger part. The poet's dilemma is whether to struggle toward the noble cherry tree on the crag or to be content with the sloe bush at his feet. The poem was printed by Allan Ramsay in *The Ever Green* (1724), and its long stanza was revived by Robert Burns in "The Jolly Beggars." Montgomerie's other poems include the scurrilously inventive "Flyting betwixt Montgomerie and Polwart" (1621); some versions of the Psalms; and a large number of sonnets, lyrics and songs, the best of which reveal a fluent and radiant talent for love poetry. Montgomerie's poems were edited by J. Cranstoun for the Scottish Text society (1887), with a supplementary volume edited by G. Stevenson (1910); *The Cherrie and the Slae* was edited by H. H. Wood (1937).

*See* C. M. Maclean, *Alexander Scott, Montgomerie, and Drummond of Hawthornden as Lyric Poets* (1915). (E. G. M.)

**MONTGOMERY, JAMES** (1771–1854), British hymnologist, poet and journalist, who is best remembered for his hymns and versified psalms, which are among the finest in the English language, uniting fervour and religious insight in simple verse. He was born at Irvine in Ayrshire, Scot., the son of a Moravian minister, on Nov. 4, 1771, and educated at a Moravian school at Fulneck, near Leeds. After starting life as a shop assistant, he became a journalist and edited the *Sheffield Iris* (1794–1825), being twice imprisoned for printing allegedly seditious reports.

Montgomery wrote 22 books of verse, notably *The Wanderer of Switzerland* (1806), the story of exiles from revolutionary France; *The World Before the Flood* (1813), *Greenland* (1819), which contains some of his best descriptions, and *Pelican Island* (1828), portraying life on earth from the shellfish to the advent of man. In 1835, through the agency of Sir Robert Peel, he received a pension of £150 a year. He died in Sheffield on April 30, 1854.

See *Poetical Works*, 4 vol. (1841); *Memoirs of the Life and Writings of James Montgomery*, ed. by J. Holland and J. Everett, 7 vol. (1854–56). (W. L. G. JA.)

**MONTGOMERY, RICHARD** (1738–1775), British and American army officer, was born in County Dublin, Ire., on Dec. 2, 1738. Educated at Trinity college, he entered the British army in 1756 and took part in the Seven Years' War. He returned to England and became well acquainted with members of the parliament interested in development of American colonies. In 1772 he left the army, settled in New York and married a daughter of Robert R. Livingston, a justice of the New York supreme court. In 1775 he served as a delegate to the provincial congress and became a brigadier general in the continental army. When sent to invade Canada he was hampered by harsh weather and undisciplined troops but managed to capture Montreal and meet Benedict Arnold's contingent. They pushed on to Quebec barely 800 strong, but in the assault on Dec. 31, 1775, Montgomery was killed. His body was interred by the Quebec garrison, but was removed in 1818 to St. Paul's church, New York city, where congress had provided a memorial. (H. H. P.)

**MONTGOMERY, ROBERT** (1807–1855), English minor poet, who wrote popular religious verse, was the natural son of Robert Gomery, a theatrical clown. He was born in 1807 at Bath, where he was educated and edited an unsuccessful paper. In 1828 he published a florid, rhetorical religious poem, The *Omnipresence of the Deity*, which was an immediate success and went through 28 editions in his lifetime. Lord Macaulay's scathing ridicule in the *Edinburgh Review* (April 1830) did not deter Montgomery's admirers. Most popular among 32 other works were *Satan* (1830) and *Woman* (1833). In 1833 he received a B.A. at Oxford and in 1835 took orders. After holding various preforments he died at Brighton on Dec. 3, 1855.

See *Poetical Works*, 6 vol. (1839–40). (W. L. G. JA.)

**MONTGOMERY,** a town and district in Multan division, West Pakistan. The town, headquarters of the district, lies 95 mi. S.W. of Lahore. Pop. (1961) 75,180. In 1865, Sahiwal village, which lay on the newly opened railway from Lahore, was chosen as the district headquarters and renamed Montgomery after Sir Robert Montgomery, lieutenant governor (1859–65) of the Punjab (Panjab). It was then in a desolate sandy area and singularly comfortless until reached by irrigation from the Lower Bari doab canal in 1913. The town is well planned and is an important cotton centre. There are two colleges affiliated with the University of the Panjab.

MONTGOMERY DISTRICT lies in the Bari doab, or tract between the Sutlej and Ravi rivers, extending also northwestward across the latter. Pop. (1961) 2,134,072. Area, 4,224 sq mi. The climate is arid and hot, the average annual rainfall at Montgomery town being 10 in. The principal crops are wheat, cotton, pulses and oilseeds; manufactures include cotton goods and lacquered woodwork, and there is cotton ginning and pressing. Okara (pop. 68,299 [mun.]) has a factory for cotton spinning and weaving.

The important archaeological site of Harappa (*see* INDUS CIVILIZATION) in the southwest indicates a very early connection between the northwestern part of the subcontinent and Sumerian culture. Ruins at Kamalia, Akbar, Satghara and Bavanni mark the sites of forgotten towns. (K. S. AD.)

**MONTGOMERY,** the capital of Alabama and seat of Montgomery county, located on a sharp bend on the Alabama river at the head of navigation of that stream, is one of the older and more historic cities of the deep south. The city has an average temperature in January of 48.9° F. and in July of 81.7°, the annual mean temperature being 65.6°. The annual rainfall is 51.73 in. Pop. (1960) city 134,393, standard metropolitan statistical area (Montgomery and Elmore counties) 169,734. For comparative population figures see table in ALABAMA: *Population*.

**History.**—Montgomery's early history is a story of Indians, Spaniards and Frenchmen, squatters and traders, speculators and settlers. In its earliest history the site of Montgomery was inhabited by the mound builders. Later, Indians migrated to the region and established their towns of Tawasa and Econchati on the same ground. In 1540 De Soto and his entourage camped on the site. The Frenchman Jean Baptiste le Moyne, Sieur de Bienville, headed an expedition up the Alabama river and in 1713 built Ft. Toulouse a short distance above the present site of Montgomery. During the American Revolution the site was headquarters for the British sympathizers in the area.

The territorial government of Alabama was established in 1817 and the land in the new territory was sold in August at the Milledgeville, Ga., federal land office. John Scott and Andrew Dexter bought the land on which the present city of Montgomery is located. Shortly after the land sale three towns, New Philadelphia, East Alabama and Alabama were established on the site. In Dec. 1819, the legislature of Alabama chartered these three consolidated towns as Montgomery. The name was chosen in honour of Brig. Gen. Richard Montgomery, who was killed at Quebec in 1775.

The new town became the home of Georgians, Carolinians and Virginians who lifted the westward movement. It was chartered as a city in 1837; in the 1840s it became one of the most important inland towns in the region. It was an important political centre for its immediate vicinity as well as the state as a whole and became the state capital in 1847. During the next few years it became the centre of southern political opinion in the secession movement and eventually became the first capital of the Confederacy in 1861. It was captured by federal troops in 1865.

Montgomery's recovery from the American Civil War was slow. Because of its central geographic location in the state and its being the state capital it benefited from the expansion of railroads in the 1880s. In the 20th century industrialization and population increased steadily.

The city has many points of historic and artistic significance. Among these are the state capitol, which was also the first capitol of the Confederacy. It stands on a hill at the head of the main business street and is one of the finest examples of Georgian architecture in the U.S. It was there that Alabama voted to secede from the union on Jan. 11, 1861 and the Confederate States of America was organized there on Feb. 4, 1861—hence the popular designation of Montgomery as the "Cradle of the Confederacy." Other important buildings are the first White House of the Confederacy, where Jefferson Davis resided and which contains a collection of his personal belongings; the state's department of archives and history, which contains one of the largest collections of historical materials on the south and also extensive museum collections; the Museum of Fine Arts, which contains several historic collections; and the Alabama State coliseum, which contains one of the largest indoor arenas in the U.S.

**Commerce and Industry.**—Montgomery is an important centre and market for cotton, livestock, yellow pine and hardwood; it has many jobbing and wholesale businesses and is one of the principal cities in the nation for the manufacture of commercial fertilizer. It is the largest cattle market in the southeast, marketing approximately $30,000,000 worth of cattle annually. There are three large stockyards with full facilities for handling sales to the several local packing plants and to those in distant cities. Surrounding the city are rich farmlands and cattle ranches.

Montgomery is the site of Maxwell and Gunter air force bases. Maxwell is headquarters of the Air University system, consisting of the Air War college, Air Command and Staff college, Research Studies institute and the Air University library. Gunter is the location of the U.S. Air Force Extension Course institute and a branch of the School of Aviation Medicine. The personnel of these bases add much to the civic, commercial and cultural life of Montgomery. In addition to these air force bases, Montgomery has a fine municipal airport, Dannelly field.

**Education, Communication and Recreation.**—Montgomery has several private schools as well as an extensive public school

system. It is the site of Huntingdon college, (Methodist, established 1854); Alabama State college, moved there from Marion in 1887; and a centre of the University of Alabama.

There are two daily papers and one weekly; the *Advertiser*, a morning paper, has been published continuously since 1828. City parks cover about 500 ac. The annual Blue and Gray football game has been played at Cramton bowl since 1939.

**Civil Rights.**—Led by the Rev. Martin Luther King (*q.v.*), then a Montgomery minister, Negroes organized a peaceful boycott of the public busses in Dec. 1955 to protest segregation; a year later segregation on busses was prohibited by court order. A drive to register Negro voters in 1965, centred at Selma, was countered with terrorism and violence. The slaying of Rev. James J. Reeb of Boston resulted in a protest march on Montgomery, led by King and joined by thousands. After the march, Viola Gregg Liuzzo of Detroit, having transported fellow-marchers to Selma, was murdered as she drove back to Montgomery. (G. T. C.)

**MONTGOMERY** (Trefaldwyn), a municipal borough and the titular county town of Montgomeryshire, Wales, lies 2 mi. from the Severn and 7 mi. S. of Welshpool. Pop. (1961) 972. The smallest borough in point of population in England and Wales, Montgomery is a quiet market town with a Georgian town hall and streets. The cattle and sheep market is locally important. There are traces of Neolithic habitation within the Early Iron Age camp of Ffridd Faldwyn on a hill above the town; but the district appears to have been waste hunting ground at the time of the Domesday survey, and there was no Welsh settlement when Roger de Montgomery, a follower and relative of William the Conqueror, erected his motte-and-bailey castle, called after his ancestral home in Normandy. This castle, with a hamlet round it, is at Hendomen, a mile northwest of the present town. The Welsh name (meaning "Baldwin's town") presumably took its name from Baldwin de Bollers, a subsequent tenant of the crown. In 1223 Henry III built a stone castle (now ruined) on a rock at "New Montgomery," the existing town, which was given a royal charter in 1227 and was re-incorporated in 1885. The Montgomery boroughs returned one member to parliament until 1918, when the seat was abolished. The parish church of St. Nicholas was built about 1227 and contains two 15th-century roofs, screens and stalls. Henry's castle, later held by the Mortimers, passed to the Herberts in the mid-16th century. George Herbert, the Caroline divine and poet, was born in the castle, which was surrendered in 1644 to the parliamentarians by his elder brother, Lord Herbert of Chirbury, and dismantled by them. The 8th-century Offa's dike, a mile east of the town, there divides Wales from England. (J. D. K. L.)

**MONTGOMERY OF ALAMEIN, BERNARD LAW MONTGOMERY,** 1st Viscount (1887– ), British field marshal, one of the outstanding military leaders of World War II, was born in London on Nov. 17, 1887; he was the son of Bishop H. H. Montgomery, of north Irish stock, and was educated at St. Paul's school and at Sandhurst Royal Military academy. Having served with distinction in World War I, he was recognized as a first-rate trainer of troops, with his forcible insistence on physical fitness, youth and efficiency in leaders. In World War II he commanded a division in France and held the southeastern command in England before succeeding to the command of the British 8th army in Egypt (Aug. 1942). There he restored the troops' shaken confidence and, combining drive with caution, inaugurated an unbroken series of successes in Africa and Europe by defeating Rommel at El Alamein (Oct.–Nov. 1942), pursuing the Germans to their surrender at Tunis, and then invading Sicily and Italy. Under the supreme command of Gen. Dwight D. Eisenhower, Montgomery commanded the Allied armies which broke into Normandy in June 1944, and led the 21st army group (British and Canadian) through northern France and across the Rhine to receive the German surrender on Lüneburg heath on May 4, 1945.

After commanding the British Army of the Rhine, Montgomery served as chief of the imperial general staff (1946–48), chairman of the Western Europe Commanders'-in-Chief committee (1948–51), and deputy supreme Allied commander in Europe (1951–58) in NATO. Convinced that it is important for a commander's personality to impress itself on his troops and fellow countrymen if their confidence is to be won, Montgomery made himself one of the best-known figures of the day. His periodical pronouncements on strategy and military organization aroused widespread interest, as did the publication of his *Memoirs* in 1958. (J. R. M. B.)

**MONTGOMERYSHIRE** (Welsh, Sir Drefaldwyn), a county of Wales, is bounded on the English side by Shropshire, with Denbighshire and Merionethshire as its northern and northwestern and Radnorshire and Cardiganshire as its southern and southwestern neighbours. Area 797 sq.mi.

Its physical limit to the north is the Berwyn mountains, and in the south the ranges of Rhydd Hywel, the Kerry hills and Clun forest. From east to west it is the only Welsh county to extend from the Shropshire plain across the Pumlumon (Plynlimon) massif to reach tidal waters in the Dyfi (Dovey) estuary. Geologically it consists mainly of Ordovician and Silurian grits and shales, with some little Devonian on the southeastern border and two volcanic intrusions in the east and southeast to give the spectacular Breidden hills (Moel-y-Golfa, 1,324 ft.) and Corndon hill (1,684 ft.). The Paleozoic rocks were formerly worked for lead, with some silver and zinc, while the volcanics are still of value for road metal.

The county contains three different types of topography. First there is an arc of mountain and moorland running from the Berwyn mountains in the north, through Pumlumon in the west, to the Kerry hills and Clun forest in the south and east. These areas are more than 1,000 ft. in elevation, exceeding 2,700 ft. (Moel Sych) in the Berwyns, and just under 2,500 ft. in Pumlumon. Secondly there are the valley lowlands, including part of the Dyfi valley but comprising mainly the valleys of the upper Severn (Vale of Powys or Powis) and its northern parallel and also the tributary streams of Vyrnwy, Cain and Tanat. These, together with the upper Wye in the extreme southwest of the county, tongue deeply into the mountains and are extensions from the English plain. The third element consists of intermediate plateau surfaces of between 600 ft. and 1,000 ft. in height, frequently broken into separate blocks as a result of dissection, and heavily blanketed by glacial boulder clay. Glacial action has also caused modifications of drainage, so that in these plateaus post glacial gorges contrast markedly with semi-mature valleys and basins.

Vegetation and soils within the county vary from the peat, heather or *Nardus-Molinia* moorland of the mountains, where the Forestry commission is particularly active, through the heavy clays of the plateaus, mainly in grass, to the fertile alluvium of the vales which, though liable to flooding, form a rich parkland landscape. It is this juxtaposition of mountain, plateau and vale which makes Montgomeryshire a border county. (J. G. T.)

**History.**—The earliest known living site in the central marches of Wales is a Neolithic open settlement on Ffridd Faldwyn, above the town of Montgomery, covered by a later hill fort of the Early Iron Age. Traffic in axes of stone and flint passing this way followed valley routes between north and south Wales, whereas many of the round barrows of the ensuing Bronze Age are on high ground and are related to moorland ridgeways, notably that along the Kerry hills which formed part of a west-east trade route from Cardigan bay to the lower Severn valley by way of the south Shropshire hills. The upper Severn valley was always an important line of diffusion. Distribution of stone and bronze implements also indicates ways following natural passes, such as the Carno-Dyfi route in the west of the county, the Bwlch-y-Fedwen in the northwest and the Tanat valley in the northeast. Otherwise the hill country of central Montgomeryshire suggests little evidence of occupation until the Early Iron Age, when the eastern part of the county was thick with hilltop camps, including a number of major hill forts, with penetration westward from the Severn basin. The builders of these strongholds may have been the introducers of Brythonic speech. The wedge of invasion thus indicated formed the basis for the geographical distinction of the future Powys and the shire of Montgomery. (L. F. Cv.)

The Roman occupation of Wales was primarily a military one, although this does not preclude peaceful relations with the native inhabitants. In Montgomeryshire the principal Roman forts were

the Forden Gaer (Lavnbrinta ?) and Caersws (Mediolanum ?), both in the Severn valley, with smaller forts at Llanfair Caereinion on the road from Caersws to Chester, at Carno and probably at Caer Gaer near the source of the Wye and the Plynlimon lead mines, as well as at Pennal, just over the Merioneth border in the Dyfi estuary and on the road from Carmarthen to Caernarvon.

The dark ages were eventually lightened by the spread of Christianity through the efforts of the Celtic saints, St Garmon, St Tysylio and St Beuno who are particularly associated with this area. The Anglo-Saxon invasion reached the borders of Wales about A.D. 600 and the supremacy of Mercia under its rulers Penda and Offa has left its mark in the immense mid-8th-century earthwork of Offa's dyke, which in Montgomeryshire stretches from Carreghofa in the north to Castlewright in the south, with the exception of about three miles under the Breidden hills where the Severn takes its place. By the time of Domesday Book the English had crossed the dyke, but their place names are not found beyond the Severn.

The unification of Wales under Rhodri Mawr (d. 877) was of short duration and three principal divisions of the country emerged, of which Powys, which at one time stretched from Mold as far south as Glasbury-on-Wye, was the central one. About 1200 Powys became divided between two branches of the descendants of Bleddyn ap Cynfyn into Powys Fadog, north of the Berwyns, and Powys Wenwynwyn, corresponding closely to the modern Montgomeryshire. The coming of the Normans chiefly affected the eastern part of Powys; a line of motte-and-bailey castles thrust westward from Roger de Montgomery's stronghold of Shrewsbury and terminated in his castle at Montgomery (named from his Norman patrimony), built near the Roman site of the Forden Gaer to control the ford of Rhydwhiman, while Roger's possessions were flanked by the FitzAlan lordships of Oswestry and Clun to north and south. Powis (Powys) castle, on the southern edge of Welshpool, now belongs to the National trust.

The principal family on the borders of Powys in the middle ages was that of the Mortimers, while the interior was largely held by the Charltons and their successors as heirs through marriage of the old Welsh rulers. The whole area was mainly Yorkist in sympathy during the Wars of the Roses. The central and south Welsh marches remained unshired through the late medieval period and it was not until 1535 that the present county was formed, based physically on the old principality of Powys but administratively on the royal fortress of Montgomery on its extreme eastern border. During the middle ages the civilizing force of the Cistercian monasteries had been followed by the introduction of Flemish families in the 14th century and, as a result of the activities of both of these, Powys became one of the leading wool-producing and manufacturing regions of Wales.

In the Civil War the sympathies of the county were mainly with the king, but the principal royalist strongholds, Montgomery and Powis castles, put up little effective resistance. The predominant influences in the 17th, 18th and 19th centuries were those of the Herberts and, in the north of the county, the Vaughans of Llwydiarth and their heirs the Wynns of Wynnstay. These families and their connections held a practical monopoly of the parliamentary representation.

The county seat has been invariably held by the Liberals since 1880. The seat of the Montgomery boroughs was abolished in 1918. (J. D. K. L.)

**Population and Administration.**—The population in 1961 was 44,165. The peak was reached in the mid-19th century (69,607 in 1841), since then the population has steadily decreased except for a temporary 6% increase between Sept. 1939 and Feb. 1941 caused by wartime movements. This increase however has continued in Newtown and Welshpool. Welsh is commonly spoken in the mountain regions of the west and north but the towns and lowlands (except the Dyfi and upper Severn valleys) are almost exclusively English in speech.

Llanfyllin (pop. [1961] 1,252), Llanidloes (2,381), Montgomery (972) and Welshpool (6,330) are municipal boroughs, while Machynlleth, and Newtown and Llanllwchaiarn are urban districts. Welshpool is the administrative centre. There are four rural districts and 46 parishes. The county is in the dioceses of Bangor, Hereford and St. Asaph and in the Wales and Chester circuit, assizes being held at Welshpool.

**The Economy.**—The late 18th and early 19th centuries witnessed a great development of communication (canals and coach roads) within the county, and trade increased rapidly. In 1794 the Montgomeryshire Canal act was passed, which provided for the construction of a branch canal from the Ellesmere canal to Welshpool, with a future extension to Newtown; the canal is no longer used. The factory system and the new facilities for communication caused the flannel industry to gravitate to the larger centres, e.g., Welshpool, Newtown, Llanidloes and Machynlleth, but it later declined in all these places.

Another industry besides flannel manufacture which fell into decay was lead mining, formerly carried on extensively in the Llanidloes district in the south and in the neighbourhood of Llangynog in the north. Attempts have been made to reinstitute some of the mines and to get metal from the waste tips which disfigure many of the higher hill slopes. Slate quarrying was carried on at Llangynog and in the Machynlleth district, while hard stone for building and road mending is found in various parts.

Montgomeryshire has considerable areas of rich farm land in the valleys and east of the county, with rolling country rising to purely hill pastures in the west. Commercial cattle and sheep raising are important. Kerry Hill sheep are indigenous. A considerable quantity of milk is produced on the lowland farms. Rough grazings cover 40% of the county and 51% of the remaining area is under grass. Oats and mixed corn are the chief crops, and small family farms predominate. Montgomeryshire is said to be the best wooded of all the Welsh counties, hedgerow timber being specially characteristic.

The county was formerly a recognized source of oak timber for the navy. After 1880 there was much planting of soft woods on the hill slopes below 1,000 ft., the Kerry hills being thickly timbered before 1914. Extensive areas of hill land, particularly in the southwest of the county on the Plynlimmon slopes and in the northwest round the Liverpool corporation reservoir, are owned by the Forestry commission.

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(H. Ca.)

**MONTH.** In astronomy, a month, or lunar month, is the period of time required for the moon to make a revolution with respect to some point in the heavens. The synodic (ordinary) month is measured with respect to the sun; it is thus the average interval between successive new moons. The modern calendar disregards the moon completely; for a discussion of calendar months, *see* CALENDAR. Other kinds of lunar month are defined as follows: tropical, the average period required for the moon to undergo an increase in orbital longitude of 360°, as measured from the equinox; sidereal, the average period of revolution of the moon with respect to the stars; anomalistic, the average interval between successive passages of perigee, i.e., successive closest approaches of the moon to the earth; nodical, the average interval between successive northward passages of the moon across the ecliptic. Because of perturbations of the moon's orbit, the lengths of the months vary. Average values (in days) are: synodic, 29.530588; tropical, 27.321582; sidereal, 27.321661; anomalistic, 27.554550; nodical, 27.212220. *See* MOON. (W. Mz.)

**MONTHERLANT, HENRY MARIE JOSEPH MILLON DE** (1896– ), French writer of novels, essays and plays. His works, which expose without restraint the alternating phases of his complex character, are composed in a style of exemplary firmness and conciseness. He was born at Neuilly-sur-Seine on April 21, 1896, into an aristocratic Catholic family of Catalan origin. Montherlant has devoted his life to his writing and the cultivation of his personality.

His early works were directly inspired by his personal experiences: *La Relève du matin* (1920) evokes the intense inner life of his Catholic schooldays; *Le Songe* (1922), a semi-autobiographical war novel, opposes masculine courage and self-sacrifice to feminine sentimentality; *Les Olympiques* (1924) consists of lyrical prose sketches praising athletics and football; *Les Bestiaires* (1926; Eng. trans., *The Bullfighters*, 1927), a novel about bullfighting, and the travel reminiscences in *Aux fontaines du désir* (1929) and *La Petite Infante de Castille* (1929) all record Montherlant's feverish search for the peacetime equivalents of the physical excitement, heroism and comradeship he had found at the front during his two years of war service. The dominant egocentricity and highly oratorical style of these first works have marked affinities with Chateaubriand and the *culte du moi* period of Maurice Barrès (*q.v.*).

In the 1930s, Montherlant's manner grew more terse and trenchant as he turned to less personal themes: *Mors et vita* (1932), *Service inutile* (1935), *L'Equinoxe de septembre* (1938) and *Le Solstice de juin* (1941) are volumes of arrogant social essays in which Montherlant expresses contempt for the conditions of French democracy and foretells, indeed welcomes as a salutary lesson, the German victory of 1940. To these should be added *Textes sous une occupation* (1953) and *Carnets* (1957); the latter, made up of extracts from his notebooks, is of particular importance for understanding Montherlant's development. Overt social criticism is a conspicuous feature of the novel *Les Célibataires* (1934; Eng. trans., *Lament for the Death of an Upper Class*, 1935), an ironical study of two impoverished and antipathetic noblemen unable to settle in modern democratic society.

Montherlant's major work of fiction, also produced in the 1930s, is *Les Jeunes Filles*, a novel written, for the most part, in letters, the four sections of which are entitled *Les Jeunes Filles* (1936; Eng. trans., *Young Girls*, 1937), *Pitié pour les femmes* (1936; Eng. trans., *Pity for Women*, 1937), *Le Démon du bien* (1937) and *Les Lépreuses* (1939; Eng. trans., *The Lepers*, 1940). This sardonically misogynistic work, describing the relationship between a libertine novelist and his adoring women victims, exalts the pleasures of the body and of artistic creation, while scornfully rejecting feminine possessiveness and sentiment. A similar arrogantly virile outlook marks Montherlant's one other novel of importance, *L'Histoire d'Amour de la Rose de Sable* (1954; Eng. trans., *Desert Love*, 1957).

After 1942, Montherlant turned to the writing of plays. *La Reine morte* (1942), *Le Maître de Santiago* (1947; Eng. trans., *The Master of Santiago and four other plays*, 1951), *Don Juan* (1958), *Le Cardinal d'Espagne* (1960), are set in 16th- or 17th-century Spain; *Malatesta* (1946), in the Italian Renaissance; *Fils de personne* (1943), *Demain il fera jour* (1949), *Celles qu'on prend dans ses bras* (1950) and *Brocéliande* (1956) in contemporary French middle-class homes; *La ville dont le prince est un enfant* (1951), in the Catholic college of *La Relève du matin*; *Port-Royal* (1954), in a French convent at the end of the 17th century. These are all essentially dramas of character, in which the protagonists strive to remain true to their high, sometimes perilously inflated, ideal of themselves. Like his novels and essays, they collectively reveal a constant preoccupation with pride and self-mastery as well as a dual attraction to sensual pleasure and the austerer forms of Christianity, which has earned Montherlant the not undeserved title of "a man of the Renaissance."

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(R. D. D. G.)

**MONTHOLON, CHARLES TRISTAN,** COMTE DE (1783–1853), French general who was one of Napoleon's companions in exile on St. Helena and became a leading propagandist of the "Napoleonic legend," was born in Paris on July 21, 1783. As a naval cadet he went with the French expedition to Sardinia in 1793. A volunteer for the army in 1799, he was attached to the staff of his brother-in-law, Gen. B. C. Joubert, in Italy. On the *coup d'état* of Brumaire (Nov. 1799), he declared himself a wholehearted supporter of Napoleon Bonaparte. He served creditably in ensuing campaigns and distinguished himself in that of 1809, at the end of which he was created comte. After being plenipotentiary at Würzburg (1811–12), he was entrusted, as general of brigade, with the defense of the *département* of Loire in 1814.

Montholon and his wife (née Albine de Vassal) accompanied Napoleon to St. Helena. There Montholon settled with Napoleon at Longwood. When Emmanuel de Las Cases (*q.v.*) left the island, Montholon took his place as chief recipient of Napoleon's dictated observations. Gaspard Gourgaud, who was soon on bad terms with Montholon and would have fought a duel with him if Napoleon had not forbidden it, also left Napoleon; but Montholon remained till Napoleon's death (May 1821). Some of Montholon's letters were published in the *Recueil de pièces authentiques sur le captif de Sainte-Hélène* (1821); and he and Gourgaud together began to publish the *Mémoires pour servir à l'histoire de France sous Napoléon* in 1823.

Montholon was restored to his rank in the French army after the revolution of 1830. In 1840, however, he acted as chief of staff to Louis Napoleon in the coup at Boulogne. For this he was imprisoned at Ham till 1847. He then went to England and published his *Récits de la captivité de Napoleon à Sainte-Hélène*. An avowed exponent of the "Longwood policy," he set himself to represent Napoleon as a martyr persecuted by Sir Hudson Lowe (*q.v.*); and his final version of events should be read in the light of his letters and of his conversation as recorded by Basil Jackson (*Notes and Reminiscences of a Staff Officer*, 1903).

Returning to France after the revolution of 1848, Montholon was elected to the legislative assembly as deputy for Charente-Inférieure in 1849. He died in Paris on Aug. 21, 1853. His correspondence with the comtesse de Montholon (whose own *Souvenirs de Sainte-Hélène, 1815–1816*, appeared in 1901) was published in 1906. *See* also NAPOLEON I.

**MONTI, VINCENZO** (1754–1828), Italian poet in the neoclassical tradition, author of a fine translation of the *Iliad*, was born at Alfonsine (Romagna), Feb. 19, 1754. He went to Rome in 1778 and wrote poems inspired by Catholicism and enthusiasm for the papacy (*Il pellegrino apostolico*, 1782; *La Bassvilliana*, 1793). When the French invaded Italy he became their supporter, attacking the papacy with *Il fanatismo* and *La superstizione* (publ. together, 1797), and singing Napoleon's victories (*Prometeo, Il bardo della Selva Nera, La spada di Federico II*; 1806). Napoleon rewarded him by appointing him professor of poetry at the University of Pavia. After the fall of the empire, he extolled the Austrian government. He died in Milan, Oct. 13, 1828.

As a poet, Monti has considerable merit. Some parts of the *Bassvilliana* and of another early poem, *La bellezza dell'universo*, and many of his shorter lyrics, are excellent. But his masterpiece is his translation of the *Iliad* (1810), which remains one of the achievements of the neoclassical age. The best edition of Monti's poems is by G. Carducci (1858–69). For a portrait of Monti *see* ITALIAN LITERATURE.

*See* G. Reichenbach, *V. Monti* (1930). (F. DI.)

**MONTICELLI, ADOLPHE JOSEPH THOMAS** (1824–1886), French painter of Italian origin, noted for his mood-evoking use of colour and texture, was born in Marseilles on Oct. 14, 1824. After early studies in his native town, he worked in Paris under Paul Delaroche. But his real teachers were the great masters at the Louvre: the Venetians, Rembrandt, Watteau and Monticelli's personal friend Eugène Delacroix. He returned to Marseilles and remained about 15 years. His personal style developed toward 1860 and brought him considerable recognition in Paris, where he returned in 1863. He received from Napoleon III a commission for the Tuileries palace and sold to many foreign collectors, especially in Scotland. The war of 1870 obliged him to flee Paris and he returned to Marseilles on foot. He died in Marseilles on June 29, 1886. Monticelli had memorial exhibitions in Paris in 1908 and 1953; and in Marseilles in 1936. Later artists found his swirling impasto effects and violent colour particularly interesting. Examples of his works are in the Metropolitan museum, New York, and the National gallery, Washington, D.C.

*See* Armand Agrel and Emile Isnard, *Monticelli* (1926); Gustave Coquiot, *Monticelli* (1926). (M. N. B.)

**MONTLUÇON,** an industrial town in central France, on the Cher river, 57 mi. (91 km.) N.N.W. of Clermont-Ferrand by road, a subprefecture of the *département* of Allier. Pop. (1962) 54,947. Situated at a point where five *départements*—Allier, Puy-de-Dôme, Creuse, Indre and Cher—are close to each other, Montluçon is an important industrial, commercial and agricultural centre. The town is dominated on the right bank of the Cher by the old feudal castle of the dukes of Bourbon; on the left bank, called Ville Gozet, stand the factories which have largely contributed to the modern economic development of the city. These include steelworks and factories producing oxygen and nitrogen, mirrors, glass, chemicals, rubber tires, underwear, textiles, stoneware and earthenware; there are also dye works, tanneries, a wax factory, etc.

All the architectural and picturesque interest of Montluçon is to be found in the old town, which contains two fine 12th- and 16th-century churches. Its steep and winding streets are still edged by a number of old wooden houses dating from the 15th and 16th centuries. The castle houses a museum, and the municipal library is in the former Ursuline convent. The town has excellent highway and rail services and an airport. There are numerous schools, the most important being the boys' and the girls' *lycées* and the national technical school, the latter of which is very modern in design. About four miles away is Néris-les-Bains, a very old Gallo-Roman city and a charming spa.

Montluçon, which formed part of the duchy of Bourbon, was taken by the English in 1171 and by Philip Augustus in 1181; the English were defeated there in the 14th century. Its industrial development dates from the early 19th century, when coal was discovered in the Commentry area and the Berry canal was constructed. (MA. F.)

**MONTMORENCY,** the name of a noble and illustrious family of France, derived from the town of Montmorency (in the modern *département* of Seine-et-Oise). With extensive ramifications, the family provided 6 constables of France and 12 marshals, as well as many other high officers under the crown, and accumulated duchies under the *ancien régime*. The styling of the head of the house as "premier baron of France" or "premier Christian of France" is traceable to the 14th century, but its significance is uncertain; it may have meant that the barony of Montmorency was the principal fief of the Île-de-France, though in the 16th century it was described as the premier barony "of the kingdom."

**The Montmorency in the Middle Ages.**—The origins of the family are obscure, but its descent has been traced back to Bouchard I de Montmorency, who was living in the second half of the 10th century. His descendants built up their estates in the neighbourhood of Paris and acquired prestige by defending the capital against foreign invaders. An Alberic de Montmorency is cited as constable of France in 1060, a Thibaut as constable in 1083. Bouchard IV, who died soon after 1124, is remembered for his quarrel with the abbey of St. Denis, whose lands he ravaged before being reduced to obedience by the royal army. His son Mathieu I, constable of France from 1138, married first Aline, a natural daughter of Henry I of England, and second Adelaide of Savoy, widow of Louis VI of France; took part in the administration of France during Louis VII's absence on the second crusade (1147–49) and was still living in 1160. His grandson Mathieu II the Great helped to capture Château-Gaillard (1203–04), took part in the Albigensian crusade, was constable of France from 1219, served under Louis VIII in the southwest (1224–25) and supported the queen mother, Blanche of Castile, during the troubled minority of Louis IX. On his death (1230), the family divided into two branches, the children of his second wife, Emma de Laval, settling in Brittany under the name of Montmorency-Laval. Mathieu II's great-grandson Mathieu IV (died *c.* 1305), who was grand chamberlain of France from *c.* 1285, was sent to help the Angevin Charles I of Naples after the Sicilian Vespers (1282), took part in the ill-fated French invasion of Aragon (1285) and in the conquest of Guienne from the English (1294) and also led an attack on Dover (1295). His great-grandson Charles (d. 1381), marshal of France from 1344, fought the English in the Hundred Years' War and was one of the negotiators of the peace of Brétigny in 1360. Under Louis XI of France, the elder sons of Charles's grandson Jean (d. 1477), namely Jean, sire de Nivelle (*c.* 1427–77), and Louis, sire de Fosseux (d. 1490), supported Burgundy, and were accordingly disinherited from the barony of Montmorency in favour of their younger half brother Guillaume (d. 1531), who was chamberlain and councilor to Charles VIII and Louis XII of France.

**Anne de Montmorency and His Descendants.**—Anne de Montmorency (1493–1567), born at Chantilly on March 15, 1493, was the second of Guillaume's four sons by his wife Anne Pot and was known till 1522 as the sieur de La Rochepot. He was brought up with the comte d'Angoulême, later Francis I of France. He was present at the battles of Ravenna (1512) and Marignano (1515), was sent to England as a hostage (1519), attended the Field of Cloth of Gold (1520), took part with Pierre Bayard in the defense of Mézières (1521) and, after raising an army in Switzerland, fought in Italy again (1522), capturing Novara and Vigevano. Francis I created him marshal of France (Aug. 1522), conferred the Order of St. Michael on him and admitted him to his council. After more service in Italy (1523–24), Montmorency defended Provence against the duc de Bourbon. He was captured with Francis I at Pavia (1525) but was soon released and helped to bring about the treaty of Madrid. In March 1526 he was appointed grand master of France (that is, superintendent of the royal household) and governor of Languedoc. Until 1541 he was the king's chief minister, while the chancellor Antoine Duprat attended to finance and justice. Montmorency controlled war, the royal household, public works and foreign affairs. His many extant letters reveal his prodigious ministerial energy; he was also irascible and ruthlessly authoritarian. In 1527 he succeeded in bringing England into the League of Cognac against the Holy Roman emperor Charles V, but by 1529 he favoured peace with Charles and helped to negotiate the peace of Cambrai. He attended Francis I's meeting with Henry VIII of England at Calais (1532) and prepared his meeting with Pope Clement VII at Marseilles (1533). In 1536, by means of a "scorched earth" strategy, he compelled Charles V to withdraw from Provence. He was appointed constable of France in Feb. 1538. He had, however, several enemies at court, notably the duchesse d'Étampes, the admiral Claude Annebaut and the cardinal François de Tournon; and in 1541 he fell into disgrace and went into retirement.

Recalled to court on Henry II's accession (1547), Montmorency savagely crushed a revolt at Bordeaux (1548). He was created duc de Montmorency and a peer of France in July 1551. As a military commander he was brave rather than skilful, and his attempt to relieve St. Quentin, which the Spaniards were besieging, ended in his defeat and capture (1557). He was released at the peace of Câteau-Cambrésis (1559), but it was not until the accession of Charles IX (1560) that he was able to return to court. Catherine de Médicis then hoped to use him to counter the influence of the house of Guise, but he disapproved of her policy of tolerating the Huguenots and formed a "triumvirate" for the protection of Catholicism with François de Guise and the marshal de Saint-André (Jacques d'Albon). In the first of the wars of religion he was wounded and captured at Dreux (1562). After his release, he and his son François expelled the English from Le Havre (1563). Wounded at the battle of St. Denis (Nov. 10, 1567), the constable duc de Montmorency died in Paris two days later. Anne was a notable patron of the arts. His collection included Michelangelo's "Captives," and he employed the architect Jean Bullant on his châteaux of Chantilly, Fère-en-Tardenois and Écouen.

The eldest of Anne's five sons by Madeleine of Savoy was François de Montmorency (1530–79). He fought in Piedmont (1551), defended Thérouanne (1553) and was appointed lieutenant general of the Île-de-France (1556). In 1557 he visited Rome to obtain a papal dispensation releasing him from his betrothal to Jeanne de Piennes, so that he could marry Diane de France (*q.v.*). He succeeded his father as duc de Montmorency in 1567. Having been a close friend of the Huguenot leader, his cousin the admiral de Coligny (son of Anne's sister Louise), he became a leader of the moderate Catholic party of the Politiques and was imprisoned in the Bastille in May 1574, but was released before the "peace of

Monsieur" (1576). He died on May 5, 1579.

François was succeeded as duc de Montmorency by his brother HENRI I (1534–1614), who, under the title of sieur de Damville, by which he is usually remembered, had fought in various theatres of war and became governor of Languedoc (1563) and marshal of France (1566). As a leader of the Politiques he administered Languedoc independently of the royal government and of Paris. In 1593 he acknowledged Henry IV as king and, in December, was rewarded with the office of constable. According to Brantôme he was illiterate. He died at Agde on April 1, 1614.

HENRY II de Montmorency (1595–1632), son of François by his second wife, Louise de Budos, was appointed to succeed his father as governor of Languedoc in 1608 and became grand admiral in 1612. Duc de Montmorency from 1614, he campaigned against the Huguenots in 1620 and took part in the sieges of Montauban and Montpellier. In 1625 the fleet which he commanded recaptured the islands of Ré and Oléron, and in 1628 he fought against Henry de Rohan in Languedoc. In 1629–30 he served as lieutenant general in Piedmont, defeating the Spaniards at Avigliana. Marshal of France from Dec. 1630, he joined the faction of Gaston, duc d'Orléans, and tried to raise Languedoc against the cardinal de Richelieu. Defeated in battle at Castelnaudary (Sept. 1, 1632) and taken prisoner, he was tried before the *parlement* of Toulouse and, despite the pleas of several prominent persons, was executed as a traitor on Oct. 30, 1632. His widow, Maria Felicia Orsini (1600–66), took the veil and became superior of the convent of the Visitation at Moulins.

Henry II's beautiful sister CHARLOTTE de Montmorency (1594–1650) had been married in 1609 to Henry II de Bourbon, prince de Condé (*see* CONDÉ, PRINCES DE), who had to send her abroad to escape King Henry IV's passionate attentions. Later she courageously upheld her children's cause during the Fronde. The peerage duchy of Montmorency, extinct on her brother's death, was revived for the Condés in 1633; but its name was changed to Enghien in 1689.

**The Elder Lines of Montmorency.**—The most famous descendant of the sire de Nivelle (*see* above) was his great-grandson PHILIPPE de Montmorency, count of Horn, beheaded with the count of Egmond (*q.v.*) in 1568. The duelist FRANÇOIS comte de Boutteville (*see* DUEL), beheaded in 1627, was sixth in descent from the sire de Fosseux and was the father of two remarkable children: ISABELLE ANGÉLIQUE (1627–1695), notorious for her intrigues as duchesse de Châtillon and later as duchess of Mecklenburg; and FRANÇOIS HENRI, the great marshal duc de Luxembourg (*q.v.*). The duchy of Beaufort, granted to the latter's eldest son CHARLES FRANÇOIS (1662–1726) in 1688, was renamed Montmorency in 1689; acquired through marriage (1767) by a senior branch of the line of Fosseux, it became extinct with RAOUL in 1862 (Napoleon III, however, gave the title duc de Montmorency in 1864 to Adalbert de Talleyrand-Périgord, son of Raoul's sister Alix). Other French ducal titles held by descendants of the marshal duc de Luxembourg were: Châtillon (1696; renamed Boutteville 1736; extinct with the last successor to the Luxembourg title in 1861); and Beaumont (1765–1878).

The house of Montmorency-Laval, which furnished three of the family's marshals of France, including the notorious Gilles de Rais (*q.v.*), acquired the title of duc de Laval in 1758 (extinct 1851) and the Spanish title of duque de San Fernando Luis in 1815.

*See* F. Decrue, *Anne de Montmorency*, 2 vol. (1885–89). (R. J. K.)

**MONTPELIER,** the capital of Vermont, U.S., and seat of Washington county since 1811, is located on the upper Winooski river near the centre of the state, 7 mi. from Barre and 40 mi. E.S.E. of Burlington. It commands the best route through the northern Green mountains for many alternate routes out of the Connecticut valley. Montpelier citizens led in developing turnpikes, stage routes, railroads and federal highways and benefited by each, except the Central Vermont railway which left the city on a spur.

Its economy has been based on state government, insurance, the granite industry, printing and local commerce, with minor specialties in machinery and baking. Employment of white collar and professional workers in government and insurance offices raises the median of school years completed beyond that of the high school graduate. Vermont college, a Methodist college organized in Newbury in 1834 and moved to Montpelier in 1868, is a junior college for women.

Because of official printing, Montpelier publishers steadily led the state in imprints, and 19th-century editors, notably of the Federalist–Whig–Republican *Watchman* (established 1806) and the Democratic *Patriot* (established 1826) were influential in state politics.

Named for Montpellier, France, the town was chartered in 1780 by 60 proprietors from Massachusetts and western Vermont; it established a town meeting in 1791 and was named the state capital in 1805. It defeated several attempts by Burlington and other towns to succeed it as the capital, climaxed in 1857 when fire left the state house a granite shell.

Montpelier's greatest relative importance was in stagecoach days: it ranked second to Burlington in 1840. The village, incorporated in 1828 with less than a quarter of the original 23,040 ac., was detached in 1848 and the farming area became East Montpelier. Chartered as a city in 1895 in its period of maximum growth, it nearly doubled population from 1890 to 1910. World War I severely checked its economy, which recovered gradually, in spite of a disastrous flood in 1927, with the expansion of state bureaus. Montpelier has a council–manager form of government, in effect since 1956.

For comparative population figures *see* table in VERMONT: *Population.* (T. D. S. B.)

**MONTPELLIER,** a university town of southern France, capital of the *département* of Hérault and chief town of Languedoc, 32 mi. (52 km.) S.W. of Nîmes by road and 6 mi. from the Mediterranean at Palavas (beach). Pop. (1962) 109,116. Montpellier stands in a fruitful plain near the right bank of the small Lez river. Features of the town are a fine terrace, Le Peyrou, with views of the Mediterranean, the Pyrenees and the Alps, and the famous Botanical garden (1593). The 14th-century Gothic cathedral suffered severely during the religious wars, and the choir was rebuilt. Close to the medical school (housed in a former Benedictine monastery) is the Tour des Pins, chief relic of the medieval fortifications. The Musée Fabre contains good collections of paintings and sculptures. Montpellier possesses old houses of the 15th, 16th and 18th centuries.

The Lez is canalized to connect Montpellier with the Canal du Midi and with the sea at Palavas. Situated in the richest wine-producing region of France, it is an important market for wine and dessert grapes. The cultivation of early vegetables and of fruit (apples, cherries and peaches) has developed in the locality. Manufactures include chemicals, textiles, electronic apparatus and licorice. The town is the centre of an *académie* (educational division), of a bishopric, of courts of appeal and assizes, of tribunals of first instance and of commerce, and of a council of labour relations. The Institute of Industrial Pharmacy and the European Institute of Agronomic Studies are also located there.

Montpellier rose into importance in the 8th century. In 1141 it acquired a charter, later materially extended, and the same century saw the rise of its school of medicine. Several of the ablest teachers of that school were members of an important Jewish colony established in the town, and Rabelais lectured there in the 16th century. The school of law dates from 1160, and the university was founded by Pope Nicholas IV toward the close of the 13th century. The bishopric of Maguelonne was transferred to Montpellier in 1536. In the wars of religion it was a Huguenot centre; Louis XIII took it after a long siege in 1622. The town walls, except the royal citadel then just built (1624), were razed in 1628. Louis XIII made Montpellier the seat of one of the *généralités* of Languedoc, and the states of that province met there during the 17th and 18th centuries.

**MONTPENSIER, ANNE MARIE LOUISE D'ORLÉANS,** DUCHESSE DE (1627–1693), French princess, was born in Paris on May 29, 1627. As her father, Gaston, duc d'Orléans (*q.v.*), had the designation Monsieur, she was known as Mademoiselle. From her mother, Marie de Bourbon-Montpensier, who died after the childbirth (June 4, 1627), she inherited a huge for-

tune, including Eu and Dombes (*qq.v.*) as well as Montpensier. Tall and with an august mien, she set her heart on an exalted marriage; but the government would neither promise the future Louis XIV to the restless Monsieur's daughter in 1638 nor make a premature peace with the Habsburg powers in time for her to catch the Holy Roman emperor Ferdinand III in 1647.

In 1651, during Mazarin's first exile (*see* FRONDE), Mademoiselle pulled Monsieur along the path of collaboration with Condé, though Mazarin's friends tempted her with talk of marriage to Louis XIV after all. At the same time she refused the dispossessed Charles II of England. In the third war of the Fronde she took possession of Orléans for the princes on March 27, 1652, by personal escalade against token opposition. Finally she saved Condé's army from annihilation in the battle of the Faubourg St. Antoine on July 2, 1652, having the cannon of the Bastille fired against the royal troops (Monsieur's authorization of this was extorted by her). Mazarin remarked, "That cannon has killed her husband."

On the king's return to Paris (Oct. 1652), Mademoiselle went into exile till 1657. Residing mostly at St. Fargeau and quarreling with Monsieur about the Montpensier fortune, she began writing her *Mémoires*. She was again exiled from court from 1662 to 1664 for refusing to marry Afonso VI of Portugal.

To everyone's stupefaction, Louis XIV on Dec. 15, 1670, consented to Mademoiselle's plea for permission to marry a mere gentleman. For the withdrawal of the royal consent three days later and for subsequent events *see* LAUZUN, ANTONIN NOMPAR DE CAUMONT, DUC DE. Mademoiselle died in Paris on April 5, 1693.

Mademoiselle's *Mémoires* cover her life to 1688. Uninhibitedly egocentric, she wrote straightforward autobiography, very different from the tendentious apologias of the more sophisticated memorialists. A first edition appeared in 1729, a fuller one in 1735, the best, by Adolphe Chéruel, in four volumes, in 1858–59. Mademoiselle also left two short novels and literary "portraits."

(J. G. R.-S.)

**MONTPENSIER, ANTOINE D'ORLÉANS,** DUC DE (1824–1890), French prince whose role in history resulted from his father's controversial policy on the "Spanish marriages." He was born at Neuilly, Seine, on July 31, 1824, the sixth son of Louis Philippe, duc d'Orléans, who became king of the French in 1830 (*see* BOURBON: *Table IV*). From 1842 to 1848 he spent most of his time with the French army in Algeria; but on Oct. 10, 1846, when Queen Isabella II of Spain was married to her cousin Don Francisco de Asís, Montpensier was simultaneously married to her sister the infanta Luisa, despite French promises to Great Britain that he should not marry her until Isabella had produced an heir.

When revolution had deposed his father (1848), Montpensier settled in Spain. Because of his sympathies with Liberal generals he was expelled by the minister L. González Bravo in July 1868, but returned from Portugal when Isabella was deposed in September. A candidate for the throne, he killed one of his rivals, Don Enrique de Borbón, duque de Sevilla, in a duel in March 1870. Exiled to the Balearic Islands at the start of Amadeo's reign, he returned in 1871, to sit in the *Cortes*. Alfonso XII, whose accession he had favoured, married his daughter María de las Mercedes in 1878. When she died six months later, Montpensier retired from public life. He died at San Lúcar de Barrameda on Feb. 4, 1890.

(JE. V.)

**MONTREAL,** the largest city of Canada, is on Montreal Island in Quebec province, at the confluence of the St. Lawrence and Ottawa rivers; it is about 180 mi S.W. of Quebec and 121 mi E. of Ottawa, Ont. The island consists of nearly horizontal strata of Ordovician limestones, through which volcanic rocks erupted at the end of Devonian time. Subsequent erosion of the softer limestone has left the volcanic neck of Mount Royal, 769 ft. high, standing in the centre of the island. Minor surface features are the Pleistocene terraces.

Montreal started as a settlement by the St. Lawrence, near St. Paul street, and grew northward from the river; from there it spread around the mountain on both sides, encircling it and encroaching on its lower slopes. Pop. (1961) Montreal, 1,191,062; metropolitan area, 2,109,509. Important suburbs include Verdun (78,317), St. Michel (55,978), St. Laurent (49,801), Montreal North (48,433), Lachine (35,630) and LaSalle (30,904).

By origin the population of Montreal in 1961 was 67.6% French, 17.7% British and 14.7% other. For the Montreal metropolitan area the figures were 64.5% French, 21.8% British and 13.7% other. The French live mainly on the eastern side of the city (east of Park avenue) and the southern side (south of Sherbrooke street). The west side of the city, that is, Notre Dame de Grace, the area just south of the mountain, and the included city of Westmount, is predominately British.

By religion the city in 1951 was 78.6% Roman Catholic, 6.5% Jewish, 5.7% Anglican, 3.9% United Church and the rest various.

**History.**—Montreal Island with Mount Royal (Mont Real), which he so named, was discovered by Jacques Cartier in 1535. Cartier was welcomed by a large band of Huron Indians who took him to their stockaded settlement of Hochelaga where he held prayers with them and read to them from the Gospel of St. John. The Indians guided Cartier to the top of the mountain where the view greatly impressed him. No other explorers arrived until Samuel de Champlain reached the island in 1603. His journals make no mention of Hochelaga which presumably had been obliterated by hostile Indians. In 1611 Champlain laid out beside the river the site of a settlement, Place Royale, but it was not then permanently occupied, although traders gathered every summer at the spot. Meantime Cartier's narrative had led to a desire in France to convert the savages, and an "Association of Montreal" was formed for this purpose, the word "Montreal" having become a general name for the unknown district. In 1641 the association sent out Paul de Chomedey, sieur de Maisonneuve, with about 50 associates, including Jeanne Mance, to found a mission station on Montreal Island. The mission was duly established May 17, 1642, under the name of Ville-Marie de Montréal. The original site, at first a fort, was beside the natural harbour created by a projecting point of land, later the Pointe à Callières, and a small island (Ile Normandin, Market Gate Island), the island being later obliterated and the locality entirely altered by the later harbour construction. On the high bank above flood water the settlers built a hospital (Hôtel Dieu), its site on the present St. Sulpice and St. Paul streets, and a house for Maisonneuve, later the first Sulpician seminary.

Other houses were built nearby and the bush track connecting them became St. Paul street. The mission was harassed in its early years by constant Iroquois attacks, the whole period from 1642 to 1701 being one of intermittent Indian war and truce. The island was handed over in 1663 to the feudal proprietorship of the Order of St. Sulpice which had arisen out of the Montreal movement. Maisonneuve was removed from office (1664) and returned to France.

Progress in the 17th century was slow. The settlement had a population of 196 in 1650, 472 in 1660, 766 in 1667 and 1,442 in 1710. The town was roughly fortified with ramparts and palisades in 1685 and in 1723 with the stone walls (18 ft.), bastions, gates and sally ports which henceforth forfade all Indian attack. In the old French regime from 1713 to 1754 (peaceful in Montreal, since the war of 1744–48 did not reach it) the town became the great centre of organization of exploration and trade (Compagnie des Habitants, 1700; Compagnie d'Occident, 1717; the Vérendryes, etc.) and especially of the fur trade which absorbed the main energy of the colony to its later harm. The visiting Swedish naturalist, Peter Kalm (1749), described the town and adjacent country in glowing terms. The Seven Years' War brought desolation to all New France. After the fall of Quebec in 1759 Montreal still held out. It was invested in the autumn of 1760 by the converging armies under Jeffrey Amherst and was surrendered by the marquis de Vaudreuil, its last governor, along with all remaining posts in New France. Vaudreuil and his French forces were given transport to France along with many Canadian seigneurs and their families.

At the time of the conquest Montreal covered little more than the fortified area of high ground between the St. Lawrence river and the valley of St. Martin's Brook (later Craig street). But

small suburbs (*faubourgs*) were already being settled outside the gates: the Quebec suburb (downstream); St. Joseph (upstream); and St. Lawrence on the inland side. As the town splits the cardinal points of the compass the designations north and south, under the French regime, were exchanged officially in 1791 for east and west. The population of the city in 1750 was 8,244. The American Revolution led to an unsuccessful attack on Montreal (1775) by Ethan Allen and to the city's abandonment by Sir Guy Carleton and surrender to Gen. Richard Montgomery. It was occupied by the army of congress (Nov. 13, 1775–June 17, 1776). A congressional delegation to Montreal (Benjamin Franklin and two others) tried in vain to convert Canada to the American colonists' cause and retired on the approach of British forces, leaving behind a printing press, the first in the town. Following the conquest there had been an influx of British traders; after the war a great number of Loyalists swelled the British element in Montreal and opened up the adjacent eastern townships. In the troubles that arose in Lower Canada between French and English, Montreal became the centre of the agitation and open violence that preceded the rebellion in 1837–38. After the rebellion 12 rebels (*les patriotes*) were hanged in Montreal at a spot that has been marked with a monument beside the Jacques Cartier bridge. When the two Canadas were reunited (1840) Montreal became for a short time (1844–49) the capital but lost that position in consequence of the riots over the Rebellion Losses bill and the burning of the parliament buildings in 1849.

Montreal made great economic progress at this epoch. Steam navigation had begun in 1809 with the "Accommodation," an 85-ft. wooden paddle steamer built at Montreal by John Molson (1763–1836), the brewer and banker; the Molson family continued to be interested in steam navigation on the St. Lawrence until about 1860. Steam altered the entire aspect of river navigation, displacing Quebec in favour of Montreal. The opening of the Lachine canal (1825) connected ocean with inland steam navigation. Then began the prominence of the Montreal route under the Allan line and other steamship companies; but all St. Lawrence ships used sail and steam jointly until the end of the 19th century.

In the meantime railways were being built that would connect Montreal with New York, Portland, Me., Boston, Mass., Toronto and Chicago. The Victoria bridge across the St. Lawrence was opened in 1860 by the visiting Prince of Wales. At confederation, 1867, Montreal was already the metropolitan city of Canada. It had a population in 1871 of 115,000. After confederation the history of Montreal merged into the general history of Canada but was locally marked by the Fenian raids (1870), the great floods (1886), the completion of the Mount Royal tunnel (1917) and the opening of the Harbour (later Jacques Cartier) bridge (1930). (*See* also CANADA: *History.*)

**Sites and Shrines.**—Among the chief points of historic and scenic interest in and around Montreal are the Place d'Armes, where stands the Maisonneuve monument and around which are grouped the Seminary of St. Sulpice (1685), the church of Notre Dame, built 1824 (original church, 1656), and the later building of the Bank of Montreal, etc. In the old French town also is the Château de Ramezay, preserved as a public museum; it was the seat of one of the French governors (not the last) and of several British governors. Beside it is the Jacques Cartier square with a monument erected in honour of Lord Nelson. Nearer the river stands the famous Bonsecours church. The original church was erected in 1657 by Marguerite Bourgeoys, founder of the Congregation de Notre Dame. The present church was built in 1771. The Bonsecours market dates from 1843.

The Champs de Mars, a military parade ground since the French regime, is used as a parking lot. Among sites of general interest in the city are the Museum of Fine Arts, the Roman Catholic St. James's cathedral, McGill university, the University of Montreal behind the mountain, the stone towers (dated 1694) of the Grand Séminaire and the Shrine of St. Joseph. Of chief interest is the view from the top of the mountain, which is reserved as a public park.

**Navigation, Commerce and Industry.**—Montreal as a port owes its prominence to the fact that it is at the head of 1,000 mi. of unimpeded navigation from the Atlantic ocean and that further direct navigation is blocked by the Lachine rapids beside Montreal Island. The rapids were early bypassed by canals; the oldest is the Lachine, now little used. The St. Lawrence seaway (*q.v.*) completed in 1959, enables ships drawing 25.5 ft. to navigate between the head of the Great Lakes and the Atlantic ocean. Montreal is 2,760 mi. from Liverpool (via Strait of Belle Isle), as compared with 3,043 mi. between New York and Liverpool. The harbour extends 16 mi. along the river. At its upper end is the Victoria bridge (railway and vehicles) and about two miles lower down the Jacques Cartier bridge (vehicles).

CANADA WIDE FEATURES

BONSECOURS CHURCH, BUILT IN 1771

The port has 10 mi. of high level concrete piers and wharves, a harbour terminal railroad of 62 mi. of track, four grain elevators of a total capacity of 15,162,000 bu. and unrivaled grain and cargo apparatus. Chief commodities passing through the port are grain and petroleum. Navigation opens in April. Regular passenger schedules end in November but navigation carries on into December. Experts claim that conditions in the gulf below render a longer navigation season doubtful. Complementary to the facilities of the port are the existence of many large manufacturing plants in Montreal and its metropolitan area. The principal products are clothing, electrical apparatus, railway rolling stock and tobacco.

**City Government.**—Municipal government in Montreal, as in all Canadian municipalities, is under the control of the provincial legislature which creates, alters and abolishes at will. With one insignificant exception, elective representative government was unknown under the French regime. Under the British regime the town was governed by the military authorities and the justices of the peace. Between 1832, when Montreal was incorporated as a city, and 1940, various forms of city government were tried, none of which proved satisfactory. After 1940, as a result of amendments made to its charter, Montreal was administered by a mu-

nicipal council whose meetings were presided over by a mayor elected by the whole of the taxpayers and also by an executive committee composed of six city councilors. In 1940 the mayor became ex-officio a member of the executive committee and certain administrative powers were conferred on him.

Of the councilors, 33, designated "A" class councilors, were elected by property owners, 33 "B" class councilors were elected by property owners and tenants and 33 "C" class councilors were appointed by 11 designated public bodies. The office of "C" councilor was abolished following the referendum during the election of 1960. Bill 38 in 1940 also enacted that councilors should serve gratuitously, although the salaries paid to the mayor and chairman of the executive committee were retained and those of the other five executive committee members were raised. Salaries for councilors were reintroduced in 1942.

The Champagne commission, appointed in 1960 to inquire into the city's electoral or political system and its administrative system, recommended a Canadian parliamentary form of government, the division of the city into 45 wards to be represented by one councilor each and the executive committee to become explicitly the supreme administrative authority.

The Montreal metropolitan area, as defined by the dominion census, contains, in addition to the city of Montreal, 83 other cities, towns and municipalities. The creation of the Montreal Metropolitan corporation in April 1959 was an early step toward a unified government. This corporation constructed the Metropolitan boulevard across the middle section of Montreal Island, regulates the closing hours of commercial establishments on Montreal Island and is empowered to control the finances of 14 of the municipalities on the island.

**Education.**—In Montreal, as throughout Quebec, the public-school system is separated from top to bottom between Roman Catholics and Protestants; most children of parents not affiliated with either religion attend the Protestant schools. In the 1960s there were about 200,000 students in Roman Catholic schools and about 70,000 students in Protestant schools.

The University of Montreal, a French-language institution, is supported by the province and controlled by the Roman Catholic Church. Established in Montreal in 1876 as a branch of Laval university, it became autonomous in 1920, by the 1960s it had grown to include a considerable number of affiliated institutions (including a number of classical colleges, most of which are eight-year institutions offering four years of secondary education) and other attached institutions. McGill university, a co-educational, privately endowed, nondenominational institution, is one of the largest English-speaking universities in Canada. It originated in a bequest for that purpose in the will of James McGill (1744–1813), a Scots emigrant who prospered in the fur trade; instruction began in 1829 in the faculties of arts and medicine. The women's college, Royal Victoria, the gift of Baron Strathcona, was opened in 1899 to provide teaching and residential facilities for women. Another integral part of the university is MacDonald college at Ste. Anne de Bellevue, about 25 mi. S.W. of Montreal; the gift of Sir William McDonald, it opened in 1907 and houses the faculty for agriculture, the school of household science and the institute of education. After about 1907 the university grew vigorously. Sir George Williams university (founded 1929; incorporated 1948) is an outgrowth of formal educational work of the Montreal Young Men's Christian association. It has an extensive evening division as well as regular daytime instruction. The bachelor's degree is the highest degree awarded by the university; the language of instruction is English.

*See* also references under "Montreal" in the Index.

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(M. C. BA.)

**MONTREUIL** (MONTREUIL-SOUS-BOIS), a town on the outskirts of Paris in the *département* of Seine, France, 4½ mi. (7½ km.) E. of Notre Dame de Paris. Pop. (1962) 87,040. It stands at the foot of the hills of Bagnolet and Romainville on the western slopes of the Rosny and Fontenay hills. The town is served by the Paris metropolitan line and by bus, and is crossed by a main road, the rue de Paris, which links Paris with the town hall, a huge building in cubic style built in 1935. The industrial quarter, Ste Monitrol, extends on both sides of the rue de Paris. Almost in the centre, where the town first began, before A.D. 1000, stands the graceful 12th-century church of SS. Peter and Paul, where Charles V of France was baptized. To the northeast a magnificent public park, 20 ac. in extent, occupies the site of the park of the former château of Montreuil. Peaches and pears, which in past centuries made Montreuil famous, are tending to disappear, along with the city's rural character. Numerous small factories characterize the industrial activity of the town, which is very varied. (M. KA.)

**MONTREUX,** a town of the canton of Vaud, Switz., is situated on the Lake of Geneva 25 km. (15½ mi.) S.S.E. of Lausanne by road. Pop. (1960) 12,212. The town stretches 6 km. (4 mi.) along the eastern shore of the lake. Its natural setting below a mountain range protecting the area from northerly and easterly winds has made the Montreux area a fashionable holiday resort. The nearby château of Chillon is the best-known piece of architecture in Switzerland. Built in the 9th century on a rocky islet close to the shore of the lake, it was rebuilt in the 13th century in its present form. Montreux is on the railway from Geneva and France to Italy via the Simplon tunnel. It is also the terminus of mountain railways. The tourist trade is important, while the villages (Caux, Chernex, Glion, Chamby and Les Avants) above Montreux live mainly by agriculture and viticulture. (R. M. AN.)

**MONTREUX CONVENTION.** This convention, signed on July 20, 1936, by the participants of a conference held in Montreux, Switz., established a new international regime of the Turkish straits replacing that of the Lausanne convention (*see* LAUSANNE, CONFERENCES OF). The Montreux convention continued in force, in the post-World War II era.

On its basis merchant vessels of all countries enjoy freedom of transit and navigation through the straits in time of peace and war, provided Turkey is not belligerent. If Turkey is a belligerent, only merchant vessels of a country not at war with Turkey enjoy this freedom (art. 2–7 and annex I). War vessels (defined in annex II) enjoy freedom of transit only under limitations. The non-Black sea powers are restricted in time of peace to no more than nine light surface vessels in course of transit of a maximum aggregate tonnage of 15,000 tons (art. 10–14). The Black sea powers are not limited in tonnage, and even their capital ships may be sent through the straits, but only singly. They may also send their submarines constructed or purchased outside of the Black sea, if they travel on the surface (art. 11–13). In time of war, Turkey not being belligerent, freedom of transit remains the same for nonbelligerent powers. If Turkey is at war, or under threat of war, passage of warships is left to its discretion, under reservations (art. 20–21).

The convention established (art. 18) the Black sea regime for non-Black sea powers. Their aggregate tonnage, jointly, in that sea in time of peace is limited to a maximum of 30,000 tons, but may be raised up to a maximum of 45,000 tons if the tonnage of the strongest Black sea fleet increases by at least 10,000 tons. No non-Black sea power, however, may have in the Black sea more than two-thirds of the aggregate tonnage, nor may it keep its vessels of war there longer than three weeks.

The convention abolished the International Commission of the Straits, and transferred its functions to the Turkish government (art. 24). Turkey was authorized to remilitarize the zone of the straits immediately. The convention was concluded for 20 years. If not denounced two years prior to the expiry of this period, it was to continue automatically. A new conference must be summoned in the event of denunciation (art. 28). A procedure was set up for amending the convention at the expiry of each period of five years; in most cases unanimity is required for such amendment, in some other cases a very strong majority (art. 29).

For the post-World War II efforts of the U.S.S.R. to amend the convention and for bibliography *see* STRAITS QUESTION. *See* also TURKEY: *History*; BOSPORUS.

(M. SA.)

**MONTROSE, MARQUESSES AND DUKES OF.** The Scottish dukedom of Montrose was created in 1488 for DAVID LINDSAY (1440–1495), 5th earl of Crawford, for loyalty to James III during the rebellion of the earl of Angus and Prince James. This grant was rescinded on the accession of James IV but it was restored in 1489 for life only. WILLIAM (*c.* 1463–1513), 4th Lord Graham, chief of that name, whose wife was the duke's niece, was created earl of Montrose in 1503. JOHN (1548–1608), 3rd earl, an eminent statesman, was commissioner-general (viceroy) for Scotland from 1604 to 1608. His grandson JAMES (1612–1650), 5th earl, was created marquess of Montrose in 1644 (*see* MONTROSE, JAMES GRAHAM, Marquess of), whose son, JAMES (1633–1669), was known as "the good marquess." The latter's grandson, JAMES (1684–1742), 4th marquess, was created duke of Montrose and marquess of Graham (1707) for his services in promoting the Act of Union. After helping to suppress the Jacobite rebellion in 1715, he was made keeper of the Scottish great seal (1716–33). His son, David (1705–1731), was created Earl Graham in the peerage of Great Britain.

JAMES (1755–1836), 3rd duke, was a supporter of William Pitt the Younger and while marquess of Graham and member of the house of commons, he secured the repeal of the proscription of highland dress. He was one of the commissioners for Indian affairs (1791–1803) and president of the board of trade (1804–06). JAMES (1878–1954), 6th duke, was chairman of the Scottish Nationalist party (1924–34). His son, JAMES (1907– ), 7th duke, succeeded to the title in 1954. (T. I.)

**MONTROSE, JAMES GRAHAM,** MARQUESS OF (1612–1650), Scottish general who won a series of spectacular victories in Scotland for Charles I in 1644, was born in 1612 and became 5th earl of Montrose in 1626 (*see* MONTROSE, MARQUESSES AND DUKES OF). He was educated at St. Andrews university, and at the age of 17 married Magdalene Carnegie, daughter of Lord Carnegie (afterward earl of Southesk). Not long after the outbreak of the religious troubles in Scotland in 1637 he joined the party of resistance to Charles I. He signed the covenant protesting against ecclesiastical innovations in 1638 and suppressed the opposition to the popular cause which arose in the north around Aberdeen and in the country of the Gordons. After the signature of the treaty of Berwick in 1639, Montrose was one of the covenanting leaders who visited Charles. Montrose wished the clergy to confine themselves to their spiritual duties and the king to maintain his independence and not be subject to a faction. In the Scottish parliament that met on Aug. 31, Montrose was opposed to the earl of Argyll's policy of giving the three estates equal powers in choosing the committee of articles, for this would eliminate the royal voice in the direction of proceedings and would give an opportunity for Argyll's own ambition.

Rather than give way, Charles prepared to invade Scotland in 1640. Montrose, though still faithful to the original aims of the covenant, had become distrustful of the antiroyalist trend and of those who led it. In Aug. 1640 he signed the Bond of Cumbernauld as a protest against the "particular and indirect practising of a few," in other words, against the ambition of Argyll. But he still served in the covenanting army against the king and in the same month displayed his gallantry in the forcing of the river Tyne at Newburn. After the success of the invasion, Montrose was charged with intrigues against Argyll and was imprisoned in Edinburgh castle in June 1640. After the king's visit to Scotland Montrose shared in the amnesty tacitly accorded to all Charles's partisans.

When the Civil War began in England (*see* CIVIL WAR, ENGLISH), Montrose opposed Scottish intervention on behalf of parliament and pressed Charles to allow him to make a diversion in Scotland. The marquess (afterward duke) of Hamilton's impracticable policy of keeping Scotland neutral stood in the way of Charles's consent. But when a Scottish army entered England in Feb. 1644 to take part against the king, Montrose, created marquess, was appointed lieutenant general in Scotland. After an unsuccessful attempt in April to invade Scotland with under 2,000 men, he made his way in August, almost alone, to the Highlands, where the clans rallied to his summons and he was joined by an Irish force. He defeated his opponents, with military skill, at Tippermuir, Aberdeen, Inverlochy, Auldearn, Alford and Kilsyth.

In the name of the king, who appointed him lieutenant governor and captain-general of Scotland, he summoned a parliament to meet at Glasgow on Oct. 20 with the object of organizing the Lowlands. The parliament never met, for Charles was defeated at Naseby on June 14, 1645. Montrose was called to his help, but his Highland force had melted away and he gained little support from Lowlanders, who were alienated by his marauding Irish and Highland troops. David Leslie (afterward Lord Newark), the best of the Scottish generals, was promptly dispatched against Montrose and his small force, which he routed on Sept. 13, at Philiphaugh. Montrose made his way to the Highlands but failed to organize an army. He embarked for Norway in Sept. 1646 and went to Paris in 1647, but could get no support from Henrietta Maria. Three years later, burning to avenge the death of the king, he was restored by the exiled Charles II to the nominal lieutenancy of Scotland. Charles, however, did not scruple, shortly afterward, to disavow his noblest supporter in order to become a king on terms dictated by Argyll and his adherents. Montrose landed in the Orkneys in March 1650 and crossed to the mainland with no more than 1,200 men. He tried in vain to raise the clans and on April 27 was routed at Carbisdale. After wandering for some time he was surrendered by Neil Macleod of Assynt, to whose protection, in ignorance of Macleod's political enmity, he had entrusted himself. Montrose was sentenced to death on May 20 and was hanged in Edinburgh on May 21, 1650. To the last he protested that he was a real covenanter as well as a loyal subject.

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**MONTROSE,** a royal and small burgh and seaport of Angus (Forfarshire), Scot., lies 30 mi. N.E. of Dundee by road. Pop. (1961) 10,702. The town, which is spacious and has plentiful trees and gardens, occupies a sandy peninsula and is bounded by the North sea, the North and South Esk, and by Montrose basin, a tidal lagoon about 7 mi. in circuit, which is a wintering place for pink-foot geese and other migratory water birds. Attempts by Dutch workmen to drain the basin in 1670 were wrecked by a severe storm. In the mouth of the channel of the South Esk lies the island of Rossie, or Inchbrayock, connected with the burgh by means of a suspension bridge, and by a drawbridge with the south bank near the large fishing village of Ferryden. The harbour lies between the suspension bridge and the sea, and is provided with a wet dock. Montrose is a seaside resort with fine links, including golf and putting courses. The spired church and the town hall are of the 18th century. There is some industry such as the making of jute and other fibre products, and pharmaceutical chemicals. The soft fruits of Angus, as well as imported fruit, are canned or made into preserves. Timber is imported and local beer is shipped to Newcastle. Montrose received its charter from David I and was made a royal burgh in 1352. It was destroyed by fire in 1244. There Edward I accepted John de Baliol's surrender of Scotland on July 10, 1296. From the harbour the Old Pretender embarked in 1716 for France. In 1745 the Jacobites gained possession of the town and had some successes against the government. Among famous names connected with the burgh are James Graham, 1st marquess of Montrose, born at Old Montrose; John Erskine who introduced at Montrose in 1534 the study of Greek into Scotland; Joseph Hume, the politician; and Andrew Melville, the theologian and religious reformer.

**MONT-SAINT-MICHEL,** a rocky islet off the coast of Normandy, France, in Manche *département*, lies just north of Pontorson from which it is accessible by a mile-long causeway. Pop. (1962) 132. About 1,000 yd. in circumference, it forms, with the nearby islet of Tombelaine, a granite outcrop, rising sheer (about 300 ft.) out of the strand (La Grève) of the Bay of Mont-Saint-Michel. Around the base of the *mont* are medieval walls and towers above which rise the clustered buildings of the village with the ancient abbey crowning the pile.

The strand, a vast sandy tract (100,000 ac at low tide), is formed by a whitish-silvery sediment (*tangue*) comprised largely of ancient continental loam, enriched by sea-brought elements. In parts of the strand, called *lises*, the *tangue* is liable to become liquid and for imprudent walkers there is a danger at low tide of *enlisement* ("drowning in the mud"). Such accidents are rare and the real dangers of the bay are unexpected fogs, and irregular arrivals of extremely rapid high tides.

In the 8th century, an oratory was established there by St. Aubert, bishop of Avranches, apparently at the command of an apparition of St. Michael the Archangel, and the place soon became a resort for pilgrims. In 966 Richard I, duke of Normandy, replaced the oratory by a Benedictine abbey, which was generously endowed in Normandy, in England (where the priory of Saint Michael's Mount [*q.v.*] in Cornwall was given to Mont-Saint-Michel by Edward the Confessor), and in Brittany. In the 12th century under its noted abbot, Robert of Torigny, it became a celebrated seat of learning.

In 1203 the Breton allies of King Philip Augustus burned the village and part of the abbey. Philip Augustus afterward compensated the monks by providing money for the construction of La Merveille, which became the monastery proper. A system of fortifications was then begun and in 1256 St. Louis made a pilgrimage to the *mont* and contributed to the cost of the ecclesiastical stronghold. During the last 30 years of the Hundred Years' War, the abbey persistently resisted the English. In 1469 Louis XI instituted there the Order of St. Michael which, however, is not known to have held any session at the abbey. During the Wars of Religion, the Huguenots were unable to capture the fortress, which opened its gates to Henry IV in 1595. In 1622 the Benedictine monks of Mont-Saint-Michel were replaced by the Maurists (*q.v.*), who restored a more regular monastic life and wrote valuable histories of the abbey.

In the 18th century the monastery declined and at its dissolution in 1790 housed only seven monks. A number of its ancient manuscripts and documents are preserved in the municipal library at Avranches. The monastery, which had been used as a place of detention since the time of Louis XI, was officially transformed into a state prison by Napoleon I in 1811, and remained as such until 1863.

From 1874 onward restoration was carried on steadily. The abbey is now a national monument and a leading tourist attraction. The oldest part of it is a subterranean Carolingian church (10th century), a simple building with two naves. Around it are grouped a number of 11th- and 12th-century buildings including the Crypte de l'Aquilon (pilgrims' reception hall) over which is the vaulted Promenoir (monks' walk); the monks' dormitory; and the nave and transept of the church, which is a fine example of the Norman Romanesque style. In the 13th century were built Belle Chaise (housing the abbot's tribunal), the abbot's lodgings and, notably, La Merveille on the north side of the rock. La Merveille, built in a superb Norman Gothic style, comprises three stories: (1) the Cellier and the Hospitium (pilgrims' reception room); (2) the Salle des Hôtes, where distinguished guests were feasted, and the so-called Salle des Chevaliers which was the Scriptorium; and (3) the refectory and the cloister. In the 15th century the church choir and the crypt under it were rebuilt in Flamboyant style. The central tower and spire (495 ft. above the sea, crowned by the gilded "St. Michael and the Dragon" by E. Frémiet) were erected as part of the 19th-century restoration.

The northern side of the mont is wooded. The eastern and southern sides are surrounded by towered ramparts (mostly of the 14th and 15th centuries) enclosing the village, which has a long narrow street, several lanes with steps and some picturesque medieval houses, as well as a small 15th-century parish church. Most of the houses are hotels or souvenir shops. (P. Le.)

**MONTSERRAT,** an island of the Lesser Antilles in the Caribbean, lies 27 mi S.W. of Antigua and is 11 mi. long and 7 mi. broad, with an area of 32 sq.mi. It is a serrated range of volcanic peaks rising in three main hill masses, the summits of which are forested. Chances mountain, 3,002 ft. in the southern hills above the still-active volcano Soufrière, is the highest point. The average temperature on the island is 27° C. (81° F.), and rainfall averages 94 in. Water is plentiful. The system of government is ministerial, the executive council consisting of two official and four unofficial members from whom three ministers are appointed.

The island's population was 12,108 in 1960. Plymouth, the capital and only port, had at that time a population of 1,911. Primary education is compulsory and free, and there is one government secondary school. In 1956 access to Montserrat was facilitated by the completion of Blackburne airfield. Previously, visitors were dependent on ships that sailed irregularly.

The principal crop is sea island cotton. The most important exports include cotton lint, lime products and vegetables.

Montserrat was discovered in 1493 by Columbus and colonized by Sir Thomas Warner in 1632. In 1871 it became part of the Leeward Islands federation, which endured until 1956. In 1958 Montserrat joined the West Indies federation (*q.v.*), which was dissolved in 1962. (Rn. T.)

**MONTSERRAT,** the Mons Serratus of the Romans, is a mountain in northwest Barcelona province, Catalonia, Spain. It is famous for its Benedictine monastery of Santa Maria de Montserrat and for the ancient wooden statue of the Virgin and Child venerated there for hundreds of years by numerous pilgrims, who attribute many miracles to the intercession of the Virgin.

Jagged pinnacles (hence its name, meaning "serrated mountain") rise from the mountain's huge base and it is cloven by ravines; the monastery stands on the edge of the widest of these, the Valle Malo, at an altitude of 2,400 ft. Most of the mountain is of gray conglomerate rock and its highest peak is San Jerónimo (4,054 ft.). The Llobregat river flows past it on the east. Remains indicate that it was inhabited during Neolithic and Bronze Age times.

Hermits of Santa Maria were residing on the mountain during the 9th century and in 888 the Benedictine monastery of Ripoll was granted jurisdiction over them. From the 11th to the early 15th centuries a regular priory flourished there and obtained independence as an abbey in 1409 which status it has held almost continuously since. The present basilica was begun in 1560 and the present monastery in 1755, though it had to be extensively rebuilt after destruction by French troops during the Peninsular campaign in 1812.

The Virgin's statue was removed from the church when the monastery was temporarily suppressed in 1533. In 1844 it was brought back and in 1880 was canonically crowned to symbolize the placing of Catalonia under the patronage of the Virgin Mary as Our Lady of Montserrat. The faces of the Virgin and of her Child are black from the smoke of the lamps and candles burning through the centuries. In 1137 the statue was said not to be the work of human hands, which implies that it was very old, dating perhaps from the 12th century (although it was restored in the 13th, as is indicated by its style; according to one tradition it was carved by St. Luke, brought to Spain by St. Peter and found [880] in the Santa Cueva [cave] by shepherds where it had been hidden during the Moorish occupation). It has undergone subsequent restorations and at the beginning of the 19th century the face of the Child was altered.

The monastery has also an important collection of paintings, mostly Spanish and Italian, including a "Saint Jerome" by Michelangelo da Caravaggio and a "Saint John" by El Greco; a library which includes manuscripts and incunabula, especially from its own early printing presses; a biblical museum; and an archaeological collection containing remains of the old church. (X. D. S.)

**MONTT, MANUEL** (1809–1880), Chilean statesman and president, was born in Petorca on Sept. 8, 1809. He studied law at the Instituto Nacional, and from 1835 to 1840 he was rector of that school. He served in the administration of Pres. Joaquín Prieto, was elected to congress in 1840, and was minister of the interior and minister of justice under Pres. Manuel Bulnes. Montt was elected president of Chile in 1851 and served until 1861. He represented the conservative oligarchy and was authoritarian and inflexible in his beliefs, but he also worked for the economic and social progress of his nation. His administration, with the able assistance of the minister of the interior, Antonio Varas, is

remembered for its outstanding advances in technology, commerce and banking, the codification of Chilean laws, the promotion of public education and immigration, the colonization of the area south of the Bío-Bío river and the abolition of entailed estates. Montt was a nationalist and protected the interests of the state in controversies involving the Roman Catholic Church. Revolts against his regime occurred in 1851 and 1859, but Montt put them down. On giving up the presidency in 1861, he became president of the supreme court of justice, a post he held at the time of his death, Sept. 20, 1880. A son, Pedro (1848–1910), was president of Chile in 1906–10. (J. J. J.)

**MONTT, PEDRO** (1848–1910), Chilean statesman, son of Manuel Montt (*q.v.*), was born in Santiago, Chile, in 1848. He graduated in law at the Instituto Nacional in 1870. Six years later, he was elected a member of the chamber of deputies, and in 1885 he became its president. In spite of holding two cabinet offices in the government of Pres. José Balmaceda, Montt figured in the parliamentary opposition to him and in 1891 took a very active part in the revolution which put an end to the president's power. He then went to the United States, first as agent of the Revolutionary Junta and, after the recognition of the new government, remained as minister of Chile. In 1901 Montt was an unsuccessful candidate for the presidency, but in 1906, as the candidate of the National Union ticket and supported by all the country's articulate elements, he was elected by a large majority. During his term he helped to prevent armed conflict between Chile and Argentina, fostered railway development, and promoted sanitation and health projects. He died on Aug. 16, 1910, at Bremen, Ger. (J. J. J.)

**MONTÚFAR Y RIVERA MAESTRE, LORENZO** (1823–1898), an outstanding Guatemalan historian as well as a noted Central American statesman and diplomat, was born in Guatemala City on March 11, 1823. He received degrees in philosophy and law from the University of Guatemala in 1846. He began his career as a professor of civil law, meanwhile writing many articles and publishing journals. A lifelong Liberal, he vigorously opposed dictatorships, especially that of Rafael Carrera in Guatemala, and was frequently exiled for his political opinions. While in El Salvador, he was elected to the Guatemalan congress which proscribed Carrera, but on the latter's return Montúfar was forced to flee to Costa Rica.

In Costa Rica he assumed a career as a lawyer, magistrate and publisher of a new nonpolitical periodical. He served as Costa Rican minister of foreign relations and helped to organize the Central American defense against William Walker, an adventurer from the United States who had seized control of Nicaragua.

Montúfar traveled extensively in Latin America, the United States and Europe and was at home in each of the Central American republics. As one of the leading advocates of Central Americanism, he repeatedly urged that the Central American Federation be re-established. He held numerous government posts and negotiated treaties for some of the many Central American boundary disputes. In 1891 he was an unsuccessful candidate for the presidency of Guatemala. His most significant historical work is the seven-volume *Reseña histórica de Centro América* (1878–88), which covers much of the Carrera era. (T. L. K.)

**MONUMENTS, PRESERVATION OF** (Latin *monumentum* or *monimentum*, Old French *monere*, "to remind"; literally, that which by its survival commemorates anything). In the broadest sense all these can be classified as monuments: a cave painting that survives from the Paleolithic period; a Neolithic village site; cairns; tumuli; a church constructed in western Europe during the medieval period; the bronze statue of Amida Buddha in Kamakura, Japan; the ruined and abandoned Mayan city of Chichén-Itzá in Yucatan, Mex. Besides historical buildings and archaeological sites, the United States government has classified certain outstanding natural features, such as natural bridges, the Grand canyon in Arizona and a fossiliferous site (Dinosaur National monument, Utah), as monuments preserved as public property and maintained or guarded by the national park service. In a more restricted sense the word monument is also used to refer to a written document or record.

This article deals with the causes of the deterioration of monuments; with technical principles followed in their preservation; and with some of the statutory provisions employed by different governments to ensure their preservation as part of the artistic and historic heritage of man. For descriptions of various kinds of monuments, *see* also such articles as ARCHAEOLOGY; SCULPTURE; NATIONAL PARKS AND NATURE RESERVES.

Monuments are, as with all other things, subject to decay and destruction in the course of time. Such environmental factors as temperature change, sunlight, erosion by wind or water, plant life, atmospheric oxygen and the waste products of industry, earthquakes and storms all contribute to the progressive decay of monuments. Man himself, through building operations, agriculture, acts of vandalism and war, is perhaps the most dangerous agent of destruction. Realistically, preservation should be considered as an effort to slow an inevitable process.

During the 20th century, advances in the natural sciences have aided in the preservation of monuments. Laboratory analyses have replaced hit-or-miss methods and clarified such problems as those involved in the decay of wood, stone and glass, and when metals rust or corrode. New techniques and products have given rise to new methods of treatment. The development of fungicides has aided tremendously in the preservation of monuments of organic origin. The rapid development of plastics since World War II has yielded materials that are highly resistant to weathering and chemical attack. They have been successfully used, particularly to preserve smaller monuments, since cost is a limiting factor.

Efforts to rescue a monument from oblivion may accelerate the process of disintegration. A wooden ship buried in sand or mud for centuries may appear to be in an excellent state of preservation when raised. However, on exposure to air the wood will shrink, warp, crack or break into small particles. A slow, tedious and (at times) expensive series of treatments is necessary to remove the water gradually; e.g., the 17th-century warship "Vasa" sunk in Stockholm harbour and raised in 1961. At times the water may have to be replaced with a stabilizing agent. Structures of unbaked clay may also survive for many centuries, but when they are exposed to the air by archaeologists, elaborate precautions may be necessary to prevent their rapid dissolution. Thus, for example, the ruin (13th century A.D.) in Casa Grande National monument (Arizona), with mud walls more than 4 ft. thick standing about 34 ft. high, is now sheltered by a roof supported on girders. A similar solution was developed to protect the ruins of the Greek city of Gela (5th century B.C.) in Sicily. The mud-brick walls are sheltered by a roof supported on girders; tempered glass sheets, held in place with stainless steel rods, protect the vertical surface.

Monuments of stone, however solid and enduring they may appear as compared with wooden or earthen structures, are also subject to decay. A monument moved from one country to another may be subjected to accelerated weathering. This was the case with Cleopatra's Needle, a granite obelisk from Heliopolis which was moved to the Embankment in London. In temperate zones, frost will widen existing cracks and contribute to the destruction not only of the surface but also of the structure itself. Plants, from simple molds and mosses to trees, also attack monuments. In the humid tropics, buildings may be torn apart by the growth of trees; roots penetrate masonry and separate block from block, eventually destroying the monument. Such sites as Angkor (Cambodia) and Chichén-Itzá (*q.v.*) have been stabilized following the removal of the forest cover, but constant efforts are necessary to prevent the return of vegetation.

The use of coal and petroleum products for fuel and in manufacturing contributes to the pollution of the air and endangers monuments. Such impurities as carbon monoxide, oxides of sulfur, ammonia and hydrogen sulfide may be present in various quantities in the atmosphere. During the late 1950s, for example, nearly 50,000 tons of petroleum products were consumed daily in Los Angeles, Calif., yielding an estimated 2,700 tons of impurities, including sulfuric and nitric acids and various hydrocarbons. Under such conditions marble, limestone, sandstone and many other monument materials are subject to attack. Carvings lose their

features, and the weathering of exposed surfaces is tremendously accelerated. Smaller monuments may be sheltered, but large structures can only be safeguarded by stringently enforced anti-pollution laws.

In addition, there are the direct effects of man; large-scale construction in such projects as superhighways and dams has sometimes caused the loss of monuments or necessitated their transfer. As an important example, the United Nations Educational, Scientific and Cultural organization (UNESCO) on behalf of Egypt and the Sudan launched an international campaign in the 1960s to save the monuments of Nubia. The Aswan high dam was expected to raise the level of the Nile and flood most of the archaeological sites and monuments. Structures of mud or in a poor state of repair had to be abandoned. A number of the nominated monuments that were salvageable were to be moved out of the reach of the waters and some transferred to other countries. The Nile islet of Philae, which houses a group of temples constructed in honour of Isis during the Ptolemaic and Roman periods, was to be protected by a series of small dikes. In 1961 two plans were considered for the protection of the most important monument of all, the rock-cut temple of Abu Simbel constructed by Ramses II. The first was the construction of an elliptical dam to preserve the monuments *in situ*, and the second was to detach them from the cliff and lift them above the water level by the use of hydraulic jacks (*see* ABU SIMBEL; NUBIA). These projects were costly, and an insufficient number of pledges were made. In 1962 the simpler and less expensive method of cutting the temples into blocks that could be assembled on the plateau above was approved. The equivalent of $19,126,000 was promised for the project by 47 countries; the United Arab Republic budgeted an additional $11,500,000.

However dangerous large-scale construction can be to monuments, there usually is an interval between the preparation of plans and the actual building that permits salvage or protective measures. On the other hand, such time may not be available in war. During World Wars I and II, attempts were made to avoid damaging important historic monuments by withholding bombing attacks on such cities as Kyōto (Japan), Paris and Rome. When cities that belligerents decided had overriding strategic value were subjected to attack, many monuments were inevitably damaged or destroyed.

Such vandalism as written or carved initials, detached or broken pieces for souvenirs, as well as deliberate and senseless destruction, is a constant menace. Measures to control vandalism include the passage and application of laws, posting of guards, placement of barriers, such as mesh screens, tempered glass or railings, and programs to educate the public to respect human cultural heritage.

Complete agreement about the degree to which preservative measures are to be carried out does not exist. In general, radical reconstruction, which introduces features absent in the original monument and which was frequent during the 19th century, is now frowned upon. If repairs are necessary, materials similar to the original are employed if feasible, but no attempt is made to age the replaced section artificially, as was once done. Decisions taken about preservation depend on a blend of technical and historical factors. For example, during 1958 it was felt necessary to reerect some of the fallen elements of Stonehenge (England), which were in danger of rapid deterioration. The work of archaeologists had furnished considerable documentation about the appearance of Stonehenge when it was in use, and in theory the work of restoration could have been executed to the limits of the knowledge available. However, restoration was carried out only to the way it appeared in sketches and descriptions made at the end of the 18th century.

Controversy also exists about the aesthetic value of reconstructing a monument that has been completely destroyed. However, for historical reasons such reconstruction has been undertaken, as in the case of the Kinkakuji, or Golden pavilion. This building was a famous example of Japanese architecture erected during the Muromachi period (1336–1573) in Kyōto. It was burned down in an act of vandalism, and the government built an exact replica of it in 1955.

Increasing prominence is also given to a monument's site, from which anachronistic elements may be removed and its aesthetic appearance improved. In extension of this principle there have been projects in which an entire community has been considered to be a historic monument; government regulations have been imposed to limit the kind of work that may be done to a historic building, and to aid private owners financially to carry out necessary repairs. One of the most ambitious projects of this type was the preservation and restoration of colonial Williamsburg (Virginia) with the aid of funds from John D. Rockefeller, Jr. This was the political centre of the colony of Virginia from 1699. Old buildings that still survived were restored to their original condition, and buildings constructed subsequent to this period were razed or moved (*see* WILLIAMSBURG). Controversy exists about plans for building replicas of several important buildings, although careful historical and archaeological research formed the basis of this program. An analogous effort was the complete reconstruction of the Stare Miasto (old town) of Warsaw (*q.v.*), which had been destroyed during World War II. All of the old buildings were duplicated by the government, even to the reproduction of murals dating from the Renaissance.

Nearly all countries have some form of legislation involving measures to be followed for the preservation of monuments, as well as penalties to be invoked for noncompliance. There is also an international convention for the protection of monuments in the event of armed conflict. National legislation may affect only those properties owned or controlled by the government, as in the case of the United States; or it may also control historic sites and monuments in private hands and include movable, *e.g.*, smaller statuary, paintings and objects recovered from an archaeological site, as well as immovable monuments. This is the case in such places as France, Italy, Turkey, Mexico, Peru and Japan, including all Latin-American countries and virtually all lands of the near east. Usually, to implement the legislation, some form of central organization exists, staffed with architects, historians and archaeologists. It may have only advisory powers over monuments not owned by the state, or it may have considerable discretionary powers over the care, maintenance and disposition of all monuments.

**United Kingdom.**—The first Ancient Monuments Protection act was passed in 1882 (45 & 46 Vict., c. 73), and the scope of legislation has been progressively increased by later acts of parliament. The ministry of works is entrusted with the execution of the legislation, and its general responsibilities are outlined in the Ancient Monuments Consolidation and Amendment act of 1913 (3 & 4 Geo. V., c. 32) and the Historic Buildings and Ancient Monuments act, 1953 (1 & 2 Eliz. II, c. 49). Under the provisions of the act of 1953, councils have been established for England, Scotland and Wales whose duty it is to advise the minister on the treatment of monuments and to report if any monument is in danger of destruction, removal, neglect or injudicious treatment.

The minister of works does not have the power to interfere with ecclesiastical buildings in current use or with inhabited buildings (the latter are, however, controlled by legislation in the Town and Country Planning acts of 1944 and 1947 and subjected to restrictions similar to those affecting scheduled monuments; *see* below). Sites in the charge of the ministry include crown property and those placed under the guardianship or ownership of the ministry by private owners (guardianship confers on the ministry the duty of preserving, maintaining and managing a monument, but the title of ownership remains in private hands). The ministry may accept as a gift or purchase, with the consent of the treasury, ancient monuments, including inhabited houses.

The ministry compiles and publishes lists of monuments to be preserved as a matter of national importance. This is known as scheduling, and when a monument is to be scheduled the ministry must notify the owner and occupier. The most important restriction is that three months' notice of any intention to repair, alter or demolish the monument must be given to the ministry. If the owner objects to its recommendations, the ministry may issue a preservation order to place the monument under its protection.

Three private societies also are concerned with the preservation

of monuments: the Society for the Protection of Ancient Buildings; the Ancient Monuments society; and the National Trust for Places of Historic Interest or Natural Beauty. The National trust (founded in 1895) is the most important and was incorporated by the National Trust act (1907) and empowered to acquire by gift, purchase or devise sites and buildings to be held in perpetuity for the public. The trust has been given many important town and country houses in addition to places of scenic beauty. It carries out its work under several acts of parliament under which tax concessions can be obtained in respect of houses made over to the trust.

**United States.**—The Antiquities act (1906), the National Park Service act (1916) and the Historic Sites act (1935) are the basis of the program for the preservation of monuments belonging to the federal government. Since 1933 all historical and archaeological properties of the federal government have been under the administration of the national park service of the department of the interior. The secretary of the interior, through the national park service, is empowered to conduct studies to determine which sites and buildings have exceptional historic value. Through gift, purchase or otherwise, any personal or real property (with the exception of that owned by any religious or educational institution or owned and administered for public benefit) may be acquired without the consent of the owner. However, no property may be acquired that will obligate the treasury unless congress has appropriated funds for that purpose.

The national park service has an advisory board on national parks, historic sites, buildings and monuments to recommend historic sites and buildings as eligible for preservation or national recognition. The act of classification carries no legal implication and does not diminish the right of the owner to do as he pleases with a historic monument. In addition, a National trust was established in Oct. 1949. Although it is chartered by congress, its activities are financed entirely through voluntary support. It may receive donations of sites, buildings and objects significant in U.S. history and culture to preserve and administer them for the public benefit.

In addition, many states and municipalities have their own legislation, particularly in cases where important historic monuments or archaeological sites are to be found. The Arizona Antiquities act (1960), for example, places jurisdiction over all ruins, archaeological sites, historic and prehistoric monuments and structures, and other objects of antiquity owned by the state under the director of the Arizona State museum. Only educational institutions, public museums or nonprofit corporations organized for scientific and research purposes would be considered eligible to obtain excavation permits from the director.

**France.**—The *classement* or classification system of France was based on the law of March 30, 1887, in which important historical structures were classified and registered as national monuments. This law has since undergone a number of modifications that successively widened the scope of protection. At present prehistoric and archaeological sites, the buildings surrounding a national monument, the area within a 500-m. radius of a national monument, and movable objects considered to have historic, artistic or scientific value can also be classified as national monuments and come under the supervision and protection of the ministry of fine arts.

Property belonging to the state, *départements* or municipalities, and other bodies or individuals can be classified as national monuments by a decree of the minister of fine arts (with the proprietor's consent in the last two cases). The decree also determines the conditions of classification. If the owner opposes the interpretation or execution of the decree, the matter may be referred to the council of state, which has the power to impose a decree. In addition, the minister may, in the name of the state and in the interest of the public, expropriate property that has been or is about to be classified as a national monument.

Classified monuments cannot be destroyed, displaced or undergo restoration or repair without the consent of the minister of fine arts. The ministry may also undertake, at the expense of the government and with the consent of the owner, repairs or maintenance of a classified monument that does not belong to the state. Should the owner object, the ministry may obtain a prefectorial decree authorizing temporary occupation of the property to carry out necessary repairs.

Similarly, the minister of fine arts may classify movable or smaller objects as national monuments, in which case they are subjected to the same protection as larger monuments. The effects of classification remain, whether or not there is a change in ownership, and such classified objects cannot be exported from France.

**Japan.**—A law for the preservation of ancient shrines and Buddhist temples was first enacted in 1897. Since then several other laws have widened the scope of protection and of the administration of the government over cultural property. In 1950 the Cultural Properties Protection law superseded all previous legislation. The administration of the law was placed in the charge of the Cultural Properties Protection commission, attached to the ministry of education, which has complete independence of authority. The five members of the commission are appointed for a term of three years by the minister of education with the consent of both houses of the diet. It is equipped with a secretariat composed of a general affairs division (in charge of administrative matters) and a preservation division.

The law protects immovable and movable monuments (cultural property), including in the latter category paintings, sculpture, objects from the applied arts, examples of calligraphy, books and ancient documents. It also includes objects of ethnic or folk customs (such as food, clothing and houses) that are used in traditional occupations and religious festivals. These monuments are classified as "important art objects"; in this group those with very high cultural value are designated as "national treasures." Prehistoric, archaeological and historic sites are also protected by this law. As in the case of the United States, places of scenic beauty or areas of great scientific value can also be set aside as national monuments. The distinguishing feature of the Japanese law is the inclusion of such "intangible" cultural property as drama, music and the skills employed in applied arts that have substantial historic or artistic value. This enables the government to aid, *e.g.*, through subsidies, in the preservation of cultural traditions, which would otherwise be lost or forgotten.

The commission has overall charge of all monuments belonging to the state. It also controls classified cultural property under private ownership. The owner or custodian of an important cultural property is held responsible for its care. Permission must be obtained from the commission before any repairs or alterations are carried out. Subsidies for repairs ranging from 50% to 99% of the total cost have been granted by the government. If it is dissatisfied, the commission may undertake care and restoration itself. Important cultural property cannot be exported from Japan except, with permission of the commission, to carry out exchanges or for similar reasons. All archaeological excavations come under the protection of the commission, and if any object considered to be of national value is discovered, it becomes the property of the state, with suitable compensation paid to the owner of the land.

The commission, in carrying out the protection of "intangible" cultural property, has taken motion pictures of Bunraku (large puppet) theatre, kabuki and nō plays. Similar documentation has been made of traditional skills in such manufactures as ceramics, lacquer wares and textiles. People with outstanding traditional skills, whether in the theatre or in the applied arts, may be granted a subsidy by the government. Such persons may be required to exhibit or demonstrate their skills for as long as three months at the expense of the national treasury. The commission also encourages the transmission of such skills to apprentices so that they may be maintained.

**Convention and Protocol for the Protection of Cultural Property in the Event of Armed Conflict.**—During April and May 1954 UNESCO (in co-operation with the government of the Netherlands) sponsored an intergovernmental conference at The Hague on the Convention and Protocol for the Protection of Cultural Property in the Event of Armed Conflict. The conference adopted a convention (together with regulations for its execution)

and a protocol. The fifth instrument of ratification was deposited with the secretariat of UNESCO in May 1956, and both international agreements entered into force later that year. By Dec. 1963, 50 nations had become parties to the convention, and 47 to the protocol.

Cultural property was defined as movable or immovable property of great importance to the cultural heritage of all peoples, such as monuments of architecture, art or history, archaeological sites, groups of buildings of historic or artistic interest, works of art, and manuscripts, as well as scientific collections and important collections of books. According to the provisions of the convention, cultural property would be respected and used for no purpose that would be likely to expose it to destruction or damage in the event of armed conflict. However, if military use is made of a monument, it loses its immunity.

During armed conflict those items of cultural property placed under special protection are to be marked with a distinctive emblem, a shield consisting of a royal-blue square, one of the angles of which forms the point of the shield, and of a royal-blue triangle above the square, the space on either side being taken up by a white triangle.

Among the various measures mentioned in the convention and protocol is the prohibition of theft, pillage, misappropriation or acts of vandalism against cultural property in territories under the control of a warring state. Should there be any question about the status of a given monument, inspectors may be appointed who, taking into account the security needs of the warring country to which they are accredited, will examine the monument in question.

UNESCO not only keeps instruments of ratification of the convention and protocol and acts as an arbitrator but also keeps an international register of cultural property placed under special protection.

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**MONUMENTS AND MEMORIALS,** broadly speaking, include all objects of whatever size or nature, that have been put on view for the primary purpose of recalling to mind specific events or personages. Their production is a distinctive characteristic of societies which put value upon the individual human being and hold an objective view of historical events. (*See* also RELIGIOUS ARCHITECTURE; SCULPTURE, SEPULCHRAL; BASILICA.)

**Early History.**—Most of what are loosely referred to as monuments or memorials in ancient Egypt—obelisks, sphinxes, historical wall reliefs and the like—were not so much intended to recall to mind a past fact as to create a present situation by a process of collective solipsism. The pictorial and verbal statements they made about the power or divinity or military prowess of gods and Pharaohs were intended to create history rather than commemorate it. By the act of tangibly stating them, they were to bring realities into existence. (*See* EGYPTIAN ARCHITECTURE; PYRAMID.)

It was in Mesopotamia, where true awareness of individual personality first appeared, that monuments and memorials proper seem to have originated. A typical, though late, extant example is the stele of Hammurabi in the Louvre (*c.* 1650 B.C.), which was set up to record and commemorate that king's codification of old Babylonian law. References are frequent in the Bible to a similar practice among the ancient Hebrews—a characteristic expression of their vivid consciousness of personal relationships between individuals (*e.g.*, the cairn commemorating an agreement between Jacob and Laban, Gen. xxxi, 44–54) and between man and God (*e.g.*, the Bethel pillar, Gen. xxviii, 18–19). Relatively simple types of inscribed stones like these remained the generally standard form of monuments and memorials until Greek times. Then, with the developing ideal of classical humanism as a stimulus, they became major vehicles for artistic expression. (*See* also PRE-HELLENIC ARCHITECTURE.)

**Greece.**—The most notable early Greek monuments and memorials were connected with the great national games which were established from the 8th century B.C. on (apparently as an outgrowth of primitive funeral games) at Olympia, Nemea, Delphi, on the Isthmus of Corinth and elsewhere. While the actual prizes offered were seldom substantial—tripods being prominent in early times and simple wreaths later—winners in the various contests had the important additional privilege of setting up monuments on the grounds to commemorate their victories. Such memorials, which might be anything from small models of discoids or chariots to life-size single figures and groups, in time furnished the occasion for creating some of the greatest works of Greek art. Typical is the "Bronze Charioteer," excavated at Delphi in the 19th century, it once formed part of a complete group of chariot, horses and the goddess Nike erected to commemorate a victory in the Delphic chariot races (*c.* 475 B.C.). Similarly commissioned was the original "Discobolus" (discus thrower) by Myron, executed *c.* 450 B.C., which was so famed throughout antiquity that it has come down in several copies. A later example is the choragic monument of Lysicrates at Athens, erected 335–334 B.C. by Lysicrates to commemorate his victory in a choral contest. It consists of a square base and circular superstructure decorated with six engaged Corinthian columns, capped by a convex roof on which stood his tripod trophy supported on acanthus scrolls.

Victor monuments were, of course, only one of many types of memorial developed by the Greeks. From the 6th century on they began to commemorate their dead with steles—painted or carved slabs of stone first depicting figures of the departed and later scenes from his life. Characteristic are the steles of Hegeso, representing a late 5th-century woman in the simple act of choosing a piece of jewelry from a box held by her servant, and of Dexileos, a young cavalryman killed in the Corinthian War of 394 B.C., shown in the act of striking down an enemy. Memorials to historical events and personages often took the form of columns—usually but not always with regular base, fluted shaft, and capital—on which were set figures or other significant objects. Examples are the three-sided tapering shaft set up at Olympia, probably to commemorate the battle of Sphacteria in 425, atop which stood the Nike of Paionios; and the twisted bronze serpent column once bearing a tripod, which was set up at Delphi to commemorate the battle of Plataea in 479 (now in Istanbul, Turk.).

The Hellenistic tendency to megalomania is well illustrated in the monuments and memorials of that age, which became increasingly large, lavish and pretentious. An important early example was the so-called mausoleum at Halicarnassus in Caria, begun *c.* 353 B.C.—an enormous structure surmounted by colossal figures of King Mausolus and his queen in a chariot. Later, all the great cities of the Hellenistic east (Alexandria, Antioch, Pergamum, Ephesus) were filled with large and lavish memorials to their rulers and to their history. Particularly notable for such monuments was the Island of Samothrace, through the munificent patronage of the Ptolemies and Macedonian rulers; best known of them is the "Victory (Nike) of Samothrace" in the Louvre. (*See* GREEK ARCHITECTURE; GREEK ART.)

**Achaemenid Persia.**—Partly contributing to, and partly inspired by, Greek developments of the memorial theme, were the monuments of the Achaemenid kings of Persia (550–330 B.C.). One type is represented by the rock-cut tomb of Xerxes at Naqsh-i-Rustam near Persepolis (*c.* 485 B.C.), with a great sculptured facade depicting the king standing before a fire altar on two tiers of figures representative of 30 nations in his empire. A second and distinctively Achaemenid type is represented by monumental palaces, such as those of Xerxes I at Persepolis (*c.* 480–485 B.C.) and Artaxerxes II at Susa (404–358 B.C.). These palaces, being almost covered with depictions of the conquests, possessions and activities of their builders, were to them memorials as much (or more) as places of residence.

**Rome.**—The most characteristic types of Roman memorials were statues of emperors, practically mass-produced for erection in every important community of the empire; triumphal arches (q.v.); and columns. The columns erected to commemorate the victories of Trajan and Marcus Aurelius over Teutonic barbarians

still stand in Rome; capped by colossal statues of those emperors (now replaced by saints), they were decorated with spiral bands of relief sculpture depicting their military campaigns. No matter how these columns were originally placed, continuous friezes arranged in this manner must have been extremely difficult to follow intelligently, a fact which suggests that the Roman trend in monuments was away from objective communication, toward the primitive type of collective power symbol. Certainly this was true of the columns and colossal images erected by Constantine and his Byzantine successors, which show an almost Pharaonic spirit. (*See* ROMAN ARCHITECTURE; BYZANTINE ARCHITECTURE.)

**Sasanian Persia.**—The Sasanian kings of Persia (A.D. 226–642) raised monuments inspired both by the examples of their Achaemenid predecessors and those of their Roman and Byzantine contemporaries. Like the earlier palaces of Xerxes or Artaxerxes, the great palace of Shapur (Taq-e Kisra) at Ctesiphon (A.D. 242–272) functioned as a great memorial to the king's glory, especially his defeat of the Roman emperor Valerian. Unlike the flat-roofed palaces at Persepolis and Susa, however, a barrel vault with an 84-ft. span ran through the centre of the Taq-e Kisra, creating a great free spatial vista similar to that achieved in the contemporary architecture of Roman Syria. The Sasanian kings carved in cliffs huge memorials to themselves, like the Achaemenids, but the style shows Hellenistic and Roman influences; *e.g.*, the great relief showing Bahram II (A.D. 276–293) fighting on horseback.

**Middle Ages.**—Medieval monuments and memorials were not so much calculated to preserve the memory of individual personalities as to inspire emulation of their good works: "give us grace so to follow their good examples, that with them we may be partakers of Thy heavenly kingdom." They were embodied, therefore, in the most diverse forms. Memorials on the 12th-century pilgrimage roads from France to Santiago in Spain, for instance, included: a tall marble column at Arles near the Rhône, stained with the blood of the martyred St. Genest; a magnificent gold sarcophagus at St. Gilles, which recalled the miracles of St. Giles in Gaul; a huge cross at Ostabat, commemorating Charlemagne's campaigns against the Muslims in Spain; and, of course, many churches specifically built as memorials to the life and work of particular saints, as St. Front in Périgueux, St. Martin in Tours and Ste. Foy in Conques.

A famous example of a somewhat different but still characteristically medieval type of memorial is that erected by Pope Calixtus II in 1122 to commemorate the concordat of Worms. Destroyed in 1747 but known from drawings and descriptions, it consisted of a chapel and two contiguous rooms built inside the Lateran palace, in Rome. It was decorated with mural paintings depicting, in one place, seven popes whose successive struggles with the Holy Roman emperors over rights of investiture had been triumphally concluded and, in another, seven legitimate popes seated on thrones, with prone figures of their rivals, schismatic antipopes, beneath their feet. This monument was a fruitful source of late iconography.

The commonest medieval memorials were those marking burial places, particularly in churches. These belong in the category of tombs, but insofar as they served to recall the good works of those who had gone to paradise, they can be considered as commemorative monuments. In form they varied all the way from simple inscriptions to elaborate sculptural groups. One of the most telling indications of the spread of the Renaissance spirit was the marked change of conception that appeared in them during the later middle ages. From depicting the deceased living in paradise or asleep and awaiting the last trumpet, they came in the course of the 15th and 16th centuries to represent first, corpses and then, episodes from life—a revival in short, of the classical type of memorial dedicated to preserving the earthly fame of specific people and events. This change may be seen most effectively in London's Westminster abbey. By *c.* 1700 the suggestion of death had for the most part disappeared from the monuments there; both figures and inscriptions relate almost exclusively to the individual's accomplishments in worldly society. (*See* TOMB.)

**Renaissance.**—No classical forms were better calculated to appeal to Renaissance individualistic humanism than monuments; they were among the earliest classical motifs to be revived. L. B. Alberti, for instance, adapted the triumphal arch as the dominant element in his mid-15th-century church façades of S. Francesco at Rimini and of S. Andrea at Mantua; he made the former church, in effect, a personal monument to his patron Sigismondo Malatesta. At the same time Donatello was reviving, in his great bronze statue of Gattamelata in Padua (*c.* 1445), the classical type of equestrian monument, on the model of the Marcus Aurelius statue which now stands on the Capitoline hill in Rome. Classical monument types had been revived even earlier in painting, as in the "Hall of Illustrious Men," in Padua, decorated between 1367 and 1369 in imitation of the monument-lined effect of Greco-Roman streets, temples and houses (the subjects were drawn chiefly from Petrarch's *De viris illustribus;* repainted, 16th century). By the 15th century they were a common subject for painters (*e.g.*, the equestrian portrait of Sir John Hawkwood in Florence cathedral, by Uccello, 1436) and had become one of the roots of the developing Renaissance art of portraiture. All these precedents were coordinated and given majestic expression by Leonardo da Vinci, particularly in the monument he designed early in the 16th century for Gian Giacomo Trivulzio, ruler of Milan. Never executed, but known from Leonardo's preparatory drawings, it consisted of a heavy base complete with frieze, cornice and architrave, a tomb for Trivulzio in its side and atop it a life-size figure of him on a horse, rearing upward to crush a crouching enemy.

In the work of Michelangelo the concept of a memorial was broadened into a more general, allegorical type of expression. His magnificent tomb monument to Pope Julius II, first projected in 1505, was to have included, in addition to a great figure of the pontiff, over 47 free-standing statues ranged around a massive architectural base. Except for the figures of Moses and several slaves, it was never completed as planned, but something of its spirit may be realized from the Medici chapel in S. Lorenzo in Florence, begun 1520 and substantially complete by 1534. There Michelangelo went far beyond the simple commemoration of two rather obscure members of the Medici family to create a profound allegory on the nature of human life, the architecture in three zones corresponding to Hades (the lowest range, with the tombs), heaven (the upper area, with its dome) and earth (the intermediate area, with its clearly articulated architecture). The figures of Giuliano and Lorenzo de' Medici represent the active and passive aspects of human life; those of Dawn, Dusk, Day and Night symbolize the natural limits and conditions of human power.

**Baroque.**—Michelangelo's lead was followed on a grand scale in the baroque age, large allegorical monuments and memorials being among its most characteristic manifestations. Those by Giovanni Lorenzo Bernini in Rome are perhaps most noteworthy. Typical are his allegorical monument to truth (1644), the colossal statue of Urban VIII (1642–47) and the equestrian monument to Emperor Constantine in the royal staircase (Scala Regia) of the Vatican palace (*c.* 1665). In a lighter vein are his fountains in the Piazzi di Spagna, Navona and Barberini (*see* FOUNTAIN) and, in the Piazza Minerva, the famous obelisk carried by an elephant, a playful tribute to the "divine wisdom" of Pope Alexander VII. These were widely imitated and by the end of the 17th century had contributed a characteristically baroque air of grandeur and theatricality to almost every major city and palace in Europe.

**Neoclassicism.**—Even more than most art forms, monuments and memorials were strongly affected by the neoclassical revival of the 18th century. Although a baroque taste for allegorical themes persisted, details tended to be copied with increasing directness from specific classical models. The change in sculptural monuments can be traced particularly well in France, from its early manifestations in the numerous Roman-type monuments erected to Louis XIV at Versailles and elsewhere, through Houdon's classically draped statues of Voltaire and George Washington of the 1780s, to the coldly and completely classical monuments executed by Canova in the Napoleonic era. German regions provide good examples of the development of monuments in classical architectural form, from the two imitations of Trajan's column erected in 1717 to flank Fischer von Erlach's church of St. Charles Borromeo in Vienna, to K. G. Langhans' Brandenburg gate in

Berlin, built 1788–91 as a combination of the triumphal arch motif (the chariot group) with a reproduction of the propylaea (the 5th-century B.C. entrance to the Athenian acropolis).

Enthusiasm for classical monuments continued unabated into the first half of the 19th century. Characteristic are the many triumphal and memorial columns, such as that in the Place Vendôme, Paris; Nelson's in London; and Washington's in Baltimore, Md. Obelisks, like the Washington monument in Washington, D.C., were a popular variant on the column theme. Even in the 20th century the tradition of classical monuments remained strong enough to produce one of the most impressive of all—the Lincoln memorial in Washington, D.C. (by Henry Bacon, 1913–22).

**19th Century.**—The Victorian period was a great age of monument and memorial building. Its pre-eminent emphasis on individual achievement, its prosperity (especially in countries such as England), its development of mass democracy, its romantic admiration of the past and its dominant taste for picturesque visual forms all contributed to a veritable efflorescence of monuments—most of which, unfortunately, were more lavish and expensive than aesthetically satisfying. Characteristic is the Albert memorial in London, erected in 1872 on the designs of Sir George Gilbert Scott. An ornate combination of the medieval shrine memorial and the baroque allegorical monument, its picturesque massing and variegated outline are recognizably and distinctively Victorian.

Perhaps the most elaborate monument of the age was that to Victor Emmanuel II in Rome, begun in 1885 by Sacconi—a great loggia with 48-ft. high columns, pedimented end pavilions supporting sculptural groups, and a great equestrian statue of the king culminating the whole.

An essentially new kind of monument developed during the late 19th century—the soldiers' war memorial. To commemorate the trade and dynastic wars of earlier times, fought by professional armies, it had been sufficient simply to erect monuments to commanding generals or to place cairns and crosses on battlefields. Wars fought by theoretically volunteer armies on the basis of appeals to individual conscience and patriotism, however, demanded memorials to the common soldier. It was in the United States, after the Civil War, that the first true memorials to citizen-soldiers were erected. Almost every U.S. community of any size, north or south, had at its centre a memorial to its dead in that conflict, consisting generally of a pedestal inscribed with their names and the battles in which they had fought, with one or more figures of soldiers ranged on or around it.

**20th Century.**—Of much the same type were most of the civic monuments erected later to the dead of World War I by all the combatant nations. This war probably produced far more monuments and memorials of all sorts than any other single event in history; but with some notable exceptions, the great majority of them consisted of pompous and uninspired reworkings of old classical themes—triumphal arches, temples, urns, cenotaphs, sarcophagi and the like. Perhaps for this reason (or perhaps because of the nature of contemporary sculpture or for more basically sociological reasons), there was an evident lack of enthusiasm for erecting similar memorials after World War II. At mid-century, the practice of commemorating people and events by memorial buildings, such as auditoriums, schools and town halls, was noticeably displacing the older types of sculptural monuments.

## FAR EAST

**India.**—Among Indian monuments and memorials two types are outstanding: (1) the stupa (mound or tower) built during the centuries of Buddhist ascendancy and (2) the mausoleum of the succeeding Islamic period. In concept the stupa has a good deal in common with the medieval Christian type of memorial, that is, its purpose was to recall to mind and inspire emulation of a way of life more than to commemorate a specific personage. The stupa developed in response to instructions given by the dying Buddha in 483 B.C. that his body be cremated and the relics distributed beneath earth mounds to commemorate his nirvana. In form the stupa seems to have originated as a fusion of two distinct traditions of a divine world-shelter, one, the "four-cornered heaven" (Varenna), apparently introduced to India by the conquering Aryans; the other, a circular domical shape, derived from the primitive huts of the native Dravidian culture. In the classic type of Buddhist stupa (e.g., the great stupa at Sanchi, 2nd–1st B.C.) these two elements may be recognized in the great dome (*anda*) and the square coffin (*harmika*) which caps it. Over the *harmika* a third element developed, a spire surmounted by first one, then three honorific umbrellas; it was this form which later inspired the pagodas of China, Tibet and Japan.

The most famous Islamic mausoleums of India are the 16th-century tomb of Humayun at Old Delhi and, of course, the Taj Mahal (q.v.) at Agra, erected in the 17th century by Shah Jahan as a memorial to his wife. Standing on a platform 18 ft. high it is approached by a formally planted avenue, its great white dome rises 1,000 ft. in the air, and the whole is reflected in the Jumna river flowing beside it. This memorial has often been called the most perfect building in the world. (*See* also INDIAN ARCHITECTURE; ISLAMIC ARCHITECTURE.)

**China and Japan.**—Except for stone memorial steles erected to warriors and other notable persons from the Han period onward, the most distinctive monuments and memorials in China, as in India, were erected under the influence of Buddhism. Most important of them was the pagoda. The pagoda originated as a variant of the small memorial spire set on the *harmika* of Indian stupas, but under the influence of differing traditions in building and symbolism, it soon came to dominate the other elements of the stupa, often, indeed, reducing them to mere vestiges. In form the Chinese pagoda seems to have been derived from small wooden watchtowers of the Han period, later examples were larger and often in brick and stone (e.g., the six-sided pagoda at She Shan, Kwangsi, built of white stone on a radial plan, began c. A.D. 600).

Following Chinese precedent magnificent pagodas were also built in Japan, from the 5th century on; one of the finest is in the centre of the complex at Horyuji. *See* also CHINESE ARCHITECTURE; JAPANESE ARCHITECTURE; and references under "Monuments and Memorials" in the Index. (AN. G.)

**MONUMENTUM ANCYRANUM:** *see* ANCYRANUM, MONUMENTUM.

**MONVEL** (JACQUES MARIE BOUTET) (1745–1812), French actor and author, was born at Lunéville on March 15, 1745. He made his debut at the Comédie Française in 1770 and subsequently conquered his physical shortcomings (he was a small, thin man without good appearance or voice) by developing an impeccable diction and stressing the intellectual penetration of his rules. A scandalous episode forced him to leave for Sweden (1783), where he was appointed reader to the king. He returned to Paris in 1788 and, having lost his status at the Comédie Française, acted for a while at the Variétés Amusantes du Palais-Royal. In 1791 he became a member of the Théâtre de la République. He sympathized with the revolutionaries and became engaged in political propaganda, which he regretted later. In 1795 he was given a professorship for elocution at the Conservatoire. Monvel was the author of a score of plays and comic-opera librettos. He died in Paris in 1812. (A. M. N.)

**MONYWA,** the administrative centre of the Lower Chindwin district of the Union of Burma. Pop. (1953) 26,172. The town is situated on the eastern bank of the Chindwin and, being connected by rail with Sagaing and thus with the main line to Rangoon, is a transhipment point for produce brought by boat down the Chindwin. It was formerly a railhead but in the 1950s the line was extended northeastward to tap the irrigated lands of Shwebo. The district lies on both sides of the Chindwin on the northern margin of Burma's Dry Belt. West of the river are extensive stretches of dry dipterocarp forest (*indaing*) and there are teak forests on the wetter hills. (L. D. S.)

**MONZA,** a city in the province of Milan, region of Lombardy, northern Italy, is situated on the Lambro, a tributary of the Po, 15 km. (9 mi.) N.N.E. of Milan by road. Pop. (1961) 86,527 (commune). Near the Porta d'Agrate is the nunnery in which the nun of Monza (see Alessandro Manzoni's *I promessi sposi*, republished 1847) was supposedly enclosed. The cathedral (351) was enlarged at the end of the 13th century, and the green and white marble façade was erected in the 14th century by Matteo da

Campione. On the left is the brick tower (1592–1606) 278 ft. high. Within the church are the iron crown (*corona ferrea*) of Lombardy (said to have been beaten out of one of the nails used at the Crucifixion, and used after 1311 for the coronation of the Holy Roman emperors and of Napoleon at Milan in 1805) and the treasury containing the relics of Theodelinda (*see* LOMBARDS), comprising her crown, fan and comb of gold, and the golden hen and seven chickens, representing Lombardy and her seven provinces, and crosses, reliquaries, etc., of the Lombard and Gothic periods. The church of Sta. Maria in Istrada (1357) has a rich terra-cotta façade of 1393. The old communal palace, Arengario, has pointed arches and a square tower. The Vila Reale (royal palace) of Monza (1777–80) lies in the northern part of the town, on the banks of the Lambro, and is used for art exhibitions. Monza is a busy industrial community, noted for its felt hats and carpets, and manufacturing textiles, machinery, paint, plastics, furniture and glass. It is the site of the famous *autodromo* (automobile-racing track) which, because of its elliptical shape and concrete banked curves, is claimed to be the fastest in the world.

Monza (anc. Modicia) was a village until the time of Theodoric (d. 526). During the period of the republics Monza was sometimes independent, sometimes subject to Milan. The Visconti built a castle in 1325. Monza has withstood numerous sieges and was repeatedly plundered—notably by the forces of Charles V. At Monza, King Humbert I was assassinated on July 29, 1900; an expiatory chapel was dedicated in 1910.

**MONZONITE,** a name proposed by the Norwegian geologist Waldemar Christofer Brögger for plutonic rocks containing abundant and approximately equal amounts of plagioclase and potash feldspar (*q.v.*), with subordinate biotite and hornblende (an amphibole) and sometimes minor quantities of pyroxene, usually orthorhombic. Quartz, nepheline and olivine are occasionally present; their presence is usually denoted by adjectival modifiers, viz., quartz-monzonite, but in the type region (Monzoni, Italian Tyrol) they rarely occur as major constituents. In Monzoni, moreover, the plagioclase is often as calcic as labradorite (*q.v.*) and commonly it shows prominent zoning. Rocks similar to those of the type area have been described from Norway (as akerites), Montana (yogoite, shonkinite), Sakhalin Island off the Pacific coast of the U.S.S.R. and at numerous other localities throughout the world. The type is not to be regarded as rare, but its members ordinarily occur in rather small, heterogeneous masses associated with, and perhaps gradational to, diorites, pyroxenites or gabbros.

The name quartz-monzonite early achieved wide and completely unjustified acceptance in the United States as a name for the commonest type of granite, in which quartz is a major constituent, plagioclase is rarely as calcic as andesine and pyroxene is very rare and almost never rhombic. Such rocks may form rather large and often exceedingly homogeneous masses. Although gradually dying out, this confusing usage is deeply enshrined in the text and journal literature. The student, and perhaps most especially the casual reader, must be on his guard against it. (F. Cs.)

**MOODY, DWIGHT LYMAN** (1837–1899), U.S. evangelist, the foremost of the last quarter of the 19th century, who, though never ordained, conducted scores of mass evangelistic campaigns in the largest cities of the United States and Great Britain, was born in East Northfield, Mass., on Feb. 5, 1837. Moody left his mother's farm at 17 to work in his uncle's shoe store in Boston, where he was converted from Unitarianism to orthodox evangelicalism. Moving to Chicago in 1856, he prospered rapidly in the boot and shoe business until 1860, when he dedicated his life to Christian work. Between 1861 and 1873 Moody served on the Christian commission of the Young Men's Christian association, was president of the Chicago Y.M.C.A., founded the Moody church and engaged in Sunday school and slum mission work. In 1873 he began his first evangelistic meetings in Great Britain. His colourful, dramatic sermons and intense conviction, together with the pleasing baritone voice and moving gospel hymns of his choir director, Ira David Sankey, attracted wide attention. Thousands of persons professed conversion. Returning to the United States in 1875 he repeated his success. His most successful revivals were those in Edinburgh, Glasgow, London, New York, Philadelphia, Chicago and Boston. In addition to conducting revivals, he founded in Northfield, Mass., the Northfield seminary for girls in 1879 and the Mount Hermon school for boys in 1881, the Moody Bible institute, Chicago, Ill., in 1889, and directed annual Bible conferences at Northfield.

Moody had no formal theological training and felt that sectarian doctrines were a divisive force among Christians. Deploring the higher criticism, the social gospel movement and the theory of evolution, Moody preached "the old-fashioned gospel," the literal Bible and the premillennial Second Coming. Although he worked ardently in various charitable activities, he insisted that social problems could be solved only by the divine regeneration of individuals. His city-wide revivals were financed by prominent Christian businessmen who sincerely believed that Moody would alleviate the hardships of the poor by converting them to honesty, sobriety, industry and piety. Evangelical ministers of all denominations co-operated with Moody, but there is little evidence that his revivals had much influence outside the ranks of the regular churchgoers. He died in Northfield on Dec. 22, 1899. *See* also REVIVALISM.

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**MOODY, WILLIAM VAUGHN** (1869–1910), U.S. poet-dramatist, whose greatest success, ironically, was a prose play, *The Great Divide*. Born in Spencer, Ind., July 8, 1869, in 1889 he entered Harvard, where he became an editor of the *Harvard Monthly*, in which his early poems appeared. After graduating, he taught for several years, first at Harvard (1894–95), then at The University of Chicago (1895–1901). Moody's mature work was done between 1900 and 1910, when many U.S. writers were striving toward greater freedom of form and subject. He first attracted attention by several outspoken poems on contemporary issues: "An Ode in Time of Hesitation," "On a Soldier Fallen in the Philippines" and "Gloucester Moors," later collected in *Poems* (1901). Increasingly interested in a poetic theatre, Moody wrote a trilogy of poetic dramas: *The Masque of Judgment* (1900), *The Fire-Bringer* (1904) and *The Death of Eve* (incomplete). *The Great Divide* (1906) was a notable contribution to the U.S. stage; another prose play, *The Faith Healer* (1909), was less successful.

Moody's work is characterized by seriousness of purpose and artistic integrity. Questioning in spirit, it is basically optimistic, affirming the beauty and dignity of human life and its ultimate significance. His poetry is marked by subtle rhythms, sensuous imagery and dramatic lyricism. In 1909 Moody married Harriet Tilden Brainard. He died of a brain tumour on Oct. 17, 1910.

Moody's other publications include *The Poems and Plays of William Vaughn Moody* (1912); *Selected Poems of William Vaughn Moody* (1931); *Some Letters of William Vaughn Moody* (1913); *Letters to Harriet* (1935).

*See* D. D. Henry, *William Vaughn Moody, a Study* (1934). (W. L. A.)

**MOON,** in astronomy, the name given to the satellite of any planet, specifically to the satellite of the earth. The moon has been an object of worship to man (*see* particularly DIANA; SELENE; SIN) as well as one of his first guides to the regular measurement of time (*see* CALENDAR). Numerous superstitions still survive attributing terrestrial effects to the influence of the moon, but only the movement of the earth's tides is directly affected by the moon. (*See* TIDES.)

This article is divided into the following sections:

I. Lunar Theory
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  2. Gravitational Theory
II. Physical Nature of the Moon
  1. The Apparent Motion of the Moon
  2. Moon's Surface
  3. Origin of Surface Features
  4. Origin of the Moon
  5. Brightness of the Moon
  6. Constants of the Moon's Size and Motion

## I. LUNAR THEORY

**1. Historical.**—In ancient times the moon was a very important body for night illumination and a great deal of attention was given to its motions. The observations made were of an exactitude far in advance of those in other physical sciences. Hipparchus (2nd century B.C.) discovered the eccentricity of the moon's orbit and the motion of the apse. The inclination of the orbit to the ecliptic and the motion of the node were also determined by him. He explained the motion of the moon as uniform in a circular orbit with the earth placed eccentrically, and this was amply sufficient for the observations of that time. The numerical values were derived from observations of eclipses. For fixing the quantities which require the lapse of long intervals of time for their accurate evaluation he made use of the oldest eclipse observations available. At the times of eclipses the inequality in longitude due to eccentricity cannot be separated from an important solar perturbation called the evection. Consequently, he got a value of the eccentricity in longitude (true value 6°.29) erroneous by the amount of the evection (1°.27). The latter inequality was discovered by Ptolemy (fl. A.D. 140). No great improvement in the knowledge of the moon's motion was made, except for slightly improved accuracy in the mean motions, till Tycho Brahe (1546–1601) discovered another inequality due to solar attraction, called the variation, which has greatest effect when the moon is 45° or 135° distant from the sun on either side. The coefficient of this term is 0°.66. The explanation of all these inequalities and the construction of an adequate theory of the moon's motion had to await the discovery of universal gravitation.

**2. Gravitational Theory.**—Newton's theory of gravitation was based largely on the comparison of the motion of the moon with that of bodies falling freely on the earth. The portion of the *Principia* that specially refers to the motion of the moon is contained in propositions 22, 25–35 of book iii. Newton succeeded in proving that the principal periodic inequalities as well as the mean motions of the perigee and node were due to the sun's action, and he added some other inequalities which had not been deduced previously from observation. The result which he obtained for the mean motion of the perigee was only about half the observed value, but it appears from manuscripts that are extant that he succeeded later in explaining the observed motions within 5%. Newton's results were given in a geometrical form but he probably first obtained them by the method of fluxions (*q.v.*). No substantial advance was made on Newton's work till Alexis Clairaut developed his analytical theory 60 years later. Clairaut's work was followed by that of d'Alembert, Euler and Laplace in the 18th century.

The problem of the lunar motion is solved in two steps. In the first step, or "main problem," it is assumed that the sun, earth and moon behave as mass particles and that the centre of gravity of the earth-moon system moves in a fixed ellipse about the sun. After the solution of the main problem, the remaining forces are treated by introducing small variations in the main solution. These additional effects include: the variation in the elliptic orbit of the sun caused by perturbations of the moon and planets; the direct perturbation of the moon by the planets; the elliptical shapes of the earth and moon; and relativity effects.

The solution of the main problem gives the co-ordinates as harmonic series where the arguments are linear functions of the time involving the four fundamental frequencies, $n$, $n'$, $\pi$, $\theta$, which designate the mean motions of the moon, the sun, the moon's perigee and its node, respectively. In practice the arguments are expressed in terms of the angles $D$, $l$, $l'$ and $F$, whose motions are $n-n'$, $n-\pi$, $n'$ and $n-\theta$, respectively. The periods of revolution of the arguments $D$, $l$, $F$ and $nt$ are the synodic, anomalistic, nodal and sidereal months listed in the section *Constants of the Moon's Size and Motion*, below. The coefficients are power series in the arbitrary parameters: $e$ the eccentricity of the moon's orbit, about 0.055; $e'$ the eccentricity of the earth's orbit, about 0.017; $\gamma$ the sine of half the inclination of the moon's orbit, about 0.045; $m$ the ratio of the mean motions of the earth and moon, about 0.075; and $\alpha$ the ratio of the mean distances of the moon and sun, about 0.0025. The parameters $e$, $e'$, $\gamma$, $m$ and $\alpha$ are determined from observation. The planetary perturbations introduce new terms involving the periods of the planets in the arguments, and they introduce secular changes in the fundamental arguments and in the coefficients resulting from the solution of the main problem.

The development of the equations can be made algebraically with all the parameters appearing explicitly. After the expansions are completed the numerical values of the parameters are substituted. This method is elegant and facilitates changes in the parameters; it is however very laborious. An easier method of obtaining a given accuracy is to substitute numerical values of the parameters at the outset. Small changes in the parameters are then made from approximate algebraic developments.

The three most recent lunar theories are those of P. A. Hansen, of C. E. Delaunay and of G. W. Hill and E. W. Brown.

Hansen made a numerical development and obtained results of much greater accuracy than any preceding. His results were used internationally from 1862 to 1922. Corrections by S. Newcomb were applied after 1833.

The most complete algebraic development of the lunar theory is the monumental work of Delaunay. His results were not quite accurate enough for comparison with observations, but they have been of great value in many theoretical studies including the examination of other theories, and in the second half of the 20th century in the discussion of the orbits of artificial satellites.

Toward the end of the 19th century Hill re-examined the methods previously used in the lunar theory and developed methods by which results of a given accuracy could be obtained with much less labour than before. His methods have been effective in the discussion of the general problem of three bodies (see THREE BODIES, PROBLEM OF) and in the practical solution of the lunar problem. Two of his conclusions were: (1) that the expansion should be algebraic except for $m$, the numerical value of which should be substituted at the outset since this parameter is the most accurately known and is the one that gives by far the most trouble in the algebraic developments; and (2) the co-ordinates should be referred to rotating rectangular axes as introduced by Euler. His method of determining the motion of the perigee is elegant and effective. J. C. Adams used a similar method to determine the motion of the node.

After 1923 the co-ordinates of the moon generally used were computed from the developments of Brown, who employed the methods developed by Hill and Adams. The series for the co-ordinates contains about 1,500 terms—about five times as many as were employed by Hansen. The following are excerpts from Brown's expressions. The epoch is 1900, Dec. 31, Greenwich mean noon, from which $T$ is computed in Julian centuries of 36,525 days; $r$ denotes a revolution or 360°.

| | |
|---|---|
| Mean longitude | $= 270°\,26'\,11''.71$<br>$+ 1336°\,307'\,33''.6726\ T$<br>$+ 7''.14\ T^2 + 0''.0068\ T^3$ |
| Empirical term | $+ 10''.21 \sin (240°.7 + 140°.0\ T)$ |
| Longitude of perigee | $= 334°\,20'\,40''.40$<br>$+ 11°\,109'\,27''.32\ T$<br>$- 37''.17\ T^2 - 0''.045\ T^3$ |
| Longitude of node | $= 259°\,10'\,59''.78$<br>$- 1°\,134'\,8''.31\ T$<br>$+ 7''.48\ T^2 + 0''.008\ T^3$ |

The following are all the periodic terms in the moon's longitude with a coefficient over 2.2", as given in Brown's tables. The parallactic term is included because of the attention it has attracted. The largest of the planetary terms, due to Venus, has a coefficient of 14".27 and a period of 273 years. The next largest planetary terms are two or three of the order of 1".

| | |
|---|---|
| $+ 22639''.500 \sin l$<br>$+ 769.016 \sin 2l$ | Largest terms in equation of centre. |
| $- 4586.435 \sin (2D - l)$ | Evection. |
| $- 2370.151 \sin D$ | Parallactic inequality. |
| $+ 2369.912 \sin 2D$ | Variation. |
| $- 668.311 \sin l'$ | Annual equation. |
| $- 411.608 \sin 2F$ | Reduction to ecliptic. |

The largest terms in the moon's latitude and horizontal parallax are:

| Latitude | Parallax |
|---|---|
| $+ 18461''.\sin F$ | $3422''.6$ |
| $+ 1010''.\sin(F + l)$ | $+ 186.5\cos l$ |
| $- 1000''.\sin(F - l)$ | $+ 34.3\cos(l - 2D)$ |
| $- 624''.\sin(F - 2D)$ | $+ 28.2\cos 2D$ |

The sine of the horizontal parallax is the ratio of the earth's equatorial radius to the distance of the moon. The constant of lunar parallax is the ratio of the earth's radius to the moon's perturbed mean distance (multiplied by the number of seconds in a radian).

The computation of a precise ephemeris of the moon by evaluating the series involves considerable calculation, and to assist in this work Hansen and his predecessors and Brown prepared voluminous tables. Brown's tables fill 650 quarto pages, and even with the tables a man working full time could extract the data just fast enough to keep up with the moon.

The advent of the electronic calculator made feasible the direct evaluation of the formulas and the tables were no longer needed; moreover, the tables were not as accurate as the series, so the direct calculation gives improved accuracy. The direct calculations of the co-ordinates for the years 1952–71 were compiled by W. J. Eckert, Rebecca Jones and H. K. Clark; the results are contained in the *American Ephemeris and Nautical Almanac* and other national ephemerides beginning with 1960, and for the years 1952–59 in a supplemental volume. In this calculation the empirical term was omitted and the following correction applied to the mean longitude: $-8''.72 - 26''.74\ T - 11''.22\ T^2$.

When Brown's solution was completed the accuracy was more than equal to that of the best observations, but recent improvements in observing techniques have surpassed the accuracy of the theory. A new solution of the main problem which contains more than 6,000 terms including those as small as ″.00002 has been completed by W. J. Eckert and H. F. Smith, Jr.

Because of the moon's nearness to the earth and its rapid angular motion, it has long played an important part in the formulation of physical theory. In addition to the motion of the moon providing the key to the discovery by Newton of his law of gravitation, more recently it led to the discovery of the irregular rate of rotation of the earth. When the rotation of the earth is used to measure the time of observation of a celestial object, any irregularity in the earth's rotation is reflected in the difference between the observed and computed position of the object. The magnitude of the effect is greatest for the most rapidly moving object, and first appeared in the motion of the moon. It was of course known that the ocean tides are slowing down the rotation of the earth, but the discrepancies were of a more irregular nature. Newcomb found that the discrepancies during the 18th and 19th centuries could be well represented by a sine term with a coefficient of about 10″ and a period of 260 years, and this is essentially the "empirical term" in the mean longitude used by Brown. For some time it was thought that this term might be due to an oversight in the theory, but it was later established that it is due to irregularities in the earth's rotation; the motion of the moon is now used to correct the time determined by the rotation of the earth.

An interesting aspect of the lunar motion is the rapid rotation of the ellipse and of the plane of the orbit. The annual motion of the perigee is approximately 146,000″ and that of the node 70,000″. In each case all but about 10″ results from the effect of the sun, and the remainder from the shape of the earth, the action of the planets, the relativity effect and the shape of the moon.

(W. J. Et.)

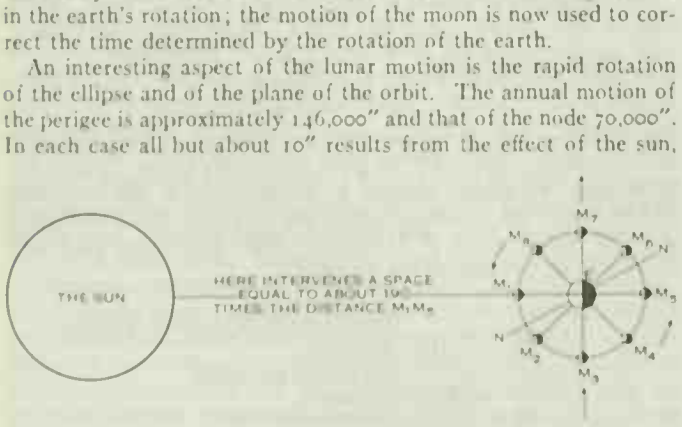



DIAGRAM OF THE PHASES OF THE MOON (M), SHOWN IN EIGHT POSITIONS

The part shown in white is illuminated by sunlight, and the phase of the moon is determined by the position of the illuminated hemisphere relative to the direction of the line joining the moon and the earth (E)

## II. PHYSICAL NATURE OF THE MOON

**1. The Apparent Motion of the Moon.**—The sidereal month is 27.32 days and in this interval the moon makes on the average a complete revolution relative to the stars. In the meantime, the earth is moving in its orbit round the sun and it is not till after the lapse of an additional 2.21 days that the moon is in the same position relative to the sun's direction, the synodic month being 29.53 days.

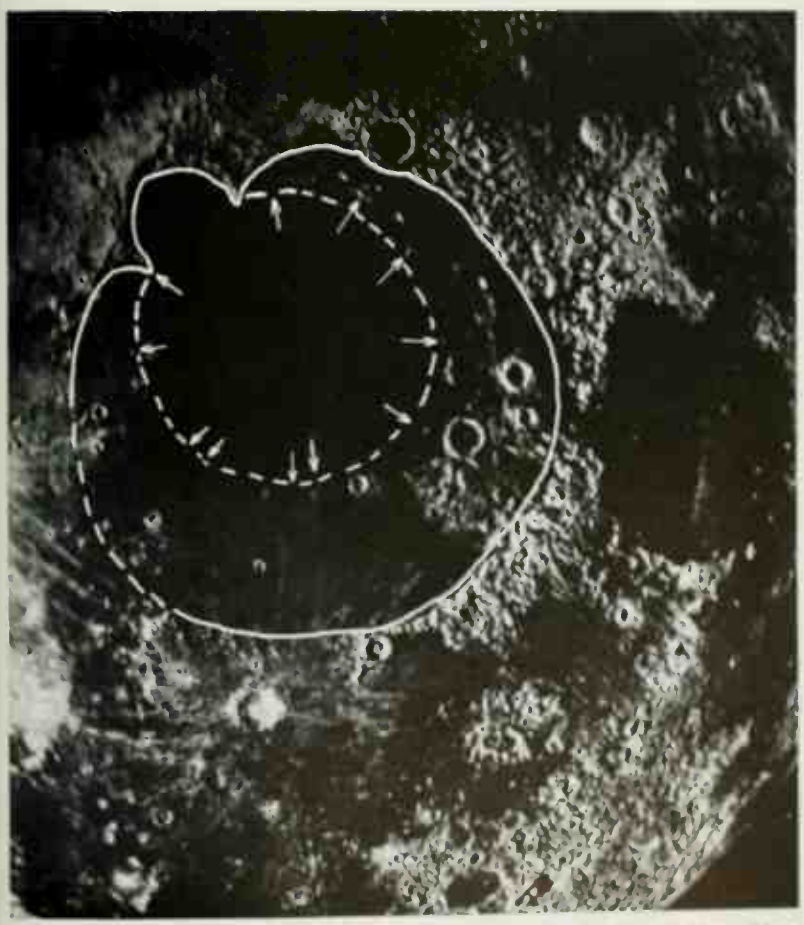
The moon being an opaque body, shining by reflected light, only that portion of the hemisphere that is illuminated and turned toward the earth can be seen. At new moon, $M^1$, (*see* figure) the hemisphere turned toward the earth is wholly unilluminated by sunlight, while at full moon, $M^5$, the fully illuminated hemisphere is turned toward the earth. At intermediate phases the hemisphere turned toward the earth is only partially illuminated. Near new moon (on both sides) the moon appears as a narrow crescent with the horns turned away from the sun; near full moon the defective edge is that farthest from the sun's direction; *i.e.*, before full moon the eastern side (left in northern hemisphere) and after full moon the western side. In the diagram the plane of the paper may be taken as that of the earth's motion round the sun. The moon's orbit does not lie exactly in this plane but is inclined to it at an angle of about 5°. If this were not so the moon would eclipse the sun at every new moon and would itself be eclipsed by the earth at every full moon. The line NN′ may be taken as representing the line of intersection of the two planes. This line, known as the line of nodes, is in slow rotation, making about one revolution against the arrows in about 18.6 years. At two seasons each year the sun is near the direction of NN′ as seen from the earth, and at these seasons eclipses occur. (*See* ECLIPSE.)

To understand the positions in which to expect the moon at any time it is most convenient to consider its position relative to the sun. When the moon is new it is in the same direction as the sun. Consequently it rises and sets with the sun, crosses the meridian with the sun and cannot be seen from the earth. Relatively to the stars the sun moves eastward about 1° per day, while the moon moves about 13° in the same direction. The moon, therefore, appears about 12° farther east of the sun day by day, and 13° farther east of the stars in its neighbourhood. When the moon is one day old it will lie about 12° east of the sun, it will be due south about 48 minutes after the sun and it will describe in the sky the same arc as the sun will do about 12 days later, if it is assumed, as is approximately true, that the orbital planes of the sun and the moon coincide. Similarly when the moon is at first quarter or 90° east of the sun it will be due south six hours after the sun and it will describe in the sky the same arc that the sun will describe in three months' time. Consider the case of a moon a week after new on March 21. On that day the sun will rise six hours before noon and set six hours after. At sunset the moon is due south and in the position occupied by the sun at noon on June 21. Consequently, for observers in the northern hemisphere, it will be more than 12 hours above the horizon, rising more than 6 hours before it souths. In the latitude of London it will rise about 8½ hours before it souths, *i.e.*, about 9:30 A.M., and it will not set till about 2:30 the next morning. As is well known, in fairly high north latitudes, the moon near the full rises at nearly the same hour for several nights in the autumn, giving rise to the phenomenon of the harvest moon. The explanation of this is very simple. The full moon in the autumn is in the same part of the sky as the sun is in the spring. Now, in the spring, the time the sun is above the horizon is steadily increasing from day to day. This increase is happening for the autumn full moon 13 times as fast. Consequently, although on the average the moon is 48 minutes later day-by-day in southing, its rising is not retarded by anything like this amount. In the spring the phenomenon is reversed, and the rising of the full moon is delayed by more than 48 minutes from day to day. Referring to the diagram, it will be seen that when the moon is near the position $M^1$ although the hemisphere turned toward

South pole and part of Mare Nubium

Full view of the side of the moon visible from earth, a composite picture made from telescopic photographs of the first and last quarters. The dark, smoother areas are called *maria*, or seas, although no open water is present on the moon. Letters indicate the approximate places where U.S. spacecraft have impacted on the moon: (A) Ranger 7, Mare Nubium (Sea of Clouds), July 1964; (B) Ranger 8, Mare Tranquillitatis (Sea of Tranquility), February 1965; (C) Ranger 9, crater Alphonsus, March 1965

The moon at first quarter



Mare Imbrium with foreshortening eliminated. The *mare* is nearly circular with Sinus Iridum at the top and slightly to the left. Broken line indicates area of collision with celestial body and arrows point to mountainous peaks on the periphery of this area. It appears that the colliding object came in through Sinus Iridum and produced the unsymmetrical area outlined

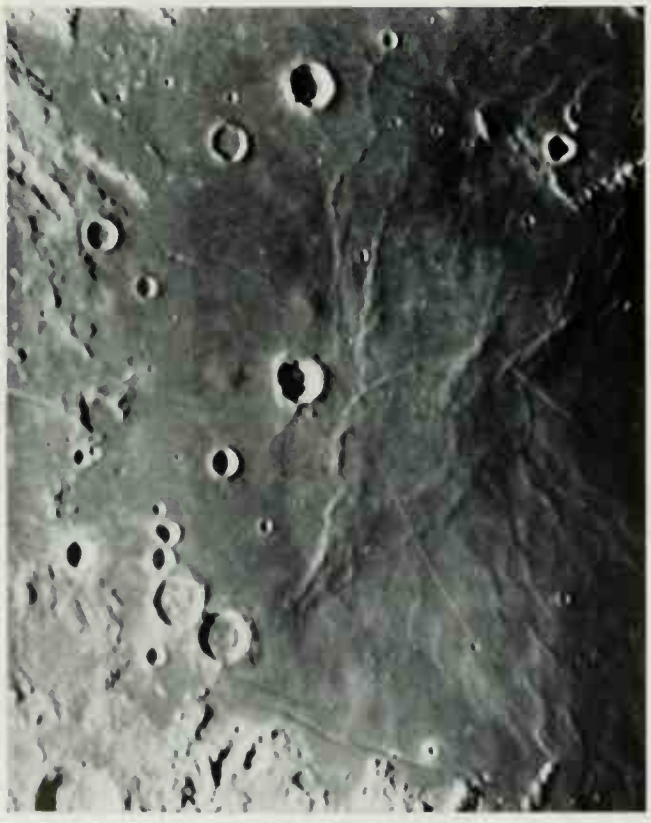
Mare Imbrium

## THE MOON AND ITS CRATERS

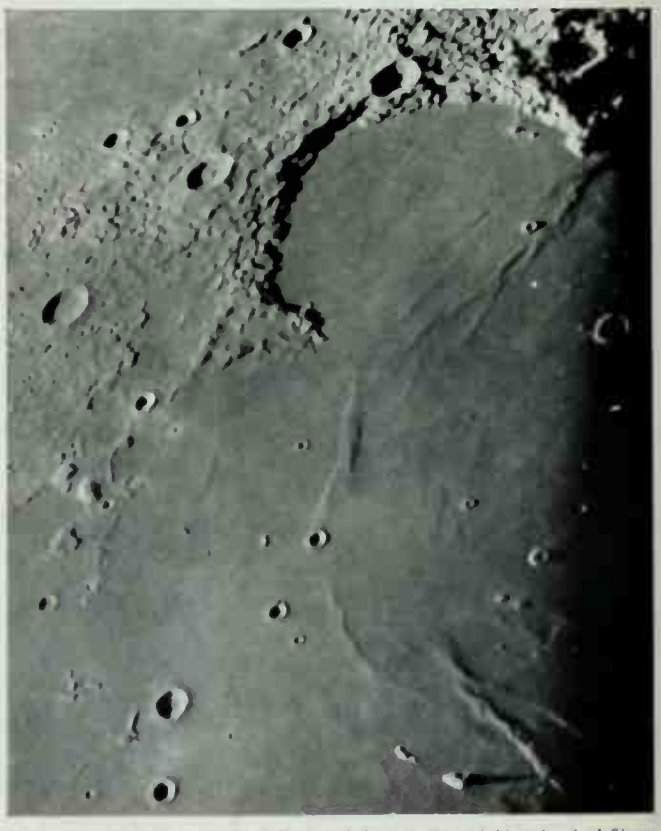
# MOON

The craters Alphonsus (top), Arzachel (bottom), and Alpetragus (centre). The dark spots within Alphonsus indicate regions where gases may have escaped from the interior in the past

Area around the crater Copernicus



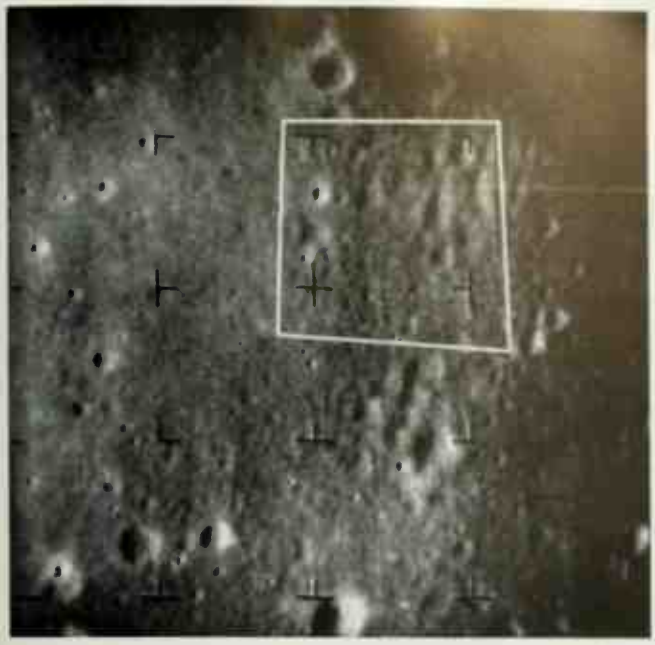
Eastern part of Mare Tranquillitatis showing the wrinkles on the surface of this *mare*



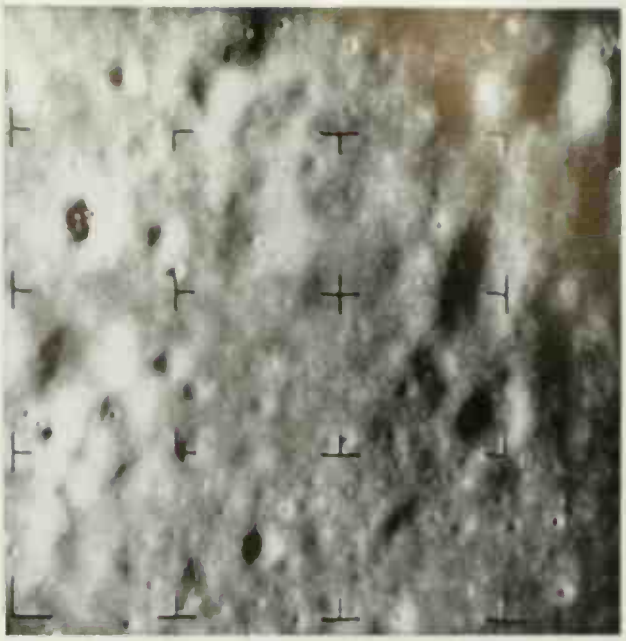
Great wrinkles in the surface of Mare Imbrium in the neighbourhood of Sinus Iridum

DETAILS OF THE MOON'S SURFACE

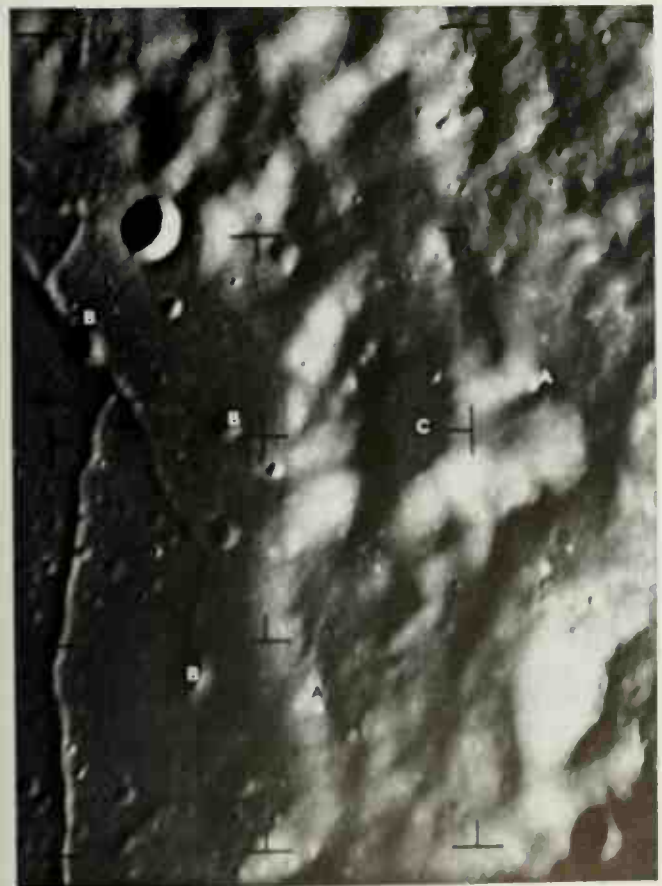
BY COURTESY OF (TOP LEFT, BOTTOM LEFT, BOTTOM RIGHT) G. P. KUIPER, (TOP RIGHT) LICK OBSERVATORY PHOTOGRAPH



Moon's surface photographed in July 1964 by Ranger 7 camera from an altitude of 12 mi. The entire area shown is about 4 mi. by 4 mi. with craters as small as 45 ft. in diameter. The crater at upper left within outlined box is about 300 ft. in diameter. *See* photograph at right



Close-up of area in box on photograph at left relayed by Ranger 7 from an altitude of about 3 mi. at approximately 2.3 sec. before impact. In this view large rocklike objects can be seen in the centre of the 300-ft. crater referred to in photograph at left. Smallest craters shown are about 30 ft. in diameter

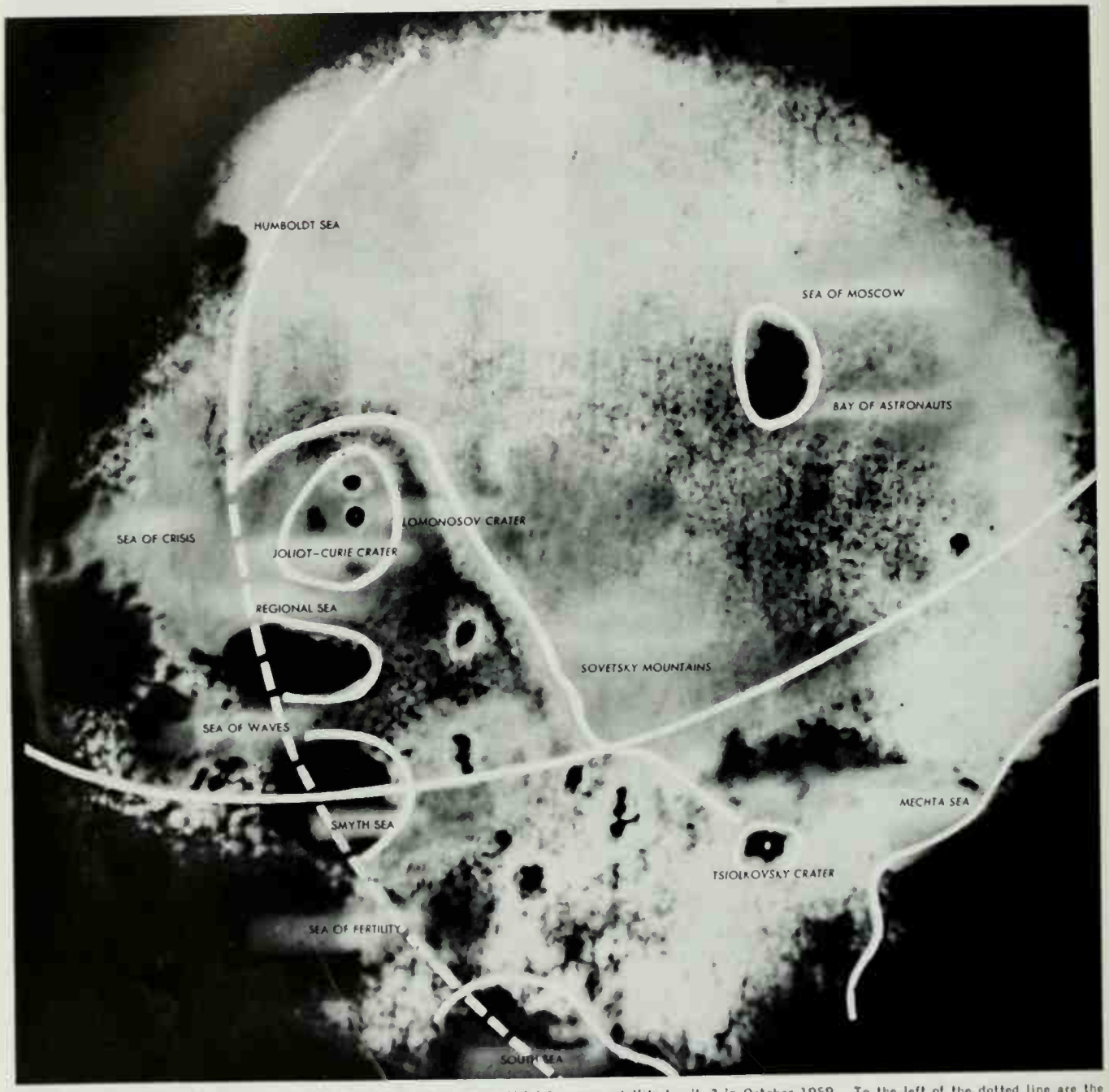



East wall of crater Alphonsus photographed in March 1965 by Ranger 9 from an altitude of 137 mi. at about 1 min. 32½ sec. before impact. (A) The lighter mountain tops; (B) "volcanic" craters; (C) "lake" among the mountains. The mountainous crater walls have fewer craters than the floor

Part of west wall and floor of crater Alphonsus photographed by Ranger 9 from an altitude of 133 mi. (A) The central peak, 1,300 ft. high; (B) "volcanic" craters; (C) debris from the great collision site to Mare Imbrium to the north; (D) a smooth area high on the west wall which scientists named "Lake Tritonis"

U.S. SPACECRAFT PHOTOGRAPHS OF THE MOON

# MOON




Photograph of the side of the moon not visible from earth taken by the U.S.S.R. space satellite Lunik 3 in October 1959. To the left of the dotted line are the names of regions and landmarks visible from the earth. Other names in italics are those given by Soviet scientists to surface features

VIEW OF THE FAR SIDE OF THE MOON

UNITED PRESS INTERNATIONAL

the earth is not illuminated directly by sunlight it is illuminated indirectly by light from the illuminated hemisphere of the earth. This light is about 50 times as bright as the full moon and consequently near the time of new moon, after twilight, the whole hemisphere of the moon can be seen faintly illuminated by earthshine, (*q.v.*). This phenomenon can be observed very well in a small telescope.

The moon always presents nearly the same face to the earth, from which it follows that, when referred to a fixed direction in space, it revolves on its axis in the same time in which it performs its revolution. The rate of actual rotation is substantially uniform, while the arc through which the moon moves from day to day varies somewhat. Consequently, the face which the moon presents to the earth is subject to a corresponding variation, the globe, as seen from the earth, slightly oscillating in a period nearly equal to that of revolution. This apparent oscillation is called libration and its amount on each side of the mean is commonly between 6° and 7°. There is also a libration in latitude, arising from the fact that the axis of rotation of the moon is not precisely perpendicular to the plane of its orbit. This libration is more regular than that in longitude, its amount being about 6° 44′ on each side of the mean. In consequence of the libration about six-tenths of the lunar surface may be seen at one time or another, while the remaining four-tenths are forever hidden from view. It is found that the direction of the moon's equator remains nearly invariable with respect to the plane of the orbit, and therefore revolves with that plane in a nodal period of 18.6 years. This shows that the side of the moon presented to observation is held in position, as it were, by the earth, from which it also follows that the lunar globe is more or less elliptical, the longer axis being directed toward the earth.

**2. Moon's Surface.**—The surface of the moon has been a subject of careful and continuous telescopic study from the time of Galileo's first observations with a telescope (1609). The earliest detailed map of the moon is in the *Selenographia* (1647) of Johannes Hevelius. Borrowing from geography and classical mythology, Hevelius assigned names to the different regions of the moon. Giovanni B. Riccioli in his *Almagestum novum* (1651) gave to the more conspicuous smaller features the names of famous astronomers and philosophers, and designated the dark areas as seas and oceans, with quite fanciful names, Mare Imbrium, Oceanus Procellarum, etc. This nomenclature has been retained. During the years following these works, more extensive and detailed maps and photographs were published (see *Bibliography* below). By 1959 the side of the moon facing away from the earth had been photographed by Soviet observers. In 1959 Gerard P. Kuiper prepared an extensive atlas. In 1963 the U.S. air force published a 1:1,000,000 scale map of the moon.

The moon as seen by the naked eye is a beautiful object with bright and dark patches, but as seen in even a small telescope it is magnificent and the various formations stand out as in the photographs. The most interesting time to watch the moon with a telescope is near half moon. The boundary between the bright and dark portions, known as the terminator, then shows a very rugged appearance and even a short stay at the telescope enables one to watch the sun's light catch new mountain peaks. The most striking formations on the moon are the craters, which are of all sizes up to 200 km. or more in diameter and are scattered over the surface with great profusion, frequently overlapping. These craters closely resemble the volcanic craters on the earth, and it is possible that they have a similar origin. They have, however, often so large a diameter compared with height that the analogy may not be so close as at first appears. The typical crater has a surrounding ring that may rise as high as 20,000 ft. above the general level. The floor of the crater may be higher or lower than the outside level. Often there may be a central peak or peaks within the crater. The darker areas of the moon which are not so much covered by craters have been considered to be seas of lava which have spread over the moon's surface at a later date than that of the formation of most of the craters. Another striking feature on the moon is the great quantity of small craters which extend in rays from a number of craters to many hundreds of miles.

On July 31, 1964, the U.S. spacecraft Ranger 7 approached the moon's surface carrying six television cameras of differing characteristics. Exposures were made as it approached the moon, and more than 4,000 still television photographs were transmitted to the earth. These pictures were of very high quality and in one of the last transmitted to earth resolved surface features that measured less than one metre. The spacecraft then crashed onto the lunar surface. In Feb. 1965 Ranger 8 performed a similar mission, transmitting about 7,000 pictures of another part of the moon's surface.

As pictures from the spacecraft of higher and higher resolution were observed, craters of smaller and smaller size appeared. These craters are only partly randomly distributed. Some occur in clusters, indicating that they were produced by the fall of secondary objects thrown from the great craters. In fact, the lunar rays probably consist of such secondary craters. Many of the smaller craters are remarkably similar in shape to the somewhat larger ones, having no central peaks, but many of them are also remarkably symmetrical in shape. The pictures with highest resolution show craters with ill-defined walls, indicating that erosion on a small scale has partially destroyed the limbs of the craters and partially filled the craters and the surrounding areas with the products of this erosion. Such erosion is probably produced by micrometeorite bombardment and also probably by some effects of light, heat and atomic bombardment. Small craters, with dimensions of only a few yards, are too numerous to be regarded as caused by meteorite bombardment and must be the result of secondary objects produced from the larger craters. These pictures give no evidence for volcanoes of the terrestrial type.

No small cracks similar to the well-known larger ones were observed, indicating that such smaller cracks, if they are present, have been filled by erosion. Smaller ridges similar to the larger ones present in the *maria* exist. Arguments as to the character of the smooth material of the *maria*, i.e., lava or finely divided material, are not resolved by these pictures nor are the questions in regard to the strength of superficial material of the lunar surface to such an extent that general agreement among students of the subject has been secured.

In March 1965 Ranger 9 impacted on the moon's surface within Alphonsus crater. One of the flight's most interesting discoveries was the apparent smoothness of the crater's walls and central ridges. There also appeared to be evidence of volcanic action within the crater. Ranger 9 transmitted approximately 5,800 still television photographs of the moon; of these, approximately 200 were transmitted live to television sets in the U.S., the first time such a process was accomplished.

E. Pettit and S. B. Nicholson found the temperature of the midsolar point of the full moon to be 134° C., and that of the limb (the edge of the disk of the moon) at the same time to be 67° C. During the lunar night the temperature falls to −113° C. Similar changes occur during an eclipse, when the moon is plunged into darkness in about one hour. J. C. Jaeger and A. J. A. Harper showed that these thermal changes imply that the surface is covered with a highly insulating layer of dust lying on material with the thermal conductivity of dry soil or pumice, though the surface does not consist of either of these.

**3. Origin of Surface Features.**—The most important feature from the standpoint of the genesis of the moon's surface features, the great collision site in Mare Imbrium, was pointed out by G. K. Gilbert in 1893. An object estimated by him to be 160 km. (100 mi.) in diameter must have approached the moon from the northeast at an angle less than the vertical. It plowed out a deep area in the moon and scattered fragments of its own body, and probably of the moon too, over the central region of the disk to a distance of about 2,000 km. from the point of collision. The illustration shows an outline of this region, and pictures of the moon in various phases show the many ridges and grooves radiating from the collision area. The debris fell on older craters and scarred the walls of others, *e.g.*, Ptolemaeus and Alphonsus, and other craters were subsequently formed. The collision of the object produced the great circular areas of broken up and shattered, or melted, rocky material that settled into the present configuration of the

*mare* with its many faults, piles of rubble and melted, granular or dusty materials. The markedly asymmetric aspect of the collision area indicates that the object struck with a velocity less than that of sound.

Other circular *maria*, Serenitatis, Crisium, Nectaris and Humorum, were formed in the same manner. The superpositions of craters and *maria* show that the events belong to a unified series; *i.e.*, some craters were formed, then a *mare*, more craters, then another *mare*, etc. These violently formed structures cover the entire surface of the moon and similar collisions must have occurred on the earth's surface. These terrestrial collisions should have been more numerous than the lunar ones because the greater gravitational field of the earth increases the numbers of objects captured and makes the collisions more energetic. Thus, no areas of the earth existing at the time of these collisions should have remained undisturbed, and the energetic collisions should have broken up all structures to considerable depths. Since appreciable areas of the earth of some $3 \times 10^9$ years of age are known, these lunar collisions must have occurred mostly before this time and are very old.

Other irregular smooth areas of the moon, also known as *maria*, do not have this circular shape, *e.g.*, Mare Tranquillitatis, Mare Fecunditatis, Mare Nubium, Oceanus Procellarum and many bays. Mare Tranquillitatis, in particular, looks like a very black lava flow, possibly from Mare Serenitatis. Its shape is very irregular and some old craters within the *mare* appear to be distorted, as though by a heavy liquid. Mare Nubium and Oceanus Procellarum also appear to be lava flows, though distortion of old craters is not evident. Generally it has been assumed that the lava flowed from the moon's interior, as occurs on earth. Gilbert suggested that the appearance of lava was produced by great collisions and that melting heat was supplied by their kinetic energy. Z. Kopal pointed out that comet collisions could have provided the melting energy. R. B. Baldwin proposed that the object that fell in Mare Imbrium broke through a solid crust into a molten interior and lava flowed over the moon's surface. T. Gold suggested that all the *maria* consist of dust produced by erosion from light and particle radiations, and that this dust is now traveling over the surface. H. C. Urey accepted Gilbert's interpretation, but also suggested that great amounts of dust or sandy material could have been produced by the great collisions. Whether the craters are of volcanic or collisional origin has been a subject of controversy since the middle of the 19th century. Many small craters, such as those along a curved fissure west of Copernicus, can be positively identified as the results of plutonic effects, probably the escape of gases and some dust from the moon's interior. They are much broader and lower than terrestrial volcanoes. The largest of these craters can be compared in size only to terrestrial *caldera* which result from the collapse of the terrestrial surface into an underlying cavity from which lava has flowed. Nevertheless, the evidence for the collisional origin of most of the craters (of all sizes) is overwhelming.

N. A. Kozyrev was the first person to observe an eruption of any kind on the moon—in the neighbourhood of the central peak of Alphonsus. He reported the fluorescent spectrum of the $C_2$ molecule indicating that carbon compounds were leaving the moon's interior. It is probable that this occurs at many other points, and that other gaseous substances are being produced as well. In less than 30 years, for example, the crater Linnè all but disappeared. Where Bernhard Schmidt observed a crater 11 km. in diameter, D. Alter found only a diffuse whitish area with no discernible crater at all. These plutonic effects seemed to be more of the nature of hot springs than of volcanoes. J. A. Greenacre has observed temporary reddish-orange spots near the crater Aristarchus, indicating current plutonic effects.

**4. Origin of the Moon.**—At the end of the 19th century George H. Darwin advanced a theory of the moon's origin that attracted considerable attention for several decades. On the basis of the mathematical theory of the tides, Darwin suggested that the moon had been originally part of the earth, but was broken away by tidal action and receded from the earth. F. R. Moulton showed that this theory was most improbable, and his conclusion was later confirmed by H. Jeffreys. It is most difficult to find mechanically possible processes by which an object such as the moon could be removed from the earth. Darwin's theory was devised partly in order to account for the different densities of the earth and moon (5.52 and 3.34 grams per cubic centimetre, respectively), which difference is only partly explained by the high pressure and compression within the earth. It was supposed that the moon came from the outer parts of the earth and hence did not acquire metallic iron-nickel from the core.

Another popular theory of the genesis of the moon gained currency after the publication (1862) of Lord Kelvin's paper on the solidification of the earth. The moon and the terrestrial planets, generally, were believed to have been formed in a completely melted condition, and have cooled and solidified since. Kozyrev's observation that gases are now leaving the moon's interior constitutes very strong evidence to the contrary. The interior temperature of the moon seems to be increasing rather than decreasing. Harold C. Urey has shown that the more volatile elements are not highly concentrated in the surface regions of the earth as would be expected on the basis of the extremely high temperature origin.

The most probable theory, then, is that the earth and the other terrestrial planets accumulated from solid objects, and that the moon is an object that was not assimilated by the earth as it grew. The meteorites are most probably representative of the primordial objects which accumulated into the planets. Though some fractionation of the elements in melting processes is evident in these objects, there is little or no evidence for systematic loss of the more volatile elements, other than gaseous substances, from them. The terrestrial planets apparently vary in composition to some extent, as indicated by their varying densities. Hence the solid materials were fractionated to some extent, probably by the loss of silicates with the large amounts of gaseous substances which are evidently not present in the planets in the proportions observed in the sun and stars. The moon has a low density, and calculations indicate that its ratio of iron to silicon and other non-gaseous elements is similar to these ratios in the sun. Thus the moon may be some primordial object which accumulated prior to the earth and other planets and did not go through all the heating and collisional processes to which the materials of the terrestrial planets were subjected.

**5. Brightness of the Moon.**—The sun is about 465,000 times as bright as the moon, with an observational error of about 20%. A real variation in brightness of 20% results from the moon's varying distance from the earth and sun. The moon's albedo, the fraction of the light received that is reflected, is only 0.073. Because of the roughness of the moon's surface, the amount of reflected light decreases more rapidly with the phase than would be expected from the area of illuminated surface. The total brightness of the moon is equal to about 0.25 of a meter-candle, equal, that is, to a 100 candle-power lamp at a distance of 22 yards.

(H. C. U.)

**6. Constants of the Moon's Size and Motion.—**

| | |
|---|---|
| Synodic month (relative to sun) | 29.53059 days |
| Sidereal month (relative to stars) | 27.32166 days |
| Tropical month (relative to equinox) | 27.32158 days |
| Anomalistic month (relative to perigee) | 27.55455 days |
| Nodal or draconic month (relative to node) | 27.21222 days |
| Revolution of perigee (direct) | 3232.6 days |
| Revolution of node (retrograde) | 6793.5 days |
| Mean eccentricity | 0.054900 |
| Mean inclination of orbit to ecliptic | 5° 8′ 43″ |
| Inclination of moon's equator to ecliptic | 1° 32′ |
| Lunar parallax | 57′2″.5 |
| Mean apparent diameter | 31′5″.2 |
| Mean distance from earth | 238,855 miles |
| Diameter | 2,159.9 miles |
| Diameter in terms of earth's diameter | 0.27250 |
| Mass in terms of that of earth | 1/81.30 |
| Density in terms of water | 3.34 |
| Density in terms of that of earth | 0.6058 |
| Ratio of gravity to gravity at the earth's surface | 0.166 |
| Maximum geocentric libration in longitude | 7° 54′ |
| Maximum geocentric libration in latitude | 6° 50′ |
| Fraction of moon's surface always invisible | 0.410 |

*See* also references under "Moon" in the Index.

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**MOONEY, JAMES** (1861–1921), U.S. ethnologist who became the best-read authority of his day on the early history of the Indian tribes north of Mexico, was born Feb. 10, 1861, in Richmond, Ind. After editing for the *Richmond Palladium*, he joined the staff of J. W. Powell's Bureau of American Ethnology at the Smithsonian Institution in 1885, remaining until his death. He developed the tribal synonymy of F. W. Hodge's classic *Handbook of the American Indians* (1907). His *Siouan Tribes of the East* (1894) combined a historical and literary quality seldom reached in ethnographic writing. The Cherokee of the Great Smoky Mountains of North Carolina were Mooney's favourite people; his *Sacred Formulas of the Cherokee* (1892) and *Myths of the Cherokee* (1900), completed afterward by Frans M. Olbrechts as *The Swimmer Manuscript* (1932), represented but a fraction of his long participation in the life of the eastern Cherokee; much remains in manuscript. He wrote an even more famous classic, *The Ghost Dance Religion and the Sioux Outbreak of 1890* (1897), a pioneer study in applied anthropology, and at his death Mooney was the leading authority on the Kiowa of the southern plains. He was a founder of the American Anthropological Association and president of the Anthropological Society of Washington (1914–15).

After Mooney's death on Dec. 22, 1921, J. R. Swanton edited and brought out *Aboriginal Population of America North of Mexico* (1928), which, though incomplete, was the first conservative tribe-by-tribe estimate for the continent. His manuscripts are in the Bureau of American Ethnology archive.

*See* J. N. B. Hewitt *et al.*, "James Mooney," *Amer. Anthrop.*, vol. 24, no. 2, pp. 209–214 (April–June 1922). (W. N. F.)

**MOONFLOWER,** any one of four species of tropical and subtropical American twining herbaceous vines belonging to the genus *Calonyction*, a member of the morning-glory family (Convolvulaceae; *q.v.*). The leaves are heart shaped or arrow shaped and the flowers large, showy, and fragrant. The latter are night blooming—hence the name moonflower—but may remain open the following morning, closing by noon. The flower's salverform shape (*i.e.*, the flaring portion of the corolla spreads at right angles to a long slender tube) distinguishes the moonflower from the common morning-glory, which has funnel-shaped blooms. *Calonyction aculeatum*, with white flowers three to six inches across, and *C. muricatum*, with purple flowers two to three inches across, are commonly cultivated for ornament.

Although perennial in the tropics, the plants bloom the first year from seed (which germinates more readily if notched or if soaked overnight in warm water before planting) and are grown as annuals in the Temperate Zone. The vines may grow to 30 ft. or more in a season. (G. H. M. L.)

MOONFLOWER (*CALONYCTION ACULEATUM*)

**MOONSTONE,** an alkali feldspar exhibiting a bluish to white iridescent lustre, or schiller, or a milky opalescence, whence its value as a gemstone. Nearly all moonstones of commerce come from Ceylon, principally from Dumbara District, occurring in acid granulites and pegmatites and in gem gravels. Moonstones have macroscopically monoclinic or nearly monoclinic symmetry. The optical phenomenon of iridescence or opalescence is connected with a cryptoperthitic unmixing process on a submicroscopic scale of the potassium-sodium aluminum silicate of which it is composed, $(K,Na)AlSi_3O_8$, into regions respectively rich in $KAlSi_3O_8$ and $NaAlSi_3O_8$. These are apparently shaped and so arranged that crystal planes (501) reflect the light most intensely. X-ray investigations indicate that the sodium-rich regions are nearly pure $NaAlSi_3O_8$ (triclinic) showing twinning on the albite and pericline laws (*see also* FELDSPAR). They can be of the low- or high-temperature state. Depending on this, among other factors, the time required for homogenization and consequent disappearance of the schiller phenomena by heat treatment near the melting temperature (ca. 1,050° C) may be of the order of months or minutes. The potassium-sodium ratio of different moonstones varies from approximately 85/15 to 40/60, the Ceylon moonstones often having a ratio around 65/35. Frequently feldspars showing bluish schiller and called moonstones by jewelers are in fact plagioclase (peristerites) or labradorite (*q.v.*). More detailed information on the unmixing of alkali feldspars is given under FELDSPAR: *Unmixing at Low Temperature*. (F. H. L.)

**MOONWORT** (MOON FERN), the popular name of a small fern (*Botrychium lunaria*) of the family Ophioglossaceae. It is little grown in the wild garden. It has a fleshy rootstock and a stout fleshy glabrous frond three to six inches long, with a sterile and fertile portion, the former bears several pairs of close-set, semicircular or moon-shaped pinnae, the latter is pinnately branched and covered, on the face opposed to the sterile portion, with small globose sporecases that burst transversely. Moonwort is widely distributed

A GRAPE FERN

in the north and south temperate and cold zones and is found in pastures, grassy banks, and rock ledges.

**MOORE, GEORGE AUGUSTUS** (1852–1933), Irish novelist and man of letters, best known for his autobiographical trilogy *Hail and Farewell*, was born at Moore hall, County Mayo, on Feb. 24, 1852. He was educated at Oscott college, near Birmingham, which he detested. When he was 18 his father died, and in 1873, as soon as he had come of age, Moore turned his back forever on the horse-racing and political activities of his landlord forebears and went to Paris to become a painter. He had no talent and did not succeed, but the Paris years were not wasted, for they gave him a deep sense of the artist's vocation, the acquaintance of such great men as Manet and Degas, and, since these were the days of the Impressionist revolt, a liking for innovation. A rather mannered account of these years is to be found in his first autobiography, *The Confessions of a Young Man* (1888).

The embarrassed condition of the Moore estates forced him to return to London to seek a living. He had already decided that he was not a painter but a writer, and he set himself to introduce a new note of French naturalism into English fiction. The results were *A Modern Lover* (1883) and a much better novel, *A Mummer's Wife* (1885), which has all the characteristics of his early fiction: circumstantial realism, mundaneness of subject, absence of melodrama and a simple prose realization of place and setting which is yet so deep as to be paradoxically almost poetic.

Moore wrote nothing so good as *A Mummer's Wife* until *Esther Waters*, his best novel, appeared in 1894. *Esther Waters* has every quality of the earlier book, but it has more variety, charm and compassion. It was an immediate success, and he continued in similar vein with *Evelyn Innes* (1898) and *Sister Teresa* (1901).

In 1901 he surprisingly returned to live in Ireland, influenced partly by his detestation of the South African War and partly by the Irish literary movement in which his friends W. B. Yeats and Edward Martyn played a part. Returning to Dublin, he became an entirely uncharacteristic supporter of the Gaelic league and other Irish activities, supported Yeats in his theatrical forays and collaborated with him in a play, *Diarmuid and Grania* (1901). Out of this new absorption in Ireland came the collection of stories called *The Untilled Field* (1903) and the short, poetic novel, *The Lake* (1905), one of his own favourites. On his return to London, however, he began to publish the books which are the real fruit of this odd interlude, the wonderful three-volume account of his sojourn in Ireland called, collectively, *Hail and Farewell* (1911–14). In this work he found a prose form entirely his own, which suited his spirit to perfection. Discursive, reminiscent, ranging from childhood memories to the events of yesterday by the most natural of transitions, affectionate and satirical by turns, *Hail and Farewell* is like a sustained conversational monologue which is both a carefully studied piece of self-revelation and an acute portrait gallery of Moore's Irish acquaintance. Above all it is a prolonged and perfectly modulated display of the workings of the comic spirit.

The growing narrowness of the Irish mind, politics and clericalism sent him back to England and to a new, equally strange and unpredictable literary departure, *The Brook Kerith* (1916), an elaborate retelling of the Gospel story. Much praised and often alleged to be his masterpiece, it is written in a prose heavy with its author's preoccupation with style, is repetitive and often rather dull, though it has beautiful passages and, whatever its merits as plausible narrative, the central metaphysical idea is surprisingly satisfying. He continued his attempts to match an epic theme with prose worthy of it in *Héloïse and Abélard* (1921).

In 1918 he published *A Story-Teller's Holiday*, a unique and characteristic blend of autobiography, anecdote, Irish legend and satire, and in 1924 he returned to autobiography with *Conversations in Ebury Street*. In the same year came his version of the story of *The Pastoral Loves of Daphnis and Chloe* and, in 1926, an Irish legendary romance, *Ulick and Soracha*. From his return to England in 1911 until his death on Jan. 21, 1933, he lived in Ebury street, London, a legendary figure himself, but, as the years went by, perhaps a slightly neglected one. His books are of so many different kinds that it is difficult to sum him up. As an innovator in fiction he may not now seem so important as he once did, but *Esther Waters* will always deserve readers; and in *Hail and Farewell* Moore gained the rare achievement of finding an original prose form of his own outside the novel.

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**MOORE, GEORGE EDWARD** (1873–1958), English ethical theorist, epistemologist and metaphysician who exercised an enormous influence on the philosophical thought of his time, was born in London on Nov. 4, 1873, the third son of Daniel Moore and his wife Henrietta Sturge; the poet Thomas Sturge Moore was his eldest brother. Educated at Dulwich college, he entered Trinity college, Cambridge, in 1892 and was elected to a prize fellowship at Trinity in 1898. He remained at Cambridge until 1904. During those years he published *Principia Ethica* (1903) and several papers in periodicals, the most important being "The Nature of Judgment" (1899) and "The Refutation of Idealism" (1903). These works played a leading part in undermining the influence of Hegelianism and Kantianism in British philosophy. Moore was away from Cambridge, first in Edinburgh and then in London, until 1911, when he succeeded John Neville Keynes as a lecturer in moral science. He was professor of philosophy at Cambridge from 1925 to 1939 and a fellow of Trinity college from 1925. From 1921 to 1947 he was editor of *Mind*. In 1951 he was awarded the Order of Merit. He was also a holder of the Nicholas Murray Butler gold medal of Columbia university. Moore had married Dorothy Ely in 1916 and had two sons. He died in Cambridge on Oct. 24, 1958.

After *Principia Ethica*, Moore published *Ethics* (1912), *Philosophical Studies* (1922) and *Some Main Problems of Philosophy* (1953). After his death a volume of selected *Philosophical Papers* appeared in 1959 and *Commonplace Book, 1919–1953* in 1963.

**Ethics.**—Moore maintained that "good," in the sense of "good *in itself*," was a simple unanalyzable concept, resembling in this respect the concept of "yellow." He held in particular that any attempt to analyze "good" in terms of concepts which were not themselves ethical (*e.g.*, such concepts as "approval" or "desire") was fallacious, and he called the fallacy which he thought to be involved in such attempts the "naturalistic fallacy." Whether a particular state of affairs was or was not good was known by direct apprehension—a feature of Moore's doctrine which has led him to be called an "ethical intuitionist"; and whether a particular state of affairs was good, and the degree to which it was so, depended wholly on a certain selection of its nonethical (that is, purely "natural") characteristics. Moore called this selection the "intrinsic nature" of the state of affairs in question, though he never succeeded in making the meaning of this last phrase entirely clear. Further, he held that the dependence of a state of affairs' goodness on its nonethical characteristics is of a purely logical kind; hence, though the property of goodness is "nonnatural," its possession by a state of affairs is logically entailed by the possession, by that state of affairs, of certain characteristics which *are* purely "natural."

On the relationship between "good" and "right," that is, between the concept of value and that of obligation, Moore put forward a doctrine which was later called "ideal utilitarianism," namely, the doctrine which he expressed in *Principia Ethica* by saying that the assertion "I am morally bound to perform this action" is identical with the assertion "This action will produce the greatest possible amount of good in the Universe." In his *Ethics* he modified this doctrine by weakening the phrase "is identical with" to "is logically equivalent to"—in other words, the characteristic of being productive of the greatest possible amount of good was no longer claimed to provide a definition of an obligatory action, but was still given as the characteristic which all obligatory actions (and only these) must necessarily possess. Moore's theory was thus teleological, but differed from some earlier teleological theories (*e.g.*, John Stuart Mill's) by including under the "value" of an action's consequences not only their pleasantness but certain other characteristics as well.

To answer the question "What things are valuable in them-

selves?" Moore thought that it is necessary to consider what value things would have if they existed entirely by themselves; and he thought further, that if we use this way of approach it will be obvious that personal affection and aesthetic enjoyments are by far the greatest goods with which we are familiar.

**Epistemology and Metaphysics.**—Two of the chief epistemological problems with which Moore was occupied were (1) the analysis of sense perception, and in particular the question of the relationship between our "sense data" (*i.e.*, sense impressions) of material things and those material things themselves; and (2) the question whether the existence of material things and also of other minds, was absolutely certain or merely very probable. He thought that such statements as "This is a book" and "That is a pencil" were sometimes known to be true with absolute certainty and also that they were wholly and not merely partly true. But he thought that the correct philosophical analysis of such statements was very uncertain. The only aspect of their analysis of which he felt no doubt was that each involved reference to a "sense datum" which was the ultimate subject of the statement and was directly apprehended by the maker of the statement; but he never solved to his own satisfaction the problem of the relationship of the sense data to the corresponding material things.

Moore's contribution to metaphysics, and particularly to the philosophy of logic, includes some early influential work in which he maintained that propositions are composed neither of words nor of mental ideas but of concepts which are possible objects of thought and are independent of the thinker.

**Influence.**—Few of Moore's own theories were generally accepted; but by directing attention to certain problems and by attacking those problems in particular ways, he was responsible, more than anyone else, for changing the whole texture of philosophical discussion in England. This he achieved partly by his originality, philosophical power and unparalleled analytic acumen, partly by a combination of three qualities of character: lack of vanity, intellectual integrity and single-minded devotion to truth.

*See* also references under "Moore, George Edward" in the Index.

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**MOORE, GEORGE FOOT** (1851–1931), U.S. Old Testament scholar, theologian and orientalist, who possessed a knowledge and understanding of the rabbinical source literature extraordinary among Christians, was born in West Chester, Pa., Oct. 15, 1851. He graduated from Yale college in 1872 and from Union Theological seminary in 1877. In 1878 he was ordained in the Presbyterian ministry and until 1883 was pastor of the Putnam Presbyterian church, Zanesville, O. He was Hitchcock professor of the Hebrew language and literature at Andover Theological seminary, 1883–1902. In 1902 he became professor of theology and in 1904 professor of the history of religion at Harvard university. He died in Cambridge, Mass., on May 16, 1931.

Moore's chief critical work dealt with the Hexateuch, and more particularly the Book of Judges (commentary, 1895; text, translation and notes, 1898; text with critical notes, 1900). He was also the author of *The Literature of the Old Testament* (1913), *History of Religions* (2 vol., 1913–19), *Metempsychosis* (1914) and, perhaps his greatest work, *Judaism in the First Centuries of the Christian Era* (3 vol., 1927–30). He was a leading figure in the establishment of the *Harvard Theological Review*.

**MOORE, HENRY** (1898– ), regarded as the foremost English sculptor of modern times, was born in Castleford, Yorkshire, on July 30, 1898, a miner's son. After service in World War I, he studied at the Leeds School of Art and the Royal College of Art and became a teacher of sculpture. In 1940 life in bombed London inspired his "shelter drawings" and he became an official war artist. His fame grew with a major exhibition at the Museum of Modern Art, New York city (1946), and the award of the international prize for sculpture in Venice (1948). His concerns have been mastery of the nature of his materials, sculpture of spaces as well as solids and the presentation of intense psychological content. The dominant reference of his works is to the human figure in its simplest positions, *e.g.*, standing, seated or reclining. Primitive art and surrealism are influences confirmed in Moore's illuminating essays and notes, included in *Henry Moore: Sculpture and Drawings*, introduction by Herbert Read, vol. I (4th ed., 1951) and vol. 2 (1944). (Js. W. F.)

FAMILY GROUP, BRONZE SCULPTURE BY HENRY MOORE, IN THE TATE GALLERY, LONDON

**MOORE, SIR JOHN** (1761–1809), British lieutenant general who led the famous retreat to La Coruña (Dec. 1808–Jan. 1809) during the Peninsular War, was born in Glasgow on Nov. 13, 1761. He was the son of a physician and author, who took the boy with him when he was engaged to accompany Douglas, 8th duke of Hamilton, on a grand tour (1772–76). Through the young duke's influence and that of his stepfather, the duke of Argyll, Moore obtained an ensigncy in the 51st regiment, the captain-lieutenancy of the regiment raised by the duke for service in America, a seat in parliament (1784–90) and the lieutenant colonelcy of the 51st. From the age of ten he cannot be said to have had a home, but his character early displayed resolute, likable qualities. He was commanding the 51st on the outbreak of war with France (1793). From Corsica, where he distinguished himself at the siege of Calvi (1794), he was sent home in 1795, charged by the viceroy with interference in politics. But Sir Ralph Abercromby asked for his services four times, for the West Indies expedition of 1796, with the local rank of brigadier general; for Ireland, as major general (1797–98); for the ill-fated Helder expedition (1799), when he was seriously wounded; and for Egypt (1801), where he was again wounded, in the battle of Alexandria in which Abercromby fell.

In 1799 Moore was made colonel commandant, and in 1801 colonel of the 52nd regiment, with which his name is eternally connected. In July 1803 he entered upon his career as the greatest trainer of troops that the British army has known. In his camp at Shorncliffe, opposite Bonaparte's armament at Boulogne, there gradually assembled some of the best material in the service, including the 52nd, 43rd and 95th regiments which after his death formed the nucleus of the legendary light division of the peninsula. Moreover, when Sir Robert Peel asked Sir Charles Rowan of the 52nd to create a metropolitan police force in 1829, Rowan applied part of the military and almost all of the moral training learned from Moore at Shorncliffe. Knighted in 1804 and promoted lieutenant general in 1805, Moore succeeded Gen. Henry Edward Fox in the Mediterranean command (1807). In May 1808 he was sent with a force to Sweden to aid Gustavus IV who, "mad as a March hare," placed him under arrest, from which he escaped disguised as a Swedish peasant.

On his return Moore was ordered to take his division to Portugal to serve under two senior but notoriously incompetent officers. Nevertheless, after the convention of Sintra (Sept. 1808), by which the French agreed to evacuate Portugal, he succeeded to the command of the largest army Britain had put into the field since the time of Marlborough, with instructions to assist in the expulsion of the French from Spain. He arrived at Salamanca on Nov. 13 and was delayed there for a month; then, having been reluctantly forced to the conclusion that all the Spanish armies were beaten, he determined on a withdrawal to Portugal. In response to a plea that by advancing he could favour the defense of Madrid, he substituted, as a profitable diversion, "a wipe at" the French communications with Soult's corps on the Carrion river. He boldly struck north, but at Sahagún, threatened by Bonaparte in his rear, he was compelled to make a rapid retreat over 250 mi. of snow-clad country to his shipping at La Coruña. In the battle of La Coruña (Jan. 16, 1809) Moore died of his wounds after the French

had been repulsed. "I hope my country will do me justice," he said. These hopes were not fulfilled, although he had, in fact, delayed the conquest of Spain for a year and Bonaparte never again personally intervened in the Spanish theatre. (*See* PENINSULAR WAR.) Wellington, after experiencing the demoralization of his troops during the retreat from Burgos in 1812, told Sir James McGrigor, his chief medical officer, "Nothing is so unmanageable as a British army in retreat." He thought that "poor Moore" had been unjustly criticized, and said, "I consider him the worst used man that ever lived." The famous poem *The Burial of Sir John Moore* ("We buried him darkly at dead of night, The sods with our bayonets turning . . ."), incorrect in nearly every detail, but true in spirit, did not appear until 1817. Moore's tomb in the San Carlos gardens at La Coruña looks out over the Atlantic.

Moore never married. There is no reason to believe that any engagement existed between him and Lady Hester Stanhope, but his friend Gen. Paul Anderson knew that he had loved Miss Caroline Fox, afterward Lady (William) Napier, but at 46 had hesitated to offer marriage to a girl of 16.

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**MOORE, MARIANNE CRAIG** (1887– ), U.S. poet, whose work from the first was marked by originality of substance and method, accuracy of insight and observation, critical and moral severity, human compassion and lyric intensity. She was born in St. Louis, Mo., on Nov. 15, 1887. Graduated from Bryn Mawr college (Pa.) in 1909, she then studied commercial subjects and taught them at the U.S. Indian school in Carlisle, Pa.; was an assistant librarian in the New York Public library; and was acting editor of *The Dial* (1925–29), then the leading U.S. journal of literature and arts.

Her early poems were printed in college publications, but she did not begin to publish in periodicals until about 1915. In 1921, as a gift of friends, her first book, *Poems*, was published in London by the *Egoist* press. Her first U.S. volume, *Observations* (1924), won the Dial award. After 1929, living in Brooklyn, N.Y., she devoted herself to poetry and criticism, contributing to many journals in the U.S. and England, and publishing several books of verse. *Collected Poems* (1951) was awarded a Pulitzer prize, a Bollingen prize, and a National Book award, as well as the Gold Medal for Poetry of the National Institute of Arts and Letters. Her translation of *The Fables of La Fontaine* was published in 1954; a volume of critical papers, *Predilections*, in 1955; a collection of poems, *Like a Bulwark*, in 1956; and another volume of poetry, *O To Be a Dragon*, in 1959.

**MOORE, THOMAS** (1779–1852), Irish poet, author of *Irish Melodies* and of witty satires on contemporary society, was the son of John Moore, a wine merchant, and was born in Dublin on May 28, 1779. He had a precocious gift for reciting, acting, singing and writing verses. In 1794 he enrolled at Trinity college, Dublin, where he played a prominent part in the students' social life and associated for a short time with Robert Emmet and others concerned in the United Irish conspiracy. He first visited London in 1799, being entered at the Middle Temple. He was an immediate social success, and the publication of his *Odes of Anacreon* in 1800 soon attracted attention. Partly to meet his debts he published *The Poetical Works of the Late Thomas Little* (1801), a collection of love poems attacked by Francis Jeffrey and others. In 1803 he was appointed registrar of the admiralty prize court at Bermuda, but he soon became bored and returned to England by way of the United States and Canada. In 1806 he published *Epistles, Odes and Other Poems* and then began work on his *Irish Melodies* (1808–34), in which he wrote words to accompany "traditional" tunes which were mainly (as he knew) of 18th-century origin. The *Irish Melodies* enjoyed enormous success, as did *Lalla Rookh* (1817), an oriental romance for which Longmans, the publishers, promised 3,000 guineas before it was even begun. Another great success, *The Loves of the Angels* (1823), was written during a continental exile to avoid a debtors' prison.

Although Moore's songs will always be remembered in Ireland, his reputation as a lyric poet has declined sharply and there is more enjoyment to be derived from his lighter satirical pieces. His formal satires, *Corruption and Intolerance* (1808) and *The Sceptic* (1809), are unremarkable, but in *The Twopenny Postbag* (1813) and *The Fudge Family in Paris* (1818) (and *The Fudges in England*, 1835), he discovered a lighter satirical idiom that suited him admirably. Such poems are the verbal equivalent of the cartoons of James Gillray and his contemporaries and take the reader back to the politics and manners of the Regency period of which Moore is so characteristic a figure. He became a close associate of Byron, who left him his *Memoirs*. Moore sold them to John Murray, but eventually they agreed to burn them and Moore produced the *Letters and Journals of Lord Byron* (1830), which included a life of Byron, instead. For the rest of his life Moore (who had married in 1811) remained a celebrated literary "lion," often impecunious but always in demand. He died at Sloperton cottage, Wiltshire, on Feb. 25, 1852.

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**MOORHEAD,** a city of western Minnesota, U.S., is located about 220 mi. N.W. of Minneapolis-St. Paul on the Red River of the North (which there forms the boundary between Minnesota and North Dakota) opposite Fargo, N.D.; the seat of Clay county. Pop. (1960) 22,934 (mun.); Fargo-Moorhead standard metropolitan statistical area (Cass county, N.D., and Clay county, Minn.), 106,027. (For comparative population figures for the city *see* table in MINNESOTA: *Population*.)

Founded with the coming of the Northern Pacific railroad in 1871, and named for one of its directors, Moorhead was a natural transportation hub with overland road and rail traffic meeting the barges and later steamboats on the navigable Red river. It was incorporated as a city in 1881.

Moorhead is generally a residential city and a trading and shipping centre for the surrounding rich agricultural area. Principal crops include potatoes, grain and sugar beets. Industries include dairy processing, the manufacture of glass products and sheet metal fabrication. Moorhead State college, founded in 1887 as Moorhead State Normal school, and Concordia college (Lutheran), founded in 1891, are located in Moorhead.

**MOOR HEN:** *see* GALLINULE.

**MOORISH IDOL,** the name for two bizarre, Indo-Pacific tropical fishes of the genus *Zanclus*, found about coral reefs from Zanzibar to islands off the west coast of America; they are allied to the butterfly fishes (Chaetodontidae), but usually placed in a distinct family (Zanclidae). They are characterized by a deep, much compressed body, somewhat rhombic in outline, with one angle in the middle of the back, where its dorsal fin begins, thence continues down the slant toward the tail. This fin is high and pointed in front, its initial ray exserted as a long threadlike filament. The snout is produced to resemble a short beak. In *Z. cornutus* there is a slight angle before the eyes from which may project a pair of short, stout horns. These fishes have scales so small as to be almost invisible. The colour is no less striking than the shape. Three broad black bands cross the yellowish and white body: one band extends downward from the front of the back, to include the eye, and over the breast, a second begins on the dorsal fin and crosses the body onto the anal fin below it, a third occupies most of the tail fin, which is slightly forked.

*Z. cornutus* grows to be nine inches long. Another species (*Z. canescens*), which is about half as large (thought by some to be the young of *Z. cornutus*), is distinguished by a spine above the angle of the mouth. It is said that some oriental peoples regard these fishes with great respect, and whenever they catch them,

bow to them before returning them to the water. (L. A. Wo.)

**MOORS,** a word derived from the Latin *Mauri*, used by the Romans to describe the inhabitants of the territory comprising the western portion of modern Algeria and the northeastern portion of modern Morocco, which in classical times constituted the Roman province of Mauretania (*q.v.*). In recent times, like the French word *maure*, it is sometimes used (instead of Mauritanian) to describe the inhabitants of the large Saharan area lying to the south of Morocco and between that country and the republics of Senegal and Mali, of which the greater part forms the modern Islamic republic of Mauritania. In English writing of the last three centuries, Moor has more often been used as the equivalent of Moroccan and sometimes to describe the former Muslims of Spain, of mixed racial origins, who created the Arab Andalusian civilization and later settled in large numbers as refugees in north Africa at different dates between the 11th and 17th centuries. By extension (corresponding to the Spanish usage of *moro*) it is occasionally employed as the equivalent of Muslim in general, for example in the case of the Moors of Ceylon or of the Philippines, who have no connection with Morocco at all. The usage of the word has been most confusing and should be decided by the context. *See* also references under "Moors" in the Index. (N. Ba.)

**MOOSE,** in America, or elk in Europe, *Alces alces* is the largest member of the deer family, Cervidae (*see* Deer). The term elk in America is applied to the wapiti (*q.v.*). Moose are heavy-bodied, long-legged, short-necked ruminants, standing higher at the shoulders than at the hips. The muzzle is somewhat inflated and pendulous. A fleshy dewlap, up to three feet long, hangs from the throat. The enormous antlers in the males are characteristically palmate with projecting tines, although the degree of palmation varies with age, health and diet. The coat is coarse and shaggy, especially in winter, and particularly over the foreparts. The colour is dark brown, becoming grizzled in old animals.

Moose occur in the northern parts of North America and Eurasia. They live from coniferous forests northward to the tundra and southward to the limits of larch and birch forests. They prefer being near water, and often wade into forest-edged lakes and streams to feed on submerged aquatic vegetation. They also eat a variety of grasses, herbs and bark. Usually solitary, as America moose often assemble in small bands in winter and tramp the snow first in a small area to form a moose yard. Their normal gait is a stiff-legged, graceless, shuffling walk, which, however, enables the animals to cover the ground with surprising speed; they sometimes trot, but seldom do they run. Moose are usually shy, but tend to be unpredictable and belligerent. Many an unsuspecting angler has been treed by a moose whose stream he has entered.

Moose breed in autumn, at which time the male fights fiercely for the female's favour. One (sometimes two or three) ungainly, almost grotesque young is born after a gestation of 240–250 days. The mother cares for the calf until the birth of another is imminent.

Because of their antlers and large size, moose are sought as trophies by hunters. Sometimes the males can be called within gunshot range with a horn of bark by means of which the grunting call of a cow moose may be approximated. Moose calling is a locally popular sport in parts of Canada. Moose are also killed for their meat, which is beefike but somewhat dry. The fat is very strong tasting. The roast, or venison, is commonly available in restaurants in Alaska and Canada. The pressure of hunting substantially reduced the numbers of moose and virtually eliminated them from the southern parts of their range, especially in the United States. They are now generally protected by law in both North American and European nations, however, and are reappearing in haunts from which they have long been absent. (K. R. Es.)

**MOOSE JAW,** the third largest city of Saskatchewan, Can., was founded in 1882. Pop. (1961) 33,206. Forty-five miles west of Regina and about 100 mi. N. of the Canada–U.S. border, it is an important distribution centre for a large predominately wheat-growing area. It is served by both the Canadian National and Canadian Pacific railways, and is the northern terminus of the "Soo" line from the United States. Several highways converge on it, including the Trans-Canada.

Moose Jaw is one of the most industrialized of Saskatchewan's cities, with major oil refineries, a large flour milling operation with major grain storage facilities, extensive stockyards, a packing plant and an abattoir (slaughterhouse). It is the site of a Royal Canadian Air Force training depot and a provincial technical training school. (C. S. Bu.)

**MOOT,** from Anglo-Saxon *gemot*, the common term for an assembly. It is recorded from the late 8th century, either alone, or in the combination *folcmoot*, and, from the second half of the 10th century, in *hundred*, borough or *shire moot*. The *witenagemot*, "moot of the wise men," was the term for the national council. The name survives in "moot hall," the term still applied to town halls (and council buildings) in some English towns. The term came later to be used of argument or debate, and (from the 16th century) was used of the discussion of hypothetical cases by law students in the Inns of Court. (D. Wk.)

**MOPSUS,** the name of two seers in Greek mythology.

1. Son of Ampyx (or Ampycus) and Chloris, a Lapith from Thessaly. He took part in the Calydonian boar hunt (*see* Meleager), and accompanied the Argonauts, dying of a snake's bite in Libya.

2. Son of Rhacius (or Apollo) and Manto, daughter of Tiresias. Calchas (*q.v.*) is said to have died of chagrin because Mopsus outdid him in a contest of divination. He was associated with the foundation of the oracles at Claros near Colophon and Malles in Cilicia (*see* Asiatic Cities) and of other cities in Asia Minor, including Mopsuhestia ("Mopsus' hearth", modern Misis in southern Turkey) and Mopsuerene ("Mopsus' spring"). In 1947 H. T. Bossert discovered 8th-century hieroglyphic and Phoenician inscriptions at Karatepe containing the name; this suggests that he may have been a historical person.

**MOQUEGUA,** a department in southern Peru, bounded on the southwest by the Pacific ocean, on the northwest by Arequipa, on the northeast by Puno and on the southeast by Tacna. Area 6,345 sq.mi. Pop. (1961) 58,263. The coastal region and lower mountain slopes are very dry, and agriculture is possible only in the irrigated areas in the valleys of the Rio Moquegua and the Rio Tambo. Moquegua, the capital of the department, lies in the

BULL MOOSE (*ALCES ALCES*)—THE ELK OF EUROPE

midst of the extensive vineyards and olive orchards of the middle Moquegua valley. Other important crops include cotton, sugar cane, figs and maize. The products of the department are exported from the port of Ilo, 63 mi. from Moquegua and connected to the capital by a railroad. In the northwest section of the department, the Andes mountains are steep and rugged, with numerous volcanic peaks. A brief rainy season occurs at the higher altitudes in January, February and March. On the high slopes sheep and alpaca are pastured, and the Indians grow wheat, barley and potatoes. The Pan-American highway crosses the department, connecting it with Arequipa and Tacna; however, there are no roads that extend into the mountains. Mineral resources are known to exist (borax, salt, coal and sulfur), but are little developed. The department was organized in 1875. (P. E. J.)

**MORACEAE,** the mulberry family of dicotyledons, which includes among its important members the fig, mulberry and breadfruit. It contains more than 70 genera with perhaps more than 1,800 species, mostly trees or shrubs, widely distributed in the warmer parts of the earth. The largest genus, *Ficus* (the fig; *q.v.*), contains species spread through tropical and subtropical regions and includes the common fig of the Mediterranean region (*Ficus carica*), the banyan (*q.v.; F. benghalensis*) and the india-rubber

EDGAR A. POE OF "A POE"

BANYAN TREE (FICUS BENGHALENSIS) ON RÉUNION ISLAND

plant (*F. elastica*); many of the species are epiphytic, sometimes clinging so tightly round the host plant with their roots as to strangle it. *Morus* (mulberry; *q.v.*) contains species of trees or bushes in north temperate regions and in the mountains of the tropics. *Artocarpus*, including *A. altilis* (*A. incisa;* breadfruit; *q.v.*) and *A. heterophylla* (*A. integrifolia;* jack tree), are chiefly natives of the Indian archipelago.

The plants are rich in latex, which may be very poisonous as in *Antiaris toxicaria*, the upas tree of Java, or sweet and nutritious as in the cow tree (*q.v.*) of Venezuela. The latex often yields caoutchouc, as in *Ficus elastica; Cecropia* (*q.v.*), a tropical American genus, and others.

In the eastern U.S. the family is represented by *Morus* (mulberry) and one species of *Maclura* (osage orange, *q.v.*), the latter being much planted for hedges. In the western U.S. there are no native representatives of the family. From the evidence of leaf fossils, it is probable that the genus *Ficus* existed as far north as Greenland in the Cretaceous era and was generally distributed in North America and Europe from Tertiary to Miocene times.

**MORADABAD,** a city and district located in the Rohilkhand division of Uttar Pradesh, India. The city, headquarters of the district and 93 mi. E.N.E. of Delhi, is built on a ridge that lies on the right bank of the Ramganga river. Pop. (1961) 180,100, comprising that of the municipal area and the railway settlement. Moradabad was founded in 1625 and named after Murad Baksh, son of the Mogul emperor Shah Jahan, by his governor, Rustam Khan, who built the fort that overhangs the river bank, and the fine Jami Masjid or principal mosque (1631). There are four colleges affiliated to Agra university.

The city is known for the manufacture of metalware, especially ornamental brassware, which is coated with lac or tin and engraved, and cutlery. There is an electroplating plant; cotton weaving and printing are the principal cottage industries. The town lies on the main line of the Northern railway.

MORADABAD DISTRICT forms the west-central portion of Rohilkhand division. Area 2,289 sq.mi. Pop. (1961) 1,973,530. It is bounded on the east by Rampur district and west by the Ganges (Ganga). The Ramganga river crosses it on the east, cutting off a submontane section of the district toward the northeast. To the east of the Ganges lies the low *khadar* (new alluvium) land gradually rising toward the central plain area drained by the Sot river. Farther east the land drops gently toward the Ramganga. It is primarily an agricultural district, the chief crops being wheat, rice, millet, pulses and sugar cane. Moradabad has a greater number of Muslims (more than one-third of the total population) than any other district in the state.

Besides Moradabad, the main towns are Sambhal to the southwest, Amroha to the west and Chandausi to the south.

(S. S. BH.)

**MORAIS, FRANCISCO DE** (*c.* 1500–1572), Portuguese romance writer, called O Palmeirim, because of his authorship of the famous romance of chivalry *Palmeirim de Inglaterra,* was treasurer of the household to King John III and was also for a time in Paris in the suite of the Portuguese ambassador. In 1572 he was assassinated, for obscure reasons, at Évora. He appears to have written his book in France (perhaps in Paris) in 1544, but the first extant Portuguese edition came out in 1567. The *Palmeirim de Inglaterra* belongs to another branch of the same cycle as the *Amadis de Gaula* (*q.v.*); the two romances, which achieved great popularity, are the best representatives of their class, and for their merits were spared from the auto-da-fé to which Cervantes condemned other romances of chivalry in *Don Quixote.* Both the plot and the characters of the *Palmeirim* have failed to stand the test of time; its surviving merit is its style.

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**MORALES, CHRISTÓBAL DE** (1500–1553), one of the greatest Spanish composers of the 16th century. Morales was born and received his musical training in Seville, at that time one of the most active centres of musical composition in Spain, and was well educated in the other arts. In 1526 he was appointed *maestro de capilla* at Ávila, a post he held till 1530. In 1535 he joined the papal choir in Rome, where, apart from a visit to Spain in 1540, he was to serve as chorister for ten years. In 1545 he returned to Spain as *maestro de capilla* at Toledo, then the primatial see of Spain. He is known to have been in Marchena in the private service of the duke of Arcos in 1549, and in 1551 he was at Málaga. He died in 1553.

During his lifetime Morales enjoyed an international reputation, which continued to grow after his death, though his service in Rome and the publishing of much of his work there may have enhanced his reputation disproportionately in relation to other Spanish composers of the time. His works include 25 Masses, a large number of motets and other liturgical items, and a few secular pieces. His music is solemn and powerful, displaying both technical and expressive genius.

*See* H. Anglès, *Morales: Opera Omnia* (1953); R. Mitjana, *Christóbal de Morales: estudio crítico-biográphico* (1920).

(J. T. A. H.)

**MORALES, LUIS DE** (called EL DIVINO) (*c.* 1509–1586), Spanish painter, who was given his nickname because of his emo-

tional religious paintings, which appealed to the people. His favourite subjects, "Ecce Homo," "Pieta," "Christ at the Column" and "Mater Dolorosa," were repeated many times and often copied. He was the first Spanish artist of pronounced national character and one of the few Spanish painters who were summoned by Philip II to help in the decoration of the Escorial, but his picture "Christ Carrying the Cross" did not please the king and was removed to the church of San Jerónimo at Madrid. The story goes that the king met the artist again at Badajoz in 1581, a few years before his death, and, seeing that he was old and poor, allowed him a pension.

Morales' chief works are 20 panels with scenes from the life of Christ, painted for the church of Arroyo del Puerco (1560–65). One of his finest and most moving pictures is the "Pieta" in the Academy at Madrid. The Hispanic Society of America, in New York city, has a number of his works, and others are at Dresden, London (National gallery), Dublin, Madrid (the Prado) and Paris.

**MORALITY, PRIMITIVE.** Philosophers have had little comparative experience in the study of primitive morality and anthropologists, preoccupied with more concrete problems, also sometimes considered that primitive peoples were controlled by an automatic obedience to custom with little need for moral choice. Some early anthropologists indeed held that primitive peoples were essentially nonmoral in their way of life, but it has since been made clear that all peoples have moral concepts and rules governing their behaviour.

The languages of primitive peoples employ terms involving concepts which can be translated as good and bad, right and wrong, true and false. Such categories refer not only to correctness of statement or expediency of action, but also to a moral quality; *i.e.*, one involving social approval or disapproval by reference to some standard outside the immediate issue. Primitive peoples are rarely concerned with the origin of such standards and the validity of judgments made by reference to them. They rather assume that such statements are self-validating. The anthropologist, however, sees them as related to the society concerned.

In many respects the rules of primitive morality accord fairly closely with those observed in a sophisticated civilized society. But while no human group approves, for example, of indiscriminate lying, cheating or stealing, societies differ in their reasons for disapproval and in their definition of the conditions under which lying or stealing is forgivable or tolerable or even demanded.

The Navaho regard truth and honesty as virtues but do not appeal to abstract morality or to divine principles; they stress practical considerations. "If you don't tell the truth, your fellows won't trust you. You will shame your relatives. You will never get along in the world that way." They also appeal to loyalty to tradition—lying goes against the old Navaho custom. R. Redfield has pointed out that the traditional morality of the Indians of Chan-Kom, a Mexican village, resembles notably that of the American pioneers as represented by De Tocqueville—respect for the ties of marriage, orderliness of family life, emphasis upon industry, care for sobriety, honesty being taken for granted. Yet this traditional morality was not puritan; it frowned upon sexual indulgence but did not get excited about it and did not regard concupiscence as a major sin. To deny the flesh was not a good in itself or a means of grace except insofar as yielding to passion was incompatible with certain sacred ceremonies.

While sharing some moral values with civilized society, peoples in so-called primitive societies operate these values in their own way. The rules of primitive morality are not usually formulated in an abstract style, or expressed systematically. Nor is it common for primitive morality to be directly attributable for its general validity to any supernatural being or other religious entity. Specific rules may have supernatural sanction and in some communities, such as Manus in the Admiralty Islands, the elaborate moral code is guided in its observance by fear of ancestral intervention. But in most communities with developed ancestor cults, the spirits of the dead are believed to be interested primarily in the behaviour of their descendants toward them and are not regarded as arbiters of the moral conduct of everyone. Moreover, the religious sanction for morality is not usually concerned with everyday conduct in matters of lying, thieving or aggressive behaviour, but in the more serious breaches of social relations, such as incest. In such cases, as in Tikopia, moral disapproval, though privately strong, may not be publicly expressed; the primary punishment for such a sin is believed to lie in supernatural action.

The operation of the moral code varies considerably according to the conditions in which the act is committed—the group factor being very important. In the case of homicide, for example, the killing of a person belonging to another hostile group may be a matter of indifference or of congratulation, unless it draws vengeance upon the group of the killer. On the other hand, the killing of a person within one's own group may be a matter of such abhorrence that no action at all is taken and the killer is left either to expiate his sin or to be punished supernaturally. Judgment on conduct may also vary according to the relative status of the parties concerned. In a society with a well-developed system of chieftainship, everyone may think it right for the chief to behave in what would ordinarily be an oppressive way toward other members of his community.

The moral judgments of primitive peoples apply the concept of responsibility in varying forms. As a rule the principles are not regarded as having an abstract, universal character; the moral code applies only to members of one's own community or persons in immediate contact with it. On the other hand, responsibility may not be highly individualized. If someone should damage the goods or person of another, then not only the offender but also members of his kin group may equally share the odium and the responsibility, and acts of retribution or restitution may be directed against them. In judgment on the morality of actions, again, intention of the actor often is disregarded—it is the effect of the action that is taken to be significant and in this sense primitive morality is in some cases more "realistic" than that of western society.

There are some spheres of action in which moral judgment in primitive societies is markedly different from that in modern western society. One of these is witchcraft. Witches are believed to exist, to have real power and to exercise that power in an evil way to the detriment of other members of the society. But the moral disapproval really may be leveled against a suspected witch on other grounds as, *e.g.*, a misplaced protest against misfortune. Other actions involving seemingly strange judgments are infanticide and suicide. Traditionally in some societies, both literate and preliterate, infanticide has been regarded as no more than a painful necessity, as morally right in order to mitigate pressure of population on subsistence. In such societies the decision whether a newborn infant should be deprived of life is usually left to the father, and society casts no blame upon him for his decision. The basis of this attitude is that human life, especially a life which has just begun, has as such no absolute value. It may have some small sentimental value for members of its own family, but the preservation of it is judged as right or wrong according to the social and economic situation, as among the Eskimo. An analogous view is often held about suicide. There may be a strong sentimental regard for a person by his family and community, there may also be an opinion that it is unnecessary, malicious or ill-judged for him to put an end to his life in the circumstances. But, as among the Hopi of Arizona, there is not the attitude of moral disapproval that is found in a western society. Disposal of one's life is regarded in somewhat the same light as disposal of one's property—others may have an interest, even a right—but suicide is not in itself a morally wrong act.

Moral concepts and rules are closely related to the structure of society, and morality is therefore relative in the sense that, as the ends of each society vary, so do the standards of right and wrong. But as E. A. Westermarck, L. T. Hobhouse, M. Ginsberg and others have shown, all human societies have some standards of right and wrong and are sensitive to judgments in such terms. Moreover, behind the variations is some real measure of uniformity.

*See* also Ethics, Comparative; Infanticide; Law, Primitive; Marriage, Primitive; Religion, Primitive; Sexual Deviations; Social Anthropology; Superstition; Taboo; Totemism; Witchcraft.

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**MORALITY PLAY:** *see* DRAMA: *Medieval Drama.*

**MORAL REARMAMENT,** variously known as Buchmanism and the Oxford Group, is a vigorous modern revivalistic movement founded by Frank N. D. Buchman (1878–1961). Buchman was born of pietistic Pennsylvania German parents in Pennsburg, Pa. After graduation from Mount Airy Lutheran seminary in Philadelphia in 1902, he combined pastoral responsibilities with social work. A difference with the trustees of a Philadelphia youth hostel run by him caused his resignation. Later he worked successfully as secretary of the college Young Men's Christian association at Pennsylvania State university, which led to his appointment as lecturer in personal evangelism at the Hartford Seminary foundation at Hartford, Conn., and also to evangelistic work, mostly among college students. Following friction at Hartford he resigned in 1922 to "live by faith" and launch a world-wide evangelistic campaign based on God's guidance, moral absolutes and the "life-changing" of individuals through personal work. The centre of Buchman's operations was shifted to the campus of Princeton university, where he encountered even sharper opposition and where the authorities finally asked him in 1926 to cease his work. Subsequently he was successful in winning influential support at Oxford university, and the movement gradually became known as the Oxford Group (not to be confused with the Oxford Movement). During the next ten years it held increasingly successful conferences or "house parties," attended often by thousands of people, in England, the Netherlands, America, South Africa and other countries.

Up to this point the movement had been largely Protestant Christian in emphasis, but with the tensions leading up to World War II, it began to change its name to Moral Rearmament and to widen its appeal to include all faiths. On this account a number of its supporters withdrew, while many outsiders criticized it for alleged Nazi sympathies. Its appeal to the popular mind declined during this period. Controversy over its work continued during the war, when some of its members were accused of draft dodging. However, no good evidence of disloyalty has ever been uncovered, and after the war it was found that the Nazis had officially disapproved of the movement.

After World War II the group acquired and renovated a rundown hotel at Caux, Switz., and this tended to become its international headquarters, though meetings also were held annually at Mackinac Island, Mich., and "task forces" were sent to all corners of the free world to do evangelistic work, in part through plays emphasizing co-operation, honesty and mutual respect between opposing groups. Buchman was honoured in many countries for his work of reconciliation.

Buchman and his followers have always stimulated sharply opposing opinions. One study at least indicated that the majority of those whose lives were "changed" by the movement subsequently testified that the experience was personally beneficial and religiously vitalizing. At the same time these persons tended to disapprove the movement as a whole and to cease to support it, often because of its oversimplified and overgeneralized theology. Though it has by no means exclusively cultivated the upper classes, nevertheless it has always shown much interest in converting the influential and the rich, the "up-and-outs" as Buchman called them. It has steadfastly opposed Communism. The group has to its credit solid and highly publicized successes in reconciling nations, races, management and labour, and it influenced the founding of Alcoholics Anonymous. The group's reports of its work must be evaluated critically. It does not publish membership figures, but there is little doubt that it has been one of the most vital contemporary interfaith religious movements.

*See* Walter Houston Clark, *The Oxford Group: Its History and Significance* (1951); Allan W. Eister, *Drawing-Room Conversion: a Sociological Account of the Oxford Group Movement* (1950). (W. H. CK.)

**MORAL SENSE:** *see* ETHICS; ETHICS, COMPARATIVE; ETHICS, HISTORY OF.

**MORAN, EDWARD** (1829–1901), U.S. painter of marine subjects, was born Aug. 19, 1829, at Bolton, Lancashire, Eng., but went to the United States about 1845. He studied in Philadelphia with James Hamilton and Paul Weber and at the Royal Academy, in London. From 1872 he lived in New York city, where he died June 9, 1901. Best known for seascapes, he also painted a famous series illustrating the maritime history of America. THOMAS MORAN (1837–1926), noted for his evocative landscapes depicting the American west, was a brother. Another brother, Peter, and Edward's two sons, Percy and Leon, also won recognition as artists. (D. H. W.)

**MORAN, PATRICK FRANCIS** (1830–1911), cardinal archbishop of Sydney (Australia), was born at Leighlinbridge, Ire., on Sept. 16, 1830, and was educated in Rome, from the age of 12, at the Irish college of St. Agatha, where he later became principal (1856–66). He was ordained a priest on March 19, 1853. From 1866 to 1872 he was secretary to his uncle, Paul Cardinal Cullen, archbishop of Dublin. In 1873 he became bishop of Ossory, and in 1884 archbishop of Sydney. He was consecrated cardinal at Rome in Aug. 1885. He paid many visits to Rome, and as primate of Australia presided over the plenary councils of 1885, 1895 and 1905. He died on Aug. 16, 1911, at Manby palace, Sydney.

Cardinal Moran's uncompromising attitude on religious questions provoked much controversy, but he did good work in the educational sphere and arranged for the building of many schools, as well as churches and hospitals. He was active in Australian politics and a supporter of Australian federation. His most important works are the *History of the Catholic Archbishops of Dublin* (1864) and *Spicilegium Ossoriense* (3 series, 1874–84).

**MORAND, PAUL** (1888– ). French writer, author of some of the best short novels in the language, and a perceptive witty observer of the modern world, was born in Paris, March 13, 1888. He joined the diplomatic service in 1912, served as attaché in London, Rome and Madrid and became director of an economic department of the Quai d'Orsay. He was head of the French economic warfare mission in Britain (1939–40); minister plenipotentiary in London, 1940; minister at Bucharest, 1943; and ambassador at Bern, 1944.

Because of Morand's collaboration with the Vichy government, he was dismissed from the diplomatic service in 1945, and his candidature for entry to the Académie Française was opposed.

His works include *Ouvert la nuit* (1922; Eng. trans., *Open All Night*, 1923), *Fermé la nuit* (1923; Eng. trans., *Closed All Night*, 1924), *Lewis et Irène* (1924; Eng. trans., 1925), *Vie de Maupassant* (1942), *Montociel* (1947), *Journal d'un attaché d'ambassade 1916–17* (1948). (A. PE.)

**MORANDI, GIORGIO** (1890–1964), Italian painter and etcher who profoundly influenced succeeding Italian graphic artists, was born in Bologna on July 20, 1890. Educated in his native city, he first exhibited there, together with the Futurist painters, in 1914. Associated in 1918–19 with the Scuola Metafisica, a movement centring on Giorgio de Chirico and Carlo Carrà, he developed a contemplative approach to art which, directed by a highly refined formal sensibility, gave his quiet landscapes and disarmingly simple still-life compositions a characteristic delicacy of tone and extraordinary subtlety of design. Morandi was instructor of etching at the Academy of Fine Arts in Bologna from 1930. He died in Bologna on June 18, 1964.

*See* G. Scheiwiller, *Giorgio Morandi* (1945); Lamberto Vitali, *Giorgio Morandi, opera grafica* (1957). (J. C. T.)

**MORANT, SIR ROBERT LAURIE** (1863–1920), British civil servant, who was closely associated with the development of the educational and health services of Great Britain, was born at Hampstead, London, on April 7, 1863. Educated at Winchester and New college, Oxford, he went in Nov. 1886 to Siam (now Thailand) as tutor to the royal family and prepared for King Chulalongkorn an educational plan for the whole country. He

returned to England in Aug. 1894 and after some experience with social and educational work in the east end of London, he joined the education department in 1895 as assistant director of special inquiries and reports. Private secretary to successive ministers, he was largely responsible for preparing Arthur Balfour's Education act of 1902. In April 1903 he became permanent secretary to the board of education, where he was an efficient administrator. In 1907 he was created knight commander of the Bath.

He left the board of education in 1911 and was appointed chairman of the national health insurance commission. Morant then built up the vast organization by which the National Insurance act of 1911 was successfully brought into operation. Increasingly absorbed in the plan to merge his health insurance work into a wider national health organization, he became secretary to the ministry of health on its formation in 1919. He died in London on March 13, 1920, leaving a reputation in the civil service as one of the greatest administrators of his time.

*See* B. M. Allen, *Sir Robert Morant* (1934).

**MORATÍN, LEANDRO FERNÁNDEZ DE** (1760–1828), Spanish dramatist, born at Madrid, March 10, 1760, who inherited from his father, Nicolas Fernández de Moratín, also a dramatist and poet, a respect for neoclassical decorum and a prejudice against Spanish baroque drama and poetry. In his comedies, like his model, Molière, he ridiculed the vices of men in society. He constantly tried to reform the theatre and in *La comedia nueva* (1792) satirized the absurd characters and plots of the popular plays of his time. His other masterpiece, *El sí de las niñas* (1805), ridiculed ill-assorted marriages of convenience. Moratín represented the Spanish Enlightenment in his European culture gained abroad, and in his sympathy with the views of the French Encyclopaedists. Like many Spanish intellectuals, he collaborated with the Bonapartist regime (1808) and after the restoration of Ferdinand VII (1814) lived in exile in France, where he died, in Paris, on July 21, 1828. A master of prose in his best plays and in his satirical and critical works, travel notes and correspondence, and a poet of exquisite taste, Moratín was one of the outstanding Spanish writers of his time.

His *Teatro* was edited by Ruiz Morcuende (1933) and *Obras póstumas* (3 vol.) were published in 1867. (E. F. H.)

**MORATORIUM,** a term used to express a legal authorization postponing for a specified time the payment of debts or obligations. The term is also sometimes used to mean the period over which the indulgence or period of grace stretches, the authorization itself being called a moratory law. Conspicuous instances of moratoria were the 1931 moratorium on debts arising out of World War I and the bank moratorium in the U.S. in 1933 to prevent runs on deposit banks (*see* BANKING; WAR DEBT, REPARATIONS).

**MORATUWA,** a town in the Western province of Ceylon, is situated on the west coast, 12 mi. S. of Colombo, of which it is an outer suburb, connected by suburban rail services. It lies at the neck of a four-mile-long spit separating the Panadure river from the sea. Pop. (1963) 78,088. The town is governed by an urban council. Moratuwa is renowned for its carpentry and furniture manufactures, which date back to the time of the Dutch, but its real prosperity came in the 19th century when its inhabitants took contracts for buildings and furniture on the growing plantations up-country. There is a small fishing trade. (B. H. F.)

**MORAVIA, ALBERTO** (pseudonym of ALBERTO PINCHERLE) (1907– ), the best-known Italian novelist after World War II, was born in Rome, Nov. 28, 1907. He became famous in 1929 on the appearance of his first novel, *Gli indifferenti*. His fame was confirmed by the novels which followed (including *Agostino*, 1944; *La romana*, 1947; *La disubbidienza*, 1948; *La ciociara*, 1957) and by his short stories (*La bella vita*, 1935; *L'imbroglio*, 1937; *Racconti romani*, 1954). Moravia traveled widely before World War II and afterward settled in Rome, where he became editor of the periodical *Nuovi argomenti*.

Moravia's skill as a novelist lies in his power to portray with analytical precision the life of the Roman bourgeois society to which he belongs but for which he has no sympathy. His minute interest in the sex life of his characters, which he describes with crude lack of reserve, and the indifferentism which leads him to represent vice and virtue without passing judgment on them have been criticized as obsessive and amoral. In his later work he showed increasing concern with working-class life.

Most of Moravia's works are available in English translations. For a portrait of Moravia *see* ITALIAN LITERATURE.

*See* P. Pancrazi, *Scrittori d'oggi* (1951); "Inchiesta sul romanzo" in *Inquie* (Dec. 1959). (F. DI.)

**MORAVIA** (Czech MORAVA; Ger. MÄHREN), a region of central Europe, part of Czechoslovakia from 1918 to 1939 and from 1945. Bohemia lies to the west and northwest of it, Silesia to the northeast, Slovakia to the east and Lower Austria to the south. For physical features *see* CZECHOSLOVAKIA. The chief towns are Brno, Gottwaldov, Jihlava, Olomouc, Prostějov and Znojmo (*qq.v.*) in Moravia proper and Ostrava (*q.v.*) in the Silesian northeast. Coal is mined around Ostrava; lignite at Hodonín and iron ore at Mediov; crude petroleum is extracted near Breclav. Moravia has iron foundries, produces machinery and metal goods and has a clothing industry dating from the 14th century.

**History.**—The earliest known inhabitants of Moravia were Celtic tribes, the Boii, whose name is perpetuated in the name Bohemia; and the Cotini. These were succeeded about 15–10 B.C. by the Germanic Quadi. The Germanic races were pushed back from the middle Danube by the coming of the Avars in A.D. 567. The exact date of the arrival of the Slavs in Moravia, as in Bohemia, is uncertain; but by the late 8th century Moravia was settled by the Slavs, who acknowledged no particular tribe but took the general name of Moravians from the Morava river. When Charlemagne destroyed the Avar empire (c. 796) he rewarded the Moravians for their help by giving them a part of it, which they held as a fief from him. They thus became loosely tributary to him for all their lands, but their princes enjoyed independence and often made war on him and on his successors, Louis I the Pious and Louis the German. By the first half of the 9th century, Moravia had become a united kingdom, under Prince Mojmir I (ruling c. 818–c. 846). It included the western part of modern Slovakia.

German influence on Moravia and Bohemia was partly political and partly religious. Christianity had been brought to these lands by Bavarian priests, and Moravia owed allegiance to the archbishop of Salzburg and to the bishop of Passau. Mojmir's successor, Rostislav, anxious to counteract this western pressure and also to ensure that his people should learn the new faith in their own tongue, asked the Byzantine emperor to send missionaries. Cyril and Methodius (*see* CYRIL AND METHODIUS, SAINTS), who arrived in about 863, had prepared for their mission by translating the chief liturgical texts into Slavonic; and they Christianized both Bohemia and Moravia. After Cyril's death Methodius was appointed head of a province which included the whole of Moravia; and with the support of Rostislav he resolutely maintained this position, despite opposition from the German priests and a period of imprisonment in Germany. In 869 Rostislav fell into the hands of Louis the German, who blinded and deposed him.

Rostislav was succeeded by his nephew Svatopluk, who considerably extended his kingdom. The Great Moravia that he created included all Bohemia, the southern part of modern Poland and the western part of modern Hungary. At first Svatopluk supported Methodius, but later he allied himself with the Frankish clerics, who used the Latin liturgy and opposed the use of Slavonic. In 885, after the death of Methodius, Pope Stephen V forbade the use of the Slavonic liturgy, and Methodius' followers were driven out. The downfall of Great Moravia was not long delayed; Svatopluk died in 894, and the quarrels between his three sons were encouraged by the East Frankish king Arnulf. Invasions by the Magyars followed, which finally destroyed the so-called Moravian empire. The exact date of the first Magyar invasion and of the decisive battle near Pressburg (Bratislava) is uncertain, but by 907 the conquest was complete, and the name Moravia was restricted to the area later incorporated into Czechoslovakia.

After long disputes between Poland, Hungary and Bohemia, in 1029 Moravia was incorporated in Bohemia, thus becoming part of the Holy Roman empire. In 1182 it was made into a separate margraviate, but in 1197 it was restored as a fief of Bohemia. Henceforth it was usually assigned to younger sons of the Bohe-

mian house. Thus from 1349 to 1375 it was ruled by John Henry of Luxembourg, brother of Charles I of Bohemia (the emperor Charles IV). When John Henry's son and successor Jobst (Jost) died without issue in 1411, Moravia fell to his cousin, the Bohemian king Vaclav IV, who was also titular German king under the name Wenceslas. The latter's heir was his brother, Sigismund of Hungary, who in 1423 relinquished Moravia to his Habsburg son-in-law, Albert of Austria.

Albert was crowned king of Bohemia in 1438 (he was also German king as Albert II). His son Ladislas (Ladislav in Bohemia and László V in Hungary) paid homage to the Moravian estates before being crowned in Bohemia (1453), and when on his death in 1457 the Bohemian estates elected George of Podebrady as king, George also became ruler of Moravia. In 1478, however, Moravia was again separated from Bohemia by the peace of Olomouc, which assigned Moravia, with Silesia and Lusatia, to the king of Hungary, Matthias Corvinus, during his lifetime; but when Matthias died in 1490, the king of Bohemia, Vladislav, was elected king of Hungary as Uászló II and thus reacquired Moravia. In 1526, when Louis II of Hungary was killed, Moravia, with Bohemia and Silesia, was claimed by Ferdinand of Austria, the future Holy Roman emperor Ferdinand I, who had married Anna, Louis' sister.

Unlike Bohemia, Moravia accepted the hereditary right of the Austrian Habsburgs, and therefore suffered less in the religious and civil struggles which followed. Religious toleration led to a flowering of Protestantism in Moravia under Ferdinand and his son Maximilian II, and although henceforward Moravia shared Bohemia's fortunes in general, there was less friction between Slavs and Germans there, partly because its people were more backward and therefore slower to make nationalist demands. Their language was the same as that of the Bohemian Slavs or Czechs, but they were not directly involved in Bohemia's struggle with the Habsburg dynasty (*see* AUSTRIA, EMPIRE OF; BOHEMIA). Administratively detached from Bohemia, the margraviate of Moravia was merged late in the 18th century by the emperor Joseph II with what remained of Austrian Silesia; but in 1849, after the revolutions of 1848, Moravia was made a separate Austrian crownland.

The Austrian crownland, which had an area of 8,555 sq.mi., became part of Czechoslovakia in 1918. Moravia was then organized as a province (*zeme*), with its area increased to 8,612 sq.mi. From 1927 the Czechoslovakian part of formerly Austrian Silesia was added to Moravia to form a single province of 10,351 sq.mi. This province in 1930 had a population of 3,565,010, of whom 73.4% were Czech and 23.1% German (by religion, 86% were Roman Catholic). Most of the Germans were transferred to Germany after World War II. From Jan. 1, 1949, however, the province was dissolved into a number of smaller administrative units. The administrative reorganization of 1960 created two new "regions" (*kraje*) on 10,071 sq.mi. of the former territory of Moravia-Silesia: the South Moravian (Jihomoravsky) with Brno as its chief town; and the North Moravian (Severomoravsky), with Ostrava as its chief town.

*See* also references under "Moravia" in the Index. (E. WI.)

**MORAVIAN CHURCH** (UNITAS FRATRUM), a Christian communion founded in Bohemia, growing out of the reform movement of John Huss, influenced by the teachings of John Wycliffe and the Lollards. After Huss's death (1415) the movement split into two parties from whose conflicts the more moderate one, later known as Utraquists, emerged victorious (*see* HUSSITES). But there were also smaller groups more insistent on reform and purity of morals, and opposed to war. One such group found an influential leader in Peter of Chelcic (Peter Chelcicky, *c.* 1390–*c.* 1460); another group under Brother Gregory gathered in Prague and in 1457 founded a refuge in the village of Kunwald. This group (sometimes known as the Bohemian Brethren) shared some of the views of Peter, but preferred to base themselves directly on New Testament teaching, calling themselves *Fratres Legis Christi*. Their simple Christian teaching and exemplary moral life and industry attracted many recruits, new circles sprang up calling for pastoral care by an ordered ministry. To deal with this a synod was held at Lhota in 1467. They sought to re-establish the simplicity of apostolic days which they felt had been lost in the existing churches, whether Roman or Utraquist. Believing that among the Waldenses (*q.v.*) there was a ministry of apostolic tradition and also of purity of life, they obtained from a Waldensian bishop, later always reputed to have been Bishop Stephen, the consecration of Brother Michael Bradacius, elected by synod as first Moravian bishop. They gave their community the Czech name *Jednota Bratrska* (*i.e.*, Fellowship of the Brethren), in Latin *Unitas Fratrum*. The name indicated what was foremost in their minds as the mark of the Christian Church. With the Bible as the one rule of faith and life, no attempt was made to construct a special confession of faith till the *Confessio Bohemica* (1564) when a basis was required for negotiations for a union with Lutherans in Bohemia. They remained insistent on genuine practical Christian life, the maintenance of which was secured by a strict church discipline that later gained high commendation from Martin Luther. They displayed, without ever asserting it as a dogma, the priesthood of all believers. The constitution was generally presbyterian in character; chief authority was exercised by an elected body, the inner council; congregations were under the care of elders; members were carefully tested as to their sincerity and graded according to their progress in Christian faith and conduct into three classes: beginner, proficient, perfect.

Bishop Luke (1460–1528) introduced theological training. Use was made of the press; a catechism and formularies for worship were issued. The first Protestant hymnbook to appear was printed in 1501; and most important of all, the Bible was translated into Czech and issued complete in 1593, being known as the Kralice Bible (the New Testament was that translated by Jan Blahoslav in 1565). Meantime the church had grown rapidly, gaining much support among the nobility. By 1600 its membership formed half the Protestants in Bohemia and more than half in the adjoining land of Moravia, in spite of constant opposition and repeated cruel persecutions. These led, around 1550, to emigration of many members to Poland, where they founded a branch of the *Unitas* that survived about 200 years. In Bohemia and Moravia, however, the Catholic Counter Reformation gathered strength with the active support of the Habsburg emperors. In 1618 the Thirty Years' War broke out; the battle of White mountain (1620) brought the rout of the Protestants, followed by the beheading of their leading nobles and the imperial rescript in 1627 prohibiting Protestantism. The *Unitas Fratrum* was destroyed with all its churches, Bibles and hymnbooks; its members were forcibly "catholicized" or driven into exile. As an organized body it ceased to exist.

Yet secretly its old life persisted in concealed corners and secluded spots in deep forests. Faithful souls would gather for worship, their hopes sustained by Bishop Johann Amos Comenius (*q.v.*), who as an exile in northern countries laboured by his writings, by collection of money for the sufferers and by public appeal for the restoration of liberty for his beloved country (and apart from this activity, gaining a European reputation as an educational reformer). His hopes were disappointed by the peace of Westphalia, but he still believed that in the underground movement which persisted there might lie a "hidden seed" from which might issue a renewal of the *Unitas*. This happened; not in Bohemia, however, but in Germany.

Some of the "hidden seed" in Moravia escaped over the northern border and received from Count Zinzendorf (*q.v.*) leave to settle on his estate at Herrnhut in Saxony (1722). This settlement was joined by various German Lutherans. The count came to live in the community and to organize it with "statutes" which resembled the discipline of the old *Unitas*. A remarkable unifying experience of fellowship at a special communion service on Aug. 13, 1727, dispelled all tendency toward dissension from the community and created lasting evangelistic zeal. In these events the refugees from Moravia saw nothing less than the renewal of their old *Unitas Fratrum* whose traditions they had brought with them; and from their home country the new brotherhood derived the name Moravian Church, now in common use. The final step in this development was taken in 1735 when Zinzendorf accepted the episcopal order of the *Unitas* as handed down

in succession through Comenius and his grandson Daniel Ernst Jablonski. Herrnhut became famous as a model for other settlements on estates of friendly nobles.

Zinzendorf however had other ideas than the revival or extension of an independent church. His great concern was the use of this body in missionary or evangelistic service; he asserted the value of a settlement by its power to furnish evangelists. In 1732 foreign missions were begun that have remained ever since the predominant concern of the Moravian Church, which was the first among Protestant churches to treat this work as a responsibility of the church as a whole instead of leaving it to societies of specially interested persons. In countries nearer home Zinzendorf pursued similar evangelism among the existing churches, not to secure from them members for the Moravian Church but to help them where spiritual life seemed to be at a low ebb by arousing that devotion to Christ as Saviour which he felt to be the vital source of genuine Christianity, and therefore the real bond of unity between all denominations whatever their variety of theology or ritual. The number of messengers sent out was remarkable, their destinations often distant; *e.g.*, the Orthodox Church in Russia, the Copts in Egypt, as well as in Germany, Switzerland, Holland and Scandinavia. This particular kind of evangelism was called diaspora, or dispersion (I Pet. i, 1), brethren ministering among the "scattered" in all churches without drawing them into the Moravian Church. This feature still prevails on the continent; the importance of the Moravians must therefore be measured by their influence on other Christian bodies rather than by their numbers. World War II led to loss of German territory and of flourishing settlements in the east; those remaining were hampered by the division between east and west, but in both the work continues with unabated spirit.

**In Great Britain.**—The first visit of the Moravians to England was occasioned by the emigration of part of the Herrnhut congregation to the American colonies (1735) with the double purpose of securing a place of refuge in case the hostility of the church and state in Saxony made the continuance of Herrnhut impossible, and of founding a mission among the American Indians. On this journey, John Wesley (*q.v.*) made his first acquaintance with the Moravians whose influence prepared the way for his final "conversion" (1738). Further contacts with members of Wesley's circle led to requests for the placing of Moravian workers in England. From this there followed formation of the first Moravian congregation in London (Fetter lane) and participation in the Evangelical revival; Yorkshire, Wiltshire and Ireland became the chief areas of activity; John Cennick the most powerful evangelist. Zinzendorf made London his headquarters for a few years and had friendly relations with the archbishop of Canterbury and other bishops; their support gained in an act of parliament in 1749 the recognition of the Moravian Church "as an ancient Protestant episcopal Church" with certain privileges in the colonies. Enforcement of Zinzendorf's diaspora policy, however, discouraged the extension of the church beyond the formation of a few settlements; it was not until 100 years later that this policy was discarded. By that time something of the original intensity of spiritual fervour had been lost and other free churches had occupied the ground. Between 1850 and 1950 about ten new congregations were formed, chiefly in places where shifting of the population gave the opportunity. The Moravian Church has always had friendly relations, including intercommunion, with other free churches and is a member of the Free Church Federal council of Great Britain. Relations with the Church of England have also been friendly (for the Moravian Church was not formed through "dissent" from the Church of England), but negotiations for some still closer association have had no result. (C. H. S.)

**In the United States.**—The first Moravian venture in the Americas was a mission among Negro slaves in the West Indies in 1732. Both the mission motive and political uncertainty in Europe brought the Moravians to Georgia in 1735. Zinzendorf saw in America a haven from possible suppression and an opportunity to evangelize the Indians. Unsuccessful in Georgia, the Moravians went to Pennsylvania in 1740.

Zinzendorf himself was in America in 1741–43 and introduced the program of religious activity then prevailing among Moravians in Europe. For almost a century, only church members lived in the communities, including Bethlehem, Nazareth and Lititz in Pennsylvania and Salem in North Carolina. From these centres missionaries circulated among the Indians and primitive peoples abroad, and diaspora evangelists worked among neighbouring European settlers. Many children from outside the church came to the settlements to be educated in Moravian boarding schools. Closed communities, European control and a diaspora rather than denominational outlook kept the church small. Extensive growth did not come until the mid-19th century, when a reorganization of the international body gave the American more autonomy.

The two provinces (*see* below) of the Moravian Church in America have a common board of foreign missions, a common theological seminary, the same hymnal and work together on many matters. They maintain missions in Alaska, Nicaragua, Honduras, British Guiana and the West Indies. Several schools and seminaries are maintained.

More than half (about 60,000) of the Moravians in the world live in North America. North Carolina, Pennsylvania, Wisconsin and New York have the greatest number of churches. The denomination is affiliated with the National Council of Churches and the World Council of Churches.

Another U.S. Moravian group, the Unity of the Brethren, grew out of congregations established by Czech and Moravian immigrants in Texas in the 1850s and became an evangelical union in 1903. Named originally the Evangelical Unity of the Czech-Moravian Brethren in North America, it changed this to 1959 to Unity of the Brethren (the old *Unitas Fratrum*). Membership is about 6,000. A third, much smaller group was organized in Iowa in 1858. (J. R. WR.)

**Organization.**—The Moravian Church forms an international unity organized from six self-dependent provinces: Great Britain; continental Europe, comprising Germany, the Netherlands, Switzerland and Denmark; United States Northern Province; United States Southern Province; Czechoslovakia; South Africa West. Each of these is self-governing in its area through its provincial synod; they are linked together by a general synod composed of representatives of all provinces and of the mission fields. This "Unity Synod" is authoritative in all matters of doctrine and constitution common to the whole church. The Moravians adhere to their old principle that "the Holy Scriptures are our only rule of faith and practice," but at the same time declare that their interpretation of Scripture agrees substantially with the great Christian creeds. *See* also SPANGENBERG, AUGUST GOTTLIEB; and references under "Moravian Church" in the Index.

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**MORAY** (MURRAY), **EARLS OF.** Celtic in origin, Moray was one of the traditional seven provinces of Scotland, its lands corresponding roughly to the modern counties of Nairn and Moray, part of Ross and Cromarty and much of Inverness. Little is known of its rulers until about 1312, when Robert I the Bruce created his nephew, THOMAS RANDOLPH (d. 1332), earl of Moray (*q.v.*). This earl was regent of Scotland from 1329 until his death. His first son, also named THOMAS RANDOLPH (d. 1337), succeeded his father only to die within a month at the battle of Dupplin. The second son, JOHN RANDOLPH (d. 1346), defended Scotland against Edward III but was killed at the battle of Neville's Cross and the earldom passed to PATRICK DUNBAR (d. 1368), 2nd earl of March, husband of Agnes, elder daughter of the regent Thomas Randolph (*see* MARCH, EARLS OF). In obscure circumstances David II conferred the earldom upon HENRY, 1st duke of Lancaster, who died in 1361. In 1372 Robert II restored the earldom to the Dunbar line, represented by JOHN (d. c. 1392), great-nephew of Patrick of Dunbar, and it remained in this line until it passed with an heiress to ARCHIBALD DOUGLAS (d. 1455), a son of

James, 7th earl of Douglas. He was, however, forfeited in 1455. Subsequently JAMES STEWART (d. *c.* 1544), natural son of James IV, was created earl in 1501, but died without legitimate male issue. GEORGE GORDON (d. 1562), 4th earl of Huntly, held the earldom for six years before surrendering it in 1555. In 1562 Mary Stuart created her half brother, JAMES STEWART (d. 1570), earl of Moray (*q.v.*). Appointed regent of Scotland in 1567, Moray was assassinated at Linlithgow in 1570. Moray's daughter, ELIZABETH, carried the title to another JAMES STEWART (d. 1592), "the bonnie earl of Moray," whose murder by the Gordons aroused great indignation. The title has remained in this family, the present holder being ARCHIBALD JOHN MORTON STUART (1894– ), 19th earl.

(R. G. NI.)

**MORAY** (MURRAY), **JAMES STEWART,** EARL OF (*c.* 1531–1570), half brother of Mary Stuart, queen of Scots, became regent of Scotland on her abdication. He was an illegitimate son of James V by Margaret Erskine, daughter of the earl of Mar. He was appointed lay administrator of the priories of St. Andrews and Pittenweem in 1538 and Mâcon in France in 1555. Joining the lords of the congregation in 1559, he supported the Reformation of 1560. With William Maitland of Lethington he assisted in the politique rule of Mary (*q.v.*) Stuart. In 1562 he was secretly created earl of Moray, a title already held by George Gordon, earl of Huntly; a few days later he was created earl of Mar but when this title was claimed by John, Lord Erskine, he resigned it. Later in 1562, after the fall of Huntly, he publicly assumed the earldom of Moray.

Moray's favour with the queen waned when he supported John Knox against charges of treason and when he opposed the queen's marriage to Henry, Lord Darnley. After a vain attempt at a *coup d'état* he was outlawed and fled to England in 1565. He returned after the murder of David Rizzio and was pardoned in 1566. When Mary abdicated the following year he was (although not next in succession) appointed regent and defeated Mary's forces at Langside (May 13, 1568), after which Mary fled to England. He attended the York conference and allowed the Casket Letters to be produced there (*see* CASKET LETTERS). Until the pacification of 1573, a substantial part of the nobility maintained Mary's rights by force of arms, and Moray had difficulty in pursuing his vigorous, determinedly Protestant and anglophile policy. The severity of his government in the border country gave offense; his failure to prosecute the known murderers of Darnley (apart from the earl of Bothwell and a few menials) and his reliance on men like Sir James Balfour of Pittendreich cast some doubts on his integrity, as did his reputation for successfully avoiding the odium of unpleasant policies. The lack of unanimous national support for his government caused him to fall in with the demanding policies of Elizabeth. Thus he was criticized for his exposure of the duke of Norfolk's plan to marry Mary, and for imprisoning the earl of Northumberland when, after the failure of his rising, he sought refuge in Scotland.

On Jan. 21, 1570, while riding through Linlithgow, he was shot and mortally wounded by James Hamilton of Bothwellhaugh.

*See* Maurice Lee, *James Stewart, Earl of Moray* (1953) and authorities there cited. (P. G. B. MCN.)

**MORAY, THOMAS RANDOLPH,** 1ST EARL OF (d. 1332), nephew of King Robert I the Bruce of Scotland, frequently fought for him against the English, served on many embassies and after Robert's death was regent of Scotland for the young David II. He was the only son of Thomas Randolph of Nithsdale by a sister of Robert I. Captured by the English at the battle of Methven (1306), he did homage to Edward I and fought for him in Scotland until again captured (1308) by Sir James Douglas. He submitted to King Robert and rapidly regained his favour, being created earl of Moray in 1312 and lord of Man and Annandale soon afterward. By a brilliant feat of arms he captured Edinburgh castle (March 1314); on the eve of the battle of Bannockburn he prevented an English contingent from entering Stirling castle and at the battle (June 24, 1314) he commanded the Scottish centre.

Randolph took part in Edward Bruce's expedition to Ireland (1315). With Sir James Douglas he seized Berwick (1318), raided the English counties (1319) and attacked the English forces at Byland, Yorkshire (1322). He was one of the ambassadors who concluded the 13-year truce with England in 1323; in the same year he visited Avignon and persuaded Pope John XXII to recognize Robert Bruce's right to the throne. He negotiated an alliance with France (1326) and with Douglas again invaded England (1327); he then played a major part in negotiating the treaty of Northampton (1328) with England and in arranging the marriage of David Bruce to Joanna, Edward III's sister.

On the death of Robert I in June 1329, Randolph became regent of Scotland for the young David II. He died at Musselburgh on July 20, 1332. His two sons Thomas and John succeeded in turn to the earldom and were killed respectively at the battles of Dupplin (1332) and Neville's Cross (1346). (E. W.-M. B.-M.)

**MORAY,** formerly ELGIN, a northern county of Scotland, 476 sq.mi. in area, stretches 30 mi. along the southern shore of the Moray firth between Nairnshire to the west and Banffshire to the east, and shares the characteristic division of these counties into southern hills and northern lowland. The county extends 30 mi. inland, narrowing to 15 mi. in width along its high watershed boundary with Inverness-shire in the heather-clad Hills of Cromdale (Carn Eachie, 2,315 ft.).

**Physical Features.**—The river Spey enters the county at its most southerly point, and for 10 mi. its strath (broad valley, *i.e.*, Strathspey) separates the Hills of Cromdale from the lower moorlands to the north. These comprise wide peat-covered stretches of erosion surfaces between 750 and 1,300 ft. bearing wet grass moorland with molinia and sedges, and cut by southeasterly trending glens feeding the Strathspey and by Glen Lossie leading northward. Lochindorb, in the west, is the largest loch (length 2⅛ mi.); many former lochs which occupied glacially scooped hollows have been wholly or partially filled with river alluvium, and some have been artificially drained. Glacial moraine covers all the valleys. Almost the entire hill area is composed of Moine Schists, but in the southeast there is a northerly continuation of the Ben Rinne granitic intrusion of Banffshire. The hills are the home of grouse and red deer, and sheep farming dominates the economy, but Strathspey has much improved land, woodland and arable land for winter feed. The moors are separated from the rich arable lowland known as the Laigh of Moray by a complex region where erosion surfaces are fragmented by many steep valleys, and outwash fans of fluvio-glacial material provide cultivable land amid much woodland and pasture. Upper Old Red Sandstone lays irregularly onto the Moine Schists, while a belt of Middle Old Red Sandstone flanks the lower Spey and a patch of younger Permo–Triassic Sandstone reaches 5 mi. inland between Burghead and Lossiemouth. The whole lowland is plastered with boulder clay, and emergence following the post-glacial drowning has revealed important raised beaches at 25, 50 and 100 ft. Rejuvenation of the rivers has carved valley terraces throughout the county (12 are

DULSIE BRIDGE WHERE THE RIVER FINDHORN IS CONFINED TO A NARROW CHASM IN MORAY

traceable on Speyside). The lower Findhorn crosses the western corner of the plain ending in the narrow-necked Findhorn bay; it was the alteration of the river mouth by a series of 17th-century storms which initiated the formation of the famous Culbin sands west of the bay, their now afforested dunes rising to 50 ft. The rest of the coast is also sandy. Rainfall reaches a maximum in July (possibly associated with the success of barley growing) and minima in April and January; Fochabers has a mean annual total of 29.8 in., and only in the 2,000-ft. hills in the south does the total reach 50 in. Temperature ranges from 3° C. (38° F.) in January to 13° C. (56° F.) in July. The lowlands, including Strathspey, are sunny, often when rain or cloud is observed in the surrounding hills and even eastward in lowland Buchan. While westerly winds prevail, the importance of the cold northeasterlies is seen in the coniferous shelter belts in the farming regions.

(A. T. A. L.; A. M. Le.)

**History.**—There is a prehistoric stone circle at Inneramil. Christianity, introduced under the auspices of St. Columba, flourished for a period until the Columban church was expelled in 717 by King Nectan. Thereafter the district was given over to internecine strife between the northern and southern Picts, until the crushing victory of Kenneth MacAlpin, which resulted in the kingdom of Pictavia being superseded by the principality of Moravia (Latin form of Moray). Later the Norsemen raided the country, first under Thorstein and then under two Sigurds. It was in the time of the second Sigurd that the firth was fixed as the northern boundary of Moray. Sweno's stone at Forres probably marks the victory of Sweyn over Malcolm II in 1008. In spite of such interruptions, which included the battle of Torfness (Burghead) in 1040, in which Thorfinn, earl of Orkney and Shetland, overthrew the Scots under King Duncan I, the consolidation of the kingdom was gradually accomplished. After Macbeth ascended the throne the Scandinavians stayed their hand. Though Macbeth and his fainéant successor, "daft" Lulach, were the only kings whom Moray gave to Scotland, the province continued under the rule of its own mormaor, or great steward, until the dawn of the 12th century, when as an entity it ceased to exist. (The ancient province covered a much wider area than the modern county, comprising roughly the modern shires of Moray and Nairn, part of Ross and Cromarty and much of Inverness-shire.) To break up the power of the mormaors, David I and his successors colonized the seaboard with settlers from other parts of the kingdom, but from time to time the clansmen and their chiefs descended from their fastnesses and plundered the Laich (Laigh).

Meanwhile, the church had become a civilizing force. In 1107 Alexander I had founded the see of Moray and the churches of Birnie, Kinnedar and Spynie were in turn cathedrals of the early bishops until in 1224, under the episcopate of Andrew of Moray (de Moravia), the church of the Holy Trinity in Elgin was chosen for the cathedral. Abbeys were founded at Kinloss (1151) and Pluscarden (1230).

In his effort to stamp out Scottish nationality Edward I came as far north as Elgin in 1296. Sir William Wallace, however, was well supported by Sir Andrew Moray of Bothwell. Robert I ("the Bruce") recognized the assistance he had received from the men of the north by erecting Moray into an earldom on the morrow of Bannockburn and bestowing it upon Thomas Randolph (*see* Moray, Earls of). In 1644, during the Civil War, the marquess of Montrose ravaged the villages which stood for the Covenanters, but most of the great lairds shifted in their allegiance. Charles II landed at Garmouth in 1650, on his return from his first exile in Holland. There was strife between Covenanters and the adherents of episcopacy until prelacy itself being abolished in 1689, the bishopric of Moray came to an end after an existence of 561 years. The fight at Cromdale (May 1, 1690) shattered the Jacobite cause, for the efforts in 1715 and 1745 were too spasmodic and half-hearted to affect the loyalty of the district to Hanoverian rule. A few weeks before Culloden, Prince Charles Edward stayed in Elgin for several days, and a month afterward the duke of Cumberland passed through and administered the *coup de grâce* to the Young Pretender's cause on Drummossie moor in Inverness-shire.

In 1694 the barony of Culbin—a fine estate, comprising 3,600 ac. of land—was buried under a mass of sand in a severe storm. This sandy waste, the Culbin sands, has been reclaimed for afforestation by the Forestry commission. Another calamity was the Moray floods of Aug. 2 and 3, 1829.

**Population and Administration.**—The population of the county was 49,156 in 1961, of whom 202 spoke Gaelic and English. The small burghs are Elgin (11,971), the county town, and Forres (4,780), both of which are royal burghs; and Burghead (1,346), Grantown-on-Spey (1,581), Lossiemouth and Branderburgh (5,555), and Rothes (1,103). There are six county districts. In conjunction with Nairnshire the county returns one member to parliament. Moray is included in one sheriffdom with Inverness, Ross and Cromarty, and Nairn, and there is a resident sheriff substitute at Elgin. The county is combined with Nairnshire under a joint county council for the administration of major local government services such as education, classified roads and planning.

**Agriculture and Industries.**—The rich soil of the lowlands is well adapted for barley, oats are decreasing while wheat is increasing. The growing of certified seed potatoes for export is an important part of the farming economy. Some pedigree herds of Shorthorn and Aberdeen Angus cattle are maintained in the county but cattle rearing is mainly crossbreeding for beef production. Since the farming depression between World Wars I and II, many farms have turned from cattle rearing to dairying with Ayrshire and Friesian herds. Pedigree sheep breeding is not carried on to any extent but sheep wintering is the mainstay of farms in the upland areas. Market gardening and nurseries have developed since a market has been found for fruit by a fruit growers' association, and a preserving factory has been built where fruit, vegetables and poultry are canned for the export market.

The principal industries are distilling, agriculture, fishing and forestry. Whisky is the chief product. There are woollen mills, distilleries, sawmills and iron foundries at Elgin; woollen mills, distilleries and chemical works at Forres; and distilleries at Rothes. Because of the absence of coal, what little mineral wealth there is (iron and lead) cannot be remuneratively worked. The sandstone quarries yield a building stone of superior quality. Moray is one of the most heavily wooded counties in Scotland—almost 19% being under afforestation. The plantations consist mainly of larch and fir and, to a smaller extent, of oak. The firth fisheries (comprising haddock, cod, herring, etc.) and salmon netting at the mouths of the Spey and the Findhorn, are of considerable value.

(R. McG.)

**MORAY,** an eel of the family Muraenidae. More than 120 species are known; they occur in all tropical and subtropical seas, especially in rocky places or among coral reefs. At least two live in temperate zones. These fishes differ from other eels in having small, rounded gill openings and in generally lacking pectoral fins. The skin is thick, smooth and scaleless, the mouth is wide and the jaws are armed with strong sharp teeth, which enable them not only to seize and hold their prey (chiefly other fishes) but also to inflict serious wounds on their enemies, including man. They are notoriously aggressive and vicious. The species vary in maximum size from about three feet to at least ten feet. The oily flesh of morays is eaten in many parts of the world, even though a few species are reputed to be poisonous. The Indo-Pacific brown eel (*Lycodontis flavomarginatus*) occurs around coasts of the Indian ocean and eastward to Hawaii. *Muraena helena* of the Mediterranean and adjacent parts of the Atlantic was a great delicacy of the ancient Romans, and was cultivated in seaside ponds. *Gymnothorax* species include the California moray (*G. mordax*) and the Atlantic blackedge moray (*G. nigromarginatus*).

*See* also Eel.

(L. A. Wd.)

**MORAZÁN, FRANCISCO** (1792–1842), Central American statesman and general, was born near Tegucigalpa, Honduras, on Oct. 10, 1792. Of modest background and education, he early interested himself in politics. By 1824 he was secretary general of Honduras and later became a senator. At this time intense partisan struggles led to civil war within the Federal Republic of Central America; Morazán sided with the Liberal party and soon be-

came their military leader. He defeated the Conservative army at Guatemala City, the Central American capital, in 1829 and the next year was elected president of the federal republic. During his first term he introduced many liberal and anticlerical reforms, which were bitterly opposed by the Conservatives in most of the five constituent Central American states. His administration was interrupted by frequent threats of rebellion and invasion, and he had little chance to prove his executive ability.

In 1834 Morazán was re-elected president of Central America, but he continued to face opposition to his legislative program. Because he was forced to devote most of his attention to military matters, the federal republic began to disintegrate. In 1840 a rebel army defeated Morazán at Guatemala City; his army was destroyed, and he went into exile. He soon attempted a restoration of the Central American Federation by force, but was captured and put to death in San José, Costa Rica, on Sept. 15, 1842.

Although his administration was weak and impoverished, Morazán, more than any other person, symbolizes the ideal of Central American unity. (T. L. K.)

**MORAZÁN,** a department in northeastern El Salvador, consisting of deep valleys and rough mountains, the highest being Cacaguatique volcano, altitude 5,416 ft. The population in 1961 was 119,381, of which 80% was rural. Except for the northeastern third of the department, which is very sparsely settled, the population is evenly distributed in the mountain valleys and on the lower slopes. The largest town and departmental capital is San Francisco Gotera (pop. [1961] 3,688). The Pan-American highway crosses the southeastern corner of Morazán, and two branch roads serve the southern half of the department, but otherwise poor transportation facilities and the rugged terrain restrict agricultural activities. However, the department grows about 40% of the nation's henequen. (C. F. J.)

**MORBIHAN,** a *départements* of northwestern France, was formed from part of Brittany. Area 2,738 sq.mi. Pop. (1962) 530,833. It lies along the south coast of the Breton peninsula and is bounded west by Finistère, north by Côtes-du-Nord, and east by Ille-et-Vilaine and Loire-Atlantique. The *département* is ribbed from northwest to southeast by ridges of resistant granite and quartzite that correspond with the lines of the ancient folding. The rivers, such as the Blavet and Vilaine, cut southward across the grain of the country in sharply entrenched valleys to their winding estuaries (*rivières*). Since the drowning of the lower parts of the river valleys by the sea, the oblique alignment of the coastline in relation to the longshore drift has aided regularization. The estuaries are much obstructed by silting behind bars, and the offshore island of Quibéron has become attached to the mainland as a peninsula. Along the coast the winters are very mild, but the area does not enjoy the same advantages for export as the north coast of Brittany, and the cultivation of *primeurs* (early vegetables and fruits) is less important than fishing, carried on in the warm offshore waters for tunny and sardine. The ports, of which Kéroman (Lorient), Groix, Port-Louis, Etel, and Quibéron are the chief, have canning industries. The oyster culture of the Gulf of Morbihan (a Breton word meaning "little sea," which gives the *département* its name) is also important. Farming is mainly concerned with cattle rearing and dairying. There are large tracts of barren heath, such as the *landes* of Lanvaux, but the wasteland has been considerably reduced in modern times by enclosure. The *département* lies outside the limit of viticulture, but the cider apple is ubiquitous. The rural settlement is largely dispersed in isolated farmsteads and hamlets, the parishes being large. Evidence of prehistoric occupation abounds in the form of single and aligned stones and burial mounds, and the great stone monuments at Carnac and Locmariaquer (*qq.v.*), near the coast by Quibéron, are perhaps the most impressive of all megalithic remains in Europe (*see* also BRITTANY). Slate and granite are quarried in several places, and there are important workings of kaolin behind Lorient, which has naval establishments. The *département*, however, is largely a remote, rural backwater, with communications that are still relatively poor. Although the limit of Breton speech has receded westward, this Celtic tongue is still spoken in the western parts of the *département*, and many features of an old way of life survive. Calvaries and ossuaries are common in the countryside, and the religious festivals (*pardons*) are still great dates on the local calendar. The château of the Rohan family at Josselin, and the cathedral and its environs at Vannes, are especially noteworthy among numerous interesting medieval buildings.

Lorient (*q.v.*), rebuilt since its World War II devastation, is the largest town, but the capital of the *département* is Vannes (*q.v.*), which is also the seat of a bishopric. It forms part of the ecclesiastical province of Rennes (*q.v.*), where the court of appeal and the *académie* also have their headquarters. There are three *arrondissements*, centred upon Vannes, Lorient, and Pontivy.

(AR. E. S.)

**MORDENT,** in music, an ornament played on the beat, consisting of a repercussion of a main (written) note with a subsidiary (unwritten) note. The "upper mordent" comprises the main note and the note above; if the latter is to be inflected, the necessary accidental is written above the upper mordent sign. The "lower mordent" comprises the main note and the note below; if the latter is to be inflected the accidental is written below the lower mordent sign. The terms "mordent" and "inverted mordent" are also used, but there is no general agreement as to which term applies to which ornament.

**MORDOVIAN AUTONOMOUS SOVIET SOCIALIST REPUBLIC:** *see* MORDVINIAN AUTONOMOUS SOVIET SOCIALIST REPUBLIC.

**MORDVIN** (MORDVA, MORDVINIAN, MORDOVIAN), a people of Finno-Ugric linguistic stock whose historic home is the middle Volga region of the U.S.S.R. Under the Soviets they were given some autonomy in 1928, and the Mordvinian Autonomous Soviet Socialist Republic, with its capital at Saransk, was created in 1934. The Mordvin numbered 1,285,116 in the 1960s with about a third living in the republic (where they were outnumbered by Russians), and the remainder being distributed in other parts of the Soviet Union. The Mordvin tend to have dark hair and blue eyes, and generally are roundheaded, rather tall, strong and broad chested. The Moksha, a southern branch, tend to be darker, and have a traditional dialect that differs so substantially from that of a northern group, the Erzya, that the Mordvin generally communicate in Russian.

Traditionally agricultural, the Mordvin are noted as master beekeepers. The old national costume still may be seen, especially among the women, whose profusely embroidered skirts, original coiffures, large earrings and numerous necklaces covering the bosom distinguish them from Russians. Although many modern Mordvins cannot speak the original tongue, there exists a considerable Cyrillic literature of Mordvin songs and legends, some recounting the feats of their king Tushtyan, who was a contemporary of Ivan the Terrible. When practised, Mordvin faith consists of a Christian veneer over a more traditional theology involving worship of the sun (*shkay*), a water divinity believed to favour marriage, the moon, thunder, frost and a home divinity (*kardazserko*). Many Mordvin homes were reported to house small stone altars or flat stones covering small pits to receive the blood of slaughtered animals. Also, the practice of pretending to kidnap brides in the face of mock resistance has been reported to persist especially among the Moksha. Traditional burial customs seem founded on an ancestor cult: 40 days after death a person is supposed to return home and, coming from the grave, to speak through a living member of the household. *See* also FINNO-UGRIC LANGUAGES.

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**MORDOVIAN AUTONOMOUS SOVIET SOCIALIST REPUBLIC** (MORDOVIAN OR MORDOVSKAYA A.S.S.R.), of the Russian Soviet Federated Socialist Republic in the U.S.S.R., was formed as an autonomous *oblast* in 1930 and raised to the status of an A.S.S.R. in 1934. Pop. (1959) 1,000,193. It covers an area of 10,116 sq.mi. in the middle Volga basin. The west and centre of the republic are drained by the Moksha, which flows into the Oka, and its tributaries, notably the Issa, Sivin and Vad

rivers. The east lies in the basin of the middle Sura, a direct tributary of the Volga, and is drained chiefly by its tributaries the Alatyr and Insar. The surface relief is that of a very gently rolling plain, rising gradually from north to south and from west to east. In the west it is a lowland, crossed by the broad, shallow and often swampy valley of the Moksha. In the east a maximum height of 1,062 ft. is reached in the rounded hills overlooking the Sura valley. The whole area is very much dissected by river valleys and is subject to gully erosion, especially in the higher east and where the forest has been cleared. The climate is markedly continental, with January average temperatures about −12° C. (10° F.) and July averages about 19° C. (66° F.). Winter incursions of cold air from the north can bring exceptionally low temperatures. Precipitation is only very moderate, from 20 in. a year in the west to 14 in the east. The rainfall, which has a summer maximum, is very variable and droughts can occur. The republic lies at the extreme southern limit of the mixed forest zone and its natural vegetation cover of forest is predominantly deciduous, chiefly oak, lime and birch. Areas of sandy soils, mostly of fluvio-glacial origin, are in pine forest. Soils are usually of the leached or degraded chernozem or gray forest types. In the west podzols occur. These relatively fertile soils have given rise to extensive forest clearance for agriculture in the past and now little over a quarter of the area of the republic is forested. Along the rivers there are belts of flood-plain meadows.

Of the 1959 population the exceptionally low proportion of 15% was urban. In 1939 the proportion had been only 7%. There are seven towns and ten urban districts but almost half the 183,580 townsfolk live in the administrative centre of Saransk (71,034) and other urban centres are very small. The Mordvin (Mordva or Mordovinian), who numbered 1,285,116 in the U.S.S.R. as a whole in 1959, are a Finno-Ugrian nationality, related to the nearby Mari and Udmurts. In the Mordvinian republic itself they represent about 35% of the total population. They are in two groups, distinguished by language differences, the Erzya-Mordvin, living in the east, and the Moksha-Mordvin of the west and north. Only after the Revolution were written forms of their languages devised, for which the Cyrillic script was used (*see* MORDVIN). The largest concentrations of Russians, who form a majority of the population, are in the south and southeast and in the towns. There are also some Tatars, whose presence dates from the period when the area was part of the Kazan khanate. Although Russians appeared there as early as the 12th century, it was in the late 16th and 17th centuries, after the overthrow of Kazan, that they began intensive colonization, with accompanying forest clearance.

Agriculture is the mainstay of the greater part of the population. Grains dominate the arable land (forming 67% of the cropped area), with winter-sown rye by far the most important, followed by spring wheat and oats, together with lesser quantities of millet and buckwheat. Maize, the fourth crop by area, is grown only for green fodder and silage. Hemp, chiefly in the centre and east, and *makhorka* tobacco are the main industrial crops. Vegetable growing is important, particularly potatoes and peas. Despite extensive natural pastures the numbers of livestock kept are not large. Sheep and goats take first place, with cattle and pigs of minor significance. Draught horses are bred. Beekeeping is widespread. The forests of the republic are intensively exploited and timber-working within the republic is steadily expanding. Paper is made at Temnikov in the northwest, prefabricated houses at Umet and wooden crates at Ichalkov, and tannin is extracted at Zubova Polyana. Fossil oaks are obtained from river beds and used for commercial purposes. Other industry is primarily engaged in processing agricultural products: foodstuffs at Saransk, Ardatov, Krasnoslobodsk and Temnikov and hemp and wool at Shiringushi. Cement is made from the chalk which underlies much of the republic, and peat is dug to supply the Saransk peat-burning electric station. The Saratov-Gorki natural-gas pipeline passes through Saransk and is the basis of the developing chemical industry. Communications are good, with the Moscow-Ryazan-Kuibyshev trunk railway traversing the republic from west to east and lines from Gorki and Kazan to Penza crossing it from north to south. Saransk is linked by highway to Gorki, Ulyanovsk and Penza. Only in the northwest are major transport lines lacking.

(R. A. F.)

**MORE, SIR ANTHONY** (known as Antonis Mor, originally Anthonius Mus) (*c.* 1512–1578), Dutch portrait painter, was born at Utrecht in 1512 according to some, but in 1521 according to Karel van Mander. More studied his art under Jan Schoreel, and after making a professional visit to Italy he began to paint portraits in the style of Hans Holbein. His rise to eminence was rapid. In 1552 (or 1547) he was invited to Madrid by the emperor Charles V. In 1554 he was in London painting the portrait of Queen Mary for her bridegroom, Philip II of Spain. This picture (Prado museum at Madrid) is his masterpiece. For it an annual salary and, supposedly, the honour of knighthood were conferred upon him. From 1557 to 1559 More lived in Utrecht. In Aug. 1559 he accompanied King Philip to Spain, returning to Utrecht in 1560. He died at Antwerp in 1577.

The Hispanic Society of America, New York city, exhibits several of More's pictures; they may also be seen at, among other galleries, the National Gallery of Art, Washington, D.C.; the Philadelphia Museum of Art; the Art Institute of Chicago; and the National gallery, London.

**MORE, HANNAH** (1745–1833), English religious writer, best known for her philanthropic works written for the benefit of the poor, was born at Stapleton, Gloucestershire, on Feb. 2, 1745, the fourth of five daughters of a schoolmaster, Jacob More. Her elder sisters established a flourishing boarding-school at Bristol, where she was a pupil and later a teacher. From childhood she wrote verse and prose with facility, and became known for her witty and sensible conversation. She accepted a proposal of marriage from William Turner, a wealthy, middle-aged squire, but broke the engagement after he had twice postponed the ceremony. Without her knowledge, he settled an annuity on her, which freed her from teaching and made her literary and philanthropic activities possible. None of her sisters married; they spent most of their lives together in unbroken harmony.

In 1773 she made the first of more than 20 annual visits to London. The best circles opened to the vivacious young provincial. She stayed with the Garricks, talked with Dr. Johnson, Edmund Burke and Sir Joshua Reynolds and was taken up by Elizabeth Montagu and her "bluestocking" friends (*see* BLUESTOCKING), whose assemblies she described in the gay and rapid octosyllabics of *Bas Bleu, or Conversation* (written 1782, published with *Florio, a tale* . . . 1786). In 1775 Garrick produced her tragedy *The Inflexible Captive* at the Theatre Royal, Bath, and in 1777 he applied all his social influence and dramatic experience to make a success of her *Percy* at Covent Garden. *The Fatal Falsehood*, played in 1779 after Garrick's death, ran for only three nights, and Hannah More, always modest and sensible about her writings, forsook the stage.

*Sacred Dramas* (1782), which ran rapidly through 19 editions, marked the growing preponderance of devotional seriousness in her mind. Her strong piety and Christian habits had already asserted themselves in London, where she kept Sunday strictly, to the amusement of her fashionable friends; they add piquancy to her long correspondence with the agreeable skeptic Horace Walpole. In the 1780s she began to collaborate with the antislave-trade group and contributed a poem, *Slavery* (1788), to this campaign. Her friendship with William Wilberforce drew her slowly toward the Evangelicals with whom she developed a profound sympathy, and the building of her cottage, Cowslip Green, near Wrington, Somerset, proved the first step in her gradual withdrawal into a country life of religious philanthropy, in which her sisters later joined her.

Meanwhile she admonished society in a series of moral treatises, beginning with *Thoughts on the Importance of the Manners of the Great to General Society* (1788) and *An Estimate of the Religion of the Fashionable World* (1791). They were eulogized and widely read. The writing is fresh and vivacious, and there is an originality and force in her way of commending sober sense and piety which accounts for her popularity at a time when alarm at the French Revolution made religion fashionable in England. These tracts and the more important *Strictures on the Modern*

*System of Female Education, With a View of the Principles and Conduct Prevalent Among Women of Rank and Fortune* (1799) supplemented the work of the powerful Society for the Reformation of Manners, established by Wilberforce and his friends. Her most popular plea for Christianity as the religion of the home was her novel *Coelebs in Search of a Wife* (1808), which sold enormously in England and the United States.

Meanwhile Bishop Porteus had urged her to write cheap tracts for the poor, to counteract the subversive doctrines of Thomas Paine's *Rights of Man*. *Village Politics* (1792), written under the pseudonym of Will Chip and described by its author as "as vulgar as heart could wish," led to a series of "Cheap Repository Tracts," including tales, dialogues and rhymes, produced by her and her friends for three years (1795–98) at the rate of three a month. The demand was astonishing. Two million were circulated in one year, teaching the poor, in language of ingenious homeliness, to rely on the virtues of content, sobriety, humility, industry, economy, reverence for the British constitution, patriotism and trust in God and in the kindness of the gentry. Like most of her educated contemporaries in England, Miss More sincerely believed that society was static and that civilization depended upon a large permanent body of poor, for whom the best education was that which reconciled them to their fate. This conviction coloured her indefatigable philanthropic work for the poor of the Mendip hills. From 1789 she established schools for children and benefit clubs for women, and in spite of her consistently frail health visited them regularly with her sisters. She met with opposition and denigration. The farmers thought that even the most limited education would be fatal to agriculture, and the clergy, whose neglect she was making good, accused her of Methodist tendencies, which she strongly denied. She was no theologian; her concern was for the Christian life. Naturally authoritative, an "old bishop in petticoats," as William Cobbett said, she was not sour. She approved of innocent pleasure and children loved her. She outlived her sisters and died at Clifton, Bristol, on Sept. 7, 1833.

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(J. M. S. T.)

**MORE, HENRY** (1614–1687), English philosopher, Cambridge Platonist, was born in Grantham in 1614. His parents were Calvinists but even as a schoolboy he rebelled against "that hard doctrine." He went from Eton to Christ's college, Cambridge, in 1631. There he came under two main influences: Cambridge Platonism and the mystical-allegorical teachings of Joseph Mede, author of *Clavis Apocalyptica* (1627). In 1639 he graduated M.A. and was elected to a fellowship. He consistently refused preferment, devoting himself to writing and conversing with his pupils, one of the most notable of whom was Lady Conway. Her spiritualistic enthusiasms undoubtedly influenced More, especially in his later writings, even if he was simultaneously in close touch with the leading scientists and philosophers of his time. He died on Sept. 1, 1687, and is buried in the chapel of his college.

His works fall into distinct groups. He began by writing several metaphysical poems, using a style akin to Spenser's, but including satirical sketches of the type of religion to which, as a latitudinarian Anglican, he was most opposed. His religious ideas are most fully expressed in *An Explanation of the Grand Mystery of Godliness* (1660) and *Divine Dialogues* (1668). In the true spirit of Cambridge Platonism, he set out to show "that there is no real clashing at all between any genuine Point of Christianity and what true Philosophy and Right Reason does determine or allow," and to espouse the cause of religious toleration. Of his ethical writings the most notable is *Enchiridion Ethicum* (1667). But he also wrote *Conjectura Cabbalistica* (1653), at Lady Conway's request, and devoted the major part of his *An Antidote Against Atheism* (1652) to witch- and ghost-stories.

In his general metaphysics, More was at first an admirer of Descartes, but later came to hold that Cartesianism must lead to some form of mechanical naturalism and to atheism; in his 1648–1649 correspondence with Descartes, *The Immortality of the Soul* (1659) and *Enchiridion Metaphysicum* (1671)—the most important of his metaphysical writings—he argues against Descartes' identifying matter with extension. To deny that spirit is extended, he maintains, is to reduce it to a nonentity which could exert no influence on the processes of the world. Not only individual minds but God must be extended; indeed infinite space is a mode of revealing to us certain of the attributes of deity. Newton's leading ideas about space may have their roots in More's metaphysics.

More's poetry is published complete in A. B. Grosart, *The Complete Poems of Dr. H. More* (1878), and in a critical selection in G. Bullough, *Philosophical Poems of Henry More* (1931). Selections from More's philosophical writings appear, with bibliography, in F. T. MacKinnon, *Philosophical Writings of Henry More* (1925). More's correspondence with Descartes is in G. Lewis, *Descartes, Correspondance avec Arnaud et Morus* (1953), and is partly translated by L. D. Cohen in *Annals of Science*, vol. i (1936).

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**MORE, PAUL ELMER** (1864–1937), U.S. writer and critic, one of the leading defenders of humanistic principles, was born in St. Louis, Mo., Dec. 12, 1864. He was educated at Washington university and Harvard, was assistant in Sanskrit at Harvard (1894–95) and associate in Sanskrit and classical literature at Bryn Mawr college (1895–97). He served as literary editor of the *Independent* (1901–03) and the *New York Evening Post* (1903–09) and as editor of the *Nation* (1909–14). Like Irving Babbitt (*q.v.*), his associate and leader of the humanists, More was an uncompromising advocate of traditional critical standards in a time of radical departures (typified by the work of H. L. Mencken; *q.v.*) in literature and politics.

Among More's works are *Shelburne Essays*, 11 vol. (1904–21); *Life of Benjamin Franklin* (1900); *Nietzsche* (1912); *Platonism* (1917); *The Religion of Plato* (1921); *Hellenistic Philosophies* (1923); and *New Shelburne Essays* (1928–36).

*See* L. H. Hough, *Great Humanists* (1952).

**MORE, SIR THOMAS** (1478–1535), English saint and humanist, the author of *Utopia* and lord chancellor from 1529 to 1532, who was martyred for refusing to accept the Act of Supremacy of Henry VIII. He was born on Feb. 7, 1478, in Milk street, London, "the brightest star," says Thomas Fuller, "that ever shined in that *via lactea*." His father, John More, butler to Lincoln's Inn, was later knighted and became a judge, first of the court of common pleas and then of the king's bench. Thomas More was educated at St. Anthony's school in Threadneedle street, and in the household of Thomas Morton, archbishop of Canterbury. When plays were performed there at Christmas, More would improvise a part for himself, to the amusement of the audience. From such incidents Henry Medwall (*q.v.*), Morton's chaplain, may have derived the subplot of *Fulgens and Lucrece*, thus founding the English dramatic tradition of a double plot. Morton sent young More to Oxford in about 1492: according to family tradition he went to Canterbury college, afterward Christ Church; local tradition said that he was at St. Mary hall. He firmly embraced the new learning and held scholastic quiddities in contempt. Compelled by his father to study law, he entered New Inn in about 1494, and was admitted to Lincoln's Inn on Feb. 12, 1496. He was first appointed reader at Furnival's Inn, became pensioner and butler of Lincoln's Inn in 1507 and was reader there in 1511 and 1515.

At the same time, More pursued his studies of Latin and Greek literature and theology; John Colet, William Grocyn, Thomas Linacre, Cuthbert Tunstal, Richard Pace and Erasmus became his friends. During this period he wrote (*c.* 1497) Latin epigrams for John Holt's grammar, *Lac puerorum*, lectured publicly (*c.* 1501) in Grocyn's church of St. Lawrence Jewry in the City on St. Augustine's *De civitate Dei* and vied with William Lily in translating Greek epigrams into Latin. His *Lyfe of Iohan Picus Erle of Myrandula* (1510) was an abridged translation of the Latin

version of G. F. Pico. He also wrote English verses, both humorous and serious.

More lived for about four years at the London Charterhouse, sharing as far as possible the devotional life of the monks; these years laid the spiritual foundation for his whole career and although he never took vows, deciding instead upon marriage, his words to his daughter when he was in the Tower suggest that only family responsibilities had kept him from returning. "I believe, Meg," he said, "that they that have put me here ween they have done me a high displeasure. But . . . if it had not been for my wife and you that be my children, whom I account the chief part of my charge, I would not have failed long ere this to have closed myself in as straight a room, and straighter too . . ." Throughout his life he preserved some of the austere habits then formed, sparing in his diet and wearing a hair shirt next his skin, he devoted only five hours a night to sleep, spending much time in prayer and meditation. This self-discipline and his cheerful acceptance of subsequent troubles both sprang from the same basic philosophy: "We may not look at our pleasure to go to heaven in feather beds," he said. "It is not the way. For Our Lord himself went thither with great pain and by many tribulations. The servant may not look to be in better case than his master."

**Marriage and Early Career.**—While humanist and theological studies filled his leisure hours, the law remained More's profession. His learning and eloquence in English and Latin marked him out for a public career, which was only temporarily checked when, as a young member of parliament, "a beardless boy," he effectively opposed Henry VII's financial exactions and incurred the king's anger. In 1505 he married Jane Colt and settled at The Barge in Bucklersbury in the City, where four children were born: Margaret in 1505, who married William Roper, Elizabeth in 1506, who married William Dauncey, Cecily in 1507, who married Giles Heron, and John in 1509, who married Anne Cresacre. Here, and later at Chelsea, More had his children and wards educated under the best scholars available. He was a pioneer for women's education in England; his daughters became famous for learning and disputed before King Henry VIII. When, years later, Roger Ascham sought for terms in which he could praise the Princess Elizabeth's learning highly enough, he could only compare her to the daughters of Sir Thomas More. Erasmus, whom he had first met in 1497, visited his household in 1506, and with More translated dialogues of Lucian into Latin, each providing an answer to *Tyrannicida*. Erasmus returned in 1509 and wrote *Encomium Moriae*. After More's execution he was to say that "they had but one soul between them." He compared More's household to Plato's Academy for the study of science and virtue, "yet more rightly to a school for Christian religion."

More's wife, his *cara uxorcula*, died in about 1511, and he married a widow, Alice Middleton, seven years his senior, whose daughter Alice was adopted as a member of the family; she subsequently married Sir Giles Alington. After the death of Henry VII (1509), More's services were increasingly called upon, first by the City, then by the king and ultimately by the church. Colet and Erasmus called him the one genius of England.

He became a member of the Mercers' company in 1508, and acted as interpreter (1509) in the settlement of disputes between Antwerp and various London companies. When parliament was summoned in 1510, he was again a member and he also became undersheriff of London. He served on the Hampshire commissions of the peace from 1510, on a commission for array (1511) and on one inquiring into enclosures (1517), these last also in the same county. In 1512 he represented the Merchants of the Staple in negotiations with the Merchant Adventurers. At the instance of the City, he was member of an embassy sent to Flanders to negotiate with the Hanse in 1515. On Evil May day 1517, when a mob of London apprentices attacked foreign merchants, he helped to restrain the rioters, an event celebrated in the Elizabethan play *Sir Thomas More*, to which Shakespeare is thought to have contributed More's speeches on order and authority. More was himself a member of the City delegation craving the king's pardon for the rioters. In 1517 he went with an embassy to Calais to settle trade disputes; in the same year he became a member of the king's council and from October was known as master of requests. He resigned his City office in 1518.

**Humanist and Theological Writings.**—In 1501 More had written verses in "Lamentation for the Death of Queen Elizabeth" (Elizabeth of York, wife of Henry VII); in 1509 congratulatory Latin verses on the coronation of Henry VIII. In or after 1514 he wrote the *History of Richard III*, contrasting the virtues of a good king, Edward IV, with the crimes of Richard III. Though unfinished it became widely influential as a result of its inclusion in Richard Grafton's continuation of John Hardyng's *Chronicle* (1543) and Edward Hall's *Chronicle* (1548). It was included in More's *English Workes*, published by William Rastell in 1557. It was praised by Ascham for its clarity and liveliness, which, he said, "makes a man think not to be reading but present in doing." Shakespeare drew on it for his *Richard III*. During the 1515 embassy to Flanders More wrote book ii of *Utopia*, describing a pagan and communist city state in which the institutions and policies were entirely governed by reason; the order and dignity of such a state provided a notable contrast with the unreasonable polity of Christian Europe, divided by self-interest and greed for power and riches, which More described in book i, written in England in 1516. The description of Utopia is put in the mouth of a mysterious traveler, Raphael Hythlodey, in support of his argument that communism is the only cure against egoism in private and public life. More, in the dialogue, speaks in favour of mitigation of evil rather than cure, human nature being fallible. The reader is thus left guessing as to which parts of the brilliant *jeu d'esprit* are seriously intended and what is mere paradox. Satire and irony enliven the dialogue throughout, but there is no doubt that, as More says in his *Apologye*, quoting Horace, "a man may sometime say full sooth in game." Exactly how much is jest and how much earnest even More might have been puzzled to explain. The *Libellus . . . de optimo reipublicae statu, deque nova insula Utopia*, comprising both books, was published at Louvain in 1516, with commendatory letters by More's friends, Peter Giles and Jerome Busleyden. For his material More had drawn on descriptions of the new world by Amerigo Vespucci and Pietro Martire d'Anghiera; and on Plato, Pliny, Tacitus and other classical writers. This demonstration of his learning, invention and wit established his reputation as one of the foremost humanists. Soon translated into most European languages, *Utopia* became the ancestor of a new literary genre, the Utopian romance.

Particularly noteworthy among More's many Latin letters are those which he wrote to Martin Dorp (1515) and to Edward Lee (1519), defending Erasmus, and to Oxford university (1518) and to "a monk" (*c.* 1519–20), in defense of Greek studies as the foundation of sound theology. More polemized against the Frenchman Germain de Brie (Brixius) in epigrams and letters on the military prowess of their respective nations (1513–20). He helped Henry VIII with the anti-Lutheran *Assertio septem sacramentorum* (1521) and under the name of Gulielmus Rossaeus he wrote an abusive answer, *Vindicatio Henrici VIII* (1523), to Luther's attack upon the king. In a letter (*c.* 1525–26) to Johann Bugenhagen (Pomeranus) he upheld the authority of the pope against the detractions of the Lutherans. But even at the height of his learned and public career, More remained mindful of the brevity of life and the instability of fortune, in about 1522 he wrote, but never completed, a meditation on *The Four Last Things*, *i.e.*, death, judgment, heaven and hell.

**Diplomat, Speaker of the House of Commons (1523) and Lord Chancellor (1529–32).**—More was present at the Field of Cloth of Gold (q.v.) in 1520, and shortly afterward was a member of a commission for concluding a commercial treaty with the emperor Charles V. He took a prominent part and made an independent stand in an embassy conducting negotiations with the Hanse at Bruges in 1520 and 1521. He was knighted and made undertreasurer in 1521, and was chosen as speaker of the house of commons in 1523. In this capacity he contributed to the development of the parliamentary claim for freedom of speech; to the customary request to the sovereign for indulgence for himself as their spokesman, he seems to have added a plea for free speech for the commons in all their discussions. He became a justice of the

peace in 1523, high steward of Oxford university and of Cambridge university in 1524 and 1525 respectively, and he was made chancellor of the duchy of Lancaster in July 1525. The following year he headed a commission searching for Lutheran books at the Steelyard, the London headquarters of the Hanse. With Cuthbert Tunstal, bishop of London, he attended the congress of Cambrai at which peace was made between France and the empire (1529); although the French had begun negotiations without consulting their English allies and the peace represented a rebuff to England and especially a devastating reverse for Cardinal Wolsey's policies, More by brilliant diplomacy yet managed to secure the inclusion of his country in the treaty and the settlement of mutual debts.

When Wolsey fell, having failed in his foreign policy and in his efforts to procure the annulment of Henry VIII's marriage with Catherine of Aragon, More succeeded him as lord chancellor (Oct. 26, 1529). In this office he faced an immense accumulation of work, the result of the cardinal's many other preoccupations and of his practice of using injunctions to bring into chancery business properly belonging in the common law courts. More worked so hard that eventually the day came when he recorded that he called the next case "and there was none." Unlike Wolsey, he was accessible to all, a righteous judge and true friend to the poor.

High office brought prosperity and the acquisition of property and valuable wardships; it also gave More the wherewithal to extend his charity and almsgiving. For a short time (1523–24) he owned Crosby place, then in Bishopsgate; but in about 1525 he settled with his wife, his children and their families in his new "great house" at Chelsea. In the grounds he had a "new building wherein there was a chapel, a library and a gallery" for study and private devotion. At Chelsea parish church he built a costly chapel and erected his own epitaph over a tomb which, in the end, he never occupied. At his house prayers were said at table and passages read from Holy Scripture and the Fathers of the Church. No idleness was allowed, no gaming, no dicing, but everyone was encouraged in the practice of useful occupations and the pursuit of learning. So gentle was More's correction of little misdemeanours that it was sought by his children. Hans Holbein the Younger stayed at More's Chelsea house in the year 1526–27 and painted portraits of the family. (The sketch of the family group sent to Erasmus is at Basel, a copy of the painting is at Nostell priory, Yorkshire, and the portrait of More is in the Frick collection, New York; there are also individual sketches at Windsor.)

Henry VIII took great delight in More's company and held many learned discussions with him. More was one of the councilors always in attendance and the king even visited him at Chelsea. From at least as early as 1527, Henry began to entertain persistent scruples about the validity of the pope's dispensation for his marriage with Queen Catherine. More was repeatedly consulted, but he did not share the king's misgivings and he did not sign a letter from leading nobles and prelates, including the disgraced Wolsey, urging the pope to declare the marriage void (1530). Yet More had been made Wolsey's successor as chancellor. He was the first commoner who was not an ecclesiastic and the first layman not a noble to hold that office; thus, although he presided in the house of lords, he himself had no vote. Nor did he wield the political power of Wolsey, but acted as an impartial servant of the crown. He brought before parliament the indictment against Wolsey, likening him to a "great wether" that had led astray the king's flock; on March 30, 1531, he introduced the matter of the king's divorce, supported by 12 opinions from various European universities. More avoided taking sides in this latter issue, even when expressly asked his views; he would only propound the king's case, saying that the king himself knew his opinions.

While the pope delayed judgment, measures were taken to limit papal authority over the English clergy. In order to obtain the king's pardon for acquiescing in Wolsey's breaches of the 14th-century Statute of Praemunire, the convocation of Canterbury, followed by that of York, finally agreed, in Feb. 1531, to pay a heavy fine and to acknowledge the king as "their singular protector, only and supreme lord, and so far as the law of Christ allows, even supreme head." The conditional restraint of annates followed in Feb. 1532, and on May 10, 1532, articles were placed before the convocation of Canterbury depriving it of the power to enact constitutions without the king's consent. The clergy submitted on May 15. More resigned the following day (May 16, 1532), pleading reasons of health; according to Erasmus he suffered from "a sharp and constant pain in the chest."

**Anti-Heretical Writings.**—As early as March 1528 the bishop of London had given More licence to read heretical books in order to confute them, and More's *A Dialogue Concerning Heresies and Matters of Religion, Against Tyndale*, was printed in June 1529. In it he upheld the divine origin of the church's authority, denied that men have a right to free individual interpretation of Scripture and condemned Tyndale's translation of the Bible as heretical. He contradicted Luther's contention that faith alone is sufficient for salvation. Though as chancellor More was to prefer converting heretics to burning them, in *Tyndale* he justified the eradication of seditious heresy as necessary to maintain the peace and security of the state. His reasoning in *Tyndale* was the same as that he had used in *Utopia*. It was his legal pleading, rather than his actions, that, much later, gave More a false notoriety for burning heretics. He certainly hated heresy from absolute conviction, but he hated violence even more. His own son-in-law, William Roper, had been a contentious Lutheran for many of the years when he had lived in More's household; More eventually despaired of argument to convert him and turned, successfully, to prayer. In all those years Roper "never knew him in a fume."

More's style in *Tyndale* is remarkable for accuracy, and enlivened by humorous anecdotes. His later controversial writings, however, are not of the same standard and suggest a lack of concentration, easily attributable to overwork. In answer to the *Supplycacyon for the Beggars* of Simon Fish, demanding the confiscation of church property, More wrote *Supplycacyon of Soulys* (1529), visualizing the souls of the donors and founders of religious land and houses pleading in purgatory not to be deprived of the prayers for which they had made their bequests. A few years later Tyndale's *An Answere Unto Syr T. More's Dialoge* (1530) provoked *The Confutacyon of Tyndales Answere* (1532–33), about ten times as long. After his resignation More had greater leisure for controversy and apologetics. In *The Apologye of Syr Thomas More Knyght* (1533) he answered the attacks made on the clergy by Christopher Saint-German in his *Treatise Concernynge the Division Betweene the Spiritualtie and the Temporaltie* (*c.* 1532) and also defended himself against charges of corruption and cruelty while holding office. In answer to Saint-German's *Dialogue Between . . . Salem and . . . Bizance*, More wrote *The Debellacyon of Salem and Bizance* (1533). His last controversial work was the *Answere to the . . . Poysened Booke . . . Named the Souper of the Lord* (1533). He refused the large reward collected for him by the clergy in gratitude for his defense of them.

**Imprisonment, Trial and Execution.**—The Act in Restraint of Appeals (1533) had now severed the judicial links between England and Rome. Thomas Cranmer, who had succeeded William Warham as archbishop of Canterbury, declared the king's marriage void (May 23, 1533) and Anne Boleyn was crowned on June 1. Roper believed that Anne hated More for refusing consent to her marriage, and More must also have thought so, for he referred to this refusal at his trial although it was not specifically part of the indictment. After the failure of several frivolous accusations against him and the removal of his name from a bill of attainder brought (Feb. 1534) against supporters of Elizabeth Barton (*q.v.*), "the nun of Kent," More was eventually called to appear at Lambeth on April 13, 1534, to confirm by oath the Act of Succession (March 1534), which declared the king's marriage with Catherine void and that with Anne valid. This More was willing to do, acknowledging, as he had written in his letter of March 5 to Thomas Cromwell about Elizabeth Barton, that Anne was now in fact anointed queen. But he refused the oath as then administered because it entailed a repudiation of papal supremacy. On April 17 he was imprisoned in the Tower.

During his imprisonment he wrote *A Dialogue of Comfort Against Tribulacyon* (1534), a work of devotion and consolation

and humour in support of those persecuted for the sake of religion and conscience and denying that the head of a state can dictate religious belief. He also began in English and continued in Latin his *Expositio passionis Domini*, a treatise on the passion of Christ. Before this work was finished he was deprived of his writing materials and his last moving letters of farewell and encouragement to his family and friends were scrawled with a piece of charcoal. His words in the Tower give us a glimpse of More the mystic; he told his daughter "Me thinketh God maketh me a wanton, and setteth me on his lap and dandleth me."

Meanwhile the 1534 Act of Supremacy established the king as the supreme head of the Church of England, without reservation, and the Treasons act made it high treason to deprive the king of his title. For refusing the oath acts of attainder were passed against More and John Fisher, bishop of Rochester, and More's lands were sequestrated. The Carthusians, who had also refused the oath, were condemned to death on April 29, 1535; Fisher was tried on June 17, and beheaded on June 22. More was interrogated on April 30, May 7, June 3 and 14, and was tried in Westminster hall on July 1, on an indictment of four main counts. The first was his refusal to affirm the king's supremacy, the second and third concerned his correspondence with Fisher during their imprisonment, and the fourth was his denial that parliament could make the king head of the church. More's defense seems to have been allowed on the last three counts. On the first he pleaded that he had not spoken against the supremacy and that nowhere in the world is there any law that makes silence punishable. The attorney general objected that loyalty required a subject freely to confirm the law. More, however, maintained that if the common law *qui tacet, consentire videtur*, that silence implies consent, is right, then his own silence had approved rather than denied the statute. These, and More's further arguments, were not accepted and the jury pronounced him guilty. For the discharge of his conscience he then declared that in all his studies he had been unable to find that a layman could be head of the spiritual order, that the church throughout Christendom is one and indivisible and it is not within the power of one realm to make laws for it without the consent of the others; to do so would be against the unity and concord of the Christian religion.

More was conducted back to the Tower and beheaded on Tower hill on July 6, 1535. Mindful to the last of Christ's example, he put aside the cup of wine offered to him on his way to the scaffold, saying, "My master had easell and gall, not wine, given him to drink." His famous words on the scaffold, that he "died the king's good servant but God's first," triumphantly sum up his whole career. His body was buried in the chapel of St. Peter ad Vincula in the Tower. His head was placed on London bridge; it was reported subsequently to have been thrown into the river, but it may have been purchased by Margaret Roper and buried with her in Chelsea church. But a head discovered in 1824 in a box in the Roper vault in St. Dunstan's church, Canterbury, has been assumed to be More's. More was beatified on Dec. 29, 1886, and canonized on May 19, 1935; his feast day is on July 9.

**More's Literary Importance.**—The man is greater than the writer. Yet the writer, though minor as a poet in English and Latin, occupies an important place in the history of English prose. His own thesis that the English language was capable of expressing all things is amply proved by his own writings; he made it serviceable to all ends. The resourcefulness of his vocabulary is the most striking feature of More's style, both in English and Latin, and in his own language he draws freely on Latin and Greek. His sentence structure is traditional though not devoid of Ciceronian parallelism and elaborate alliteration. Though his volubility is medieval, yet his style points forward to Ascham and John Lyly. Though wordy and long-winded it is always factual, straightforward and manly. Under the restraint of classical models it is at its best in *Richard III* and *Tyndale*. It triumphs in dialogue and humorous anecdote, the mastery of which he communicated to his friends and disciples, as is plainly shown in the writings of his early biographers. His sense of humour is second only to his sound common sense which he brings to bear on all subjects. Thus the style reflects the man in the intimacy of his letters to his family no less than in the intellectual brilliance of his satire or the warmth of his devotional treatises. The complexity puzzled friends as well as opponents: "Ye use . . . to look so madly when ye mean merrily that many times men doubt whether ye speak in sport when ye mean good earnest." Even if More is no longer regarded as "the father of English prose," his works are a conspicuous landmark, and in his *Dictionary* Dr. Johnson devoted many pages to the language of Sir Thomas More.

*See* also references under "More, Sir Thomas" in the Index.

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(H. W. DO.)

**MORÉAS, JEAN** (pseudonym of YANNIS PAPADIAMANTOPOULOS) (1856–1910), French poet who played a leading part in the French Symbolist movement, was born at Athens, Gr., on April 15, 1856. Under his true name he published in 1878 a collection of poems entitled *Tragoumi Kkai Ekkilousi*. In 1879 he went to Paris where he became a familiar literary figure, frequenting the cafés of the Left Bank and taking part in the literary controversies of his time. His *Syrtes* (1884) were Parnassian in form, but *Les Cantilènes* (1886) and especially *Le Pèlerin passionné* (1891) were heralded as masterpieces of the newly-founded Symbolist school. He was the first to formulate the principles of Symbolism in the *XIXe siècle* (Aug. 11, 1885) and in Sept. 1886 he published an important manifesto in the literary supplement of the *Figaro*. He founded a periodical *Le Symboliste* (1886). But in 1891 he broke away from the main current of Symbolism to found the *école romane*, the chief members of which were Raymond de la Tailhède, Maurice du Plessys, Ernest Raynaud and Charles Maurras (q.v.). He abandoned *vers libres* to foster a return to traditional French versification and classical sources of inspiration. The new aesthetic found expression in *Enone* (1893), *Eriphyle* (1894) and in *Sylves* (1896). In his last and finest work, *Stances* (1899–1901), he retained the best of his earlier symbolist gesture in verse of classical perfection and purity. The mood of his poetry is one of pagan resignation. In the same melancholy vein and with equal lyrical power he wrote a play, *Iphigénie* (published 1904), closely inspired by

Euripides, which met with considerable success when presented on Aug. 24, 1903, in the *théâtre antique* of Orange and subsequently on the stage of the Odéon in Paris. Moréas also wrote modern adaptations of medieval *contes* (*Contes de la vieille France*, 1904), numerous critical essays (*Réflexions sur quelques poètes*, 1912) and two novels in collaboration with Paul Adam. After a long illness borne with great fortitude, Moréas died in Paris on March 31, 1910.

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**MOREAU, GUSTAVE** (1826–1898), French Symbolist painter of erotic subjects, was born in Paris on April 6, 1826. His father was an architect. The only influence that really affected Moreau's development was that of the painter Chassériau (1819–56). Moreau's first picture was a "Pietà" (1852), now in the cathedral at Angoulême. In the Salon of 1853 he exhibited a "Scene From the Song of Songs" and the "Death of Darius," both conspicuously under the influence of Chassériau. From that time he exhibited regularly, with an interval in 1869 to 1876, receiving many honours and prizes. His colour is luminous, like enamel, and his subjects are strange and mysterious. Moreau succeeded Élie Delaunay as professor at the École des Beaux-Arts, and his teaching was highly popular. He was the teacher of some of the artists of the *Fauve* movement, including Matisse and Rouault.

Moreau died on April 18, 1898, leaving to the state his house, containing about 8,000 pictures, water colours, cartoons and drawings, which form the Moreau gallery in Paris.

**MOREAU, JEAN VICTOR MARIE** (1763–1813), French general of the Revolutionary period who defeated the Austrians at the battle of Hohenlinden and finally became an opponent of Napoleon I, was born at Morlaix in Brittany on Feb. 14, 1763. The son of a lawyer, he began to study law at Rennes, then joined a regiment, but soon left it and went back to law. As *prévôt* or "provost" of the students at Rennes, he led a riot in protest when the royal government deprived the *parlements* of their principal functions (June 1788). In 1789 he raised a company of gunners in the national guard at Rennes, of which he soon became captain. Elected lieutenant colonel of the first battalion of volunteers of Ille-et-Vilaine in 1791, he served in the army of the North under Dumouriez in 1792, on the outbreak of the French Revolutionary Wars (*q.v.*). He was appointed general of brigade by the *représentants en mission* on Dec. 20, 1793, and became general of division on April 14, 1794. By that time Charles Pichegru was in command of the army of the North; and when Pichegru fell ill at the end of 1794 Moreau temporarily took his place. On the transfer of Pichegru to the army of Rhin-et-Moselle, Moreau, now a friend of his, again took command of the army of the North (March 3, 1795). When the Directory relieved Pichegru of his command because of his suspect negotiations with the *émigrés*, on March 14, 1796, Moreau was given the command of the army of Rhin-et-Moselle.

Moreau led his army throughout the campaign of 1796 in Germany and won lasting fame with his conduct of the retreat across the Black forest in the autumn. His father, however, had been guillotined as a royalist during the Terror, and he himself was now suspected of dealings with the *émigrés*. These suspicions were confirmed in 1797, when it became known that, though on April 21 he had seized documents providing clear proof of Pichegru's treason, he had not informed the Directory about them till Sept. 7. This was after the *coup d'état* of 18 Fructidor (Sept. 4) had averted the likelihood of a royalist *coup* and brought about the arrest of Pichegru. Moreau was recalled on Sept. 9, 1797.

Even so, Moreau received the command of part of the army of Italy, under Barthélemy Schérer, on Dec. 7, 1798, and the command of the whole army after Schérer's defeat at Magnano on April 5, 1799. On Aug. 4, he was placed under B. C. Joubert, but Joubert was killed at Novi on Aug. 15, after which Moreau was again in command of the army of Italy till Sept. 21, 1799. Returning to Paris, he there made the acquaintance of Napoleon Bonaparte, whose *coup d'état* of Brumaire (Nov. 1799) he abetted by holding the directors L. J. Gohier and J. F. A. Moulin as prisoners in the Luxembourg palace. Bonaparte rewarded him with the command of the armies of the Rhine and of Helvetia. At their head he won the great victory of Hohenlinden over the Austrians (Dec. 3, 1800). This victory, however, made Bonaparte envious of him.

In 1800, moreover, Moreau married a creole girl, Alexandrine Hulot, whose family was on bad terms with that of Tascher de la Pagerie, to which Bonaparte's wife Joséphine belonged. Joséphine's ill-will drove Moreau into opposition against Bonaparte. Accordingly he renewed his relations with Pichegru. The latter had escaped from Guiana and secretly re-entered France and was plotting, with Georges Cadoudal, against Bonaparte's life. These schemes became known, and Moreau was arrested on Feb. 15, 1804. For lack of proof, he received only a sentence of two years' imprisonment, which Bonaparte commuted to exile for life. Emigrating to the United States, Moreau settled at Morrisville, Pa. Finally, after the destruction of Napoleon's army in Russia, he returned to Europe on the invitation of the French royalists and of the Russian emperor Alexander I: he joined the allied leaders at Prague on Aug. 17, 1813. Wounded in the battle of Dresden (Aug. 27), he died at Lahn on Sept. 2, 1813. His body was taken to Russia and was buried in the Catholic church in St. Petersburg.

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**MORECAMBE AND HEYSHAM,** a municipal borough, seaside town and seaport in the Morecambe and Lonsdale parliamentary division of Lancashire, Eng., on Morecambe bay, 4 mi. W.N.W. of Lancaster. Pop. (1961) 40,228. A promenade 4½ mi. long extends along the sandy shore; there are a quay, two piers and a winter garden. Catering for visitors is the main industry, but plastics and razor blades are made and there is an oil refinery. The shrimps from the shallow Morecambe bay are relished. There are sailings to the Isle of Man from Heysham harbour, which is also a starting point for mail steamers to Belfast, N.Ire. Morecambe was incorporated in 1902 and Heysham urban district was added in 1928.

**MOREL,** the surname of several French scholar-printers.

GUILLAUME MOREL (1505–1564), born in Normandy and employed first as a corrector, produced some minor works of scholarship and set up his own press in 1549. After collaborating with Adrien Turnebe, he became king's printer in 1555. He was the first to edit the fragments of Menander (1553) and printed other Greek texts, classical, patristic and Byzantine.

The other Morels all belonged to one family. FÉDÉRIC MOREL (1523–1583), born in Champagne, became king's printer in 1571. He edited the French works of Joachim du Bellay (1569) and Philibert Delorme's *De l'architecture* (1568). His son, FÉDÉRIC II (1558–1630), appointed king's printer in 1581, was an outstanding scholar. He revised Jacques Amyot's translation of Plutarch's *Moralia* (1572), succeeded his father-in-law, Léger Duchesne, as professor of eloquence at the Collège de France (1586) and prepared the first edition of Empedocles, *De sphaera* (1586). As translator, editor and printer he promoted the study of the Greek Church Fathers. CLAUDE (1574–1626), Fédéric II's brother, took over the Morel workshops in 1600 and continued to publish the Greek Fathers, becoming king's printer in 1625. CHARLES (1602?–1640), the elder son of Fédéric II, appointed king's printer in 1635, published the complete works of Gregory of Nazianzus (1630), Cyril of Jerusalem (1631) and John Chrysostom (1636) and Severin Bini's *Concilia generalia et provincilia* (1636). Charles' younger brother GILLES (1616–1675), king's printer in 1639, published *Bibliothèque des Pères* (10 vol., 1643). He broke the family's connection with printing in 1646 and eventually he became *conseiller au grand conseil*.

*See* M. Maittaire, *Historia typographorum aliquot Parisiensium* (1717); J. Dumoulin, *Vie et oeuvres de Fédéric Morel* (1901).

(R. R. Ho.)

**MOREL** (*Morchella*) is a fungus of the class Ascomycetes (*see* FUNGI); less than a dozen species are known. They appear in the spring and are best recognized by their fleshy consistency and the pitted head on a stalk. Although they rate among the best of all edible fungi, they have not been grown commercially with success. Fungi with wrinkled heads, somewhat similar in appearance, belong in the genus *Helvella*, not all species of which are edible. *See* also MUSHROOM.

(AR. H. S.)

MOREL (MORCHELLA ESCULENTA)

**MORELIA,** the capital of the state of Michoacán, Mex. Pop. (1960) 100,828. Formerly known as VALLADOLID, the city's name was changed to Morelia in 1828, in honour of José María Morelos y Pavón, locally born leader of the Mexican wars of independence. The city, in the valley of Guayangareo at the southern extreme of the central plateau, lies between the Río Chiquito and the Río Grande and is at an elevation of 6,398 ft. It is 125 mi. (direct) from Mexico City and has rail, highway and air connections with all major cities of the republic.

Morelia was founded in 1541 on orders from the viceroy Antonio de Mendoza. The Tarascan Indians inhabited the area where the city was established, and people of Indian descent still predominate. When the cathedral of Pátzcuaro was moved there in 1580, the town had only eight or ten Spanish families and two monasteries. In 1582 it replaced Pátzcuaro as the capital of Michoacán. Since the late 16th century, Morelia has served as a commercial centre for an extensive agricultural region. Other than a limited hardwood lumber industry, its manufactures are limited almost exclusively to the processing of locally produced crops. Lacquer ware, pottery, serapes and jewelry are produced in the homes of the city.

The baroque cathedral, begun about 1640 and completed in 1744, is an outstanding example of Spanish Renaissance church architecture. The governor's palace is also an imposing structure of the colonial era. The Colegio San Nicolás (College of Saint Nicholas), founded in 1540 in Pátzcuaro and transferred to Morelia in 1580 and merged with another college, claims the distinction of being the oldest existing institution of higher learning in Mexico. The college did much to give Morelia the reputation of being an intellectual and art centre during the Spanish colonial period. One of the main points of interest in the city is the aqueduct (three miles in length, carried on arches), which was built in 1785 as a famine relief project.

During the Mexican wars of independence, Morelia served for a brief period as the base of operations for the revolutionary leader Miguel Hidalgo y Costilla. After the winning of independence, the city was generally known as a clerical and conservative stronghold, although often the working classes vigorously supported radical ideologies.

(J. J.)

**MORELLET, ANDRÉ** (1727–1819), French economist and miscellaneous writer, a prolific publicist of the *philosophe* party and a contributor to the *Encyclopédie*, was born at Lyons on March 7, 1727. Educated by the Jesuits there and at the Sorbonne, he took holy orders, but his designation of abbé was the chief thing clerical about him. A frequenter of the salon of Mme Geoffrin (of whom he wrote an *Éloge*), he had a ready and biting wit and Voltaire called him "L'Abbé Mord-les." As an economist he expounded the views of A. R. J. Turgot (*q.v.*). In 1785 he was elected to the Académie Française and preserved its archives during the Terror, which he fearlessly condemned in several pamphlets. He died in Paris on Jan. 12, 1819. His *Mélanges de littérature et de philosophie du XVIII^e siècle*, containing selections from his previous works, appeared in 1818, and his valuable, elegantly written *Mémoires* were published in 1821.

*See* the bibliography of Morellet's works in J. M. Quérard, *La France littéraire* . . . , 12 vol. (1827–64), vol. vi; also C. A. Sainte-Beuve, *Causeries du Lundi*, 11 vol. (1851–62), *see* the table de matières under Morellet, abbé de).

**MORELLI, GIOVANNI** (1816–1891), Italian patriot and art critic, whose methods of direct study became basic for subsequent art criticism, was born at Verona on Feb. 25, 1816. As a Protestant, he was sent to Munich university, where he acquired so great a command of German as to write his principal works in that language, although he pretended that they were translations from the Russian of "Ivan Lermolieff", i.e., an anagram of Morelli with a Russian termination. He studied medicine but never practised, and he took part in the war of 1848, after which he devoted much of his time to politics. In 1861, although a Protestant, he was elected deputy for Bergamo in the first free Italian parliament. Later, he became alarmed by increasingly democratic tendencies and in 1870 resigned his seat, but he was made a senator in 1873.

His principal achievement was to secure the passing of an act (named after him) prohibiting the sale of works of art from public or religious institutions, and the appointment of a commission to nationalize and conserve all major works which could be regarded as public property, thus undoubtedly saving many masterpieces. One of his principal assistants was G. B. Cavalcaselle (*q.v.*), but they later quarrelled. Morelli had a tendency to sarcasm which, in his books, made him many enemies; he admitted that the history of art was more intelligently studied in Germany than anywhere else at that date, but his sallies against the pedantry of German professors were not, perhaps, invariably justified.

His first book, *Italian Masters in German Galleries* (1880, Eng. trans., 1883), marks an epoch in 19th-century art criticism. The so-called "Morellian method" was followed in this and his later *Critical Studies*; essentially 19th century in its scientific rigorousness, it consisted of the apparently simple thesis that the evidence presented by the pictures themselves is superior to all other evidence, whether documentary or traditional. Further, the crux of the method was that all painters, however great, tend to fall back on a formula for rendering such details as the ear or the fingernails, and that these minor details were therefore the most characteristic parts of a picture and the surest guide to attribution. Both Morelli himself and his principal follower, Bernard Berenson, have corrected hundreds of false attributions, but the dangers of his method are obvious and did not pass unnoticed at the time; nevertheless, "it would be as absurd to return to a pre-Morellian period of criticism, as it would be to study natural science without profiting by the discoveries of Darwin" (Claude Phillips, 1890). The parallel is singularly apt.

Morelli died in Milan on Feb. 28, 1891, leaving a fine collection of pictures to his adopted city of Bergamo.

*See* the memoir by Sir A. H. Layard prefixed to Morelli's *Italian Painters: Critical Studies of Their Works. Borghese and Doria-Pamfili Galleries in Rome* (1892).

(F. J. Mr.)

**MORELOS,** an inland state of Mexico on the southern slope of the great Mexican plateau, lying south of the federal district, with the states of Puebla on the east and southeast and Guerrero on the south. Pop. (1960) 386,264, including a large percentage of Indians and mestizos. Area 1,908 sq mi. Its surface is roughly broken by mountain ranges forming many valleys. It is drained by the Amacuzac river, a northern tributary of the Mezcala, or Balsas. There is a wide variation of climate for so small a territory, the higher elevations of the Sierra de Ajusco being cold and humid, the lower spurs mild, temperate and healthful, the lower valleys subtropical, hot and unhealthful. The rainfall is light in the lower regions and irrigation is generally employed. Morelos is one of the most flourishing agricultural states of Mexico, producing sugar, rice, Indian corn, coffee, wheat, fruit and vegetables. Although the state is supposed to have several of the minerals found in this part of Mexico (silver, cinnabar, iron, lead, gold, petroleum and coal), its mining industries have been undeveloped and neglected.

Morelos is named after José María Morelos (1765–1815), one of the heroes of Mexico's war for independence. Important towns in the state are the capital, Cuernavaca, pop. (1960) 37,144, site of the famous Borda gardens and of Cortés' palace with its Diego

Rivera murals, and Tepoztlán, pop. (1960) 4,314, an Aztec Indian village made famous by the studies of Robert Redfield and Stuart Chase. Lake Tequesquitengo, a resort, was formed by the subsidence of a large area in the middle of the 19th century. The state is crossed by a superhighway, rail and air lines. (J. A. Cw.)

**MORELOS Y PAVÓN, JOSÉ MARÍA** (1765–1815), Mexican patriot under whom Mexico's first constitution was proclaimed, was born near Valladolid (now Morelia, Michoacán) on Sept. 30, 1765, of a lower-class family. Until 1790 he worked for his uncle as a cowhand. At 25 he began study for the priesthood in Valladolid and later held various curacies in the area. In 1811 he joined Miguel Hidalgo in his revolution against Spain and upon Hidalgo's death assumed leadership of the movement. Between 1812 and 1815 he controlled most of Mexico southwest of Mexico City, holding at one time or another Acapulco, Oaxaca, Tehuacán and Cuautla. He called a congress at Chilpancingo in 1813 to form a government and a constitution. In Nov. 1813, the congress declared the independence of Mexico and in Oct. 1814, at Apatzingán, promulgated the constitution. But Morelos' power was already waning. He was captured by the Spanish in Oct. 1815. Like Hidalgo he was degraded from the priesthood, and on Dec. 22, 1815, in San Cristóbal he was shot as a traitor. (R. E. Q.)

**MORENA,** a town and district located in the Gwalior division of Madhya Pradesh, India. The town (pop. [1961] 28,337), headquarters of the district, is situated in the Kunwari-Asan doab in the Chambal basin. It is a station on the Gwalior-Agra line of the Central railway and a trade centre.

MORENA DISTRICT (area 4,489 sq mi.; pop. [1961] 783,348) comprises the former princely states of Sheopur and Tonwarghar, named after the Tonwar Thakurs living there. It lies in the lower Chambal basin. The northern part is alluvial but much cut by ravines, while the central and southern tracts are forested. Other towns are Sheopur (14,591), Sabalgarh, Ambah and Joura.

Arable land and forests each cover more than a quarter of the total area. The main products are wheat, sesame and linseed. The district lacks in large-scale industries except for a cement factory, but there are many medium-sized and small factories. (S. M. A.)

**MORENO, MARIANO** (1778–1811), Argentine patriot, was an intellectual and political leader of his country's struggle for independence. Born on Sept. 3, 1778, in Buenos Aires, Moreno obtained a law degree in 1802 and practised law while holding several posts in the colonial bureaucracy. In Sept. 1809 he published a tract, the *Representación de los hacendados* ("Landowners' Petition"), which was a powerful argument for free trade and which further consolidated Argentine sentimeot against Spanish rule.

When Spanish officials were ousted from Buenos Aires in May 1810, Moreno became secretary of military and political affairs in the first junta, or revolutionary government. He was the most active and radical member of that body. Among the government decisions in which he played a prominent part were those to execute several counterrevolutionaries, including a former viceroy; to take aggressive action to extend the revolution from Buenos Aires into the provinces; to found the national library; and to establish the government newspaper, the *Gaceta de Buenos Aires*, which he edited. The opposition of conservative provincial leaders forced Moreno to resign from the junta at the end of 1810. He accepted an official mission to Brazil and Great Britain but died at sea shortly after sailing from Argentina. (T. F. McG.)

**MORE OG ROMSDAL,** a *fylke* (county) of southwestern Norway, lies between Cape Stad and Trondheimsfjord. Area 5,821 sq mi. Pop. (1960) 213,027. Long fjords and valleys, parallel to the Caledonian folding (northeast to southwest), and narrow transverse fjords and valleys (northwest to southeast), deepened along weak lines in the bedrock, have formed a system of islands and peninsulas and a concentration of magnificent scenery. Nearly half the population lives on islands. Peaks reach 5,200–6,500 ft. between the fjords and valleys of the inner tracts of mountains. Traditionally the county is subdivided into three regions: (1) Sunnmøre in the south with the port of Ålesund (*q.v.*); (2) Romsdal in the middle with the county capital, Molde, and (3) Nordmøre in the north with the fishing centre of Kristiansund (*q.v.*).

The humid climate favours pasturage for cattle farming. Potatoes are the chief farm crop and barley and oats are also grown. Fishing (cod and herring) and Arctic sealing and whaling, and their associated industries, are important. Manufactures are dominated by clothing and furniture. Motorable roads are connected by ferries to facilitate traveling in the area. (L. H. Hg.)

**MOREPORK,** the name given to two birds, from a fancied resemblance of their calls to these words. One is the Australian species of frogmouth (*q.v.*), related to the goatsuckers and nighthawks. The other is a small brown owl of New Zealand (*Spiloglaux novae-zealandiae*), still fairly common, which haunts the clumps of Maori bush and calls in the twilight. Maori names for this owl are *ruru* and *koukou*, both being attempts to turn his cry into words; he plays a lively part in Maori bird lore.

**MORESNET,** a small area of Belgium (formerly neutral territory) on the German border, southwest of Aachen. *See* EUPEN-ET-MALMÉDY.

**MORETON BAY CHESTNUT** (BLACK BEAN), a tall Australian evergreen tree (*Castanospermum australe*) of the pea family (Leguminosae), native of Queensland and New South Wales. It is grown in California and Florida for its loose clusters of bright orange-yellow flowers. The pods are almost cylindrical, about nine inches long and two inches broad, and are divided interiorly by a spongy substance into three to five cells, each of which contains a large chestnutlike seed. The seeds are roasted and eaten by the Australian aborigines; the timber, which somewhat resembles walnut, is soft, fine grained, and takes a good polish, but is not durable.

**MORETTO** (MORETTO DA BRESCIA, originally ALESSANDRO BONVICINO or BUONVICINO) (*c.* 1498–1554), leading Italian painter of the Brescian school, was probably born at Brescia.

Moretto's works display the influence of Titian, of Raphael and of other contemporary masters, but he had a distinctive style of his own, characterized by a cool, silvery tone. As a portraitist he went beyond the rendering of external form, penetrating into the character and disposition of his sitters. He worked chiefly in Brescia, where his paintings can best be studied. In 1529 he was in Bergamo, and in 1540–41 in Milan and Verona. He died at Brescia on Dec. 22, 1554.

Moretto's earliest picture may be the "Ascension" in S. Francesco della Vigna, Venice, dated 1516, but neither it nor the one of 1518 in Bergamo is universally accepted as his. The frescoes in the Corpus Domini chapel of S. Giovanni Evangelista at Brescia are datable 1521–24. In the decoration of this chapel he collaborated with G. Romanino, another leading painter of Brescia. Among his first paintings are the ceiling fresco representing the "Vision of Moses," and other paintings in the Galleria Martenengo at Brescia. The churches of Brescia possess many altarpieces by him, among which the "Coronation of the Virgin," in SS. Nazzaro e Celso, is perhaps the most notable. In the church of Paitone, near Brescia, is "The Virgin Appearing to a Shepherd Boy," and there is a large "Christ in the House of Levi" in the nuns' gallery of Sta. Maria della Pieta in Venice, dated 1544. The Vienna gallery has a "St. Justina," perhaps his finest work. The National gallery, London, has three fine portraits, including a full-length portrait of a man, dated 1526, which is one of the earliest Italian full-length portraits, and several other works. The Johnson collection in Philadelphia has a "Madonna and Donors"; the Metropolitan Museum of Art at New York a "Christ in the Desert" and an "Entombment," dated 1554, which is his latest known work. Moretto's foremost pupil was Giambattista Moroni.

*See* J. A. Crowe and G. B. Cavalcaselle, *History of Painting in North Italy*, vol. iii (1912); G. Gombosi, *Moretto da Brescia* (1943).

(P. J. Mv.)

**MORGAGNI, GIOVANNI BATTISTA** (1682–1771), Italian anatomist and pathologist, author of a work that made pathological anatomy a science and diverted the course of medicine into new channels of exactness, was born on Feb. 25, 1682, at Forlì. After graduating in 1701 at Bologna in philosophy and medicine, he acted as prosector to A. M. Valsalva (one of the dis-

tinguished pupils of M. Malpighi), whom he assisted in preparing his celebrated *Anatomy and Diseases of the Ear* (1704). When Valsalva was transferred to Parma, Morgagni succeeded to his anatomical demonstratorship, but after a time gave up his post and spent two or three years at Padua, where in 1712 he succeeded his friend Domenico Guglielmini as professor of medicine. In 1715 he was promoted to the chair of anatomy. He was honoured by various academies, by cardinals and popes, and was elected patron of the German students of the university. Morgagni died at Padua on Dec. 6, 1771.

Although his *Adversaria anatomica* (1706–19) had established his reputation as an accurate anatomist, it was not until 1761, when he was in his 80th year, that Morgagni brought out his great work, the *De sedibus et causis morborum per anatomen indagatis* (often reprinted, Eng. trans. 1769). It treats of the morbid conditions of the entire body, and contains records of about 640 dissections, the symptoms during the course of the malady and other antecedent circumstances being always prefixed with more or less fullness. Although he was the first to demonstrate the absolute necessity of basing diagnosis, prognosis and treatment on a comprehensive knowledge of anatomical conditions, Morgagni made no attempt to exalt pathological anatomy into a science disconnected from clinical medicine and remote from practical needs.

**MORGAN,** a family of U.S. financiers, ultimately the foremost leaders of finance and international banking in the United States, was founded by JUNIUS SPENCER MORGAN (1813–1890), born in Holyoke, Mass., April 14, 1813. He was a partner in the largest drygoods business in the United States, and founder of J. S. Morgan and company, in London, Eng. His son, JOHN PIERPONT MORGAN (1837–1913) was born in Hartford, Conn., April 17, 1837, and was educated at the University of Göttingen. He began his banking career in 1857 with Duncan, Sherman and company in New York city. From 1860 to 1864 he was agent in New York city for George Peabody and company, and its successor J. S. Morgan and company, of which he became head. In 1864–71 he was a member of the firm of Dabney, Morgan and company, which dissolved in 1871, when Morgan became a partner in the firm of Drexel, Morgan and company. In 1895 this firm was organized as J. P. Morgan and company, and largely through Morgan's ability, it became one of the most powerful banking houses in the world. It carried through the formation of the United States Steel corporation, General Electric, and International Harvester, harmonized the coal and railroad interests of Pennsylvania, and reorganized numerous railroads including the Chesapeake and Ohio, the Northern Pacific and the Baltimore and Ohio.

Morgan was a leader in transforming industrial conditions in the United States by the process of eliminating atomistic competition. It has been estimated that by 1902 he had about 5,000 mi. of U.S. railroads under his financial control. In 1895 the house of J. P. Morgan and company supplied the United States government with $62,000,000 in gold to restore the treasury gold reserve to $100,000,000. In the 1907 panic, Morgan headed a group of bankers who were primarily responsible for stemming the tide of panic and preserving the solvency of major banks and corporations. He was a director in many U.S. corporations, and was one of the greatest art and book collectors of his generation. He died in Rome on March 31, 1913, leaving an estate of about $70,000,000.

JOHN PIERPONT MORGAN, JR. (1867–1943), son of John Pierpont Morgan, was born at Irvington, N.Y., Sept. 7, 1867, and graduated from Harvard in 1889. He became a member of his father's firm in 1891, working in the London branch for eight years. He succeeded his father as head of the house of Morgan in 1913. In 1914 he organized a syndicate to make a $100,000,000 loan to New York city to preserve its credit. The British and French governments enlisted his services as purchasing agent for several billion dollars worth of supplies in World War I. He helped finance a great part of the Allied requirements for credits in the United States by floating $1,500,000,000 in Allied bonds. After the war his firm floated loans of nearly $1,700,000,000 for European reconstruction work. Between 1919 and 1933 the Morgan firm handled more than $6,000,000,000 in securities. Morgan served on the war reparations commission in 1922. He was a director of many corporations. In 1933 the Securities act compelled his firm to separate its investment banking and commercial banking activities into Morgan, Stanley and company (investment banking) and J. P. Morgan and company (commercial banking). Like his father, J. P. Morgan, Jr. gave generously to charities. He died in Boca Grande, Fla., on March 13, 1943. Sons of J. P. Morgan, Jr. were JUNIUS SPENCER MORGAN, born in New York city, March 11, 1892, a partner in the business after 1915, and HENRY SYDNOR MORGAN born in London, Eng., Oct. 24, 1900, who became a partner of Morgan, Stanley and company.

*See* H. L. Satterlee, *J. Pierpont Morgan* (1939); F. L. Allen, *The Great Pierpont Morgan* (1949). (J. R. L.)

**MORGAN, DANIEL** (1735–1802), American Revolutionary general, who won a brilliant victory at Cowpens, was born in Hunterdon county, N.J., in 1736, of Welsh ancestry. Having moved to Virginia in 1743, he was commissioned a captain of Virginia riflemen in June 1775. During the following winter he accompanied Gen. Benedict Arnold to Canada, and in the assault on Quebec (Dec. 31) Morgan and his riflemen penetrated well into the city, where he was hemmed in and forced to surrender. Late in 1776 he was released, and soon after commissioned colonel. In Sept. 1777 he joined Gen. Horatio Gates, then engaged in the campaign against Gen. Burgoyne, and took part in both battles of Saratoga. Morgan resigned from the army in July 1779 and retired to Virginia. After the battle of Camden, S.C., however, he joined Gates at Hillsborough, N.C., took command of a corps and was made brigadier general. Cornwallis and Tarleton attempted to entrap him in Jan. 1781, but at Cowpens (Jan. 17) he defeated Tarleton and then escaped from Cornwallis into North Carolina. In Nov. 1794 Morgan commanded troops sent to suppress the Whisky insurrection in western Pennsylvania. He was a Federalist representative in congress from 1797 to 1799, and died in Winchester, Va., July 6, 1802.

**MORGAN, SIR HENRY** (c. 1635–1688), buccaneer and deputy governor of Jamaica, was born, probably in 1635, at Llanrhymney in Glamorgan, Wales. His early career is obscure, but he was apparently well connected. In 1684 he won a libel action against the translators of A. O. Exquemelin's *De Amerikaensche Zee-Rovers* for asserting that he had been sold as a servant to a painter and for casting other aspersions on his character. It is probable that he went to the West Indies on the expedition of William Penn and Robert Venables in 1654. He sailed under Captain Christopher Myngs against Cuba in 1662 and under Edward Mansfield against the Dutch colonies shortly afterward. He rose rapidly to a commanding position among the buccaneers and privateers who infested the Caribbean at that time. In 1668 he was appointed colonel of the troops at Jamaica and commanded an expedition that captured Puerto Príncipe (now Camagüey) in Cuba. The next year he attacked Maracaibo on the coast of South America, and in 1671 led a band of about 1,000 men to capture Porto Bello and Panama on the isthmus. His destruction of old Panama was the most notable victory gained by the buccaneers, and was so complete that a new city had to be built nearby. Morgan's success, however, occurred soon after peace had been signed with Spain. He was recalled to England under arrest in 1672, but on the prospect of further trouble with Spain he was knighted by Charles II and sent out again as deputy governor of Jamaica in Jan. 1674. He held this office on and off until his death, his tenure depending upon the cordiality of his relations with successive governors; some of the governors accused him of favouring privateers while others supported his efforts to suppress them. At his death on Aug. 25, 1688, in Jamaica, probably at Lawrencefield, he was a wealthy and respected citizen.

Morgan's character has been traduced from an early date. He himself claimed that he was never guilty of the cruelty with which he was charged. He was certainly a born leader, a courageous tactician and a highly successful corsair.

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(C. C. L.)

**MORGAN, JOHN** (1735–1789), noted U.S. physician, teacher and military surgeon, was born on June 10, 1735, in Philadelphia, Pa., studied medicine under John Redman and graduated from the College of Philadelphia in 1757. After three years as surgeon in the French and Indian War he continued his studies in London, Edinburgh (M.D., 1763) and Paris. Returning to Philadelphia, he became professor of medicine in the college in 1765. Morgan's *Discourse Upon . . . Medical Schools* (1765) proposed two reforms: the separation of medicine from surgery and drug selling, and the requirement of a liberal education for medical students. Both were premature and failed. As director general of hospitals in the Continental army, Morgan tried to bring the nearly autonomous regimental surgeons under general army control, but congress would not reorganize the system. In 1777 he was summarily dismissed as responsible for the heavy mortality in the army, though congress vindicated him two years later.

Morgan died in Philadelphia on Oct. 15, 1789.

Morgan's practice was considerable; he corresponded with learned men, encouraged domestic manufactures and was a connoisseur of art. Besides his doctoral dissertation (on formation of pus) he wrote *Recommendation of Inoculation . . .* (1776), *Vindication* (1777), communications to the American Philosophical society and a journal of travels. (W. J. BL.)

**MORGAN, JOHN HUNT** (1825–1864), Confederate cavalry officer in the American Civil War, was born at Huntsville, Ala., on June 1, 1825, and brought up near Lexington, Ky. Morgan served in the Mexican War where he saw action at Buena Vista. He continued his interest in military affairs and in 1861, when Kentucky found neutrality impossible, Morgan became leader of a Confederate cavalry squadron.

A colonel by 1862, Morgan began the type of fast cavalry raids for which he became famous. Swift movement, interruption of enemy telegraphic communications, destruction of Union transportation facilities, and the dismounting of horse soldiers for combat characterized Morgan's cavalry methods. His most famous exploit occurred in 1863 when, as a brigadier general, he led nearly 2,500 men on an unauthorized raid into Indiana and Ohio. His command penetrated farther north than any other Confederate force during the war, but by the time Morgan surrendered on July 26 most of his men had been captured or killed.

Because Union officers considered him an unusually dangerous raider, Morgan was incarcerated in the state penitentiary at Columbus, rather than in a regular military prison. Despite this precaution, Morgan escaped in November and early in 1864 assumed command of the department of Southwestern Virginia. From this new base of operations Morgan quickly resumed his raiding practices, but not without censure from some Confederate officials. Already under a shadow because of his unauthorized and costly Indiana and Ohio invasion, Morgan incurred further criticism following the pillage by his men of nonmilitary establishments in eastern Kentucky. Under investigation and about to be relieved of his command, Morgan led one more raid into Tennessee but was surprised and killed by federal troops at Greeneville on Sept. 4, 1864.

*See* Cecil F. Holland, *Morgan and His Raiders* (1943); Dee Alexander Brown, *The Bold Cavaliers* (1959). (GE. W. R.)

**MORGAN, LEWIS HENRY** (1818–1881), U.S. ethnologist, a pioneer in the comparative study of kinship systems, was born Nov. 21, 1818, near Aurora, N.Y. He graduated from Union college, Schenectady, in 1840, went to Rochester, N.Y. about 1844 and there practised law for many years. He made intensive studies of the social organization and material culture of the Iroquois Indians, published in 1851 as *The League of the Ho-dé-no-sau-nee, or Iroquois*. This was followed by field trips to the Great Plains, Hudson's Bay territory and the southwest. In a monumental work, *Systems of Consanguinity and Affinity of the Human Family* (1871), he founded the scientific study of kinship (*see* KINSHIP TERMINOLOGY). In 1877 he published *Ancient Society; or Researches in the Line of Human Progress from Savagery through Barbarism to Civilization*, which became a Marxist classic and was the subject of Friedrich Engels' *The Origin of the Family, Private Property, and the State* (Eng. trans., 1902).

Morgan's theory of the evolution of the family, from promiscuity to monogamy, has long been obsolete, but much of his work remains valid and significant, notably, his compilation of data on kinship terms and the thesis that they are to be interpreted in terms of social institutions; his distinction between primitive society and civil society; and his theory of cultural evolution in terms of technology, particularly as regards subsistence. Morgan was elected to the National Academy of Sciences and was president of the American Association for the Advancement of Science (1880). He was active in state politics, serving as assemblyman (1861–68) and senator (1868–69). He died in Rochester, N.Y., on Dec. 17, 1881.

Among his other works are *The American Beaver and His Works* (1868); *Houses and House-Life of the American Aborigines* (1881); L. A. White (ed.), *Pioneers in American Anthropology: The Bandelier-Morgan Letters, 1873–1883*, 2 vol. (1940), "Extracts from the European Travel Journal of Lewis H. Morgan," *Rochester Historical Society Publications*, xvi (1937); and *Lewis Henry Morgan: The Indian Journals, 1859–1862*, (1959).

*See* Carl Resek, *Lewis Henry Morgan* (1960); Leslie A. White, "Lewis Henry Morgan: Pioneer in the Theory of Social Evolution," in *An Introduction to the History of Sociology*, ed. by Harry Elmer Barnes (1948). (LE. A. W.)

**MORGAN, LADY SYDNEY** (née OWENSON) (1776–1859), Irish novelist who was one of the most vivid and hotly discussed figures of her generation, was born in Dublin on Dec. 25, 1776. Her father, Robert Owenson, was an actor. A precocious volume of poems (1801) was followed in 1802 by *St. Clair*, a novel of ill-starred love and impassioned nature worship showing the influence of Goethe and Rousseau. But the book which made her reputation was *The Wild Irish Girl* (1806), in which she appeared rather as a patriot than a novelist, extolling the beautiful scenery, the natural wealth and the noble traditions of Ireland. Admirers called her "Glorvina," the name of her heroine, and she was lionized in London. She was invited to become companion to the marchioness of Abercorn, who in 1812 persuaded her to marry her own surgeon, Thomas Morgan. The marquess had already arranged for his immediate knighthood.

Books continued to flow from her pen. Her best novel, *O'Donnell* (1814), contains realistic descriptions of the Irish working class, which she understood thoroughly. In 1817 appeared *France*, 2 vol., a lively and partial study of French society which resembles modern journalistic reporting, and which was savagely attacked in the *Quarterly*, which accused her of impiety, Jacobinism, falsehood and licentiousness because she had praised the French Revolution. In France she also gave offense by her inability to appreciate French classical drama. Mme de Staël, however, greatly admired her *France*. Lady Morgan revenged herself in her novel *Florence Macarthy* (1818), in which a *Quarterly* reviewer is insulted with feminine ingenuity. Among many other works is *Passages From My Autobiography* (1859; ed. by W. Hepworth Dixon, 1862). She died in London, April 16, 1859.

*See* L. Stevenson, *The Wild Irish Girl* (1936); M. I. Moraud, *Lady Morgan* (1954).

**MORGAN, THOMAS HUNT** (1866–1945), U.S. biologist, winner of the Nobel prize for medicine in 1933 for his discovery of the chief principles of genetics, following the discoveries of Mendel (*q.v.*), was born at Lexington, Ky., Sept. 25, 1866. His early training in zoology (State College of Kentucky and Johns Hopkins university, Ph.D., 1890) was followed by professorships at Bryn Mawr college (1891) and Columbia university (1904–28). His early work was in experimental embryology; but at Columbia, about 1909, his skepticism about the reality of particulate bodies, genes, as responsible for the transmission of heredity led him to undertake breeding experiments with the small fruit fly or vinegar fly *Drosophila melanogaster*.

These experiments were so successful that by 1915 he and his students, A. H. Sturtevant, H. J. Muller and C. B. Bridges, had proved not only the reality of genes as corporeal elements with specified locations in the chromosomes of the cell nucleus (*see* CYTOLOGY) but were able to describe this system of genes as the *Mechanism of Mendelian Heredity*, the title of their joint

book (1915). The collective principles derived from the combined results of breeding experiments and cytological observations were referred to as the "chromosome theory of heredity" or as in the title of Morgan's culminating book on this subject, *The Theory of the Gene* (1926).

In the elaboration and proof of this comprehensive theory of the system of hereditary transmission Morgan considered himself as leader of a team of younger men, all working in close collaboration. Subsequent research in genetics and applications of the theory to problems of evolution and development have been based on the foundation laid by the "Morgan school." Morgan left Columbia in 1928 to establish and direct the Kerckhoff Laboratories of Biological Sciences at the California Institute of Technology, Pasadena, which became a leading centre of research in genetics. There his interests returned to experimental embryology, especially problems of fertilization and self-sterility. Except for frequent summer trips to Woods Hole, Mass., Morgan remained at Pasadena, where he died on Dec. 4, 1945, while actively engaged in research on marine organisms.

His chief books other than those cited above indicate the wide range of his biological interests: *Development of the Frog's Egg* (1887); *Heredity and Sex* (1913); *The Physical Basis of Heredity* (1919); *Evolution and Genetics* (1925); *Experimental Embryology* (1927); *The Scientific Basis of Evolution* (1932); *Embryology and Genetics* (1933).

Morgan was president of the National Academy of Sciences (1927–31), of the American Association for the Advancement of Science (1930) and of the 6th International Congress of Genetics (1932).

*See* A. H. Sturtevant, "Thomas Hunt Morgan," in National Academy of Sciences, *Biographical Memoirs*, vol. 33 (1959). (L. C. D.)

**MORGAN, WILLIAM** (*c.* 1545–1604), Welsh bishop who translated the Bible into Welsh. Born of poor parents in a remote Caernarvonshire valley, he entered St. John's college, Cambridge, in 1564, helped, it seems, by the Wynn family of Gwydir castle. It was Cambridge, perhaps, that made him a Protestant, and it was there that he learned Hebrew. Ordained in 1568, in 1578 he became parish priest at Llanrhaeadr ym Mochnant, Denbighshire. In 1595 he was appointed bishop of Llandaff and in 1601 moved to St. Asaph, where he died on Sept. 10, 1604.

Earlier scholars had seen the need for the scriptures in Welsh, and an act of 1563 had resulted in translations of the Book of Common Prayer and New Testament in 1567. Morgan's translation of the Bible and Apocrypha (1588) was meant to complete the earlier work. His Latin dedication to Queen Elizabeth I mentions the encouragement of Archbishop Whitgift and the help of other Welsh scholars, of whom Edmwnd Prys, author of the "metrical psalms" in Welsh (1621), should be mentioned.

The influence of Morgan's translation cannot be overestimated. With few prose patterns to follow he adapted the diction and style of earlier literature, particularly poetry, and a revision of his work (1620) by John Davies confirmed this tendency. It established a standard literary Welsh which in the following two centuries was taught to the Welsh people in general.

*See* also WELSH LITERATURE.

*See* T. Parry, *Hanes Llenyddiaeth Gymraeg* (1944; Eng. trans. *A History of Welsh Literature*, 1955), with useful bibliography. (G. H. Hu.)

**MORGANATIC MARRIAGE,** a marriage perfectly valid according to law, between a male member of a sovereign, princely or extremely noble house with a woman of lesser birth or rank than his, contracted with the proviso that she shall not thereby accede to his rank and that the children of the marriage shall not succeed to their father's hereditary dignities, fiefs and entailed property, which he, however, retains. The name is derived from the medieval Latin *matrimonium ad morganaticam*, variously interpreted as meaning "marriage on the morning-gift" (Ger. *Morgengabe*), with the implication that this morning-gift or dowry was all that the bride need expect; or "restricted marriage" (Gothic *maurjan*, restrain); or simply "morning marriage," celebrated quietly at an early hour. Essentially a German institution, the system was followed to some extent by some sovereign dynasties outside Germany when they came to formulate rules governing their marriages in imitation of the *Hausgesetze* or house laws of the Germans. It was quite alien to France and to England.

The practice comes from the German notion of *Ebenbürtigkeit* or *Gleichbürtigkeit* (evenness or equality of birth), which in the middle ages had a widespread application in German law. It required parties to many sorts of transaction to be of the same standing or estate, but could not be an impediment to marriage in the law of the church. Though the notion gradually lost much of its force, it remained valid for princely marriages even after mediatization (*q.v.*). Often the wife received some title transmissible to her children; such for instance was the origin of the houses of Teck and of Battenberg. Morganatic marriages became quite common in the house of Hohenzollern, but the most remarkable was that of the Austrian archduke Francis Ferdinand (*q.v.*). Even after the deposition of a dynasty, its members may observe their house law and regard as morganatic those of their marriages which fall short of its requirements.

**MORGANTOWN,** a university city and river port in north central West Virginia, U.S., about 60 mi. S. of Pittsburgh, Pa., on the Monongahela river, the seat of Monongalia county. The first settlement, in 1758, was wiped out by Indians, but in 1787 Col. Zackquill Morgan, son of the first settler of West Virginia, founded the community which bears his name. Morgantown was chartered as a town in 1785 by the Virginia assembly and as a city by the West Virginia legislature in 1905. In 1971 it adopted a council-manager form of government. It is the seat of West Virginia university, chartered in 1867 as Agricultural College of West Virginia and renamed the following year. With the opening in 1959 of a new medical school, the university began a modernization program which included moving the entire physical plant to a new location about 3 mi. from the old campus. Morgantown has a large river traffic and ships much coal from the rich mines in the vicinity. Limestone is also quarried nearby. Manufactures include glass products, textiles, chemicals, construction materials and pottery. Among the recreational facilities available are Cooper's Rock State forest and Mont Chateau State park, located a few miles northeast of the city. For comparative population figures *see* table in WEST VIRGINIA: *Population*. (K. K. McC.)

**MORGENSTERN, CHRISTIAN** (1871–1914), German lyric poet, born in Munich on May 6, 1871, one of a family of painters, is famous for his nonsense verse, which, however, implies a deeper meaning. This metaphysical humour is found in his collections of lyrical poetry, *Galgenlieder* (1905), *Palmström* (1910), *Palma Kunkel* (1916), *Der Gingganz* (1919); a selection appeared in English translation (1919). Tuberculosis ended his studies at the University of Breslau and caused his death in Merano, Italy, on March 31, 1914. In 1909 he met Rudolf Steiner (*q.v.*), the anthroposophist, who influenced him greatly. His humour mainly relies on the incongruous juxtaposition of human experiences and on the subtle but skeptical exploration of the possibilities of language. Several volumes of more plodding serious poetry were also published. *Stufen* (1918) is a collection of aphorisms.

*See* M. Bauer, *Morgensterns Leben und Werk*, 3rd ed. (1941); M. Bauer and M. Morgenstern, *Christian Morgenstern, ein Leben in Briefen* (1952). (H. S. R.)

**MORGENSTIERNE, GEORG VALENTINE VON MUNTHE AF** (1892– ), Norwegian philologist, specialist in the Indo-Iranian border languages and professor of Indian language and literature in the University of Oslo since 1937, was born at Kristiania (Oslo) on Jan. 3, 1892. He studied Indian literature and philology in Kristiania, Bonn and Berlin, subsequently visiting Afghanistan (1924), Baluchistan and the North-West Frontier (1929). In 1927 appeared the *Etymological Vocabulary of Pashto*, and, in 1929, "Parachi and Ormuri," the first of three volumes of *Indo-Iranian Frontier Languages*. Morgenstierne's articles, often giving a comprehensive survey of the language dealt with, have appeared mostly in the *Norsk Tidsskrift for Sprogvidenskap* (N.T.S.); as a result of a tour in 1949, a description of the Waigali language appeared in vol. xvii of N.T.S. Morgenstierne has allied his knowledge of the ancient languages

(*cf.* "Orthography and Sound-System of the Avesta," N.T.S., vol. xii) with an ability to record the features of the living frontier languages. His work represents an invaluable collection of historical and phonological studies. (J. E. B. G.)

**MORGENTHAU, HENRY, JR.** (1891– ), U.S. secretary of the treasury under Pres. Franklin D. Roosevelt, was born in New York city on May 11, 1891, the son of Henry Morgenthau, U.S. ambassador to Turkey during World War I. He studied two years at Cornell university, Ithaca, N.Y., and in 1913 bought a dairy and fruit farm in Dutchess county, New York, only 15 mi. from the Hyde Park home of Franklin D. Roosevelt. The two men, drawn together by their mutual interest in farming, conservation and social welfare, became intimate friends. During Roosevelt's governorship, Morgenthau served as state conservation commissioner and as chairman of the governor's agricultural advisory committee. In 1933 he accompanied Roosevelt to Washington, where he served successively as chairman of the Federal Farm board, governor of the Farm Credit administration, undersecretary of the treasury, and (from Jan. 1934 to July 1945) secretary of the treasury.

Conservative and orthodox in his economic views, Morgenthau was frequently torn between his intense loyalty to the president and his conviction that a balanced budget was essential to the nation's welfare. In the end, loyalty prevailed and the secretary threw himself wholeheartedly into the task of financing the New Deal domestic program and the nation's responsibility in World War II. Between 1934 and 1945 he was responsible for spending about $370,000,000,000, about three times as much as his 50 predecessors combined. This gigantic fiscal operation was accomplished without serious scandal and with a minimum dislocation of the national economy.

As a department head, Morgenthau proved himself an industrious and effective administrator, surrounding himself with an able and dedicated staff, insisting on high standards of departmental efficiency. When he resigned shortly after Roosevelt's death, he had served longer than any other secretary of the treasury except Albert Gallatin (1801–13). After retirement, Morgenthau devoted himself mainly to his farm, to philanthropic interests and to foreign travel. His voluminous official records, filling more than 800 bound volumes, were turned over to the Franklin D. Roosevelt library at Hyde Park.

*See* J. M. Blum, *From the Morgenthau Diaries* (1959). (M. R. E.)

**MORGHEN, RAFFAELLO** (1758–1833), Italian engraver, was born at Naples on June 19, 1758. He studied first under his father, and then under Giovanni Volpato. He assisted this master in engraving the famous pictures of Raphael in the Vatican, and the print that represents the miracle of Bolsena is inscribed with his name. He married Volpato's daughter, and moved to Florence to engrave the masterpieces of the Florentine gallery. He died at Florence on April 8, 1833.

**MORIAH,** a place name of ancient Palestine twice mentioned in the Bible. In Gen. xxii, 2 it is an unidentified land in which was situated the mountain where Abraham offered Isaac. Later this mountain was believed to be the site of the Temple of Jerusalem (*i.e.*, Mt. Zion), except by the Samaritans and others who believed that Moriah was Mt. Gerizim (*q.v.*). In II Chron. iii, 1 Solomon erected the Temple on Mt. Moriah "where the Lord had appeared to David his father, at the place that David had appointed, on the threshing floor of Ornan, the Jebusite."

(J. S. I.)

**MORICZ, ZSIGMOND** (1879–1942), Hungarian novelist and a master of realism, was born at Csecse on June 29, 1879. He became one of the leaders of the progressive writers associated with the review *Nyugat*, of which for some years he was the editor. From 1940 until his death in Budapest, on Sept. 4, 1942, he edited *Kelet Népe*, the peasant writers' review.

Moricz found his subjects in the life of the villages and country towns he knew and his novels portray the peasant, fighting for his emancipation, as in *Sárarany* ("Gold in the Mire"; 1910) and *A boldog ember* ("The Happy Man"; 1935), the collapsing way of life of the decaying provincial nobility, as in *Kivilágos kivirradtig* ("Till the Small Hours of Morning"; 1924), *Úri muri* ("Gentry Spree"; 1927) or *Rokonok* ("Relatives"; 1930); or the failure of those who work for the happiness of the people, as in *A fáklya* ("The Torch"; 1917). In Moricz's world marriage and family life are fraught with bitter conflicts, but he also evokes pure, and even idyllic, loves as in *Pillangó* ("Butterfly"; 1925). He wrote the finest children's book in Hungarian, *Légy jó mindhalálig* ("Be Good till Death"; 1920), and also two monumental historical novels, *Erdély trilógia* ("Transylvania, a trilogy"; 1922–35), and *Rózsa Sándor* (1940–42). In his novels finely characterized types of Hungarian society come into collision, and as a result their fierce energies collapse or degenerate into murderous passion. Some of his works are veritable Dances of Death of the morbid and doomed elements of society. He is a master of Hungarian, his style absorbing elements of both the old language and the dialects. (T. Ky.)

**MORIER, JAMES JUSTINIAN** (*c.* 1780–1849), English writer and diplomat, the author of books which formed English opinion on Persia for many years. He was born in Smyrna about 1780, his father being consul-general of the Levant company at Constantinople. In 1807 he entered the diplomatic service and was in Teheran in 1809 and during 1810–15, from 1814 as head of the embassy. He wrote two admirable and popular travel books on Persia, Armenia and Asia Minor (1812 and 1818) and some forgotten novels; but his fame rests on his sparkling picaresque novel *The Adventures of Hajji Baba of Ispahan* (1824) in which he built up a picture of Persia that was long regarded as authoritative even in the highest quarters. The Persian translation (1905) was accepted in Persia as an original work with a satirical intention and influenced the development of the novel there. Morier's less successful *The Adventures of Hajji Baba of Ispahan in England* (1828) is largely a satire on English civilization. He died at Brighton on March 19, 1849.

James Morier has been confused with his elder brother JOHN PHILIP (1776–1853), secretary to Lord Elgin at Constantinople, who accompanied the grand vizier on the Turkish campaign (1800) against Napoleon's representative in Egypt.

*See* his *Adventures of Hajji Baba of Ispahan* with introduction by C. W. Stewart (1923) and by R. Jennings (1949).

**MÖRIKE, EDUARD FRIEDRICH** (1804–1875), one of Germany's greatest lyric poets, was born at Ludwigsburg on Sept. 8, 1804, into a cultured, professional family. After studying theology at Tübingen (1822–26), Mörike held several curacies before becoming, in 1834, pastor of Cleversulzbach, the remote Württemberg village immortalized in *Der alte Turmhahn*, where inhabitants and pastor are seen through the whimsical but percipient eyes of an old weathercock. All his life Mörike suffered from psychosomatic illnesses, no doubt intensified by unconscious conflict between humanism and church dogmas. When only 39, Mörike retired on a pension, but after his marriage to Margarete von Speeth in 1851, he supplemented his pension by lecturing on German literature at a girls' school in Stuttgart. After happy years of rich literary achievement, tensions caused by Margarete's jealousy of Clara, Mörike's sister who lived with them, almost killed his creative urge. Mörike spent his last two years with Clara and his younger daughter, separated from Margarete, and died poor and unhappy in Stuttgart on June 4, 1875.

The variety of Mörike's small output is astonishing. Everything he wrote has its distinctive flavour, but in his early days romantic influences preponderate. His novel, *Maler Nolten* (1832), in addition to its stylistic perfection and psychological insight into mental unbalance, explores the realm of the subconscious and the mysterious forces linking Nolten and his early love even beyond the grave. Mörike's poems in folk-song style and his fairy tales also smack of German romanticism, though his best folk tale, *Das Stuttgarter Hutzelmännlein* (1853), is peculiarly his own, with its Swabian background and humour. In his *Novelle*, *Mozart auf der Reise nach Prag* (1856), Mörike penetrates deeper into Mozart's personality than do many longer studies. It is, however, as a lyric poet that Mörike is supreme, some critics putting him next to his master Goethe. Mörike handled free rhythms, sonnets, regular stanza forms and, more particularly in his later poems, classical metres, with equal virtuosity. The

"Peregrina" poems, immortalizing a youthful love of his Tübingen days, and the sonnets to Luise Rau, his one-time betrothed, are among the most exquisite German love lyrics. Often at night or early dawn Mörike sank into what he calls the "abyss of contemplation," where flashes of creative inspiration came to him almost subconsciously. From such moments derive poems which by their imagery convey man's oneness with an infinite universe, as he contemplates the starry sky, listens to the music of the spheres, or senses the pulsation of vital forces. In Mörike's classical period the poet is no longer so personally involved, and his aim is to convey the distinctive essence of a Christmas rose, a beech tree or a classical lamp, in the belief that, as he says in his poem on the lamp, "a thing of beauty has a hallowed existence of its own."

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**MORIN, JEAN** (latinized JOANNES MORINUS) (1591–1659), French theologian whose fame rests on his *editio princeps* of the Samaritan Pentateuch and Targum, was born in 1591 at Blois, of Protestant parents. He learned Latin and Greek at Rochelle and continued his studies at Leiden, subsequently moving to Paris. His conversion to the Roman Catholic Church is ascribed to Cardinal Duperron. In 1618 Morin joined the Congregation of the Oratory and in due course took priest's orders. In 1625 he visited England in the train of Henrietta Maria; in 1640 he was at Rome, on the invitation of Cardinal Barberini, and was received with special favour by Pope Urban VIII. He was soon recalled to Paris by Richelieu, and the rest of his life was spent in incessant literary labour. The *Histoire de la délivrance de l'église chrétienne par l'emp. Constantin* (1630), gave great offense at Rome and a *Déclaration* (1654), directed against faults in the administration of the Oratory, was strictly suppressed. So, too, his great work on penance gave equal offense to the Jesuits and to Port-Royal; even after his death in 1659, the polemical vehemence of his *Exercitationes biblicae* long led Protestants to neglect his work in which he destroyed the current theory of the integrity of the Hebrew text of the Scriptures.

Morin's edition of the Samaritan Pentateuch and Targum, which appeared in the Paris Polyglott Bible in 1645, gave the first impulse in Europe to the study of this dialect. He learned it without a teacher (framing a grammar for himself) from manuscripts then newly brought to Europe.

**MORI ŌGAI** (pseudonym of MORI RINTARŌ) (1862–1922), one of the creators of modern Japanese literature, was the eldest son of a samurai physician, and himself studied medicine, at first in Tokyo and from 1884 to 1888 in Germany. In 1889 he published *The Dancing Girl*, an account of the unhappy attachment between a German girl and a Japanese studying in Berlin. This was, in Mori's words, an *"Ich roman"*—a story closely based on his own experiences. It represented a marked departure from the impersonal Japanese fiction of preceding generations, and was the first of innumerable autobiographical revelations by Japanese writers. Another work closely connected with Mori's stay in Germany was his beautiful translation of Hans Christian Andersen's *Improvisatoren*. Mori's most popular work, *Gan* (*The Wild Goose*, 1911–13; part translation by B. Watson in Donald Keene, *Modern Japanese Literature*, 1956), is more "novelistic" than any other of his writings, but the suicide in 1912 of Gen. Maresuke Nogi after the death of the emperor Meiji moved Mori so profoundly that he abandoned fiction in favour of painstakingly accurate historical works that depict samurai morality. The heroes of several of his works are warriors who, like General Nogi, commit suicide in order to follow their masters to the grave. Despite his early "confessional" writing, Mori shared with his samurai heroes a reluctance (akin to traditional Japanese impassivity) to dwell on the emotions. His detachment, in part possibly the result of his scientific training, made his later works seem cold, but their strength and integrity were strikingly close to the samurai ideals he so admired.

*See* Yoshitaka Takahashi, *Mori Ōgai* (1954). (DON. K.)

**MORIOKA**, the capital and largest city of Iwate prefecture, northeastern Honshu, Japan, is located on the upper reaches of the Kitakami river southeast of the towering volcanic cone of Mt. Iwate (6,696 ft.). Still retaining the atmosphere of the feudal period, when it was the Nambu fief castle town, Morioka is primarily an administrative, commercial and cultural centre. It is well known for its traditional iron-kettle handicrafts and horse fairs in the spring and autumn. Morioka is served by the Tohoku railway line. Pop. (1960) 157,441. (J. B. Ke.)

**MORIORI**, the aboriginal inhabitants of the Chatham Islands of New Zealand, were a Polynesian people of culture allied to but less highly developed than that of the Maori (q.v.) of the South Island. They lived on fern root, eels, fish, karaka berries and birds. Albatrosses were obtained by perilous expeditions to the outlying rocks where they nested. The clothing of the Moriori was of sealskin and rudely woven flax. Their social organization was similar to that of the Maori but they were a peaceful people, quarrels being settled by duels with a kind of singlestick. Numbering a few hundreds when discovered in the late 18th century, they were easily conquered and enslaved by a warlike party of Maori in 1835 and were gradually assimilated. In the 1960s about 170 Polynesians lived in the Chatham Islands; the majority are of mixed Maori-Moriori-European stock. The rest of the population is European. *See* also CHATHAM ISLANDS.

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**MORISCOS** (pejorative form of Sp. *moro*, "Moor" or "Muslim"), the name given to the Spanish Muslims who accepted Christian baptism, and to their descendants.

To facilitate the Reconquest (*see* SPAIN: *History*), surrendering Muslim communities in Aragon and Valencia were usually guaranteed in their religion by treaty, as were those of Granada in 1492. But the crown found this pledge embarrassing to uphold against the proselytizing zeal of the clergy. In 1499 Cardinal Jiménez de Cisneros' coercive measures in Granada provoked a rebellion there, and the insurgents were offered (1502) the choice of baptism or exile. In 1525, because of ecclesiastical pressure again, the emperor Charles V enforced the baptism of the Muslims of Valencia and Aragon, and prohibited Mohammedanism in Spain.

The "New Christians" were never accepted on equal terms by their "Old Christian" neighbours, from whom, however, they were racially indistinguishable, for most of them were descended from converts to Islam. They continued openly to speak, write and dress like Muslims, and some, secretly, to worship as Muslims; they practised the vendetta, terrorizing whole districts, and were suspected (often rightly) of abetting the Algerians and Turks. They were subjected to discriminative taxation while their staple industry, the silk trade, was reduced by a misguided fiscal policy; they were ill-taught in their new faith, yet militant for ignorance by church and Inquisition. By the mid-16th century many felt they "had little to lose except their lives and their debts." The direct motive for revolt was provided by an edict issued by Philip II in 1567 forbidding the Granadan Moriscos their language, customs and costume. Taking advantage of an administrative crisis, the Moriscos of Granada rebelled on Dec. 26, 1568 and were suppressed with great expense and difficulty in a war lasting more than two years.

Though the Granadans were deported *en masse* and scattered through northern Spain, and missions laboured vainly to instruct the Valencians, the Moriscos remained an unassimilable minority. Evidence of their political and religious infidelity led to royal consultations as to how they could be deported without ruining Spain's economy. The order for deportation was finally published on Sept. 22, 1609, and completed some five years later. The number expelled has been variously estimated from 150,000 to 1,000,000; the probable total, as shown by contemporary censuses, being 300,000. The immediate result was the repeopling, in the 17th century, of the Barbary states, which received most of the emigres. The long-term loss to Spanish agriculture is incalculable.

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Reglá, *La Expulsión de los moriscos y sus consecuencias* (1953); H. Lapeyre, *Géographie de l'Espagne morisque* (1960). (K. GA.)

**MORISON, JAMES** (1816–1893), Scottish theologian and founder of the Evangelical Union, was born in the Secession manse at Bathgate, Linlithgow, on Feb. 14, 1816. Licensed to preach in 1839, he made many converts in northeast Scotland, chiefly through stressing the universal nature of the atonement, contrary to the Calvinism of the Westminster Confession. Called in 1840 to Kilmarnock, he became famous as an evangelist, though a minority within the congregation was suspicious of his near-Arminian theology. Thence arose a definite charge of heresy, and in 1841 the synod of the United Secession church removed his name from its ministerial roll. Within the next two years he and three others (including his father, Robert Morison) who shared his condemnation resolved to associate, and at Kilmarnock on May 16, 1843, a new denomination came into being: the Evangelical Union, popularly called Morisonians. It trained its ministers, first at Kilmarnock and then in Glasgow, in a college over which Morison presided and from which he issued the commentaries which established his reputation as a scholar. Those on Matthew (1870) and Mark (1873) were outstanding. He died on Nov. 13, 1893, in Glasgow.

In 1897 the Evangelical Union and the Congregationalists (both numbering about 90 congregations) united as the "Congregational Union of Scotland, comprising the Evangelical Union and the Congregational Union as existing in 1896."

*See* Harry Escott, *A History of Scottish Congregationalism* (1960). (H. WA.)

**MORISOT, BERTHE** (1841–1895), French painter of the Impressionist school, was born in Bourges on Jan. 14, 1841, the daughter of a high government official. She decided early to be a painter and pursued her goal with the seriousness and abnegation of a dedicated artist. At first attracted by Corot, under whose guidance she worked between 1862 and 1868, she subsequently fell under the spell of Edouard Manet who had a liberating influence on her and in whom she, in turn, aroused an interest in outdoor painting. Manet did several portraits of the attractive young woman who was to marry his brother Eugène. Unlike Manet, Berthe threw in her lot with the Impressionists, with whom she exhibited regularly and in whose struggles she courageously participated. Her delicate and subtle art, the freshness of her technique, her exquisite colours and her true originality won her the admiration and affection of her Impressionist colleagues, but also ridicule and contempt from ignorant critics. A woman of great culture and charm, she counted Mallarmé, Degas, Renoir, Monet and many others among her close friends. She died in Paris on March 2, 1895.

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**MORITZ, KARL PHILIPP** (1757–1793), German writer, was born on Sept. 15, 1757, in Hameln, Hanover. His most important works are his two autobiographical novels, *Andreas Hartknopf* (1786) and the earlier *Anton Reiser* (4 vol., 1785–90), which is, with Goethe's *Wilhelm Meister*, the most mature 18th-century German novel of contemporary life. He was also an influential writer on aesthetics, notably in *Versuch einer deutschen Prosodie* (1786), which greatly impressed Goethe, *Über die bildende Nachahmung des Schönen* (1788) and *Götterlehre* (1791). Not the least interesting of his works is his *Reisen eines Deutschen in England* (1783).

Moritz's family was very poor and he was first apprenticed to a hatter, but patrons helped him to study theology. His restless and unhappy nature led him to abandon that in an attempt to become an actor. This failed, however, and after completing his studies he taught in Dessau, Potsdam and finally in a grammar school in Berlin, where he was briefly editor of the *Vossische Zeitung* (with which Lessing had been associated). In 1786 he traveled to Italy, where he met Goethe, whom he later advised on artistic theory. After his return to Berlin in 1789 he became professor of aesthetics and archaeology at the Academy of Arts. He died on July 26, 1793, in Berlin.

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**MORLAND, GEORGE** (1763–1804), English genre, landscape and animal painter, was born in London on June 26, 1763, son of the painter and picture restorer Henry Robert Morland. At the age of ten, Morland exhibited sketches at the Royal Academy, and he was bound apprentice to his father from 1777 to 1784. He drew from the antique and copied from George Stubbs' *Anatomy of the Horse*, from Gainsborough, C. J. Vernet and Reynolds. In 1780 his first signed engraving was published, and a year later his first oil painting, "Hovel With Asses," was exhibited at the Academy; now also he began, unknown to his father, to paint *galanteries* (scenes of love and compliment) for a Drury Lane publisher, and to associate with the demimonde.

After his articles had expired, he studied briefly at the Royal Academy schools, and held his first one-man show of paintings on private premises, having previously rejected George Romney's offer to employ him as his studio assistant. Throwing off parental restraint, in 1785 he visited Calais and St. Omer, and rode as an amateur jockey at Margate, Kent. In July 1786 he married Anne Ward, sister to William, the engraver. Settled in lodgings in Marylebone, London, Morland painted the series "Laetitia, a Harlot's Progress" (engraved by J. R. Smith), and in 1787 he abandoned portraiture for sentimental rustic genre, which, through Ward's engravings, satisfied a steady public demand for the picturesque. Morland's deliberate flaunting of commissioned work in which the patron dictated the subject, scale and medium and his policy of selling through an intermediary anticipated the situation whereby artists sought to please a wide public with unexceptional, easily comprehensible works.

Morland's best work occurs between 1787 and 1794 and a typical example is the "Inside of a Stable" (National gallery, London) exhibited at the 1791 Academy, the year in which the artist's extravagances forced him, despite his successes, to flee his creditors. After 1794 his powers deteriorated, and he alternated between periods of dissipation and concentrated work until his arrest in 1799. Released by the Insolvent act, 1802, but enfeebled in health and still pursued by creditors, he escaped to his brother Henry's house in Dean street, Soho. This same Henry had, during the previous eight years, unscrupulously exploited him, selling nearly 500 of his paintings alone. Arrested again on Oct. 19, 1804, Morland died of a brain fever ten days later.

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**MORLEY, HENRY** (1822–1894), English man of letters, educationalist and popularizer of English literature. Morley was born in London on Sept. 15, 1822. He attended the Moravian school at Neuwied, on the Rhine, and the loving and friendly atmosphere there formed his educational views for life. He studied medicine, but, when his partner's dishonesty made him give up his medical practice, he set up a school at Liscard, near Liverpool, and by making work interesting, abolishing punishments and appealing to the child's higher motives, achieved an astonishing success. In 1851 he moved to London and worked for Dickens' *Household Words* and its successor *All the Year Round* and for the *Examiner*. He wrote biographies (*Palissy the Potter*, 1852; *Jerome Cardan*, 1854; etc.) and dramatic criticisms (*Journal of a London Playgoer 1851–60*, 1866) but his main work was educational. He was evening lecturer in English literature at King's college, London (1857–65), and from 1865 professor at University college. He was a most popular lecturer, able to communicate his own enthusiasm, and he used this gift in his monumental unfinished history *English Writers* (11 vol. up to 1616, 1864–95). He was indefatigable in making good literature available and edited a vast number of cheap editions of the classics. He died at Carisbrooke, Isle of Wight, on May 14, 1894.

*See* H. S. Solley, *Henry Morley* (1898).

**MORLEY, JOHN MORLEY,** VISCOUNT (1838–1923), English Liberal statesman who made a notable contribution to literature and wrote the official biography of W. E. Gladstone, was born at Blackburn on Dec. 24 1838, the son of Jonathan Morley, a surgeon. He was educated at Cheltenham college and at Lincoln college, Oxford, where he gained second class honours in classical moderations followed by a pass degree. He settled in London to write and gradually came to be known as a journalist and thinker of strong temper and marked unconventionality, not hesitating, for instance, to advertise his atheism by spelling God with a small "g." From 1867 to 1882 he edited the *Fortnightly Review* with conspicuous success, maintaining it as the leading journal of radical opinion. He wrote several interesting essays on the French *philosophes* of the 18th century, whose elegant manners and rational temper appealed to him (*Voltaire*, 1872; *Diderot and the Encyclopaedists*, 2 vol. 1878; a less tidy character, *Rousseau*, 2 vol. 1873). Many of his shorter articles for the reviews were later collected and republished. He also wrote a life of Edmund Burke (1867) and a celebrated treatise *On Compromise* (1874), of which it was said that the only trace of compromise was in the title.

He stood unsuccessfully for parliament in 1865 and 1868, but he was well known in the political world, and spent many years on terms of intimacy with the rising Joseph Chamberlain. In 1880 he became editor of the daily *Pall Mall Gazette*, to which he gave a strong radical tone. His *Life of Richard Cobden* (1881) set out with force and clarity the doctrine of the Cobdenite school with which Morley felt strong sympathy. Chamberlain secured him a seat in parliament by a deft trick in 1883; Morley succeeded Sir Charles Dilke's ailing brother as Liberal member for Newcastle upon Tyne. Chamberlain and Dilke, already in the cabinet, wanted Morley's abilities to put before the commons views they privately agreed with, but were prevented by office from expressing. Morley was heard with interest, but his speeches were too ornate and unconversational to hit off the house's taste exactly. He became a prominent member at once, but was never a dominant one.

Prominence in the commons brought closer contact with Gladstone, and Morley was captivated by his charm. Though Morley was an atheist and had lived for years with another man's wife, he became a close friend of the intensely pious Gladstone and this drew him away from Chamberlain's orbit. When the Liberals split over Irish policy in 1886, Morley took the Home Rule side and was chief secretary for Ireland in Gladstone's brief third ministry. He played a useful though subordinate part in the negotiations between the prime minister and Charles Stewart Parnell over the first Home Rule bill. Morley's intransigence helped to prevent the Round Table conference (1887) from re-uniting the party; his nickname of "Honest John" indicates his downright method of setting out differences and clashes of opinion, and his temper in committee was unco-operative. He was nevertheless in demand as a public speaker, and also found time to write a useful short life of *Walpole* (1889), in the Twelve English Statesmen series which he edited, a work informed by his brief experience in office. In Gladstone's last government (1892–94) Morley was again Irish secretary. He had advanced high enough in the party to be able to threaten to break the cabinet up on a trumpery point, was prominent in the intrigues that divided the leaders, and helped to prevent Sir William Harcourt from becoming prime minister, at the price of having to hold the same Irish post himself under Lord Rosebery. A quarrel with Labour voters cost him his Newcastle seat in 1895, though he was returned for the Montrose burghs at a by-election in the following year.

In the late '90s he busied himself with a life of Oliver Cromwell (1900) and to his delight secured the family's permission to write the official *Life of Gladstone* (1903). The three stout volumes were a great literary success; only in the mid-20th century, as more of Gladstone's voluminous papers have become available, has it become clear how inaccurate and biased Morley's picture of him was. At that time Morley was preoccupied with the troubles of South Africa; he was a leading "pro-Boer," and opposed the South African War fiercely on the simple ground that it was wrong.

Morley's chief political ambition was to be foreign secretary, though he knew little of the complications of European diplomacy and was rather an opponent than a defender of traditional British interests. Instead he became secretary of state for India when the Liberals returned to office in 1905. He dominated his London colleagues and the viceroy, Lord Minto (see MINTO, GILBERT JOHN ELLIOT-MURRAY-KYNYNMOND, 4th Earl of), alike, and accepted instantly any suggestion from a subordinate hinting at resignation; while constantly threatening his colleagues that he would resign himself. He introduced Indians into the imposing, but largely powerless, viceroy's council, though he said privately that India was unfit for self-government, and needed benevolent supervision. He was pleased to find himself in the role of enlightened despot. On the change of government in 1908, he went to the house of lords as Viscount Morley of Blackburn and was active there in support of the budget of 1909 and in the subsequent controversy over the Parliament act of 1911. In one of the least improvised and most effective of his speeches, he told the lords that if they did not pass the parliament bill a mass creation of Liberal peers would make them do so; this secured an exiguous but adequate majority of 17.

Morley became lord president of the council in Nov. 1910, as age compelled him to turn from administration to advice, though he did still sometimes deputize both for Lord Curzon, his successor at the India office, and for Sir Edward Grey at the foreign office. In the crisis of Aug. 1914 he finally did resign, feeling rightly that the conduct of a great war was no task for an austere, old-fashioned Cobdenite, and he passed his last nine years in retirement at Wimbledon, where he died on Sept. 23, 1923. Morley published two volumes of *Recollections* in 1917; a continued *Memorandum on Resignation* appeared posthumously in 1928.

Writing in elaborate, Ciceronian English, he expressed, over some 50 years, his rationalist faith in unfettered intellect as the only sound guide to conduct. Some of Morley's ideas reflect the attitudes of John Stuart Mill, a close personal friend, but his interest in the political writers of the 18th century was historical and literary as well as philosophical. In many ways he was a 19th-century exponent of the ideas of the *philosophes* which, allied to his defense of Cobdenite principles and Gladstonian Liberalism, made him an isolated if forceful member of the Liberal party.

*See* besides the *Recollections*, F. W. Hirst, *Early Life and Letters of John Morley*, 2 vol. (1927); J. H. Morgan, *John, Viscount Morley* (1924); J. W. Robertson Scott, *Life and Death of a Newspaper* (1952).

(M. R. D. F.)

**MORLEY, THOMAS** (1557 or 1558–1603?), English composer, organist and theorist, the first of the great English madrigalists. He held a number of church musical appointments, first as master of the children at Norwich cathedral (1583–87), then by 1589 as organist at St. Giles, Cripplegate, in London, and by 1591 at St. Paul's cathedral. In 1592 Morley was sworn in as a gentleman of the Chapel Royal. By 1602 he was in ill health and his place at the Chapel Royal was filled in 1603. Since the appointment as gentleman was normally made for life, it seems likely that he died earlier that year.

It is highly probable that Morley became a Roman Catholic early in life, perhaps under the influence of his master, William Byrd, who remained a Catholic until his death. By 1591 Morley had defected, for in that year he engaged in espionage work among the English Catholics in the Netherlands. The mission nearly cost him his life, but he obtained useful information against the Catholic party in England. Evidently Morley realized the possibilities offered by the new popularity of Italian madrigals fitted with English texts and began publishing sets of madrigals of his own composition (in 1593, 1594, 1597, and two sets in 1595). These include a considerable proportion of Italian madrigals which Morley reworked and published with no acknowledgment of the original composers, a practice not uncommon at the time. In 1598 Morley published a volume of English versions of selected Italian madrigals, in that year he received the licence to print music in England for 21 years (this monopoly, originally granted to Byrd and Thomas Tallis in 1575, had expired in 1596). In 1597 he published his textbook, *A Plaine and Easie Introduction to*

*Practicall Musicke*, one of the most important contributions to modern knowledge of the theoretical basis of composition of Morley's own time and of earlier generations whose work was based on strict modal structure.

Morley's compositions are written in two distinct styles that may be chronologically separate. As a pupil of Byrd he was brought up in the pre-madrigalian English style of broad and strong polyphony. In 1576 he wrote two of a number of Latin motets that survive in manuscript sources; all these motets may well belong to his earlier period of presumed Catholicism. On the other hand his madrigal volumes of the 1590s employ the style of the Italian madrigal and are characterized by a direct effectiveness, gentle harmonic warmth, springy rhythms and clarity of texture. His *First Book of Consort Lessons* (1599), containing compositions by Morley himself and various contemporaries arranged for an instrumental sextet composed of treble and bass viols, flute, cittern, lute and bandora, is one of the few remaining examples of music for a group of instruments commonly in use at the time. In 1601 Morley edited *The Triumphs of Oriana*, a collection of 25 madrigals by various composers in praise of Oriana, who may or may not be identified with Queen Elizabeth I. His last volume of original compositions, *The First Booke of Ayres* (1600), contains "It was a lover and his lass." Morley is not always at his best when composing for voice and lute and the volume suggests a definite falling off in creative power. His masterpieces are the six-voice motets, "Laboravi in gemitu meo" and "De profundis clamavi."

For Morley's works see *The English Madrigal School*, ed. by E. H. Fellowes, vol. 1–4 (1921); *Morley: Keyboard Works*, ed. by T. Dart, 2 vol. (1959); *Morley: Collected Motets*, ed. by T. Dart and H. K. Andrews (1959); *The First Book of Consort Lessons, Collected by Thomas Morley, 1599 & 1611*, ed. by S. Beck (1959); *A Plain and Easy Introduction to Practical Music*, ed. by A. Harman with a foreword by T. Dart (1952).

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**MORLEY,** a municipal borough in the Batley and Morley parliamentary division of the West Riding of Yorkshire, England, 5 mi. S.W. of Leeds. Pop. (1961) 40,338. The town is on a spur of the Pennines, at an altitude of 450–600 ft. In the neighbourhood are the ruins of Howley hall, dating from 1580. There, during the Civil War, the parliamentary army sustained a heavy siege from the Royalists. The chief industries are connected with the manufacture of woolen materials, but coal mining, stone quarrying, glass making, tanning and bookbinding are also carried on. Morley was chartered in 1885 and greatly enlarged in 1937. It was the birthplace of the earl of Oxford and Asquith (1852–1928).

**MORMAOR** (MORMAER), a title of the rulers of the seven provinces into which Celtic Scotland (*i.e.*, the part of the country north of the Forth and the Clyde) was divided (Gael *mor*, "great," and *maor*, "steward" or "bailiff"). These seven mormaorships, or original "earldoms" of Scotland, as they were afterward called, were: Angus, Atholl with Gowrie, Caithness with Sutherland, Fife, Mar with Buchan, Moray with Ross and Strathearn with Menteith.

**MORMONS:** *see* LATTER-DAY SAINTS, CHURCH OF JESUS CHRIST OF.

**MORMYR** (MORMYRID), any bony fish of the family Mormyridae, restricted to the fresh waters of Africa. They are soft-rayed fishes with abdominal pelvic fins, small mouths with few teeth, small eyes, restricted gill openings and small scales. The brain is proportionately very large, with a great convoluted cerebellum, and enlargements in other regions that suggest that these fishes have the various senses well developed. A loosely attached bony plate on each side of the head covers a vesicle that communicates with the internal ear. Paired electric organs of mild potency, present in the tail, set up a continuous electric field around the fish which acts as a sensory screen. More than 100 strange-looking species are known, some having the mouth at the end of a long snout that resembles the trunk of an elephant; hence the common name "elephant nosed" for some species of *Gnathonemus*. Most mormyrs feed on small prey, aquatic vegetation or organic debris. The Nile species of *Mormyrus* are represented in ancient Egyptian mural paintings and hieroglyphics.

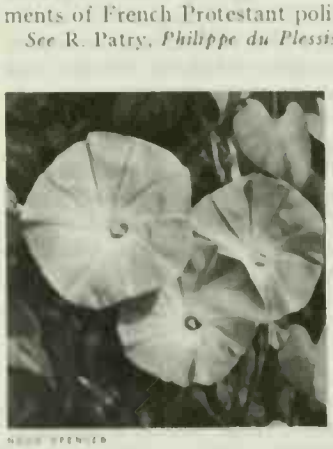
*See* also FISH. (C. HU.)

**MORNAY, PHILIPPE DE** (1549–1623), SEIGNEUR DU PLESSY-MARLY, usually known as DUPLESSIS-MORNAY, French Protestant diplomat and author, was born at Buhy in Normandy on Nov. 5, 1549, son of Jacques de Mornay, seigneur de Buhy, and of Françoise du Bec-Crespin. By his mother's influence Philippe received a Protestant education. He studied Hebrew, law and German at Heidelberg (1568–69) and visited Venice, Padua and many other Italian cities (1569–71). While at Cologne (1571–72) he wrote two "Remonstrances," encouraging the people of the Low Countries to resist Spanish rule. Mornay was in Paris at the time of the massacre of St. Bartholomew's day (Aug. 24, 1572) and only narrowly escaped. For the next four years he resided chiefly at Jametz (Meuse) and at Sedan, where he married (Jan. 1576) Charlotte Arbaleste (d. 1606). He took some part in the fifth War of Religion and was wounded and captured by the forces of the (Catholic) Holy League at Dormans on Oct. 10, 1575. But he concealed his identity and was released for a small ransom. Mornay became a valued counselor of Henry of Navarre (afterward King Henry IV) and conducted for the Protestant cause a series of important embassies to England and the Low Countries (1577–82). The reconciliation between Henry III and Henry of Navarre in April 1589 was negotiated by Mornay. As reward for his services he was appointed governor of Saumur.

After the death of Henry III (Aug. 1589), Mornay helped Navarre in his struggle for the French throne, conducting embassies on his behalf and fighting with his forces. But Henry IV's reconciliation with the Catholic Church (1593) ended their cooperation. The publication of Mornay's *De l'institution . . . de l'Eucharistie* (1598), in which he used scriptural quotations to attack Catholic eucharistic doctrine increased the breach. He was accused of misquotation by Jacques Davy Duperron, bishop of Evreux, and at a public disputation at Fontainebleau in 1600 it became clear that Mornay had lost Henry IV's favour. He played no further part in national affairs and in 1621 was deprived of his governorship. He retired to La-Forêt-sur-Sèvre (Deux Sèvres), where he died on Nov. 11, 1623. His only son, Philippe, had died fighting at Guelders in 1605.

Mornay's numerous writings include political tracts such as the *Discours au roi Charles* (1572) and *Remonstrances aux estats pour la paix* (1576). His religious works include *Discours de la vie et de la mort* (1576), *Traité de l'église* (1579) and *Le Mystère d'iniquité* (1611), a history of the papacy. He probably edited, with his own additions, the *Vindiciae contra tyrannos* (1579) of his friend Hubert Languet (*q.v.*). His *Mémoires et correspondance* (collected edition, 12 vol., 1824–25) contains many documents of French Protestant policy.

*See* R. Patry, *Philippe du Plessis-Mornay* (1933).



HORTICULTURAL FORM OF THE COMMON MORNING GLORY (IPOMOEA PURPUREA)

**MORNING-GLORY,** the name given to certain flowering vines of the genera *Ipomoea* and *Argyreia* of the family Convolvulaceae (*q.v.*), native to the tropics. The common morning-glory (*I. purpurea*) is a widely cultivated twining annual vine in temperate North America. It bears broad, heart-shaped, short-pointed leaves and large funnel-form, blue or purplish flowers, two to three inches long. There are many races in cultivation, some with double flowers, and varying in colour.

Others of the genus include the Brazilian morning-glory (*I.*

*setosa*), with purplish hairs and rose-purple flowers; the bush morning-glory (*I. leptophylla*), a shrubby perennial in Texas and New Mexico; and the Ceylon morning-glory (*I. tuberosa*), cultivated in many tropical countries. Of the same family are the woolly morning-glory (*Argyreia speciosa*) and the silver morning-glory (*A. splendens*), both tropical Asian vines with rose flowers and silvery leaves.

**MORNY, CHARLES AUGUSTE LOUIS JOSEPH, DUC DE** (1811–1865), a leading figure in French politics and society during the second empire, was born in Paris on Oct. 23, 1811, the illegitimate son of Louis Bonaparte's estranged wife Hortense de Beauharnais (*see* HORTENSE) by Charles Joseph, comte de Flahaut. He was fictitiously registered as the son of a certain Auguste Demorny and later assumed the equally fictitious title of comte de Morny. He began his career as a lieutenant in the French army, serving mainly in Africa (1832–36), and was decorated for bravery; but neither his interests nor his ambitions were military. He was above all addicted to the social pleasures of the aristocrats and plutocrats of his day. Resigning his commission, therefore, he gave himself up to a gay Parisian life and to the business of making a fortune by active speculation and by manufacturing sugar from beet. He was elected to represent Clermont-Ferrand in the chamber of deputies in 1842 and re-elected in 1846 but did not reach the first rank in politics until his half brother, Louis Napoleon, became president of the republic in 1848. He was elected deputy for Puy-de-Dôme in 1849.

Morny played an important part in the *coup d'état* of Dec. 2, 1851. Becoming minister of the interior on the day of the *coup*, he organized the plebiscite which made Louis Napoleon dictator. He was, however, unsuited by temperament for ministerial office and resigned in Jan. 1852, before Louis Napoleon became emperor as Napoleon III in December. After a short period as ambassador to Russia (1856) he at length found a congenial outlet for his gifts in the presidency of the legislature, to which he had been appointed in 1854. In this office he abandoned his formerly reactionary role and tried to persuade Napoleon III to give the country more liberty. Seeing that the dictatorship could not last, he urged Napoleon to give it up voluntarily rather than be compelled to do so; and it was he who introduced Napoleon to Émile Ollivier (*q.v.*). Morny was created duc in 1862.

Morny was perhaps the most seductive and brilliant of the leaders of the second empire. He was its most outstanding dilettante, a patron of the theatre, literature and musical comedy, a devotee of horse racing, a great speculator and a lifelong pursuer of women, while his very remarkable political acumen, exceptional intelligence and tact gave him the right to rank highly among France's statesmen. He might have achieved more had he not died prematurely, in Paris, on March 10, 1865.

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**MORO, ANTONIO:** *see* MORE, SIR ANTHONY.

**MORO,** the name customarily used to denote as a whole the nine different Philippine linguistic communities that profess Islam. The term was first applied by Spaniards who also used this name for the Muslims (*see* MOORS) of north Africa. Four of the Moro groups, the Tau Sug and Samal of the Sulu archipelago, and the Magindanao (*q.v.*) and Maranao of the island of Mindanao, comprised 92% of the Philippine Muslims that in the 1960s numbered about 1,000,000. The remaining groups, Bajau, Jama Mapun, Melebuganon, Sangir and Yakan, are not always considered as Muslim by other Moro but are usually so designated.

Although Muslim missionaries reputedly did not arrive in the Philippines until the late 14th century, Spanish forces in 1571 found the indigenous inhabitants of the southern islands to be largely Muslim. Muslim rulers and colonies were also found and conquered by the Spaniards in the central and northern islands; but for the next 330 years Spain was not able completely to subjugate the Muslim areas in the south. These centuries of intermittent warfare gained the Moro a reputation as raiders and pirates and left a heritage of mutual fear and hostility between the Moro and their Christian neighbours to the north.

Final pacification of the Moro was accomplished as a result of U.S. military campaigns (1899–1913) during which John J. Pershing (*q.v.*) first distinguished himself. The Moro area was separately administered under the U.S., but was included among Philippine political divisions with the establishment of the republic.

The long period of isolation from the rest of the Philippines, plus continuing southeast Asian cultural influences, have served to distinguish the Moro from other Filipinos. There is partial preference of a sociopolitical system similar to those in Indonesia and Malaya. Formerly each Moro group was organized around three hereditary classes with ultimate authority vested in a sultan. The Tau Sug, Samal and Maranao groups were headed by the sultan of Sulu who also claimed suzerainty over North Borneo. The Magindanao recognized two major and several minor sultans. The Maranao were led by 14 major title-holders and a host of lesser dignitaries. Although these systems now have no official existence, hereditary leadership and traditional authority continue to play an important role.

The Moro are adherents to the Sunni branch of Islam (*q.v.*) but pagan and Shi'ite elements are to be found in their religious practices. Contact with the Muslim world is maintained chiefly by pilgrimages. A growing number of religious leaders are being trained in the middle east.

There is considerable variation among Moro groups; each has its own language, traditional area and specific customs. The Tau Sug are noted sailors and traders, the Samal are mainly fishermen. The Maranao (famous for their brasswork) and Magindanao practise typically Philippine forms of agriculture. Living arrangements vary from the multi-family great house to single family households. Costumes differ but traditionally involve some form of headdress and a sarong-like garment. Musical instruments such as lutes, drums, gongs and flutes are used in various combinations. *See also* PHILIPPINES, REPUBLIC OF THE; SULU.

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**MOROCCO** (AL MAMLAKAH AL MAGHRIBIYAH or AL MAGHRIB; FR. MAROC), a kingdom in northwest Africa independent since 1956, comprises the former protectorates of French Morocco and Spanish Morocco, the former international zone of Tangier, and since 1958 the former Spanish Southern Protectorate of Morocco. It is bounded on the north by the Mediterranean, on the east by Algeria, on the southeast and south by French and Spanish Sahara, and on the west by the Atlantic. Forming the western part of northern Africa or the Maghreb, it is separated from Europe on the north by the 9-mile-wide Strait of Gibraltar. Area 174,471 sq.mi., excluding places of Spanish sovereignty (Ifni, Ceuta, Melilla and the islands of Alhucemas, Chafarinas and Peñón de Vélez de la Gomera). The political capital is Rabat, but Fès, Meknès and Marrakesh (Marrakech) are traditional capitals and Tangier is the summer capital.

This article is arranged in the following sections:

I. Physical Geography
  1. Structure and Relief
  2. Climate
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  8. Defense
VI. The Economy
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## I. PHYSICAL GEOGRAPHY

**1. Structure and Relief.**—Morocco has the most varied landscape of all the north African countries, with its plains, plateaus and high mountains; with the rigid lines of the Saharan platform (*see* SAHARA) and the Atlantic *meseta* and the soft folds of the surrounding sedimentary ranges.

Southern Morocco, south of a line running from Agadir on the west coast to Figuig in the east, belongs to the Sahara, a platform of Pre-Cambrian and Primary rock folded, flattened and hardened by metamorphism. Its northern border was sharply raised and broken at the time of the Tertiary foldings and the Quaternary upheaval of the Atlas mountains, producing the asymmetrical mountain range of the Anti-Atlas (8,304 ft. in Jabal or Djebel Aklim) which is continued to the northeast by Jabal Sagho (Djebel Sarho). These mountains dominate, to the north, the plains of the Sous and the Dadès, which are separated by the volcanic range of the Siroua (10,840 ft.). To the south they fall away toward the broad valley of the Dra and the depression of Tafilalt which form the northern edge of desert plateaus called *hamadas* (Hamadas of the Dra, the Kemkem, the Ghéris, the Ziz, the Daoura and the Guir).

Eastern Morocco, which is merely an extension of Algeria, affords a contrast between the limestone shelves and shaly crests of the Beni Snassen mountains, which dominate the coastal plain of the Triffa and the inland plain of Oujda, and the uniformity of the High plains of the Dahra. The High plains, rising to 3,900 and 4,300 ft., slope toward the watershed of the Middle Moulouya, their cliffs overhanging the flat corridor which runs from Oujda to Taza. To the south rise the outliers of the High Atlas. In the High plains, which are almost waterless and are poorly drained by the network of the Al Haï watercourse, are some enclosed depressions called *shotts* (Tigri and Gharbi shotts).

The High (Great or Grand) Atlas mountains stretch from the Atlantic to the eastern border of Morocco. They form a chain 484 mi. long, in which nearly all the peaks exceed 6,500 ft. The western part, between the plains of the Haouz and the Sous, is the highest but also the narrowest and most broken. There Primary rocks rise to heights of more than 13,000 ft. (Jabal Toubkal 13,730 ft.) and the passes known as Tizi n'Màchou, Tizi n'Test and Tizi n'Tichka are also high. The coast is rocky and indented, with Cape Guir and the Bay of Agadir. To the east of the valley of the Rdat the High Atlas is made up of great parallel chains of Liassic and Jurassic limestone moderately folded and faulted and dominated by the Jabal M'Goun (13,356 ft.) and the Jabal Ayachi (12,260 ft.), to the east of which is the high pass of Tizi n'Talghemt. Toward the south the rivers Dadès, Ghéris and Ziz run through wild gorges to the Sahara. To the east of Ayachi the High Atlas becomes lower and breaks up into outlying hills that cut into the southern part of the high eastern plains.

The Middle (or Moyen) Atlas, the barrier between eastern and Atlantic Morocco, is a massif of Liassic and Jurassic limestone which is a northern offshoot of the central High Atlas. Its ranges, made up of sharp anticlines separated by broad synclinal valleys, exceed 8,000 ft. and reach their highest points in the Jabal Bou Iblane (10,466 ft.) and Jabal Bou Naceur (10,958 ft.). To the north the Primary massif of Tazzeka rises above the Taza gap. To the northwest the mountains give way to plateaus which overlook the plain of Fès. They are partly covered by lava and by Recent volcanic cones, the dark colour of which contrasts sharply with the limestone. The Middle Atlas is rich in karstic forms (sinkholes, pits and caves) and very well watered; it is the country of the great springs, the "water-tower of Morocco."

The Rif range separates Morocco from the Mediterranean. It forms a crescent of complex structure running parallel to the coast between Ceuta and Melilla. The principal chain reaches its highest point in the Jabal Tidiguin (8,045 ft.) and breaks up toward the east. It forms part of the Rif heights that reach out toward the south with marl and Cretacean and Tertiary shale through which the Ouergha, an affluent of the Sebou (Sebu), has cut its course. These heights are repeated in the "pre-Riffian heights," low hills of Tertiary age that extend south beyond the Sebou. At their extremity are small groups of higher, calcareous hills, the "pre-Riffian garlands" like the range of the Zerhoun north of Meknès. In the eastern part of the Rif these heights give way to broad ridges and undulating sandstone and limestone plateaus. (*See* also ATLAS MOUNTAINS.)

The plains and plateaus of Atlantic Morocco are the vital region of the country. The low, marshy plain of the Sebou (the Rharb) and the high plains (originally lakes) of Meknès and Fès, as well as the depression of the Innaouen and the Taza gap, are on the site of a former Tertiary (Miocene) strait. From Rabat to the Middle and High Atlas the *meseta* is a solid tableland of Primary soils, leveled and packed down, which bulges out into the central range in the north and into the Rehamna and Jebilet hills that lie between the broad Tadla-Bahira plain and the Haouz (plain) of Marrakesh. Thin sheets of Cretaceous and Eocene deposits, rich in phosphates, form rigid plateaus. The *meseta*, which is crossed by the sunken valleys of the Bou Regreg, Oum er Rbia and Tensift rivers, falls toward the sea, giving place between Rabat and Mogador (Essaouira) to a narrow plain whose straight coast, broken only by the peninsulas of Casablanca and Cape Cantin, is violently buffeted by the strong Atlantic swell.

**2. Climate.**—The climate of Morocco varies with the latitude and passes by stages from the Mediterranean type in the north (temperate climate, warm and dry in summer, fairly mild in winter) to the Saharan type in the south. But the influence of the Atlantic is even more important because the country lies open to its moist winds as well as to the cold ocean current from the Canary Islands which cools the coasts. Very important too are the relief and altitude, which increase rainfall, lower temperatures, cause snow and vary the temperature gradients. On the coast, for example, Tangier has monthly average temperatures varying between 12° and 24° C. (54° and 75° F.) and an annual rainfall of 33 in., whereas Agadir's temperatures range between 14° and 22° C. (57° and 72° F.) and the rainfall is 9 in. Inland, Marrakesh (1,510 ft. above sea level) has temperatures ranging between 12° and 29° C. (54° and 84° F.) and an annual rainfall of 10 in., and at Ifrane (4,430 ft. up in the Middle Atlas) temperatures vary between 2° and 21° C. (36° and 70° F.) and rainfall is 43 in.

Atlantic Morocco has a rainfall of more than 16 in. on its encircling mountains (with more than 32 in. and even 40 in. on the Middle Atlas and the Rif range) and on the plain north of Oum er Rbia, and cultivation without irrigation is possible even along the coast farther south because of the high humidity and the moderate temperatures. The Haouz of Marrakesh and the Sous are dry (8–12 in.) and warm like the north of eastern Morocco (except for the Beni Snassen). The rest of eastern Morocco and the southern part of the High Atlas give way rapidly to a relative desert (4–8 in.), then to the true Sahara (less than 4 in.).

The principal rivers are like Mediterranean torrents, often somewhat tamed by seepage into the limestone regions (Middle Atlas and eastern High Atlas) but reinforced by the melting snows from the high mountains. The Oum er Rbia, the most important, has a minimum flow of only 1,400 cubic feet per second (cusec) in summer and a maximum average of 7,400 cusec during April–May. In spate it can swell to 70,000 cusec—the Sebou to as much as 105,000 cusec; the Moulouya, almost dry in summer, swells violently. The great rivers of the southern slopes of the High Atlas, very irregular and drained by their irrigation of numerous oases, are dry at their entry into the desert except during times of spate.

**3. Vegetation.**—The diversity of relief and climate enables a great variety of plants to grow. The desert, with its contrast between great bare expanses (sometimes thinly scattered with stunted plants) and exuberant palm groves, begins south of the Anti-Atlas, the Sagho mountains and the High eastern plains. In the north it gives way to regions which are less arid though still unsuited to cultivation without irrigation. The High plains of eastern Morocco and the Middle Moulouya form a kind of steppe, with esparto and white artemisia (*Artemisia alba*). The low-lying corridor between Taza and Oujda, the Haouz of Marrakesh, and the Tadla are partly alluvial plains scattered with clumps of *Zizyphus lotus*, some pistachios (*Pistacia atlantica*) and a few

acacias (*Acacia gummifera*). Atlantic Morocco south of Mogador, the Sous, and the plain of Tiznit are sparsely covered with argan trees (*Argania sideroxylon*) and euphorbias, relicts of a small tropical community which is also common to Madeira and the Canary Islands. The *tirs* earths (dark, strong soil, friable when dry and often acid) and the alluvial clays of the Atlantic plains north of Safi were, before clearance, covered with dwarf fan-palms (*Chamaerops humilis*) and with maquis of wild olives and mastics (*Pistacia lentiscus*). The sandy stretches, however, sometimes carry an open forest of cork oaks, like that of Mamora forest, east of Rabat.

The mountains are covered with forests, often degenerated. Barbary thuja and, as soon as the climate becomes more continental, red juniper (*Juniperus phoenicea*) cover the semiarid mountains of the eastern Rif, the Beni Snassen, the eastern slopes of the Middle Atlas, the eastern chains of the High Atlas and the wetter parts of the Anti-Atlas and even of the Jabal Sagho. The Spanish juniper, a high-altitude tree, grows at 10,000 ft. in the High Atlas. The evergreen oak, already widespread, is by far the most important tree of the subhumid and humid regions of the western High Atlas, the Middle Atlas and the western part of the Rif. The Atlantic cedar is the typical tree above 5,000 ft. in the north and 6,500 ft. in the High Atlas, but it never grows above 9,000 ft. Alpine meadows and cushion plants are found only between 9,000 and 10,500 ft.

**4. Animal Life.**—This can be divided into four zones: the Saharan, with large numbers of reptiles and rodents, and with gazelles and fennecs; the eastern, intermediate between the Saharan and the Mediterranean zones (gazelles, jackals); the Atlantic, with a mixture of Mediterranean, tropical and European species; and the mountain zone, with moufflons in the south and a few remaining panthers. (J.-J. Ds.)

## II. THE PEOPLE

The indigenous peoples of Morocco, both settled and nomadic, are of Berber origin (*see* BERBER). Together they form a union of several tribes which have given themselves the collective name of *imazighen* (sing. *amazigh*), "the free men." The original Mediterranean and Semitic stock has developed many varieties of pigmentary coloration through contact with the black races of Africa.

The Berber language is spoken chiefly in the mountains of the Rif, the High Atlas and the Middle Atlas. It comprises three families of dialects in Morocco. Zenatiya, spoken in the eastern Rif, Beni Snassen, some parts of eastern Morocco, the northern and eastern borders of the Middle Atlas, and the oasis of Figuig; Tamazight, in the Middle Atlas and its western extensions, and in the central High Atlas; and Tachelhit (the dialect of the Chleuhs), in the western High Atlas, the Anti-Atlas and the Sous.

The Arab conquest of the 7th–8th centuries only arabized the towns. The chief Arab influence was the result of Bedouin invasions between the 12th and 15th centuries. As a result the plains and plateaus generally became arabized, and Arabic is also spoken in a few isolated mountain masses along the Strait of Gibraltar. The differences between dialects are less marked in Arabic than in the Berber language. Since there is no written Berber language, Arabic has become the language of administration and culture and is slowly spreading throughout the country as education develops. French and Spanish are regarded as subsidiary languages.

Berbers, Arabs and Negroes are almost all Sunni Muslims of the Malikite rite. (A few tribes preserved Christianity for a century after the coming of Islam.) There are also some Jews, partly descended from Spanish immigrants, partly from Berber tribes converted to Judaism and scattered by the Muslim conquest. The few French and Spanish settlers are Roman Catholics.

The villages were built on the mountain heights, both for defensive purposes and to leave cultivable surfaces free for crops. In central Morocco transhumance is practised; before the first winter snow most of the families leave the villages, with their sheep, goats and some cattle, for the steppes of the Moulouya or the plains of Fès and Meknès, or the Tadla borders, or the valleys of the central massif. In spring they return to their villages with adjacent cultivable areas, while some flocks, accompanied only by shepherds, may move on to the highest pastures. The most important buildings are the fortified granaries, called *tighremt* in the north and *agadir* in the south. In the far south there are true nomads who live in tents all the year round and support themselves by breeding camels and other animals. These tribes live in symbiosis with the settled farmers of the oases.

The nucleus of the town populations consists of an urban middle class and a small aristocracy, these being the custodians of culture and civilization. These two classes originate from the Andalusians who were driven from Spain and mingled with other elements; Algerians who fled to Tetuan (Titouan) at the time of the French conquest; descendants of the ancient Zenata aristocracy in Rabat and Salé; descendants of the ribat and corsairs, chiefly in the ports; and, at Fès, former Jews converted to Islam. The Berber element predominates at Meknès and at Marrakesh. Moulay Idris and Wazzan (Ouezzane) still possess a special character as holy places. Other towns, like Casablanca, owe their rise to Europeans. On the whole the towns have preserved the village form, being divided into quarters and sometimes surrounded by a wall pierced by iron gates. The traditional trades were grouped in guilds, some of which were wealthy and had considerable social importance. Some trades, *e.g.*, ironwork and building, were traditionally divided between Muslims and Jews.

Punic and later Roman influences went to fashion the general customs of the Moroccans. There was also a Sudanese influence, particularly among the Berbers of the south, but this also spread northward with the slave trade. This influence appears chiefly in the dances, similar to those of certain Negro peoples, in which spirits take possession of the dancers. This spirit worship flourishes chiefly in the towns where it underlies social discontent. Nevertheless, it is to the Mediterranean world that Morocco is linked by its ethnology, by the customs and traditions of its peasants and by its social structure. (J. H. Sc.)

## III. HISTORY

Although numerous archaeological remains indicate that Morocco was inhabited from a very remote period, the region first became known to history when in the 12th century B.C. Phoenicians from Tyre founded the town of Lixus (Larache) and probably ports of call in the north of Morocco. The Carthaginians later established a series of trading posts on the northern coast. In the 5th century B.C., during his voyage around the west coast of Africa, the Carthaginian navigator Hanno founded several towns on the Atlantic seaboard of Morocco, which enjoyed, at least on a coastal fringe, a Carthaginian and neo-Carthaginian civilization.

**Roman Morocco (1st–5th Century A.D.).**—After the fall of Carthage northern Morocco formed part of Moorish kingdoms—allies or vassals of Rome—which were to some extent involved in Rome's civil wars. In the north the emperor Augustus founded colonies of veterans. King Juba II, a faithful ally of the Romans, a fervent admirer of Hellenism and a lover of art, introduced the civilization of the Roman empire into Morocco. Following Berber revolts in western north Africa, Morocco was annexed to Rome and formed a new province, Mauretania Tingitana, with its capital at Tingis (Tangier) (c. A.D. 40). Roman territory was limited to a triangle extending from the Strait of Gibraltar to Rabat and to the Meknès region (*see* MAURETANIA). Alliances with the neighbouring tribes, a light military force and a network of communicating roads enabled this distant and half-isolated province to live in peace for 200 years.

Excavations carried out at the ruins of the large Roman town of Volubilis in the interior and at other sites show that among town dwellers in Tingitana there was a true appreciation of art. Though lacking in elegance, the monuments have real nobility. The site at Volubilis has yielded fine houses and an astonishing series of bronzes including statues, busts and pieces of furniture, which are mainly Hellenistic in style and undoubtedly imported.

Christianity reached Tingitana; apart from considerable archaeological evidence there are lists of dioceses, indicating that the

province was probably completely Christianized. Moreover, inscriptions discovered at Volubilis dating from the first half of the 7th century reveal that Christianity and Latin civilization survived the invasion of the Vandals, who passed through northern Morocco in the 5th century without settling, and were maintained until the eve of the Muslim conquest.

**The Muslim Conquest and Arab Domination, 670–740.**—The decisive battles of the Muslim conquest of north Africa were fought in the eastern part of Barbary during 647–708. Okba's raid into Morocco (*c.* 684) met little resistance, but led to only a partial and temporary submission. It was the expedition of Musa ibn Nusayr which in 710 made Morocco a Muslim country, dependent upon the Omayyad caliphs at Damascus. This Muslim conquest was, however, not an Arab invasion, since relatively few Arabs settled in the country. But the new rulers behaved like tyrants, raising illegal taxes and reducing the Berbers to slavery. In 711 the first of Musa's Muslim armies invaded Spain. In 740, in the name of the Muslim heresy, Kharijism, the Berbers rose in a successful revolt against the Omayyads of Damascus. Morocco henceforth ceased to belong to an eastern caliphate, as did nearly the whole of the western Muslim world.

**The Formation and Evolution of Berber Islam.**—Like most of Barbary, Morocco was reorganized under the influence of the doctrines of Kharijism and the land was divided up into petty kingdoms.

In the 9th century eastern Muslims, taking their stand on orthodoxy or on the Kharijite heresy, succeeded in founding kingdoms in several parts of Barbary. Idris I, a sherif who had fled from Abbasid persecution in Arabia, conquered Berber tribes in northern Morocco and a part of the Atlantic plains. His son, Idris II, resumed his work without, however, succeeding in subduing the whole country. But he founded as a capital for his little kingdom the town of Fès (808), which henceforth became a political and religious centre. The Idrisids were the first to organize, outside the tribal system, a central government, which was partly composed of Arabs. They established the sherifian tradition in Morocco and were also responsible for making a part of northern Morocco linguistically Arabic. After the death of Idris II, however, the kingdom was divided up and the power of the Idrisids rapidly declined.

**The Conflict Between the Fatimids and the Omayyads.**—In eastern Barbary there arose at Kairouan at the beginning of the 10th century the empire of the Fatimids, founded under the sign of Shi'ism and supported by the Sanhaja Kabyles. While directing their main efforts to the conquest of Egypt, the Fatimids made numerous expeditions to the Maghreb. Their hold on Fès and northeastern Morocco, however, was always precarious. In all their westward drives they encountered resistance from strong tribes of Zenata Berbers, who had the support of the Omayyads of Córdoba. Two Zenata confederations, the Banu Ifran and the Maghrawa, who had been driven back into Morocco, founded little kingdoms in the plains. Allied to the Omayyads of Córdoba, they returned to Muslim orthodoxy, together with almost the whole of Morocco, at a time when the first fruits of Spanish-Moorish civilization were reaching Fès.

**The Zenith of Berber Islam, 1053–1269.**—Morocco, which had hitherto remained rather isolated from the great events that had disturbed Barbary, came suddenly to the forefront when, as a result of religious reforms, two great dynasties, the Almoravids and the Almohads (*qq.v.*), were founded on its soil. The Almoravids, who came from Mauritania, were Saharan nomads of the Sanhaja family. They were the descendants of those Berbers who had conquered Sahara and had carried Islam to the frontiers of Black Africa. Penetrating into southern Morocco, where they founded their capital Marrakesh in 1070, they took possession of the whole country after bitter fighting against the Zenata. They made themselves the champions of orthodox Islam and of the Malikite theory of law. Yusuf ibn Tashfin was the first Almoravid sultan to bring the whole of Morocco under his authority. He extended his African possessions as far as Algiers and, having rescued the Muslim amirs in Spain, whose position was endangered by the advance of the king of Castile (1086), he deposed them and annexed their territories. This symbiosis of Muslim Spain and the Maghreb was to be of great cultural benefit to Morocco.

In the name of a new religious reform preached by one of their number, Mohammed ibn Tumart, the Almohads, Masmuda Berbers of the Atlas, revolted against the Almoravids and gradually wrested their African empire from them. Abd-al-Mumin, the disciple and successor of Ibn Tumart, conquered the whole of Barbary and brought most of Muslim Spain under his control; this last conquest was completed by his son Abu Yaqub Yusuf.

In Morocco, Berber Islam reached its zenith: a Berber was caliph and ruler of the whole of the Maghreb. The Almohads resumed the work of patronage of the Almoravids and Andalusian civilization took root in the towns of their empire, the influence of Spain giving the institutions of the Maghreb their classical form.

There was, however, a grim aspect to this highly cultured society. In order to punish their north African vassals, the Zirids of Tunisia and the Hammadids of the Constantinois, for having thrown off their allegiance to the Shi'ite doctrine, the Fatimids of Cairo sent against them three Arab tribes, the Hilal, Solaïm and Maqil (Maaqil). These nomadic Bedouins, who reached Morocco in the 12th and 13th centuries, impoverished the country, profoundly disrupted its social framework and caused grave political troubles.

Abd-al-Mumin and his successors had hoped to make use of these Arab tribes, but it was the latter who undermined from within the Almohad empire, which collapsed completely following a serious defeat inflicted in Spain by a Christian coalition at Las Navas de Tolosa (1212).

**The Marinids and the Decline of Berber Islam, 1269–1465.**—The Marinids (*q.v.*), Zenata Berbers who had settled in eastern Morocco, succeeded in wresting the country little by little from the last Almohads. Coming from the east, they made Fès their capital.

The Maghreb had been profoundly altered. Three Berber dynasties, the Hafsids of Tunis, the Abd-al-Wadids of Tlemcen and the Marinids themselves shared Barbary among them. After the Christian reconquest in the 13th century the little kingdom of Granada, a vassal of Castile, was the only Muslim possession left in Spain. However, until the mid-14th century the Marinids conducted a holy war in Andalusia, where they helped the Nasrids of Granada to consolidate their position but did not recapture any territory from the Christians. They invaded the kingdom of Tlemcen on many occasions and under Abu'l Hasan at one time conquered Tunisia. Nevertheless, they made no permanent conquests.

In Morocco, civilization assumed its classical aspects, which were to last until the 20th century. Although the country was completely won over to Muslim orthodoxy and to Malikism, the division of the land under maraboutic leaders developed everywhere. Its population was a mixture of Berber and Arab. Its towns became secondary centres of Spanish-Moorish civilization and art, of which it was to be the refuge after the fall of Granada in 1492.

The Marinids had a firm hold only on the plains and steppes, and during the 15th century the disorders caused by the Arabs grew more numerous. Disturbances by marabouts at the time of the first Portuguese arrivals on the Moroccan coast led to a period of anarchy. The Marinid dynasty collapsed and the country was divided into small, independent states.

**The Banu Wattas and the Saadi, 1465–1659.**—The Banu Wattas, who replaced the Marinids at Fès, could not prevent the Portuguese from occupying and fortifying several ports on the Atlantic coast. The Saadi, sherifs from southern Morocco with their capital at Marrakesh, gradually supplanted the feeble Banu Wattas. They put themselves at the head of a jihad (holy war) against the Portuguese, recapturing Agadir and other places. However, the threat presented by the Turks at Algiers induced the sherifs to ally themselves with the Spaniards against their common enemy. The failure, at the battle of the Three Kings in 1578, of the last Portuguese attempt to intervene in Morocco by re-establishing a dethroned Saadi was followed by the notable reign of Ahmad al-Mansur, who succeeded, with the help of a small band

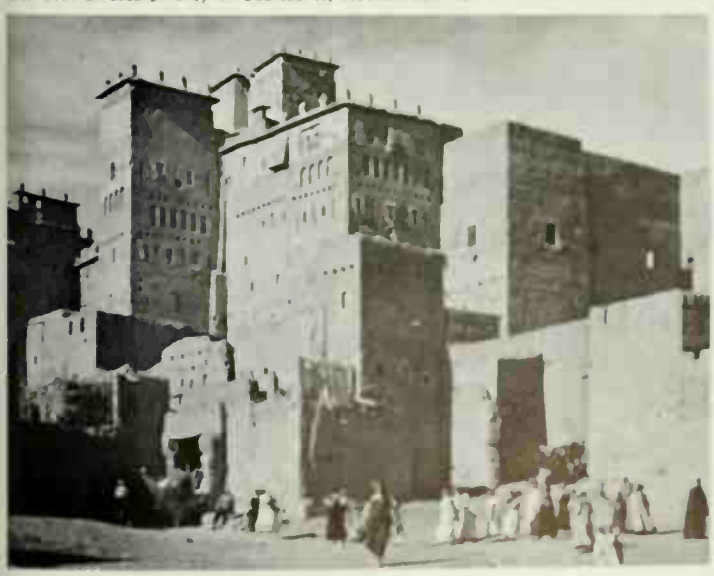
Modern section of Casablanca, the main port and commercial centre of Morocco and an important junction for international airlines

A craftsman working an intricate pattern in gold on Moroccan leather

## THE CITIES AND THE PEOPLE

A Muslim woman wearing the traditional veil as she rides a bicycle through a street in Marrakesh, south-western Morocco

Entrance to the kasbah of Taourirt (little hill with an escarpment) in Ouarzazate, southern Morocco



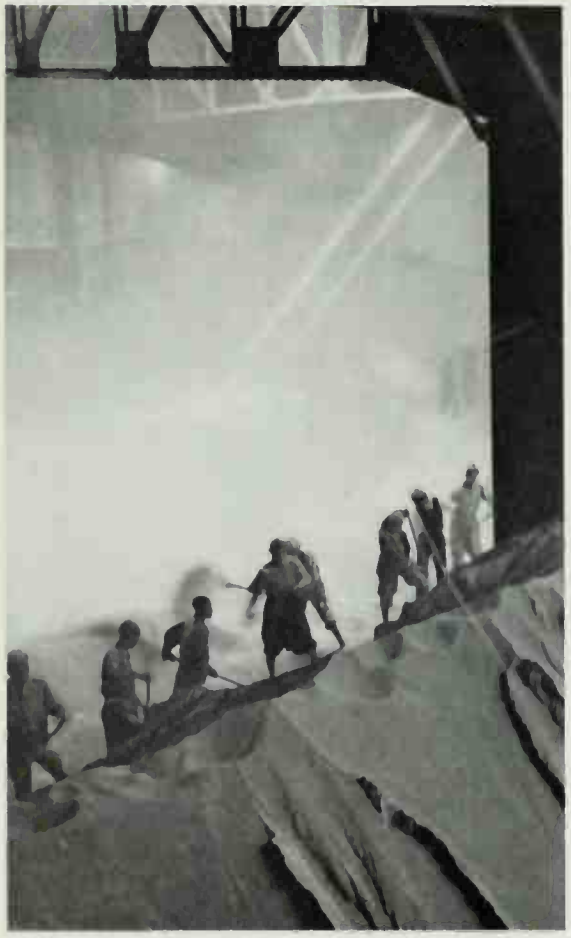
# MOROCCO

A Berber girl of the Dadès valley (on the lower slopes of the High Atlas) with facial markings and jewelry

A modern co-operative apartment building in Casablanca

An interior patio of a courthouse in Rabat showing traditional Moroccan design

Phosphate workers in Casablanca. Morocco is one of the world's largest producers of phosphates



## THE COUNTRY AND THE PEOPLE

A fantasia in the holy Muslim city of Moulay Idris in Meknès province. The tomb of Idris I, founder of the first Arab dynasty in Morocco, attracts thousands of pilgrims each year

PHOTOGRAPHS: [TOP LEFT] HAMILTON WRIGHT ORGANIZATION, INC.; [TOP CENTER] SILBERSTEIN—RAPHO GUILLUMETTE; [BOTTOM RIGHT] RAPHO GUILLUMETTE; [TOP RIGHT] AUTHENTICATED NEWS; [BOTTOM LEFT] ATLAS-RAPHO GUILLUMETTE

of renegades, in imposing for some time his authority over Tombouctou and Gao. The dynasty subsequently declined rapidly. While the last sultans of Marrakesh saw their domain being restricted, marabouts who were trying to establish autonomous provincial units quarreled over a Morocco which had fallen into a state of total anarchy.

**The Filali (Alaouite) Dynasty: Morocco in Isolation.**—Mulay Rashid, a Filali sherif from Tafilalt, succeeded in defeating the maraboutic principalities which shared Morocco among themselves, capturing Fès in 1666. Although he reunified the country, he did not live long enough to put an end to the long tradition of revolt and anarchy. His successor, Mulay Ismail (1672–1727), relying on an army of Negro slaves and lines of *qasbahs* (forts), undertook the pacification of the kingdom but was never able to establish lasting authority over the mountainous regions. He also fought unsuccessfully against the Sanhaja Berbers who were invading the Atlantic plains. His death, which left the country exhausted, was followed by disputes over the succession, which led to 30 years of bloody conflict.

From the time of Mulay Ismail, relations with Europe and with Turkish Algeria were reduced to a minimum. Morocco deliberately shut itself off within its frontiers and lived on its medieval civilization while the world around it was being transformed. The sultans who succeeded Mulay Ismail could not understand the paradoxical situation of Morocco in a world of which they condemned themselves to remain ignorant. Although they were fairly conscientious about their duties as rulers, they were incapable of resolving the economic and social problems which arose. Their efforts were limited to subduing as large a part of their empire as possible and to compelling their subjects to pay taxes. The *bled siba*, the rebellious or independent part of the country, *i.e.* "independent lands," was almost continually increasing in extent at the expense of the *bled makhzen*, the area obedient to the sultan. Mulay Mohammed (1757–90), Ismail's grandson, succeeded to some extent in restoring the authority of the sultans. Under Mulay Yasid (1790–92) the country relapsed into anarchy. Mulay Suleiman (1792–1822) brought a return to order at first but was later faced with Berber uprisings. (H. L. F. T.)

**European Intervention.**—With the reign of Mulay Abderrahman (1822–59) there began a new phase in the history of Morocco. In 1830 the French embarked upon the conquest of Algeria. When Abd-el-Kader, the leader of the resistance to the French, had established himself as ruler of western Algeria, he did homage to Abderrahman and took refuge in Morocco after being hard pressed by the French in 1843. Yielding to public feeling, the sultan of Morocco sent an army to his aid. The result was that in Aug. 1844 Tangier and Mogador were bombarded by the French fleet, and the Moroccan army was totally defeated by Marshal T. R. Bugeaud de la Piconnerie at Wadi Isly near Oujda. In September peace was signed at Tangier, the sultan undertaking either to expel or intern Abd-el-Kader if he should again enter Morocco. A convention signed at Lalla-Marnia in March 1845 defined the Algerian-Moroccan frontier. From the sea to Teniet al-Sassi the frontier was delimited on the ground, but from the latter point to the Saharan Atlas it was merely stated to which country the various tribes belonged.

In accordance with the treaty, when Abd-el-Kader again took refuge in Morocco two years later his forces were attacked by Moroccan troops and in Dec. 1847 he surrendered to the French who barred his escape to the Sahara. For the rest of Abderrahman's reign relations with France were peaceful, save for the local episode of the French bombardment of Salé in 1851.

The next ruler, Sidi Mohammed (1859–73), was called on to face a Spanish invasion. Some Anjera tribesmen outside Ceuta took offense at the building of new fortifications, destroyed the boundary posts of the Spanish enclave and defaced the Spanish arms. The usual slowness of Moroccan diplomacy in dealing with complaints was accentuated by difficulties attending the accession of the new sultan and in Oct. 1859 the Spanish government declared war. In Feb. 1860 a Spanish army entered Tetuan. Meanwhile, the British government had made clear that it would not permit a permanent Spanish occupation of the Moroccan coast or of Tangier and in April 1860 peace was restored. By its terms the Moroccan government sanctioned the enlargement of the Ceuta enclave, and agreed to pay an indemnity of 20,000,000 dourros and also to cede in perpetuity sufficient territory adjoining Santa Cruz de Mar Pequeña to establish "a fishery like that which Spain formerly had there." Neither party knew precisely where this site was and it was only in 1934, 12 years after the establishment of the Franco-Spanish protectorate, that Spain finally occupied the enclave of Sidi Ifni, which it claimed to be the area indicated. After the Ceuta episode the sultan sought to create a regular army but the attempt was not successful. Henceforth Moroccan policy was confined to reducing to a minimum the concessions necessary to pacify the foreign powers and to taking such advantage as was possible of their mutual rivalries.

Apart from acquiring a special status in Tangier the European powers by degrees assumed the right of giving "protection" to Moroccans in their service, who were thus virtually removed from Moroccan jurisdiction. During Sir John Drummond Hay's long period of office as British representative in Morocco (1844–85) Britain was the power with the most trade and influence in the country. Concerned primarily that the southern shore of the Strait of Gibraltar should not be controlled by a rival European power, Britain supported the independence of Morocco and pressed for reforms. When Sidi Mohammed died, he was succeeded by Mulay el-Hassan I (1873–94). A man of strong character, with claims to greatness, during his reign he imposed his will sufficiently to forestall any pretext for major European intervention and extended the area of country which obeyed the central government. This, however, he did by the traditional method of continuous military expeditions, which suppressed rebellious tribes and enforced the payment of taxes.

In 1880 British efforts resulted in the summoning of an international conference at Madrid, which the sultan hoped would result in the reduction of grants of "protection" to Moroccan subjects. In fact the Madrid convention not only regulated the system of "protection" but also extended the most-favoured-nation treatment already enjoyed by France since 1767, by Britain since 1856 and by Spain since 1860. In 1894 Mulay el-Hassan I died and was succeeded by his son, Mulay Abd-el-Aziz, then 14 years old. For six years the traditions of the last reign were carried on under the regency of the previous sultan's chamberlain, Ba Ahmed ou Musa. On the latter's death in 1901 the sultan took over the government himself. Full of good intentions, fond of the company of Europeans and willing to take advice from them, he was anxious to modernize his country but lacked experience. Moreover, some of his entourage, both Europeans and Moroccans, encouraged his taste for expensive toys and for diversions unseemly in Moroccan eyes, such as bicycle races for the courtiers in the palace gardens. When he attempted to introduce a modern form of land taxation, lack of preparation and of trained administrators produced a chaos in which few taxes were collected at all. The deterioration in internal security was soon shown by the rising of a pretender, known as Bu Hamara, in the region of Taza, east of Fès. Though defeated in his attempt to capture Fès, Bu Hamara was able to set up a rival government in the eastern Rif, which was only suppressed in 1908 after Abd-el-Aziz had been deposed.

The glaring contrast between Morocco's decadent medieval regime and its military impotence on the one hand and the forces of western Europe, insistently demanding new outlets, on the other, made it clear that Morocco's loss of independence was imminent. In 1901–02, in an effort to conserve the essential Morocco, the sultan signed away his rights in the central Sahara, in the Touat area. A secret draft agreement in 1902 between France and Spain provided for a division of the country, in which France would take the Marrakesh area and Spain all the rest, including Fès. The Spanish government, however, failed to ratify this agreement. In the same year the French and Italian governments agreed not to obstruct each other's plans in Morocco and Libya respectively. In 1904 an Anglo-French agreement gave France a free hand in Morocco as far as Britain was concerned (apart from an undertaking that the Moroccan coast of the straits should not be fortified) in return for British freedom of action in Egypt.

Later in the year Spanish acquiescence in French designs was secured by a French undertaking that Spain should be free to set up in a northern zone the same sort of administration that France might establish in the remainder of the country.

In 1905 a spectacular visit of Kaiser Wilhelm II to Tangier showed that German aspirations had also to be taken into account. The result was the international Algeciras conference (*q.v.*) in 1906 which, while recognizing the independence and integrity of the Moroccan empire, in fact further limited its freedom of action by setting up international organizations to participate in its affairs, legitimizing French preponderance with Spanish participation. The Moroccan government's finances were to be entrusted to a state bank of issue with a controlling French interest and Franco-Spanish gendarmerie were established in the ports. In 1907 French troops found reasons for occupying Oujda and the Beni Snassen mountains, on the Algerian border, while an attack on European workers at the harbour works at Casablanca resulted in a French landing there and the gradual extension of French influence to the surrounding country. In 1909 a similar attack on Spanish workers in the Rif mines (for which a Spanish company held a concession, granted originally by the pretender Bu Hamara) led to the landing of a Spanish force of 90,000 men and eventually to a settlement by which the tiny enclave of Melilla was enlarged. Southwest of Tangier, a Moroccan sherif, Ahmad al-Raisuni, who was both a government official and a bandit, had established a fief. There he successively captured and held to ransom Sir Harry Maclean, military adviser to the sultan; Ion Perdicaris, an American millionaire; and Walter B. Harris, a famous *Times* correspondent. Meanwhile, in 1908 increasing popular discontent with the weakness of the government and its subjection to European influence led to the rebellion of the sultan's brother and deputy in Marrakesh, Mulay Abd-el-Hafidh. After defeating Abd-el-Aziz's forces, he was recognized by the powers as sultan in Jan. 1909. In 1910 French troops further extended their sphere of operations, while the proclamation of another pretender in Meknès led Mulay Abd-el-Hafidh himself to invoke French aid, whereupon a French force occupied Fès. In 1911 Spanish troops occupied Larache and Alcázarquivir. After a final demonstration, in which the German gunboat "Panther" appeared off Agadir, German opposition was bought off with the grant to a portion of French territory (Togoland) in west Africa.

**The French and Spanish Protectorates.**—In March 1912 Mulay Abd-el-Hafidh signed the treaty of Fès establishing a French protectorate over the whole country except insofar as it was stipulated that France would recognize Spanish interests deriving from Spain's geographical position and territorial possessions on the Moroccan coast. The Spanish protectorate was established by a Franco-Spanish convention held the following November. While officially remaining an integral part of the sherifian empire, the northern tenth of the country was in fact treated as an independent unit. The sultan delegated all his powers in that area to a viceroy who was himself a member of the royal family and was treated by the Spanish government as ruler of the region. Mulay Abd-el-Hafidh, who had deposed his brother for excessive compliance with the foreigner, was then forced by a sense of shame into abdicating. In his place the French secured the appointment of another brother, Mulay Yusuf, who made co-operation with France the ruling principle of his 15 years' reign.

The signing of the treaty of Fès marked the failure of the central government to maintain the independence of the country. A rising in Fès was speedily suppressed, but there then followed the traditional Moroccan reaction—the appearance of popular leaders with tribal support. The first of these was al-Hiba, a Mauritanian chief, who sought to master the plain of Marrakesh as did the Almoravids in the 10th century. Having defeated him, the French consolidated their hold on the south by strengthening the position of the local chiefs, in particular Thami al-Glaoui, who was made a counterweight to the sultan. Far more serious was the rising under the Rifi leader, Abd-el-Krim (*q.v.*), formerly in Spanish employ. Originating in 1919 at Ajdir, near Alhucemas, among the Banu Uriaghel, a Berber tribe, the rising reached formidable dimensions after Abd-el-Krim I had, in 1921, inflicted a crushing defeat on the army of the Spanish general M. F. Silvestre at Anual, west of Melilla. During the next four years the whole Rif and the country as far as the walls of Tetuan was under an autonomous Moroccan administration directed by Abd-el-Krim. The rising was suppressed in 1926 by the co-operation of large French and Spanish armies.

Meanwhile, the two protecting powers had established the system by which Morocco was governed for the duration of the protectorate. The outward forms of the sultan's government were maintained and legislation was issued in his name or that of his viceroy in the north. Theoretically the sultan remained an absolute ruler, but in practice the country was administered by departments set up by the French and Spanish authorities and staffed mainly with Frenchmen or Spaniards. Tangier (*q.v.*), with its surrounding territory, was created an international zone administered under a statute issued in 1923. By these means Morocco was transformed in less than 50 years from a medieval empire into a modern kingdom. A splendid system of roads, ports and railways was created, and modern educational and medical services were established. A European population of more than 400,000 in the southern and 100,000 in the northern zone came into being. Of these about 100,000 lived in rural areas (mainly in the French zone) and developed a flourishing modern agriculture. New capitals were created at Rabat and Tetuan, and an industrial city and port at Casablanca. Valuable phosphate mines were developed in the south and iron mines in the north.

The general tone of the protectorate in the south was set by the first resident general, Marshal L. H. G. Lyautey (*q.v.*), who was not only a great soldier and administrator but also had much sympathy for the people whom he governed. His successors were able enough, but lacked his imagination and failed to win the support of the young Moroccans who soon began to graduate from the schools which the French had founded. Already in 1926, the year of Abd-el-Krim's surrender, groups of young men were forming societies to demand reforms giving Moroccans more scope for administrative and political activity.

In July 1936 Melilla, an enclave in the Spanish zone, was the first Spanish city to rise against republican government. Participation of Muslim Moroccan troops under Gen. Francisco Franco in Spain was a factor leading to a marked liberalization of Spanish policy in the protectorate.

World War II greatly stimulated the growth of political consciousness and in 1944, as the result of the atmosphere created by the war, the presence of Allied troops in north Africa and the resurgence of the Arab world, an organization calling itself the Istiqlal or Independence party was formed, demanding the restoration of Moroccan sovereignty. The sultan, Mohammed V (Sidi Mohammed ben Yusuf), who had succeeded as a youth of 18 on his father's death in 1927, made no secret of his sympathy with nationalist aspirations. On the occasion of his visit to Tangier in 1947, the first by a sultan since the protectorate was formed, he made an important speech which emphasized Moroccan connections with the Arab world and ignored France. The French government replied by appointing a military resident general, Gen. Alphonse Juin, and subsequently introducing some minor administrative reforms. In Dec. 1952 the Istiqlal leaders were arrested and in Aug. 1953 the services of al-Glaoui were enlisted to organize a supposedly popular movement against the sultan. The latter was then deposed and sent into exile. The measure was a complete failure and the falsity of the claim that the action had widespread Moroccan support was obvious. The popularity of the deposed sultan was immensely enhanced and the elderly prince, Mulay Arafa, who replaced him on the throne, was a nonentity who, after two attempts on his life, refused to leave his palace. Moreover, the French authorities did not take the opportunity of introducing radical reforms to mollify Moroccan opinion. Urban and rural terrorism broke out, and finally an armed rising took place in the Rif in 1955. In the autumn of that year the French government, which was then faced with a rebellion in Algeria, decided to bring the sultan back from Madagascar to France and to appoint a regency council to replace Mulay Arafa. Any value which this expedient might have had was defeated by

the action of al-Glaoui who, in a dramatic gesture, went to the sultan and on his knees acknowledged his error and begged forgiveness. The French government then yielded completely and by the declaration of La Celle St. Cloud (Nov. 1955) recognized the principle of independence for Morocco, which was implemented by the agreement of March 1956, which terminated the treaty of Fès. The Spanish government, which had regarded French policy toward the sultan with increasing apprehension for some time past, had not recognized his deposition. Spain thus avoided the troubles which had beset France, and in April 1956 recognized the independence of Morocco.

**Independent Morocco.**—The difficulties confronting the new state were enormous. Great as had been the transformation which had taken place since the establishment of the protectorate, Morocco had had no practice in self-government. There had been no constitutional development and there was a grave shortage of technicians, doctors, lawyers and teachers. It thus proved necessary to retain the services of 10,000 French and Spanish officials. Economic life had been closely integrated with that of France and Spain and could not easily or rapidly be disentangled. The two zones had entirely different economies and administrative and educational systems, and these had to be reunited; the international Tangier zone, which had hitherto had a free money market, also had to be brought in. In the south the frontiers had never been delimited and Morocco was left with unsettled claims on the Sahara and Mauritania. The "liberation army" had to be absorbed (in the early months of independence sections of it were operating in the south and were involved both in the rising of the Ba Imran [Amrane] tribe in Ifni in the autumn of 1956 and in certain raids into Mauritania), and the future of the French and Spanish troops in Morocco was left for later consideration, as was the problem of U.S. air bases which the French government had granted under the protectorate, without consulting the sultan. It was eventually agreed that French troops would be withdrawn by the spring of 1961, except for personnel at certain air-training schools, who would leave in 1963. The evacuation of U.S. air bases began in 1961. The last Spanish forces withdrew in Aug. 1961.

These various tasks had to be accomplished while the neighbouring and related territory of Algeria was involved in a violent conflict with France in which Moroccan sympathies were entirely with the Muslims fighting for independence. The former French departments were converted into ministries headed by Moroccan ministers who formed a cabinet responsible to the sultan. The first government was led by Si Embarek Bekkai, an army colonel and a nationalist without party affiliation. The remaining ministers were drawn from the Istiqlal and from the smaller Parti Démocratique de l'Indépendance (P.D.I.), with a few Independents. The sultan declared his intention of transforming the state into a constitutional monarchy, and as a first step nominated a consultative assembly representative of all main sections of opinion. He later emphasized his intentions by changing his title from sultan to king. The liberation army was largely absorbed into the new royal forces which were formed by the transfer of Moroccan regiments formerly serving under the command of the French and Spanish authorities. In Oct. 1956 the international status of the Tangier zone was abolished and agreement was secured for its reabsorption. In April 1960 Tangier was totally integrated into the Moroccan economy and its free monetary market and absence of import-export controls were revoked. Morocco accepted the Eisenhower doctrine (*q.v.*) in 1957. In Feb. 1958 the franc currency of the southern zone replaced the peseta currency of the northern zone and in 1959 a new Moroccan currency was established for the whole country based on the *dirham* (*see Trade and Finance*, below). The Moroccan government at the same time established an issue bank which took over the functions which the Banque d'Etat du Maroc had assumed after the Algeciras conference.

The principles of constitutional development were laid down by the king in the royal charter of May 1958 (*see Government and Constitution*, below, for constitutional development). In 1956 the diversion by the French authorities of a chartered Moroccan plane carrying five Algerian rebel leaders as the guests of the king and the arrest of the passengers led to disturbances at Meknès and the massacre of more than 40 French settlers. In April 1958 an agreement was reached with Spain for the cession of the Spanish protectorate of Southern Morocco, but not Ifni. In Oct. 1958 Morocco joined the Arab league. At the end of 1958 a dissident movement broke out in the Rif, but was brought to an end by an ultimatum of the king and the dispatch of troops to the area (Jan. 1959).

The original ministry was modified in Nov. 1958 by the elimination of the P.D.I. ministers. In May 1958 a movement for a more homogeneous Istiqlal ministry resulted in the appointment of Ahmad Balafrej, secretary-general of the party, as prime minister. However, this did not satisfy the more active left-wing members and in Dec. 1958 the king appointed Abdullah Ibrahim as prime minister with Abderrahim Bouabid as deputy. The new government was strongly supported by the powerful Labour leader Mahjoub ben Saddiq (Seddik). In Jan. 1959 the Istiqlal party split in two, the seceding element being led by Mehdi ben Barka, who had been president of the consultative assembly. The new movement had the sympathy of the prime minister and his deputy, but was opposed by the president of the party, Allal el-Fasi, and by the secretary-general, Ahmad Balafrej, who retained control of the party machine. Finally in Sept. 1959 Mehdi ben Barka announced the formation of a new party, to be called the Union Nationale des Forces Populaires (U.N.F.P.). This comprised dissident Istiqlal, dissident P.D.I. and some Liberal Independents, while a new party, the Mouvement Populaire, having connections with the Berber tribal areas, came into being. On the occasion of the long-delayed local government elections in 1960, the king dismissed the government of Abdullah Ibrahim and himself assumed the premiership with Crown Prince Mulay Hassan as his deputy, promising the issue of a constitution by the end of 1962. In Jan. 1961 a conference at Casablanca, presided over by the king, founded the Casablanca group of African states. On Feb. 26, 1961, after a minor operation, King Mohammed died and was succeeded by the crown prince, who took the title of Hassan II. The new king continued his father's policy, forming a new government in June 1961.

In 1963 elections were held under a constitution drafted by the king's advisers but overwhelmingly ratified by plebiscite. This established a two-house parliament while reserving ultimate authority to the king. Universal, including female, suffrage yielded a lower house with 41 Istiqlal and 28 U.N.F.P. members (both in opposition) while the newly formed governmental Front for the Defense of Constitutional Institutions (F.D.I.C.) gained 69 seats. Before further elections were held several leading figures in the U.N.F.P. were arrested for alleged conspiracy to assassinate the king and forcibly overthrow the regime. As Istiqlal (complaining of administrative obstruction) as well as U.N.F.P. boycotted the remaining elections, the government secured a big majority in regional councils and the second house. After a much-criticized trial 11 accused (8 in their absence) received death sentences in March 1964. In Oct. 1963 Algerian failure to open promised negotiations on Moroccan frontier claims was followed by an Algerian surprise attack on the desert outpost of Hassi Beida. The Moroccan army recaptured the post and repelled further Algerian attacks on undoubted Moroccan territory. Peace was restored by the mediation of the Ethiopian emperor and the African Unity organization. Relations improved with the January Arab summit conference in Cairo.

(N. Ba.)

## IV. POPULATION

The last censuses before independence gave the following population figures: French zone (1952) 8,093,847, including 362,814 Europeans and 196,156 Jews; Spanish northern zone (1950) 1,010,117; the territory of Ifni (1950) 38,285; areas of Spanish sovereignty in the north (1950) 141,302; Spanish southern zone (1950) 3,678; and the international zone of Tangier (1946 est.) 175,000. After independence the 1960 census showed a total population of 11,626,470, of whom about 153,000 were Jews, 195,000 French, 73,000 Algerians and 121,000 Spanish.

The Muslim population has a high rate of increase. So have the Jews, but their population figures have been affected by migration to Israel. Most of the Jews live in the towns, nearly one-half of them in Casablanca.

Population is densest on the western plains and on the borders of the mountain massifs; the high regions do not lend themselves to permanent habitation. The populations of the chief towns were as follows (1960 census): Casablanca 965,277; Marrakesh 243,134; Rabat 227,445; Fès 216,133; Meknès 175,943; Tangier 141,714; Oujda 128,645; Tetuán 101,352; Kenitra (formerly Port Lyautey) 86,775; Safi 81,072; Salé 75,799; El Jadida (Mazagan) 40,302; El Qsar El Kebir (Alcázarquivir) 34,035; Larache 30,763; Essaouira (Mogador) 26,392; Melilla and Ceuta (Spain in Morocco) 79,056 and 73,182 respectively. (*See* also separate articles on these towns.)

In 1907, outside the ancient Spanish possessions, there were not more than 5,000 Europeans in Morocco, of whom 4,000 were in Tangier. European immigration was rapid after the French protectorate had been established. The European population was essentially urban. Casablanca had 135,000 in 1952, Rabat 41,000, Oujda 27,000, Meknès 21,000, Fès 15,000, Marrakesh 12,000 and Kenitra 9,000. The rural population of European extraction consisted of about 4,700 colonists (10,000–12,000 including their families) who lived on the land. After independence the European population declined and in 1960 numbered about 320,000.

(A. Am.)

*Population of Morocco*

| Political subdivision | Population (1960 census) | | |
|---|---|---|---|
| | Total | Urban | Percent urban |
| Independent Prefectures | | | |
| Casablanca | 965,277 | 965,277 | 100.0 |
| Rabat | 227,445 | 227,445 | 100.0 |
| Provinces | | | |
| Agadir | 843,758 | 58,068 | 6.9 |
| Al Hoceima | 191,495 | 13,559 | 7.1 |
| Beni Mellal | 474,001 | 66,217 | 14.0 |
| Casablanca | 1,407,241 | 258,001 | 18.3 |
| Fès | 830,999 | 260,191 | 31.3 |
| Ksar-es-Souk | 380,949 | 27,416 | 7.2 |
| Marrakesh | 1,990,808 | 390,038 | 19.6 |
| Meknès | 577,137 | 233,568 | 40.5 |
| Nador | 347,566 | 19,367 | 5.6 |
| Ouarzazate | 434,486 | 9,064 | 2.1 |
| Oujda | 523,130 | 237,205 | 45.3 |
| Rabat | 1,156,555 | 264,122 | 22.8 |
| Tangier | 164,216 | 141,714 | 86.3 |
| Tarfaya | 18,361 | 1,521 | 8.3 |
| Taza | 445,745 | 38,242 | 8.6 |
| Tetuán | 647,271 | 200,022 | 30.9 |
| Total | 11,626,470 | 3,411,037 | 29.3 |

*Note.* Provincial capitals bear the same name as the provinces.

## V. ADMINISTRATION AND SOCIAL CONDITIONS

**1. Government and Constitution.**—Under the French protectorate the sultan's enactments had to be ratified by the French resident general, and similar conditions obtained in the Spanish zone and the international zone of Tangier. With independence the sultan (renamed king in 1957) was again the unfettered source of all power, both executive and legislative. A cabinet had been set up in 1955 but the ministers were chosen by the king and responsible only to him (the king himself became prime minister in 1960), and a national consultative assembly with very limited powers existed from 1956–59. The king also held supreme religious authority as *amir-al-muminin*, or commander of the faithful.

The interim Basic Law of June 2, 1961, was a statement of principles and of civil liberties rather than the text of a constitution, but it announced the coming grant of a constitution and representative institutions. This law was approved by plebiscite on Dec. 7, 1962. It defined Morocco as an Arab and Muslim kingdom and constitutional monarchy, it confirmed Morocco's faithfulness to the Arab league and the charter of the Casablanca conference; it fixed the method of royal succession and the powers of the king, which included supreme command of the armed forces and sole power in case of national emergency; it provided for a chamber of representatives elected by direct universal suffrage, and an upper chamber of counselors indirectly elected, for a cabinet system of government, with ministers chosen by the king; for a judicial system headed by a high court of justice; for the functioning of provincial, prefectural and communal organizations; for a higher council for national development and planning; for a constitutional chamber of the supreme court with power to decide in matters of constitutional dispute; and for the means of revision of the constitution. The constitution was promulgated by King Hassan on Dec. 14, 1962.

*Local Government.*—The country is divided administratively into 16 provinces and 2 urban prefectures. The provinces are: Agadir, Al-Hoceima (Alhucemas), Béni Mellal, Casablanca, Fès, Ksar es Souk, Marrakesh, Meknès, Nador, Ouarzazate, Oujda, Rabat, Tangier (Tanger), Tarfaya, Taza and Tetuán. The prefectures are the cities of Casablanca and Rabat. At the head of each province or prefecture is a governor, appointed by the king and assisted by a secretary-general. Each province is divided into a number of *cercles*, each of which contains tribes under *caids*. In the late 1950s the government began to replace the tribe with the commune as the basic administrative unit. The communes each contain about 10,000 persons and are controlled by councils elected by universal suffrage (the first municipal and communal elections were held in 1960).

**2. Political Parties.**—During the last years of the protectorate, the struggle for independence was carried on by several parties. In the French zone, the Istiqlal (Independence) party was the most important and active, followed by the Parti Démocrate de l'Indépendance. The northern zone likewise had its parties.

After independence, the Istiqlal remained the chief party for a short time and was continuously represented in the government. But in Jan. 1959 a split occurred which produced the Union Nationale des Forces Populaires (U.N.F.P.). This was more socialist and depended on the working-class element and its trade union, the Moroccan Workers' union (U.M.T.). Other parties, more recently created, were the Popular movement, the Democratic Constitutional party and the Social Democrat party. The 1963 elections, however, were won by the newly formed F.D.I.C. (See *History*, above.)

**3. Taxation.**—The fiscal reforms of Dec. 30, 1961, were guided by economic and social rather than by purely financial considerations. The most important measure was the institution of a farm tax replacing the former *tertibs*, or direct taxes levied on farm incomes. The *tertib* was levied on actual production and bore heavily on small farmers. The new tax was levied on the potential net revenue; *i.e.*, on the productive capacity per hectare, calculated on a basis of production over the last ten years. The tax is progressive and exempts earnings not exceeding 1,400 *dirhams* (£100 or $280) annually. Under this system about 90% of farmers (*i.e.*, those farming less than 20 ha.) are exempted from the tax. The reforms also modified other taxes, such as those on salaries and professional incomes and on licences, and it replaced the tax on transactions by a tax on products and services which involved lower tax payments and more exemptions, especially for the lowest income groups.

**4. Living Conditions.**—*Employment.*—As a predominantly agricultural country, Morocco has difficulty in guaranteeing work to all its inhabitants. The constant increase in population (2.5% annually) aggravates the problem, for which economic development compensates only with difficulty.

In the country districts, underemployment takes a chronic form. It is noticeable during the "dead" seasons, when drought makes all farm work impossible. In this form, underemployment affects about 50% of the rural population and is the hallmark of the driest regions: Tafilalt, parts of Agadir, Ouarzazate, Marrakesh, etc. In the towns, underemployment takes a more serious form. Idleness is almost total, for the labour force employed in industry and commerce can only with difficulty be increased. Characteristic of this type of underemployment is the *bidonville* or shantytown. These are wretched native quarters in the suburbs (chiefly at Casablanca), where thousands of people with neither money nor belongings live heaped in hovels built of planks or sheet iron.

Under the five-year development plan (1960–64) the authorities hoped to remedy this situation by stimulating agriculture, by par-

celing out irrigated areas and by modernizing and extending cultivation. To help industry new workshops and factories were being built. Parallel with this was the development of residential districts in order gradually to eliminate the shanty towns.

Commerce and administration occupy a busy minority of Moroccans in the towns, especially in the chief centres such as Fès, Marrakesh, Rabat, Casablanca. Moroccan staffs are gradually replacing Frenchmen and foreigners, although these are still numerous in certain specialized occupations like teaching, public works, mining, public health, etc.

*Trade Unions.*—After the recognition of freedom for trade unions in 1955, the Union Marocaine du Travail (Moroccan Workers' union) was founded. By the following year it claimed 500,000 members. When the Istiqlal party split in 1959, the union did likewise shortly after, the new body being the Union Générale des Travailleurs Marocains (General Moroccan Workers' union), following the traditional Istiqlal line. The original union however remains one essential element of union life. The unions' activities are varied: negotiations with the government or with employers; meetings; strikes. Members are mostly wage and salary earners but there are also some civil servants. In the early 1960s an increasing number of women were joining, many of them workers in the textile or food industries (especially in preserves).

*Housing.*—The most important feature at mid-20th century was the rapid development of the towns. They have a characteristic layout. The old centre with its low-built houses is by itself and usually surrounded by ramparts. The new, modern town nearby displays every variety of European architecture with its rows of handsome buildings ranged along broad, tree-planted avenues, its villas, etc. The shanty towns sprawl around the edges of these charming and commodious districts.

In the countryside, people live in houses that suit their mode of life. In the pre-Saharan regions the nomads still live in tents. Seminomads have tents, but also villages which they come back to for part of the year. Settled farmers have permanent houses of various designs. In the south these are of red earth with flat roofs, clustered in villages called *ksours*. In the plains there are both houses, white in colour, and huts made of branches, called *nouallas*. In the north, where it is colder and wetter, houses are of stone and have sloping roofs, usually thatched.

**5. Health.**—The ministry of health is responsible for the management of hospitals, clinics and treatment centres and controls and inspects nursing homes, pharmacies and laboratories producing drugs. Both state and private doctors can practise and many of the latter are attached to the state health service by contracts which allow them to work part-time in private health centres. In the early 1960s the health service had about 500 full-time doctors, 15,000 hospital beds and 600 clinics and treatment centres.

To make the people aware of the medical treatment available nationwide campaigns against disease by vaccination, mass X-rays, etc. are coupled with health education propaganda through the media of radio, the press and posters. Provision is also made for material assistance to the aged and the physically handicapped.

**6. Justice.**—Before the protectorate, questions of personal status and succession were dealt with according to koranic law by the *qadis* (cadis), everything else, and above all criminal justice, being judged by the *caids* (among the tribes) and the pachas (in the towns). Under the French protectorate a *commissaire du gouvernement* was placed in the Moroccan courts and given considerable powers of control over their proceedings. Two central appeal courts were set up at Rabat, one for secular justice and one for koranic law. Among the Berber tribes the regulation of persons and goods was often governed by customary law, modified by koranic law, which varied from one region to another. The French codified this customary law in 1930. It was administered by "customary courts" consisting of elders of the tribe, and there were several courts of appeal, one for each region. The Jews maintained rabbinical courts, administering the law of Moses. Foreigners were not subject to Moroccan law. Before the protectorate they were judged in their own consular courts. During most of the period of the French protectorate they came under the French judicial system, although Great Britain retained its capitulatory rights until 1937 (and longer in the Spanish protectorate) and the United States did so until Moroccan independence.

After independence the former courts continued under the name of "modern courts" dealing (in the French language) with all cases concerning foreigners. These comprise justices of the peace, courts of first instance and, at Rabat, a court of appeal. Cases involving Moroccans come before regional courts, with similar organization, the caids and pachas having lost their old judicial functions. In the former northern zone, with Tangier, however, modern and regional courts have been combined and there is a separate court of appeal at Tangier. The supreme court of justice (Majlis el Ala), or court of cassation, at the apex of the whole system, is at Rabat.

**7. Education.**—In the early 1960s more than 700,000 pupils (about one-tenth French) were undergoing primary education and about 40,000 (one-seventh French) secondary education in Moroccan schools. About 6,000 pupils (one-fifth foreigners) were receiving technical education. In addition, about 50,000 pupils were in primary schools run by the French University and Cultural mission, and 10,000 in secondary schools also run by the mission. Most of these pupils were French or other foreigners. The teaching of Jewish children is mostly carried out by the Universal Israelite alliance, subsidized by the Moroccan government.

The teaching in the French mission's establishments conforms to French syllabi and is designed to lead to French diplomas. In the national schools teaching is carried out in both French and Arabic. Secondary education (for six years) leads to a Moroccan baccalaureate, established in 1963.

Modern higher education is provided by the Moroccan university at Rabat; this was formed in 1957 from the Institute of Moroccan Higher Studies (now the faculty of arts and social science), the Centre of Higher Scientific Studies (the faculty of science) and the Centre of Legal Studies (the faculty of law and economics). A school of practical medicine was established at Casablanca in 1939 and became a faculty of medicine in 1962. These faculties award French and Moroccan diplomas; the teaching language is French or Arabic and most of the staff is French. Moroccan law and arts degrees have been established. In 1963–64, of more than 7,300 students in institutions of higher education only about 1,500 were non-Moroccan. Some Moroccans also pursue their studies abroad, especially in France.

Side by side with the modern faculties there is a traditional system of higher education given in Islamic institutions, of which the most important are the mosque of Al Qaraouiyyin (Karouine) at Fès, founded in the 9th century, where there is instruction in religion and particularly koranic law, and the Université Ben Youssef de Marrakech.

**8. Defense.**—One of the first concerns of independent Morocco (1956) was the creation of a national army. In the early 1960s this had 35,000 men under the king (as head of the armed forces) and the ministry of defense. It included former Moroccan units of the French army, soldiers of the former liberation army and new recruits. Many of its 1,300 officers, mostly Moroccans, were trained at Meknès, Tolède or Saint-Cyr. The troops occupy stations in the interior and on the frontiers. They helped to build the Route de l'Unité, finished in 1957 by volunteers. Later they were associated with UN forces in the Republic of the Congo.

The air force and the navy are smaller than the army, but the air force has a considerable number of Moroccan pilots and technicians who work with foreign technicians at the bases. Under an agreement of Nov. 1960 Soviet military aircraft were supplied to Morocco in 1961 accompanied by Soviet technicians.

## VI. THE ECONOMY

The economy is divided into traditional and modern complexes. The former is basically a subsistence economy in self-contained rural communities. The modern money economy, introduced by Europeans, encompasses agriculture, mining, industry, trade, transportation, etc. The five-year plan (1960–64) envisaged economic expansion, gave priority to agricultural development and creation of basic industries, and proposed greater state guidance and participation in these sectors. Other important sectors

scheduled for development were urban welfare, infrastructure and education. Priority was also to be given to the training of technicians and administrators.

**1. Production.**—*Agriculture.*—Morocco is essentially an agricultural country, about one-quarter of its area being cultivable. In the former French zone between 4,000,000 and 5,000,000 ha. are effectively cultivated. The regions most favourable to agriculture are the Rharb plain, the Sebou valley, the province of Casablanca, the districts around Meknès and Fès, and the Ouergha valley. As a result of important dam construction and irrigation projects the Tadla, Basse Moulouya, Haouz and Doukkala have become agriculturally productive.

Cereals are by far the most important crop of the southern zone, covering nine-tenths of the area under cultivation, but the yields are no more constant than the rainfall. During the 1950s about 1,000,000 ha. of hard wheat were grown, with annual output about 800,000 metric tons, the figures for soft wheat being about 500,000 ha. and 400,000 metric tons, for barley 2,000,000 ha. and 1,750,000 metric tons, and for maize (corn) 500,000 ha. and 300,000 metric tons. Rice, introduced to the Rharb after World War II, occupied about 5,000 ha. by the late 1950s and yielded 19,000 metric tons. (In the northern zone the production of cereals was about 250,000 metric tons from about 300,000 ha.) Market gardens occupied about 60,000 ha., of which more than half were irrigated, and made an important contribution (tomatoes, vegetables) to exports. Industrial crops have not been much developed, although cotton has been introduced into the irrigated land around the Tadla and flax was more widespread. Sugar beet was being grown in the Rharb. Two-thirds of the crop of citrus fruits was exported. Vines are cultivated almost entirely by Europeans and yield on average about 1,500,000 metric tons of grapes with three-quarters of the wine harvest of 2,000,000 hl. being exported. On the other hand the Moroccans own most of the olive trees, fig trees and almond trees. The dates, grown in the oases of the Dra valley and the Tafilalt, are rather poor and not exported.

The raising of livestock makes an important contribution to the economy, particularly in the mountains where there is green pasturage throughout the summer. Sheep, goats, cattle, donkeys, horses and mules are raised; and dromedaries in the Sahara and on the steppes of eastern Morocco. Of 15,000 metric tons of wool produced annually, about one-quarter is usually available for foreign markets. Leather is manufactured from cowhide and goathide. Pigs are reared and eaten only by Europeans.

*Forestry.*—The forested areas of Morocco produce wood, cork and some esparto. In the late 1950s annual production figures (northern and southern zones together) were about 25,000 metric tons of virgin cork and 10,000 tons of cultivated (reproduction) cork. The esparto country in the southern zone covered about 2,500,000 ha. and produced about 200,000 tons of green esparto.

*Fishing.*—This has become a major export industry and by the early 1960s the average catch (mainly sardines) exceeded 160,000 metric tons annually. The major centres are Agadir, Safi and Casablanca where are concentrated most of the fish canning plants.

*Mining.*—The principal mineral resources of Morocco, and a state monopoly, are the phosphates of Khouribga and Youssoufia (formerly Louis Gentil). By the early 1960s the annual yield was in excess of 8,000,000 metric tons, nearly all of which was exported. There is some iron, the most important production (over 900,000 metric tons annually) being at the Onichane mine near Nador, with some from the Ait Amar mine; and there are rich deposits of lead and zinc, chiefly in eastern and southern Morocco. There is some cobalt in the Anti-Atlas (Bou Azzer, 1,000 metric tons annually), and manganese in the same region (Ouarzazate) and in the east (Bou Arfa). In the northern zone only the iron workings in the hinterland of Melilla are important. In 1961 a pocket of natural gas was discovered near Essaouira (Mogador). The new oil refinery at Mohammedia depends essentially on imported supplies of crude oil.

*Power.*—The provision of power presents difficulties in Morocco, for there is little coal (about 500,000 metric tons annually in the early 1960s from the mines at Jérada, near Oujda) and little oil (75,000 metric tons in the region of Sidi Kacem in the Rharb). However, there is abundant waterpower in the Atlas mountains, and with the construction of great dams, *e.g.*, at Bin el Ouidane on the Oued el Abid, the output of hydroelectricity exceeded that of thermal electricity from 1953. About 90% of all electricity is now produced by hydroelectric stations.

*Manufacturing.*—Most of Morocco's manufacturing industries are concentrated around Casablanca and Mohammedia (Fédala), including metallurgy, textile mills, sugar mills, a tobacco factory, a cement works, brickworks, an oil refinery and vegetable canning factories. Efforts have been made, however, to industrialize the rest of the country: Kenitra has paper and cotton industries; Fès has an important textile industry (established in 1962); petroleum is refined at Sidi Kacem and at Mohammedia; and work on a chemical industrial complex, known as the Safi project, to process phosphate rock, was started in Dec. 1961.

**2. Trade and Finance.**—From 1906 foreign trade was controlled by article 1 of the Act of Algeciras which extended to all nations the Anglo-Moroccan treaty of 1856 and obliged Morocco to remain open to trade with a uniform *ad valorem* duty of 12½%. With independence, the Moroccan government negotiated with Great Britain the abolition of the 1856 treaty, thus bringing about the ending of the article of the Algeciras treaty. In 1957 a new customs tariff was promulgated with rates varying between 2% and 48%, tending to favour the import of raw materials, limit the import of inessential consumer goods and protect local industries. The former international zone of Tangier continued to benefit from a special and extremely liberal system until 1960, and in 1962 Tangier became a free port.

In the early 1960s the value of imports exceeded 2,000,000 dirhams annually. One-quarter consisted of foodstuffs, particularly tea and sugar of which the Moroccans are big consumers, and more than half of manufactured products. France was the chief supplier, other important suppliers being the United States, the Federal Republic of Germany, Cuba (sugar), China (tea) and Great Britain. Of exports, valued at more than 1,760,000 dirhams, about one-third were minerals (mostly phosphates); rather less than half were foodstuffs, including fresh vegetables, tomatoes, citrus fruit, wine, cereals and canned fish; and less than one-tenth consisted of manufactured goods. France was Morocco's chief customer, taking about half of its exports (three-fifths with Algeria), other important customers being the Federal Republic of Germany and Great Britain.

During the French protectorate the Moroccan franc (which replaced the peseta in the northern zone in 1958) had parity with the French franc. In 1958 Morocco refused to follow the 17.5% devaluation of the French franc, although it remained in the franc area. But in 1959 the Moroccan franc was devalued by 20.44% and a new monetary unit was created, one dirham being equivalent to 100 Moroccan francs. The rate of exchange thus became 5.06 dirhams to the U.S. dollar and 14 to the pound sterling. The Moroccan central bank (Banque du Maroc) was set up in 1959, and has the sole right to issue notes.

Since independence Morocco has had a single ordinary budget; this balanced at 2,143,000,000 dirhams in 1964. There is also a "development" budget 819,000,000 dirhams in 1964, of which half was derived from local sources, particularly the state phosphate monopoly.

**3. Communications.**—In the early 1960s the southern zone of Morocco had more than 6,000 km. (3,720 mi.) of main roads and nearly 5,000 km. (3,100 mi.) of secondary roads, nearly all tarred or asphalted; there were also about 40,000 km. (24,800 mi.) of tracks, very few tarred or asphalted. The northern zone had about 2,500 km. (1,550 mi.) of roads, less than half being macadamized; the greatest construction efforts were being made in this zone.

The 2,000 km. (1,240 mi.) of nationalized railway include part of the main line from Algiers to Marrakesh via Oujda, Taza, Fès, Meknès, Rabat and Casablanca, with extensions in one direction toward Tangier and in the other toward the phosphate mines of Khouribga and to Safi; the eastern Moroccan line which serves the coal mines south of Oujda, the manganese mines of Bou Arfa and

the Algerian coal mines at Kenadsa. Nearly 700 km. (434 mi.) of line are electrified, notably the Marrakesh-Casablanca-Fès section.

Casablanca (*q.v.*) is by far the most important of the ports, the traffic handled in the early 1960s was about 10,000,000 metric tons annually, of which four-fifths consisted of phosphates. It has nearly 5,000 m. (16,400 ft.) of deep-water quays and is protected from the sea by two breakwaters. In order of importance, the other ports are Safi, exporting phosphates and canned fish; Kenitra, Mohammedia (formerly Fédala), importing hydrocarbons, and Tangier. (Ceuta and Melilla are Spanish.)

The airport at Casablanca provides services with Europe and west Africa. There is also a civil aerodrome for jet aircraft at Nouaseur.

Morocco has cable communications with Europe and Algeria and telephone systems in the more important towns. Radiodiffusion Marocaine in Rabat is a state monopoly with two networks broadcasting in (1) Arabic, with some transmissions in Berber, and (2) French, Spanish and English. A state television station works from Casablanca.

*See* also references under "Morocco" in the Index.

(A. AM.; G. L. M.)

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**MOROGORO REGION, TANGANYIKA,** established in May 1963 following a reorganization of administrative units in Tanganyika, comprises Morogoro, Kilosa and Ulanga districts, which previously belonged to the former Eastern region. It is bounded north by Northern (Arusha) and Tanga regions, east by Coast and Mtwara regions, south by Ruvuma region and west by Iringa and Dodoma regions. Area 28,400 sq.mi. Pop. (1957) 547,558. Morogoro and Kilosa districts are drained by the Wami and Ruvu rivers and contain the isolated Uluguru mountains (8,858 ft.), part of the Nguru mountains (6,928 ft.) and the Ukaguru (7,432 ft.) and Usagara mountains along the faulted plateau escarpment. Ulanga district, south of the Great Rusha river, includes the Kilombero valley, and Mahenge plateau (4,400 ft.) and part of the Selous game reserve. Its rivers are tributaries of the Ruñji which, with the Mbarangandu, forms part of the eastern boundary of the region. Faulted Pre-Cambrian metamorphosed rocks predominate, flanked to the east by fossiliferous Karroo and some Jurassic and Tertiary sediments. Mean annual rainfall, generally more than 30 in., reaches 50–70 in. on high ground. Rain falls mainly during November–May, the wettest months being March and April. Temperatures may be uncomfortably hot, but are usually cool at night and on high ground. Varied soils include red and yellow latosols on slopes and poorly drained alluvial soils. Brachystegia woodland (*miombo*) is widespread with woodland savanna and some grassland.

Regional headquarters are at Morogoro near the densely populated and cultivated Uluguru mountains. Mica is mined on a small scale nearby. Among the larger African tribes are the Luguru, Nguru, Kutu (Khutu), Kaguru, Sagara, Vidunda, Pogoro, Ndamba and Bena. Cash crops include sisal, kapok, cotton, castor and sunflower seeds, sugar cane and tobacco. Wide areas are infested with tsetse fly. The veterinary department has, however, a ranch for cattle breeding on the Mkata plain. Morogoro and Kilosa are connected by rail with Dar es Salaam and with the interior.

(J. M. KE.)

**MORON,** a person with the mildest form of mental deficiency, the definition usually includes those persons with an intelligence quotient of between 50 and 70 approximately. In Great Britain morons are called the feeble-minded. *See* MENTAL DEFICIENCY: *Classification*; RETARDED CHILDREN.

**MORONE,** the name of two distinguished Italian painters, father and son, of the Veronese school.

DOMENICO MORONE (*c.* 1442–*c.* 1517) is represented by few surviving works. The frescoes he executed in S. Bernardino at Verona (1503) and in the little church of S. Niccolò di Tolentino at Paladon (now in the Museo Civico) are not well preserved. There are, however, a few signed works that reveal him as a spirited painter of much grace and decorative quality, one being the large canvas in the Reggia at Mantua, painted in 1483 for the marquis of Mantua and illustrating the fight between the Gonzagas and the Bonacolsi. Other works by or attributed to Domenico Morone may be seen in the National Gallery of Art, Washington, D.C.; in the Metropolitan Museum of Art, New York city; and at Oxford university.

FRANCESCO MORONE (*c.* 1471–1529), Domenico's son, after working as an assistant to his father, began work as an independent painter and in 1496 produced the "Crucifixion" in the church of S. Bernardino. His greatest work in fresco was the decoration of the walls and ceiling of the sacristy of Sta. Maria Organa with incidents freely adapted from Andrea Mantegna's "Camera degli Sposi" at Mantua. This work is one of the greatest monuments of local art. In the same church is an altarpiece (1501) of the Madonna enthroned between two saints, a work fine in colour and design and of remarkable finish. Francesco died on May 18, 1529.

**MORONE, GIOVANNI** (1509–1580), Italian cardinal and bishop, one of the ablest papal diplomatists of the Reformation period, was born on Jan. 25, 1509, at Milan, where his father was grand chancellor. At the early age of 20 he was named bishop of Modena, but the appointment was opposed by Cardinal Ippolito d'Este and Morone only obtained possession of the see in 1537, after agreeing to pay D'Este an annual pension of 400 ducats. In 1536 Paul III sent him as nuncio to Ferdinand I. "At last the German nunciature is no longer filled by second- and third-rate personalities," people said. The jurist Cristoph Scheurl described him as "wide-awake, pleasant, persuasive, acceptable to the king and the nobles." A shrewd observer of the German scene, Morone saw that there were faults on both sides. Some of the German apologists he reproached with reducing their Catholicism to abuse of Luther. He assisted at the diets of Hagenau (1540), Ratisbon (1541) and Speyer (1542), where he succeeded in getting Trent accepted as the locality of the council which Paul III convoked for Nov. 1. On his return to Rome he became a cardinal. In October he set out for Trent as papal legate, with Cardinals Paul Parisio and Reginald Pole, but the council did not open until 1545. In 1544 he became governor of Bologna, so he played no role in the first period of the council. He was bishop of Novara from 1553 to 1560, and bishop of Ostia from 1570.

In 1557 Paul IV imprisoned him in Castel Sant' Angelo on suspicion of unorthodox opinions on the subjects of justification, invocation of saints and veneration of relics. The charges could not be substantiated, however, and he was offered his release if he would ask for mercy, but he demanded justice. He was set free on Paul IV's death in 1559, and Pius IV proclaimed his innocence. In 1563, as president of the Council of Trent, he brought its last period to a successful conclusion. In the conclave of 1561 Cardinal Charles Borromeo proposed electing him to the papacy, but this was prevented by Antonio Ghislieri (later Pius V), who still felt uneasy about the orthodoxy of this distinguished servant of the church. Morone, as cardinal protector of England, was active in the administration of the English college in Rome (1578–79). He died there on Dec. 1, 1580.

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(EA. G.)

**MORONI** (MORONE), **GIAMBATTISTA** (GIOVANNI BATTISTA) (*c.* 1525–1578), Italian portrait painter of the Bergamask

school, was born at Albino near Bergamo and became a pupil of Il Moretto (Alessandro Bonvicino). His portraits are full of straightforward life and individuality, with genuine unforced choice of attitude and excellent texture and arrangement of draperies; there is a certain tendency to a violet tint in the flesh. Portraits by Moroni may be seen at many galleries in the United States, including those at Detroit, Minneapolis, Worcester, Mass., Cleveland, Chicago (Art institute), New York (Metropolitan Museum of Art), San Francisco (California Palace of the Legion of Honor) and Washington, D.C. (National Gallery of Art). He is represented also at the National gallery, London (the well-known "A Tailor"), and at museums on the continent.

**MOROSINI,** a noble Venetian family which gave many doges, statesmen, generals and admirals to the Venetian republic, as well as cardinals to the church. They first became prominent during the late 10th century, when they destroyed the rival family of the Caloprino for planning to surrender Venice to the emperor Otto II.

DOMENICO MOROSINI (d. 1156), elected doge in 1148, was successful in consolidating and extending Venetian power in Istria, Dalmatia and the Adriatic. MARINO was doge from 1249 to 1253. MICHELE, who played a conspicuous part in the peace negotiations with Genoa after the War of Chioggia, was doge from June to Oct. 1382. ANTONIO (born between 1365 and 1368; d. *c.* 1434) wrote a history of Venice and chronicled the events of his own time so scrupulously that he was forced by the government to amend the text. By contrast a later Morosini, ANDREA (1558–1618), was officially charged by the senate with continuing Paolo Paruta's *Annali veneti* in Latin, which he did for the years 1521–1615. Though better known, his history is less interesting than Antonio's; even so it displeased the authorities, only this time of the church, not the state. It was edited and published by his brother, PAOLO, in 1623, and translated into Italian by senator Girolamo Molin (1782). Among his other works are: *Le imprese ed espeditioni di terra santa* (printed 1627); *De iis quae veneta respublica ad Istriae oras gessit; De forma reipublicae venetae.*

FRANCESCO MOROSINI (1618–1694) rose by his actions in the Turkish wars to become one of the greatest captains of his time. He began his career in 1636. Appointed commander in chief of the Venetian navy in 1657 he conducted a series of successful campaigns against the Turks but was recalled in consequence of the intrigues of his rival, the *provveditore* Antonio Barbaro (1661). In 1665, however, he was reappointed; and when Candia was attacked he was sent to relieve it in 1667. The siege lasted 18 months, but Candia was forced to surrender to save the surviving inhabitants. Morosini was tried but acquitted of all blame, and on the renewal of the war with the Turks in 1684 he was again appointed commander in chief. After several brilliant victories he reconquered the Peloponnese and Athens; on his return to Venice he was loaded with honours and given the title of "Peloponnesiaco." Elected doge in 1688, he took command of the Venetian forces against the Turks again in 1693; the enemy, which had been cruising in the archipelago, withdrew at his approach, so great was the terror inspired by his name. He died at Napoli di Romania (Nauplia) on Jan. 6, 1694.

The family still continues.

*See* L. Damerini, *Francesco Morosini* (1932). (P. J. J.)

**MORPETH,** a municipal borough in the Morpeth parliamentary division of Northumberland, Eng., in a loop of the river Wansbeck, 15 mi. N. of Newcastle upon Tyne by road. Pop. (1961) 12,430.

The manor of Morpeth is said to have been granted to William de Merlay soon after the Conquest and passed with the borough from his family to the earls of Carlisle. The town is a borough by prescription and was incorporated in 1662. It grew up around the castle, attributed to William de Merlay, of which only the 14th-century gatehouse remains. A curious clock tower, once a prison, faces the market place, and the church is largely 14th-century.

In the valley of the Wansbeck above Morpeth are fragments of Newminster abbey, a 12th-century foundation, and a renovated manor house of the 17th century. A peel tower of the 15th century is at Cockle Park Tower, an experimental farm of the county council. Local industries include tanning, market gardening, iron and brass founding and the manufacture of agricultural implements.

**MORPHEUS,** in Ovid (*Metamorphoses* xi, 635), one of the sons of Somnus, the god of sleep. He calls up human shapes (Gr. *morphai*) of all kinds to the dreamer, while his brothers Phobetor and Phantasus assume the forms of all kinds of animals and inanimate things. It is barely possible that Ovid misinterprets his name and that it really means "dark" (Gr. *morphnos*). Whether he is a popular or a literary figure is uncertain.

**MORPHINE,** the principal alkaloid of opium, was isolated by F. W. A. Sertürner in 1806. It is used in the form of its hydrochloride, sulfate, acetate and tartrate and in various derivatives such as ethylmorphine, Dilaudid, Dicodid and methyldihydromorphinone. Morphine can also be converted into a diacetyl derivative, known as heroin, which shows a considerably higher euphoric effect and has such a powerful addicting capacity that its manufacture is prohibited.

Morphine relieves pain and produces deep sleep. In addition to its analgetic activity it possesses a euphoric effect and many undesirable side actions, which are manifested on the respiratory, the circulatory and the gastrointestinal systems. It has an emetic effect and is a general depressant. The most serious drawback to the drug is its addiction liability (*see* DRUG ADDICTION). It is most frequently administered by injection to secure rapid action. However, it is also effective if given orally.

In its power to relieve pain, morphine is without rival. However, because of its addicting potentialities it should be reserved for the more severe degrees of suffering such as gallstone or renal colic or when other analgesics have failed. In instances of metastatic cancer, if pain is severe, it is justified even to the point of addiction. Usually it is wiser not to inform the patient that morphine is being given. As a sedative it is a remedy of much value in cardiac asthma and certain types of cough, such as whooping cough. In bronchial asthma it is contraindicated because of its depression of the respiration. It is also used to allay vomiting and to check diarrhea; however, in the latter case preparations of opium are preferable. By its calmative effect it protects the system against exhaustion in debilitated conditions, as certain forms of typhoid fever. For the same purpose it is a valuable drug in treatment of internal hemorrhage, traumatic or other shock associated with pain, congestive heart failure and threatened abortion.

Morphine, whose chemical formula is $C_{17}H_{19}NO_3$, crystallizes from alcohol in colourless prisms containing one molecule of water, which is lost at 100° C. The anhydrous alkaloid melts at 254° C. and has a specific rotation of $[\alpha]_D^{25} - 132$ in methyl alcohol. One gram of the alkaloid dissolves in about 5,000 c.c. of water, about 1,100 c.c. boiling water, 210 c.c. alcohol and 1,220 c.c. of chloroform. It is freely soluble in alkalis because of its acidic character. It is also a monoacidic base, forming salts which crystallize readily. The most commonly used are the sulfate, $(C_{17}H_{19}NO_3)_2 \cdot H_2SO_4 \cdot 5H_2O$, and the hydrochloride, $C_{17}H_{19}NO_3 \cdot HCl \cdot 3H_2O$. When morphine or its hydrochloride is heated with hydrochloric acid to 150° C. under pressure, it is converted by loss of a molecule of water into apomorphine, $C_{17}H_{17}NO_2$, a substance which has lost the characteristic physiological action of morphine but has acquired that of a powerful emetic, for which it is principally used in medicine.

The preparations of morphine are incompatible with salts of iron, copper and mercury; also with alkaline earths and substances containing tannin. With ferric chloride it forms a deep blue colour which is destroyed by acids, alcohol or heating. (E. J. W.)

The structure of morphine proposed in 1925 by J. M. Gulland and R. Robinson was confirmed in 1952 by its total synthesis, accomplished by M. Gates and G. Tschudi. Starting with Schaeffer's acid, a coal tar intermediate, they succeeded in preparing morphine by a process involving 27 steps. Their synthesis was considerably too long and complicated to be feasible commercially, and its principal value was as a scientific achievement. Synthetic organic chemistry also provided a number of substances, among them Demerol, methadone, *l*-isomethadone and Dromoran, which

in part supplanted morphine as analgesics.

*See* also references under "Morphine" in the Index. (M. Gs.)

**MORPHOLOGY,** a term used in zoology and botany to cover all those studies in which the centre of interest is the form and structure of an organism largely without regard for the associated functions. Morphology is thus the antithesis of physiology (*q.v.*). In mineralogy it is the term given to the study of the crystalline form of minerals (*see* CRYSTALLOGRAPHY). In philology, morphology is the branch of grammar that examines the forms of words as well as the principles of the word formation and inflection. As the morphology of plants is treated under the article PLANTS AND PLANT SCIENCE the present discussion will be confined to animals. It is possible to distinguish between the term morphology as dealing with the general form and arrangement of parts of an animal and the term anatomy as concerned with gross and microscopic structural details, but in actual practice among zoologists the two terms are used more or less synonymously.

## ANIMAL FORMS

**Types of Symmetry.**—Although at first glance the forms of animals appear multitudinous, they are in fact reducible to a few types, known as types of symmetry. Certain animals, especially most sponges and the ameboid Protozoa, lack definite symmetry, having either an irregular shape different for each individual or else undergoing constant changes of form. But the vast majority of animals exhibit a definite symmetrical form; *i.e.*, their parts are arranged according to a geometrical pattern. Four such patterns of symmetry occur among animals: spherical, radial, biradial and bilateral.

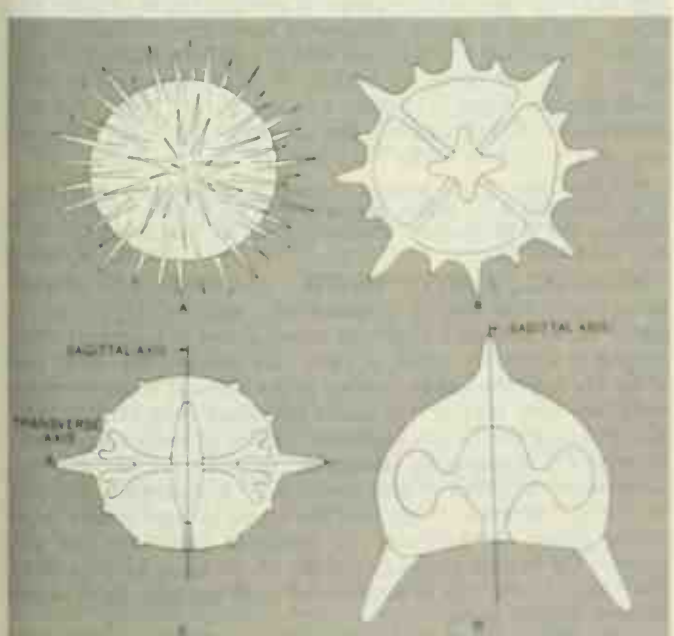
*Spherical.*—In spherical symmetry, illustrated only by the protozoan groups Radiolaria and Heliozoa (*see* PROTOZOA), the body has the shape of a sphere and the parts are arranged concentrically around or radiate from the centre of the sphere. Such an animal has no ends or sides and any plane passing through the centre will divide the animal into symmetrical halves.

*Radial.*—In radial symmetry the body has the general form of a short or long cylinder or bowl with a central axis from which the body parts radiate or along which they are arranged in circular fashion. The main axis is heteropolar; *i.e.*, with unlike ends, one of which bears the mouth and is termed the oral or anterior end, and the other of which, called the aboral or posterior end, forms the rear end of the animal and may bear the anus. The main axis is hence termed the oral-aboral or anteroposterior axis. Except in animals having an odd number of parts arranged in circular fashion (as in the five-armed starfishes), any plane passing through this axis will divide the animal into symmetrical halves. Animals having three, five, seven, etc., parts in a circle have symmetry that may be referred to, respectively, as three-rayed, five-rayed, seven-rayed, etc.; only certain planes through the axis will divide such animals into symmetrical halves. Radial symmetry is found in the phyla Coelenterata and Echinodermata.

*Biradial.*—In biradial symmetry, in addition to the anteroposterior axis, there are also two other axes or planes of symmetry at right angles to it and to each other, namely, the sagittal, or median vertical-longitudinal, and transverse, or cross, axes. Such an animal therefore not only has two ends but it also has two pairs of symmetrical sides. There are but two planes of symmetry in a biradial animal, one passing through the anteroposterior and sagittal axes and the other through the anteroposterior and transverse axes. Biradial symmetry occurs in the phylum Ctenophora (*see* COMB JELLY).

*Bilateral.*—In bilateral symmetry there are the same three axes as in biradial symmetry but only one pair of symmetrical sides, the lateral sides, since the other two sides, now known as the dorsal (back) and ventral (belly) surfaces, are unlike. Hence there is only one plane of symmetry that will divide a bilateral animal into symmetrical halves, the median longitudinal or sagittal plane, passing through the anteroposterior and sagittal axes. Bilateral symmetry is characteristic of the vast majority of animals. Types of symmetry are illustrated diagrammatically in fig. 1.

**Significance of Form.**—The forms of animals are clearly of adaptive significance. Thus the spherical and biradial forms are suitable only for a floating kind of life in a uniform medium; the radial type of symmetry is best adapted for an attached existence; and the bilateral type is necessary for efficient forward progression on a substratum. Bilateral symmetry is the most common type among animals because it is obviously more adaptable to a variety of circumstances than the other types and because through its suitability for forward progression it encourages the differentiation of head and brain. The forms of animals have little relation to internal anatomy since animals of very different anatomical construction may have the same type of symmetry. However, the spherical type of symmetry is possible only in minute animals of simple construction since in spheres the interior mass is large relative to the surface area and becomes too large for efficient functioning with increase in size and complexity.




FROM L. H. HYMAN, "THE INVERTEBRATES: PROTOZOA THROUGH [illegible]," REPRODUCED BY PERMISSION OF MCGRAW-HILL BOOK CO.

TYPES OF ANIMAL SYMMETRY. (A) SPHERICAL, (B) RADIAL, (C) BIRADIAL, (D) BILATERAL

## DIFFERENTIATION AND VARIATION

**Cephalization.**—As already indicated a concomitant of bilateral symmetry is the progressive differentiation of the anterior end as an obvious head bearing conspicuous sense organs as eyes and tentacles and enclosing a concentration of nervous tissue. There is little or no differentiation of a head among spherical, radial or biradial animals. The differentiation of the head through the concentrating of the anterior end, especially of anterior nervous and sensory structures, is termed cephalization. This process becomes more and more pronounced among bilateral animals as one ascends the scale of increasing complexity of structure and finally culminates in man and the apes with their greater development of brain.

**Segmentation.**—A feature of animal form found in certain phyla is the repetition of body parts at regular intervals along the anteroposterior axis. These intervals are typically marked by a ringlike constriction so that the body of such an animal consists of a longitudinal series of joints or segments, each of which typically contains a representative of all the body systems as a pair of kidneys, pair of nerve ganglia, etc. Such a type of animal construction is termed segmentation and occurs in the phyla Annelida, Arthropoda and Chordata. Its occurrence does not necessarily indicate relationship.

No generally accepted theory has been reached as to the origin of segmentation and its adaptive significance, but the most plausible explanation is that segmentation began in the musculature in an elongated animal swimming by serpentine movements. Such movements would presumably be facilitated by the breaking up

of the musculature into short segments, with accompanying segmental nervous control. But segmentation does not appear to be particularly advantageous since among segmented groups there is evident a tendency toward loss of segmentation through fusions of segments, dropping out of certain systems from some segments, etc. Among segmented animals cephalization involves the fusion of a number of the most anterior segments to form the head, with loss from these segments of most other systems except the nervous and sensory.

As the vertebrates are a group of animals that show both segmentation and a high degree of cephalization, one of the great problems of vertebrate morphology in the past was that of the segmentation of the vertebrate head, especially the number of segments that had gone into its composition. From a long series of embryological researches the conclusion has been reached that the vertebrate head consists of three segments anterior to the ear capsule and a variable number, 2 or 3 to 10 or 12 or more in different vertebrates, behind the ear.

**Variations of Form.**—Numerous variants of the types of symmetry (except the spherical) are possible through relative growth; *i.e.*, greater growth during the animal's development along one axis than along others. Thus a given type of symmetry may express itself in long, thin forms, short, plump forms, etc., and, in the cases of biradial and bilateral symmetry, forms flattened along either the transverse or the sagittal axis. Relative growth may also involve only one part of an animal, resulting in long-legged or long-necked forms, for instance, or types like the lobster and other crustaceans in which certain claws are enlarged out of proportion to other body parts. Again, relative growth may result in spiral types, a very common modification of bilateral symmetry seen in general body form in snails and other mollusks and in individual parts in innumerable cases. These variations of form also have adaptive significance. Thus very elongated types are frequently associated with burrowing habits, flattened forms are often bottom dwellers and the "streamlined" shape is the most suitable for rapid swimming. Among the vertebrates birds and fishes exemplify the numerous form variants possible to a single structural plan.

## ADAPTIVE NATURE OF FORM

**Convergence and Divergence.**—As the forms of animals may be assumed in all cases to have adaptive significance for certain ways of life, it follows that animals of very different internal construction, and hence of no or very remote zoological relationship, may come to resemble each other superficially. Such resemblance, of common occurrence among animals, is termed convergence. An excellent example of convergence is that of the whale, a mammal descended from land inhabitants, which has taken to the water and has come to have the form and appearance of a fish. On the other hand, animals closely related zoologically may through different habits of life come to differ greatly in superficial appearance. This phenomenon, also very common, is termed divergence. Thus the seal is closely related to the cat, although this would certainly not be evident from their external appearance.

**Homology and Analogy.**—The adaptive nature of form and the existence of such phenomena as convergence and divergence make it necessary to distinguish very clearly in zoology between genuine structural similarity and adaptive or functional resemblance. The recognition of this difference arose gradually and was only firmly established and defined by Richard Owen in 1843, who applied to structural resemblance the term homology and to functional or physiological resemblance the term analogy. This distinction between homologous and analogous structures is fundamental; it underlies all studies in comparative anatomy, embryology and classification.

Homology is understandable only in terms of the principle of evolution. Homology is intrinsic anatomical similarity indicative of a common evolutionary origin. Homologous structures may seem unlike superficially but can be proved to be equivalent by any or all of the following criteria: similarity of anatomical structure; similarity of topographical position in the animal body; and similarity of embryological development. A familiar example of homology is the forelimb of the vertebrate, which may take the form of the wing of a bird, the flipper of a seal or the leg of a horse. Investigation of these shows that they have the same arrangement of bones, are operated by similar musculature and originate from the same embryonic rudiment, the limb bud, having the same topographic relation to the body.

Analogous structures are those having a superficial and functional resemblance but which do not fulfill the above criteria. Analogy is seen in the wing of the bird and the wing of the bat. Whereas the bird wing is the entire modified forelimb, containing the whole of the limb skeleton, the bat wing is a fold of skin supported only by the hand bones. To discover what structures are homologous and to trace their evolutionary changes through a series of animals is the chief end and aim of a branch of zoology termed comparative anatomy (*see* ANATOMY, COMPARATIVE).

**Form and Function.**—The adaptive nature of form has been emphasized in the foregoing discussion. This should not be taken to mean, however, that changes of form are brought about directly by environmental action. Although the argument as to the causal relationship of form and function is an old one and cannot be said to have been conclusively settled, modern opinion is practically unanimous in negating any direct causation of adaptive structures by environmental factors. Adaptation is believed to originate through the preservation by natural selection of chance beneficial variations. Every species shows a certain amount of variation in all its characters, and those variations that happen to be most beneficial in given circumstances give their possessors a greater chance of survival. This process continued through ages eventually results in the production of highly adaptive structures related to the environmental conditions in question.

**Egg and Adult.**—Animals come from an egg cell that bears no resemblance to their adult form and achieve their final form and structure by a series of changes termed development or embryology. The question then arises whether the ultimate form and structure of an animal already pre-exist in some manner in the egg or whether they depend upon or can be altered by environmental factors, acting during development. To answer this question there arose about 1890 the science of experimental embryology, which continues to be one of the most flourishing and interesting branches of zoology.

The problem has been attacked by two main methods: (1) subjecting the embryo to various agents and conditions, such as chemical solutions or alterations of temperature; and (2) separating eggs and early embryos into pieces or grafting pieces to other embryos. The egg, of course, possesses a hereditary mechanism that causes it to develop into the same kind of animal as that which produced it, but the degree of fixation of adult characters in early developmental stages is variable among different eggs. *See* also EMBRYOLOGY, EXPERIMENTAL; DEVELOPMENT, ANIMAL; PHYSIOLOGY; and references under "Morphology" in the Index.

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**MORRILL, JUSTIN SMITH** (1810–1898), U.S. congressional leader, was born at Strafford, Vt., April 14, 1810. At the age of 15, he became a clerk and later partner in a general store, retiring to a country estate in 1848. He devoted the latter half of his life to public affairs, serving in the national house of representatives from 1855 to 1867 and in the senate from 1867 to 1898. Morrill's long service was especially notable in three areas. As a conservative financier, he sponsored the tariff act of 1861 that inaugurated the policy of high protection. A consistent champion of "sound" currency, he opposed the resort to legal tender paper money during and following the American Civil War and also opposed the various proposals for the use of silver as a standard. For special needs, and to supplement tariff receipts, he favoured internal revenue taxes.

In Washington, D.C., Morrill made an influential contribution to the landscaping of the capitol grounds, the completion of the Washington monument, the construction of the Library of Congress building and to other projects. Most far-reaching of the

measures he initiated in congress were the acts for federal aid to education. The Morrill act of 1862 provided grants of land to state colleges in which the "leading object" should be to teach subjects "related to agriculture and the mechanic arts," without excluding the general sciences and classical studies. It also provided for training in military science. This aid was supplemented in 1890 by a monetary grant. The enduring significance of these measures was in the incentive they gave to the states and in the precedent of national aid to education. Morrill died in Washington, D.C., Dec. 28, 1898.

*See* George W. Atherton, *The Legislative Career of Justin S. Morrill* (1901); William B. Parker, *The Life and Public Services of Justin Smith Morrill* (1924). (E. D. R.)

**MORRIS** (MORRISON), **CLARA** (1848–1925), U.S. actress, whose most popular roles were Camille, Lady Macbeth and Cora in *L'Article 47*, was born in Toronto, Ont., March 17, 1848. She began her stage career in Cleveland, O., at the age of 14. In 1869 she joined a company in Cincinnati and a year later was engaged by Augustin Daly for his Fifth Avenue theatre in New York. Her first role there—Anne Sylvester in *Man and Wife*—brought her immediate popularity. In 1873 she began playing at A. M. Palmer's Union Square theatre.

Her health failed at the peak of her acting career and from 1900 Clara Morris wrote books and stories about the stage until her death at New Canaan, Conn., Nov. 20, 1925. During the last 20 years of her life she appeared occasionally in vaudeville.

*See* Clara Morris, *Life on the Stage* (1901) and *Life of a Star* (1906). (S. W. H.)

**MORRIS, EDWARD PATRICK MORRIS,** 1ST BARON (1858–1935), was prime minister of Newfoundland from 1909 to 1918. Under him Newfoundland advanced from colonial status to membership in the Commonwealth of Nations.

Morris was born in St. John's, Nfld., on May 8, 1858 and educated at St. Bonaventure's college, St. John's, Nfld., and the University of Ottawa, Ont. A Roman Catholic, Morris represented St. John's West in the house of assembly from 1885 to 1918. Originally an Independent, he held office in Sir William Whiteway's Liberal administrations of 1889–94 and 1895–97. He was a member of another Liberal government, led by Sir Robert Bond, from 1900 to 1907, when he resigned because of the premier's overcautious social policies. Along with other rebel Liberals, he joined the Conservatives to become leader of a new People's party.

As prime minister after 1909 he made vigorous efforts to bring about social improvements, and, after 1914, to assist the British war effort. In 1916 he became a member of the imperial war cabinet. In 1917 Morris persuaded the Liberal party and the Fishermen's union to join him in a National government. He resigned as prime minister in Jan. 1918, and retired to England, where he was appointed to the house of lords for his "distinguished services to the Empire." He died in London on Oct. 24, 1935. (G. O. R.)

**MORRIS, GOUVERNEUR** (1752–1816), U.S. statesman and diplomat, was born in the old Morrisania manor house, in what is now the city of New York, on Jan. 31, 1752. He graduated from King's college (later Columbia university) in 1768, studied law and was admitted to the bar in 1771. An extreme conservative in his political views, he distrusted the democratic tendencies of the patriots, but a firm belief in the justice of the American cause led him to join their ranks. In 1776–77, Morris served in the New York provincial congress, which also functioned as a constitutional convention. In this body Morris distinguished himself by a successful fight to include a provision for religious toleration in the first state constitution, but failed in his efforts to obtain the abolition of slavery. He was a major advocate of a strong executive and a strong central government. He then served in the continental congress, 1777–79, where he was a chief supporter of George Washington. In 1778 he was elected chairman of the committee to treat with Lord North's conciliation commissioners, and as such presented the famous report, adopted by a unanimous vote of congress, which declared that the recognition of independence must precede any negotiations for peace.

Defeated for re-election to congress in 1779, Morris settled in Philadelphia as a lawyer. From Feb. to April 1780 he published in the *Pennsylvania Packet* a series of essays on finance, in which he criticized the issue of paper money, denounced laws passed for the benefit of the debtor class and urged the people to tax themselves for the common good. From 1781 to 1785 he was assistant to the superintendent of finance, Robert Morris (q.v.), to whom he was not related. In this office his most notable service was the preparation of a report on a decimal coinage suggesting the use of the terms dollar and cent. His plan, with some modifications by Jefferson, forms the basis of the present system of the United States. As a member of the Constitutional Convention of 1787 Morris was most active, speaking more frequently than any other delegate. He favoured a strong government in the hands of the rich and the well born and urged that the president be chosen for life with powers to appoint the senators for a similar term. Morris was instrumental in securing the executive veto and in defeating the proposal that the legislature should elect the president. He was a member of the committee of revision, where his literary skill was employed to give final form to the constitution.

In 1787 he returned to New York where he purchased the family manor from his brother. His well-known contempt for democracy, together with his multifarious commercial interests (many in association with Robert Morris), prevented him from seeking office in the new government. In 1788 he went to France on private business and remained abroad for a decade. He was a witness to the French Revolution and left a vivid account of it in his diary, fully recording his personal antipathy toward the radical developments after 1792. Appointed minister to France in 1792, he openly disapproved of the radical course of the revolution and sought to aid Louis XVI to escape from France. His open hostility to the Revolution led the French government to request his recall in 1794. Thereafter he remained in Europe for four more years and traveled extensively. He ended his active participation in politics after a brief term in the U.S. senate, 1800–03. Completely out of sympathy with the forces of republicanism, he allied himself with the extreme Federalists, who hoped to create a northern confederation during the War of 1812. His only venture into public life at this time was his service beginning in 1810 as chairman of the commission in charge of the construction of the Erie canal. Morris was witty, intelligent and cynical, and possessed enormous personal charm. Although a convinced believer in the importance of aristocratic birth and the privileges of class, he had a strong sense of public service. He died at Morrisania on Nov. 9, 1816.

*See* B. C. Davenport (ed.), *A Diary of the French Revolution*, 2 vol. (1939); Howard Swiggett, *The Extraordinary Mr. Morris* (1952). (H. Ase.)

**MORRIS, ROBERT** (1734–1806), American merchant and banker, a signer of the Declaration of Independence, was born in Liverpool, Eng., on Jan. 31, 1734. He joined his father in Maryland in 1747, entered a mercantile house in Philadelphia and at the age of 20 became a member of a prosperous firm in which he was later a partner. During the American Revolution Morris joined the patriots and associated himself with their more conservative wing in Pennsylvania. He was vice-president of the Pennsylvania committee of safety (1775–76) and was a member of the continental congress (1775–78). He was reluctant to sanction separation from Britain, and voted against it in the continental congress. Even after the Declaration of Independence was adopted, he continued to hope for reconciliation with the mother country and did not sign the document until seven weeks later. After retiring from the continental congress, he served in the Pennsylvania legislature (1778–79 and 1780–81).

Morris performed his greatest service as the financier of the Revolution. As chairman or member of various committees of the continental congress, he practically controlled its financial operations from 1776 to 1778. After the war he served as superintendent of finance under the Articles of Confederation from 1781 to 1784, and was also agent of marine during the same period, being in effect head of the navy department. He is especially remembered as the man who secured the funds which made it possible for Washington to move his army from the environs of New York

to Yorktown and to force the surrender of Lord Cornwallis (1781). Morris borrowed from the French, requisitioned from the states and also advanced money from his own pocket. While there can be no doubt that his services were very valuable, it is also true that he sought to improve his private fortune while he held public office, and that his official functions gave him advantage in his private transactions. He was, however, acquitted by congress when charged with dishonesty.

In 1781 Morris established in Philadelphia the Bank of North America, chartered at first by congress and later by the state of Pennsylvania. It is said, on insufficient evidence, that Washington offered him the post of secretary of the treasury in 1789 and that, after declining, Morris was instrumental in securing the appointment for Alexander Hamilton. Elected to the U.S. senate, he supported Federalist policies and assisted Hamilton in executing his financial plans (1789–95). Meanwhile, Morris had disposed of his mercantile and banking investments and had plunged heavily into land speculation. When his lands failed to bring him prompt profit, Morris fell into bankruptcy and was confined in a debtors' prison for more than three years (1798–1801). He died in Philadelphia on May 7, 1806.

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**MORRIS, WILLIAM** (1834–1896), English poet, artist, manufacturer and socialist, whose decorative designs revolutionized Victorian taste and whose work in all his many-sided activities was inspired by high moral seriousness. The eldest son of parents in easy financial circumstances, he was born at Walthamstow, Essex, on March 24, 1834. In 1840 the family moved to Woodford hall, a Georgian mansion on the edge of Epping forest, where Morris spent his boyhood; its remote, almost feudal life, and the beauty of the Essex countryside, with its old churches and manor houses, made a lasting impression.

**Education.**—Morris went first to a private school, and then to Marlborough. In 1853 he went up to Exeter college, Oxford, where he formed a lifelong friendship with Edward Burne-Jones (*q.v.*). Both intended to enter the church, and together they read widely, at first in theology, ecclesiastical history—especially that of the middle ages—medieval chronicles and medieval Latin poetry. Gradually their range widened to include Carlyle, Ruskin, Tennyson, Scandinavian folklore, Charlotte M. Yonge's novel *The Heir of Redclyffe*—a book that greatly impressed Morris—and, finally, the two writers who were to mean most to him—Malory and Chaucer. In the long vacation of 1854 they went to Belgium and northern France, where Morris acquired his love of Van Eyck and Memling, and of French Gothic church architecture. It was after this that he began to write poems and prose romances. His early intention of founding a monastic order gave place to enthusiasm for social reform, and the Brotherhood, as he and his friends were beginning to call themselves, was increasingly inspired by John Ruskin (*q.v.*). On another holiday in France in 1855 both he and Burne-Jones decided to be artists.

**Influence of Rossetti.**—Morris was to become an architect, and after taking his degree (1855), in Jan. 1856 he entered the Oxford office of G. E. Street (*q.v.*), where Philip Webb, who became a lifelong friend, was senior clerk. Meanwhile Burne-Jones on a visit to London (1855–56) had met D. G. Rossetti (*q.v.*). At Easter, 1856, Burne-Jones settled in lodgings at Chelsea, where Morris, a frequent weekend visitor, often met Rossetti. When Street moved to London, later in the year, Morris and Burne-Jones shared rooms in Bloomsbury, and in the autumn, influenced by Rossetti, Morris left Street and decided to become a painter.

In 1857 Morris was one of the band of disciples who accompanied Rossetti to Oxford to help in the decoration of the Union society's new debating hall, and the painting of the frescoes on its ceiling was his first practical essay in decorative art. He had earlier founded and financed *The Oxford and Cambridge Magazine* (1856), a short-lived periodical which, like the *Germ* (1850), expounded Pre-Raphaelite ideals in painting and literature, and had contributed to it poems, essays and a series of prose tales. At this time he also wrote the poems collected in *The Defence of Guenevere and Other Poems* (1858).

**Marriage.**—In 1859 he married Jane Burden, of Oxford, whose strange and haunting beauty has been made familiar by Rossetti's paintings. Their home, The Red House, at Upton, Kent, was built from designs by Philip Webb and Morris. In simplicity of design and in the novel use of red brick and tile it struck a new note in domestic architecture, and in the furnishing of this "house beautiful" Morris found his true vocation as artist and designer. In 1861, he founded the firm of Morris, Marshall, Faulkner and Company—"Fine Art Workmen in Painting, Carving, Furniture, and the Metals." Premises were taken in Red Lion square, Bloomsbury, where, with the help of Rossetti, Ford Madox Brown (*q.v.*), Burne-Jones and others, he produced the furniture, fabrics and hangings which eventually changed the Victorian outlook in interior decoration. Churches provided a market for the firm in its early days, and thus was established a style in stained glass which continued to have influence in the mid-20th century.

**Kelmscott.**—Reasons of health and increasing business in London caused Morris to leave Upton in 1865 and he settled, with his workshop, in Queen's square, Bloomsbury, where he lived until 1878 when he moved to Kelmscott house, Upper Mall, Hammersmith. In 1871 he and Rossetti had acquired a lease of Kelmscott manor, near Lechlade, Oxfordshire, which they shared until 1874. Morris later purchased the house, which is preserved as a memorial to him. This much-loved country home is described in the later chapters of *News From Nowhere;* and the surrounding meadowlands of the upper Thames set the mood and scene for the nostalgically beautiful descriptive lyrics which connect the stories of *The Earthly Paradise*.

**Major Writings.**—Morris's second volume of poetry, *The Life and Death of Jason* (1867), a classical story treated in medieval style, was followed by *The Earthly Paradise*, a collection of classical and medieval stories in verse, published in four parts (3 vol., vol. i containing parts i and ii, 1868–70). His gift for poetic narrative achieved a new strength and scale in *The Story of Sigurd the Volsung* (1877) perhaps the greatest long narrative poem of the 19th century. Morris's devotion to the heroic literature of the north had been strengthened by his first visit to Iceland in 1871; he recorded his impressions in a vivid prose journal, and his feeling for "the Northland of old" in a poem "Iceland first Seen" (in *Poems by the Way*). With the help of the Icelandic scholar Erik Magnüsson he made prose translations of several of the sagas. Other exercises in translation were the *Aeneid* (1875), the *Odyssey* (1887) and *Beowulf* (1895), this last marred by excessive archaism of style. *Love Is Enough* (1872) was an original experiment in the form of a medieval morality play, remarkable for ingenuity of construction and for the beauty of the lyric choruses. *Poems by the Way*, his last volume of verse, appeared in 1891. It contains political and miscellaneous poems, including three sections of *The Pilgrims of Hope*, a verse story of the Paris commune first published in *The Commonweal* (1885–86) and reprinted in a private edition in 1886; also some of the stirring "Chants for Socialists" which had appeared in pamphlet form or in periodicals (1884–85) and had been published by the Socialist league with sections from *The Pilgrims of Hope* and two Socialist tracts in 1885 and 1888. The later years of his life were devoted to the writing of prose romances in which he was content to resume the role of storyteller without political or controversial intent. These stories, beginning with *The House of the Wolfings* (1889) and ending with *The Story of the Sundering Flood* (1898), are set in a remote imaginary past which contains all the qualities he found best in medieval life—its romance and its melancholy, its courage in defeat, and the virtues of the communal life. In 1892 Morris refused an opportunity of becoming poet laureate on the death of Tennyson, as he had earlier (1877) refused the offer of the professorship of poetry at Oxford.

**Social Reform.**—Throughout his life Morris took an active interest in social reform, inspired by hatred of the ugliness and soul-destroying effects of industrialism, and by his ideal of a society in which art should be made "by the people, for the people, as a joy to the maker and user." He supported the Liberal party on the Eastern Question which arose out of the Bulgarian atrocities

of 1876 and was active in the Eastern Question association. In 1879 he became treasurer of the National Liberal league. Dislike of the Irish coercive legislation of 1881, disappointment at the slow progress of social reform and belief that the production of good art of all kinds was only possible in an organized social order, led him to break with the Liberal party (1883) and to join the Democratic (later Social Democratic) federation (1883) (see SOCIALISM: *Social Democracy*). In 1884 he became a leader of the newly formed Socialist league and editor of its journal *The Commonweal*, to which he contributed articles and poems. He preached socialism in writing, in lectures, at meetings in industrial towns and at street corners, being arrested in 1885, and again in 1887, after the meeting in Trafalgar square on "Bloody Sunday" (Nov. 13), which was violently broken up by the police.

The Socialist league's increasing anarchist tendencies led Morris to withdraw from it in 1890 but he continued his services to the socialist cause by lectures and writings on the relation of art to industry. He realized, however, that the time was not ripe for revolution, and that it was not likely to achieve the ends he desired. His vision of a socialist commonwealth where simplicity and happiness reigned (depicted in *News From Nowhere*) was founded on the concept of joy in labour, with "useful work" replacing "useless toil." He believed in equality based on a sense of mutual responsibility between master and man, and this ideal he strove to fulfill in his own work for the arts and crafts. His political thinking derives partly from Ruskin, partly from his own special reading of the middle ages. Two of his best prose stories describe the simple and contented world he longed for. *A Dream of John Ball* (1888) is an idealized picture of medieval England; *News From Nowhere* (in *The Commonweal*, 1890, in book form, 1891) is a Utopian dream of a future based on that past. These are timeless works unmarred by active political propaganda; the prose is firm, the descriptions clear and pure.

**Work for the Arts.**—Neither politics nor writing interfered with Morris' other activities. His training in architecture made him a pioneer in the fight for the preservation of ancient buildings. In 1877 he founded The Society for the Protection of Ancient Buildings, popularly known as "Anti-Scrape." He opposed wanton destruction and ignorant restoration, not in a spirit of mere antiquarianism, but because he felt that the monuments of the past held in their inspiration and craftsmanship a lesson for the present. In the same spirit he supported a revival of the applied arts. His own manufacturing works, which had long outgrown their limited premises in Queen's square, were transferred to Merton abbey, Surrey, in 1881, and their output was extended to the making of stained glass, carpets and tapestries.

His interest in illumination and early printed books led to a final outburst of creative energy in the foundation of the Kelmscott press (1890), with type and decorations of his own design. Its first book, *The Story of the Glittering Plain*, was issued in 1891, and its last, the Kelmscott *Chaucer*, was completed in June 1896. In all 50 books were issued; in their decoration and illustration Burne-Jones was a close collaborator. The Kelmscott press is a landmark in the history of printing. It revived the art of fine book production and set a standard for many other private presses.

**Death.**—Morris' energy and vitality at last showed signs of waning, and in the last year of his life a gradual failure of strength set in. He lived to see the great *Chaucer*, the crown of his craftsmanship, come from the press, and died three months later at his house in Hammersmith on Oct. 3, 1896. He was buried at Kelmscott on Oct. 6. His widow and two daughters survived him. The elder, May (b. 1862), devoted herself to her father's memory and published his collected works in 24 volumes (1910–15).

**Achievement and Reputation.**—It is not easy to assess an achievement as varied as that of Morris. With his creative energy went a natural humility which would have caused him to claim no more than the title of master craftsman; but he is more than that. The early poems which came to him easily combine the clear vision of Pre-Raphaelite painting with a command of lyric music which never deserted him. In his maturer work that music is enriched by a note of nostalgic melancholy echoing one aspect of his own life—regret for past happiness and a sense of much left unachieved—and by a strong feeling for natural scenery. The underlying strength which supports the predominantly decorative quality of Morris' work is already evident in tragic poems like "The Haystack in the Floods" (in *The Defence of Guenevere*) and in the unfinished *Scenes From the Fall of Troy*, unpublished in his lifetime and less well known than they deserve to be.

Morris understood the solid dense reality of feudal life as well as its romantic aspects. In the *Life and Death of Jason* and in *The Earthly Paradise* he revealed his gifts as a narrative poet. Easy and fluent as the storytelling is—in manner more akin to John Gower than to Chaucer—the characters lack the depth which came to him with *Sigurd the Volsung*. This retelling of the greatest epic tale of the north called forth his fullest powers. In his prose writings, the style of the propaganda works is forceful and direct; deliberately archaic turns of phrase and diction help to create the remote atmosphere of the prose romances.

As an artist his first inspiration came from Rossetti, but his own temperament proved alien to the sensuous side of Pre-Raphaelite art and to its too obvious moralizing tendencies. His work as decorator and designer is based on a kind of practical medievalism. He revived simple shapes and solid workmanship in furniture and provided a background of harmonious colour in his fabrics, hangings and carpets. His great artistic strength was an ever-fresh and fertile inventiveness in decorative pattern. What he produced has the lasting quality of good and sincere craftsmanship unconcerned with the mechanical cheapness of commercial manufacture. The output of his firm did much to change the heavy and tasteless Victorian interior and was fruitful in leading to later developments in the decorative arts. Original Morris interiors can be seen in the Victoria and Albert museum and at St. James's palace, London. Fine examples of his tapestries are to be seen in the chapel of Exeter college, Oxford, and in the City Museum and Art gallery, Birmingham. His only finished easel painting, "La Belle Iseult," is in the Tate gallery, London. The Morris firm closed down in 1940, but the William Morris society (founded 1956) helped to re-establish its repute, and through its efforts Morris fabrics and papers again became available.

Morris is one of the great Victorians. The high seriousness characteristic of the age directed his gifts to the bettering of his fellow-men. Dignity and a sense of purpose prevented the dispersal of his boundless decorative energy in sterile wastes of aestheticism. There is a healthy and virile freshness in all his work. He did not claim the power to sing of Heaven and Hell or to ease the burden of men's fears, but that does not mean that "the idle singer of an empty day" (as he called himself in the "Apology" to *The Earthly Paradise*) was unaware of the deeper issues which perturbed his contemporaries. "Sincerity, beauty, fitness"—these qualities Sir Sydney Cockerell, the last of his disciples, rightly called "the watchwords" of this many-sided career.

*See* also references under "Morris, William" in the Index.

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**MORRIS DANCE.** The name "morris (or morrice) dance" is found attached to a great variety of customs practised by country folk in England, as well as to some popular entertainments derived from these. The feature common to the customs, which are widespread throughout Europe and extend to Asia and America, is

that of a group of dancing men attendant on a pagan god who celebrates his revival after death.

The relative importance of the central figure, usually an animal-man of some kind, in this magico-religious rite varies considerably. He may dominate the rite to the extent that the young men in the *corps d'élite* are merely servants who wait on his every need; or they may appear as the dominant element, with the animal-man and dramatic characters relegated to the subsidiary role of comics, or they may even be omitted. The second situation was the one commonly met with in the English morris dance, as noted and described by Cecil Sharp in his investigations among the Cotswold and Derbyshire villages and by John Graham in the morris dances of Cheshire and other counties in northwest England. But the name morris has also been associated with a remarkable custom that survives in the horn dance-procession held each September in Abbots Bromley, Staffordshire. This dance includes ten characters: six animal-men bearing deer antlers, three sets of which are white and three black; a man-woman or Maid Marian and a fool, both carrying phallic symbols; a hobby horse; and a youth bearing a crossbow who shoots at the leading "stags" whenever possible (*see* FOLK DANCE: *Ritual-Ceremonial Folk Dances;* HORN DANCE). Another comparable surviving animal custom is the May day procession of a man-horse, notably at Padstow, in Cornwall. There the central figure "Oss Oss" is a witch doctor disguised as a horse and wearing a medicine mask. The dancers are attendants who sing the May day song, beat drums and in turn act the horse or dance in attendance.

The name morris is also associated with groups of mummers who act, rather than dance, the dramatic portrayal of the death-and-survival rite at the turn of the year.

Men's dances strikingly similar to the Cotswold morris, which is distinguished by its white clothes and white kerchiefs, staves and bells fastened to the leg or body, have survived in many parts of Europe—among the Basque in France, in Spain, Portugal, Austria; the Balkan countries, the middle east, in the heart of India and in parts of Central and South America. The wide distribution of this dance suggests a connection with Aryan peoples.

Throughout history the morris seems to have been a familiar sight; it was imported from village festivities into popular entertainment after the invention of the court masque by Henry VIII. The word "morris," apparently derived from "morisco," suggested a Moorish origin. Cecil Sharp suggested that it might have arisen from the custom of the dancers blacking their faces as part of the necessary disguise. (D. N. K.)

**MORRISON, ARTHUR** (1863–1945), English novelist, who described realistically the life of the poor in the East End of London at the close of the Victorian era, was born in Kent on Nov. 1, 1863. Before taking up journalism he worked as a clerk in the civil service. His novels and stories are sober in tone but the characters are portrayed with a Dickensian colourfulness. *Tales of Mean Streets* (1894) was followed by *A Child of the Jago* (1896), *To London Town* (1899), *Cunning Murrell* (1900), *The Hole in the Wall* (1902), which is perhaps his best book, and *Divers Vanities* (1905). He also collaborated in several plays, *e.g., That Brute Simmons* (1904). An opponent of socialism and trades-unionism, his attitude to the people he described is essentially paternalist. Morrison was an authority on Chinese and Japanese painting. He wrote a book on *The Painters of Japan* (1911) and his collection of pictures was acquired by the British museum. He died at Chalfont St. Peter, Buckinghamshire, on Dec. 4, 1945. (AD. C. K.)

**MORRISON, ROBERT** (1782–1834), Presbyterian minister and pioneer Protestant missionary in China, was born at Morpeth, Northumberland, Jan. 5, 1782. Ordained in Jan. 1807, he immediately set out for Canton. Despite difficulties, he mastered the Chinese language and in 1809 was appointed translator to the East India company, a post he held until his death. His principal contributions to Sinology were his *Chinese Grammar* (1815), the New Testament in Chinese (1813), the *Chinese Dictionary* (6 vol., 1815–23) and the whole Bible in Chinese (1821). His translations have naturally been superseded by later efforts, but they stand as notable memorials of patient scholarship. Morrison never forgot that his first task was that of a missionary. Only ten converts were baptized in his lifetime, but all proved faithful. In 1823 Morrison held the first Protestant ordination in China, admitting the convert Liang A-fah to the office of evangelist. In 1818, largely from his own resources and in collaboration with his colleague William Milne, he founded the Anglo-Chinese college in Malacca for "the cultivation of English and Chinese literature in order to encourage the spread of the Gospel of Jesus Christ." The college was transferred to Hong Kong in 1843. Morrison was characterized by immense powers of application, wide erudition, a humble spirit and wholehearted devotion to the cause of Christianity in the far east. He died at Canton on Aug. 1, 1834.

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**MORRISON OF LAMBETH, HERBERT STANLEY MORRISON,** BARON (1888–1965), British Labour statesman who played a leading role in London local government for 25 years and was a prominent member of the coalition government in World War II and of the postwar Labour governments. He was born at Brixton, London, on Jan. 3, 1888, the son of a policeman. From about 1905 he was constantly engaged in socialist politics and in Dec. 1914 became part-time secretary of the newly formed London Labour party. He opposed British participation in World War I; and although he would not have been fit for military service, having lost the sight of one eye at birth, he registered in 1917 as a conscientious objector and was sent to work on a Hertfordshire market garden.

After the war he returned to work for the Labour party in London, became mayor of Hackney in Nov. 1919, and in March 1922 was elected to the London county council for East Woolwich. He was member of parliament for South Hackney from 1923 to 1924 during James Ramsay MacDonald's first government, and regained his seat in 1929. As minister of transport in the second MacDonald government, he was responsible for the Road Traffic act of 1930 and the London Passenger Transport act of 1931.

Morrison again lost his parliamentary seat in 1931, but won it back in 1935. He led the Labour party to victory in the London county council elections of 1934, and was subsequently a notable leader of the council, which did much to alter the face of London. He was also the dominant influence in turning the Labour party away from its post-1931 extremism toward a pragmatic reformism. He stood unsuccessfully for the leadership of the party in 1935 and thereafter worked closely but never very happily with the victor, C. R. (afterward Lord) Attlee.

On the formation of the Churchill coalition government in May 1940, Morrison became minister of supply. The following October he became home secretary and minister of home security. He held these offices until 1945, also serving in the war cabinet from 1942. His name was given to the indoor air raid shelter used in World War II. In the 1945 general election he organized the Labour party's victory. Lord president of the council, deputy prime minister and leader of the house of commons in Attlee's governments, he was highly successful in carrying through a heavy legislative program; and he was responsible for arrangements for the Festival of Britain (1951). He became foreign secretary in March 1951, but was less successful in that post, which he held until his party lost office five months later.

When Attlee retired from the leadership of the Labour party in Dec. 1955, Morrison, who had been deputy leader since 1951, was again a candidate but was defeated by Hugh Gaitskell. He retired from the house of commons in 1959 and was created a life peer. He became president of the British board of film censors in 1960. He died at Sidcup, Kent, on March 6, 1965. His publications include *Socialisation and Transport* (1933), *How London Is Governed* (1949), *Government and Parliament* (1954) and *Herbert Morrison* (1960). (R. J.)

**MORRISTOWN,** a town of New Jersey, U.S., 30 mi. W. of New York city; the seat of Morris county and the retail-trade centre of an area that in the latter part of the 20th century was rapidly changing from one of large estates and farms to one of chemical industries, research laboratories and housing develop-

ments occupied by people who commute to New York city and to Newark. Established as West Hanover in 1710 when a forge was established to utilize the iron ore there, it was renamed in 1740 in honour of Lewis Morris, then governor of the colony. The Morristown National Historical park, established in 1933, includes Jockey hollow, where U.S. troops spent the winter of 1779–80; the Ford mansion, which served as George Washington's headquarters the same year; and the site of Ft. Nonsense, low earth works built by the troops quartered in the town in 1777, primarily, apparently, to keep them busy. Adjacent to the Ford mansion is the Historical museum with an outstanding collection of relics, books and manuscripts pertaining to Washington and the American Revolution.

Benedict Arnold was court-martialed in the Dickerson tavern and Alexander Hamilton courted his future wife Elizabeth ("Betsy") Schuyler at the Jabez Campfield mansion, still standing. Samuel F. B. Morse and Alfred Vail developed the telegraph at the Speedwell ironworks. Late in the 19th century the town was the home of millionaires and such well-known personages as Frank R. Stockton, Bret Harte, Rudyard Kipling and Thomas Nast.

Educational institutions in the Morristown area include Delbarton and the Morristown school, both preparatory schools for boys; Peck, a coeducational elementary school, and Villa Walsh, a Roman Catholic high school and junior college for women.

Morristown was incorporated in 1865. For comparative population figures *see* table in NEW JERSEY: *Population*. (E. R. D.)

**MORROW, DWIGHT WHITNEY** (1873–1931), U.S. lawyer, financier and statesman, was born in Huntington, W.Va., on Jan. 11, 1873. His father, James Elmore Morrow, served briefly as president of Marshall college, Huntington, W.Va. (1871–73), then resumed teaching in Pennsylvania. Dwight, one of five surviving children, was frail but precocious, gifted in mathematics and endowed with a strong personality. He graduated from Amherst college, Amherst, Mass. (1895), and Columbia law school (1899), then entered the firm of Reed, Simpson, Thacher & Barnum. On June 16, 1903, he married Elizabeth Reeve Cutter, a graduate of Smith college, Northampton, Mass. They settled in Englewood, N.J., where their four children were born.

Morrow became a partner in the reorganized firm of Simpson, Thacher and Bartlett in 1905 and won an enviable reputation in corporation law. He aided in drafting a workmen's compensation law in 1911 and in preparing a report in 1917 that led to prison reform in New Jersey. He accepted a partnership in J. P. Morgan & Co. in 1914. Among his notable achievements was the organization of the Kennecott Copper Corp.

After the U.S. entered World War I, Morrow went to Europe early in 1918 as adviser to the Allied Maritime Transport council. After the war Morrow helped Cuba solve its financial troubles. As chairman of the president's aircraft board in 1925 he aided in formulating a national military and civil aviation policy for the U.S.

Pres. Calvin Coolidge appointed him ambassador to Mexico in Sept. 1927. He immediately established cordial relations with Pres. P. E. Calles, temporarily settled the oil, debts and claims problems and partially restored harmony between church and state. Morrow's work was a strong precedent for the Good Neighbor policy. As a delegate to the London Naval conference in 1930 he played a vital conciliatory role. He was elected senator from New Jersey in 1930, but attended only one session of congress before his death on Oct. 5, 1931. Morrow's unimpeachable integrity, judicious temperament and thorough scholarship largely explain his success in finding acceptable solutions to extremely complicated economic and political problems.

Anne Morrow, a daughter, married the famous aviator Charles A. Lindbergh (*q.v.*) on May 27, 1929. (H. G. WS.)

**MORSE, JEDIDIAH** (1761–1826), U.S. clergyman, theologian and geographer, the "father of American geography," was born Aug. 23, 1761, in Woodstock, Conn. He attended Yale college, choosing the ministry as his life's work. Licensed to preach in 1785, he was installed as minister of the First Congregational Church of Charlestown, Mass., in 1789, which church he served for 30 years.

In theology Morse was an orthodox Calvinist and bitterly opposed the "liberal views" then entering some Congregational churches. To strengthen the cause of orthodoxy he founded the periodical *Panoplist* (1805) and served as its editor for five years. In politics he was an uncompromising Federalist.

While teaching school in New Haven, Conn., Morse became interested in geography because, as he said, "so imperfect are all the accounts of America hitherto published that from them very little knowledge of this country can be gained." (Preface, *The American Geography*, 1789). To collect and publish authentic information about the United States became his goal. The following books in the field of geography were written by him: *Geography Made Easy* (1784), the first geography published in the United States; *The American Geography* (1789); *Elements of Geography* (1795), for children; *The American Gazetteer* (1797); and, with Elijah Parish, *A New Gazetteer of the Eastern Continent* (1802). He also wrote *A Compendious History of New England* (1804) and *Annals of the American Revolution* (1824). He died in New Haven on June 5, 1826. Samuel F. B. Morse (*q.v.*) was his son. (R. E. Ar.)

**MORSE, SAMUEL FINLEY BREESE** (1791–1872), U.S. artist and inventor, was one of the most respected American artists of his day and invented the most widely used telegraph. He was born at Charlestown, Mass., on April 27, 1791, the son of Jedidiah Morse, a distinguished clergyman and geographer. At Yale college where he was a tickle student, Morse developed a passion for painting miniature portraits. After a struggle with his parents, he was permitted to study historical painting in England with Washington Allston from 1811 to 1815. On his return he found Americans cold to his historical canvases and reluctantly returned to portraiture to earn a living. He boldly portrayed the character of his subjects. Though often poor he was affable, at home in intellectual and wealthy circles and possessed a gift for friendship. After settling in New York, he became the leading founder and first president (1826–42) of the National Academy of Design.

In 1832 he was returning by ship from art study in Europe, when, after a shipboard conversation on the newly discovered electromagnet, he conceived the idea of a single circuit electromagnetic telegraph. (*See* TELEGRAPH.) Although electric telegraphs had been proposed before 1800 and Joseph Henry had published a detailed description of an electromagnetic one in 1831, Morse believed for several years that his was the first electric telegraph proposed.

Until at least 1837 Morse devoted himself chiefly to painting, teaching art at the University of the City of New York (later New York university), and to politics (he ran on nativist tickets for mayor of New York in 1836 and 1841).

By 1835 he probably had made his first working telegraph. In 1837 a science colleague at the university, Leonard Gale, introduced him to the work of Henry, and Alfred Vail, through his family's iron works in Morristown, N.J., offered to provide materials and labour to build telegraph models. Gale and Vail became partners in Morse's telegraph rights. By 1838 he had developed the Morse code, an alphabet composed of dots and dashes in its first form, in altered forms it was to become known throughout the world. In 1838, while in the process of attempting unsuccessfully to persuade congress to build a telegraph line, Morse acquired another partner, Congressman F. O. J. Smith of Maine. After failing to organize the construction of a Morse line in Europe, Morse alone among the partners persevered in promoting his telegraph, until in 1843 congress voted to pay Morse to build the first telegraph line in the United States, from Baltimore to Washington. The next year he sent the first message on this line: "What Hath God Wrought!"

Thereafter Morse was caught in a swirl of legal claims among his telegraph partners and rival inventors. A natural controversialist like his father, he fought vigorously in this and such other controversies as that in art with John Trumbull, in religion with Unitarians and Roman Catholics, in politics with the Irish and with Abolitionists, and in daguerreotypy—of which he was one of the first practitioners in America—with François Gouraud.

He established his patent rights through a series of court battles which culminated in a decision by the supreme court in 1854. As telegraph lines spread he was rewarded by many governments of Europe for his invention. In old age he was a philanthropist. He died on April 2, 1872, in New York city.

*See* Carleton Mabee, *The American Leonardo, A Life of Samuel F. B. Morse* (1943). (C. Me.)

**MORSE CODE:** *see* Telegraph.

**MORTALITY STATISTICS:** *see* Death Rate; Life Insurance.

**MORTAR:** *see* Brickwork; Mortar in Building.

**MORTAR IN BUILDING.** Mortar is a mixture of inert siliceous material with cement which, after being prepared into a plastic state with water, has the property of hardening into a stonelike mass. Mortar is used in the construction industry to bond brick, building stone, tile, concrete block and other masonry units into a single unit or structure. Its fundamental purpose is to bed fully the masonry units so that the load of the structure is distributed uniformly over the entire bonding surface of the units; it provides, moreover, a weathertight joint. Mortars should be proportioned so that the mix possesses a good plastic quality in its wet state, thereby permitting it to flow readily under the weight of the masonry unit plus a tap of the mason's trowel. The cement content should be held to a minimum consistent with the desired properties of strength and watertightness, since it is the most costly constituent of the mix. (*See* also Masonry.)

**Cementing Materials.**—The choice will be controlled by three factors: the availability of supply, the size of the structure and location—for example, the structure may be below ground level or underwater. The types of cements include hydrated lime, hydraulic lime, pozzolan cement, natural cement, slag cement, masonry cement, and portland cement. Since the size of the structure determines the magnitude of the dead weight of the material, massive structures demand the use of only those cements possessing good strength properties, such as portland cement and masonry cement.

Some cements have the property of hardening in the presence of water, and are thus termed hydraulic cement. Only those with excellent hydraulic properties should be used in structures built in water and below ground level.

Most of the cementing materials may be manufactured in a ready-to-use state whereas others must be prepared for use on the job site. With a few exceptions, the former are used exclusively in the United States; this is not the case, however, in many other parts of the world.

*Hydrated lime* is a nonhydraulic cement which must be prepared on the job site. When a limestone is calcined, the resulting product is quicklime. A quicklime that has been chemically satisfied with water is hydrated lime. The process of hydration is called slaking. Because the chemical composition of limestones vary, there are four classes of quicklimes: high-calcium, calcium, magnesian, and high-magnesian. The rate of hydration of the various classes of quicklime depends upon its (1) physical condition (fineness of grind), (2) chemical composition (calcium and magnesia content), and (3) calcining temperature. The procedures for slaking quicklimes are given below:

*Quick-slaking Lime*.—Always add lime to water. The water should cover the lime; if escaping steam is observed, the material should be hoed and enough water added to stop the steaming.

*Medium-slaking Lime*.—Add enough water to the lime to half submerge it. Hoe mixture and add a small amount of water if steaming occurs.

*Slow-slaking Lime*.—Add enough water to thoroughly moisten the lime. As the hydration continues, sprinkle the lime with small amounts of water to assure its complete hydration.

The slaked lime, kept in a putty form, is usually allowed to stand at least 24 hours before using in mortar. Some masons prefer putty which has aged for longer periods, perhaps from two weeks to as long as several months. Aging is desirable when the putty is to be used for wall plaster; however, 24 hours is satisfactory for mortars.

The mixing of the putty with sand or similar inert material produces mortar. Table I indicates the characteristics of the several classes of lime putties.

Table I.—*Characteristics of Lime Putties*

| Class | Plasticity | Sand-carrying capacity | Yield |
|---|---|---|---|
| Calcium | Fair | Excellent | Good |
| High-calcium | Fair | Excellent | Excellent |
| Magnesian | Good | Good | Good |
| High-magnesian | Excellent | Fair | Fair |

Lime putty alone does not make a wholly satisfactory mortar because of the excessive shrinkage which develops when it sets and hardens. The inert siliceous material reduces shrinkage sufficiently to prevent cracking of the hardened lime. Also it reduces cost materially.

Because of its nonhydraulic quality, hydrated lime mortars should be used only above ground level. The hardening of lime mortars is the reconversion of the lime hydrate to the original calcium carbonate and the rate of hardening is slow. Lime mortar in the centre of wall joints may develop as little as 20% of its strength in five to ten years. Therefore its use should be limited to the less important structures. A characteristic of high-magnesian lime mortars is its excessive expansion, sufficient in amount to cause the cracking and bulging of brick masonry.

Hydrated lime is frequently reduced to a dry powder form for use with other cements to provide a fatty quality in the mortar. In the United States quicklime is the usual term applied to lime putty and hydrated lime is applied to the powder form.

*Hydraulic lime* is prepared by calcining siliceous or clay-bearing limestones. The resulting clinker contains sufficient lime silicate to be hydraulic and also contains free lime so that the calcined material will slake when water is added. The slaking of hydraulic lime breaks the calcined clinker into a fine powder. Only a light sprinkling of water is necessary in the slaking process.

Although the lime is hydraulic, it should not be used for subaqueous structures. In addition hydraulic lime sets slowly and has low strength. Its use should be limited to unimportant masonry structures or for such purposes as stucco and plaster.

*Pozzolan or pozzuolana* cement is produced from natural or artificial pozzolanic materials. The natural pozzolans include pumicite, obsidian, tuff, trass, santorin and scoria originating from volcanic rock and diatomaceous earth, opal and those clays, shales and cherts containing opaline silica. Artificial pozzolans include fly-ash and water-quenched boiler slag. Because of their low strength, pozzolan cements are usually blended with portland cement at the ratio of 30% pozzolan to 70% portland cement. These blended mixtures will produce strengths approaching that of portland cement and provide plastic mixes. True pozzolanic cement has been known since the early Christian era. It is made by grinding two to four parts of pozzolan with a powdered hydrated lime.

*Slag cement* is essentially a pozzolan cement. It is produced by finely pulverizing blast-furnace slag with hydrated lime. Slag cement is used as a masonry cement because of its nonstaining characteristic.

*Natural cement* is so named because it is manufactured from a clayey limestone that produces, when calcined and pulverized, a hydraulic cement. It should not be used in structures demanding high strengths, or exposed to severe weathering.

*Masonry cement* has been developed for the specific purpose of making mortars to bond together masonry units. The exact composition of the many trade name brands are considered trade secrets by the individual manufacturers. A study made in 1934 on masonry cements manufactured in the United States indicated compositions as follows: portland cement and hydrated lime mixtures; portland cement and plasticizing agents such as limestone dust, fly-ash, diatomaceous earth, and other siliceous materials; portland and natural cement blends; portland cement; natural cement; portland and slag cement; hydrated lime; and hydraulic lime. Many of these brand cements contained water-repellent additives such as petroleum products or fatty acid derivatives. The water repellents increase the entrained air causing increased yields,

increased watertightness and increased resistance to weathering action such as freezing and thawing. The study showed a wide range of properties for the masonry cements, indicating that caution should be exercised if shrinkage, good compressive strength and resistance to freezing and thawing were important construction factors.

*Portland cement* will make the strongest and most durable mortars. However, because of its poor water-retention property, it is difficult to produce a workable (plastic) mortar. Since joints must be made watertight, it is necessary to add a plasticizer such as hydrated lime, diatomaceous earth, limestone dust and similar substances if the mortar is to work well and stick in the vertical joints. Portland cement is the product obtained by pulverizing the clinker formed when calcining properly proportioned mixtures of calcareous and argillaceous materials. Portland cement is of the same general character wherever it is manufactured. (For the history of portland cement *see* CEMENT.)

**Inert Aggregate Materials.**—Many kinds of siliceous materials combined with cement produce satisfactory mortars. The most common inert aggregate fillers are sand, crushed stone, crushed brick or burned shale and slag. The purpose of the aggregate is to reduce costs and minimize the excessive shrinkage and expansion characteristics of cements when used alone. The inert materials should be durable to weathering action, clean, strong and well graded from the smallest to the largest particle sizes. In general the maximum size of inert particles in mortars is one-fourth inch.

**The Proportioning of Mortar Mixtures.**—Numerous experiments have shown that the strength and degree of watertightness of mortar mixes having similar density and workability is directly related to the cement content. Similarly if the cement content and workability are alike, the strength and watertightness of the resulting mortar increases with density. Therefore a well designed cement-aggregate mixture requires dense graded aggregates proportioned with an optimum cement content. Typical mortar proportions are shown in Table II.

TABLE II.—*Typical Cement Aggregate Mixes for Mortars*

| Principal cement | Volume of principal cement | Volume of hydrated lime powder or putty | Volume (in damp loose condition) of aggregate |
|---|---|---|---|
| Portland | 1 | ¼ | 3 to 3½ |
| | 1 | ½ | 2½ to 4½ |
| | 1 | 1 | 4½ to 6 |
| | 1 | 2 | 6 to 9 |
| Masonry | 1 | none | 2¼ to 3 |
| Slag | 1 | | 2¼ to 3 |
| Natural | 1 | none | 2¼ to 3 |
| Pozzolana | 1 | ¼ to ½ | 2½ to 4½ |
| Hydrated lime putty (Quicklime) | 1 | | 1 to 3 |

**Additional Constituents.**—It is not uncommon to use admixtures in mortar mixes (sometimes these are added in the manufacture of the cement used in mortars) to provide special properties. The use of water repellents and air-entraining agents was mentioned in the discussions on cements. Other additives (admixtures) might include salt, magnesia or sugar.

*Salt* has proved beneficial when its value does not exceed 5%. The salt is added in dissolved form to the mixing water. It tends to assist in the process of hydration by acting as an accelerator to the chemical reactions of the cement. Its chief value is in cold weather construction. Salt causes efflorescence on the face on masonry work and, therefore, should not be used where this would be undesirable.

*Magnesia* in excessive amounts will cause unsoundness (excessive expansion). Magnesia contents to 2% may prove desirable for construction work subject to the action of sea water.

*Sugar* in water solution (not to exceed 2%) may be beneficial in extremely warm climates. It will retard setting and also prevent rapid drying, thereby permitting a longer working time for the mason. The use of sugar is a continental custom not practised in the United States.

**Special Considerations.**—Reinforcing of mortar joints is a practice which rapidly gained favour, particularly in walls below ground level. The reinforcement is a wire mat bedded into horizontal and vertical joints to withstand the bending action, when earth is backfilled against the wall.

*Repointing* mortared walls is done by "pointing" the mortar joints. Pointing is the term used to describe the filling of both vertical and horizontal joints which have weathered and the areas where mortar has crumbled out after freezing and thawing. Another practice is the resurfacing of weathered walls with a hand applied stucco finish, sometimes tooled to resemble laid stone. Still another practice is surfacing walls with a pneumatically applied mortar surface. This procedure produces a weathertight surface of high strength and durability. It also has been used with success to bond masonry units stacked into wall systems without the customary horizontal and vertical mortar joints.

*Efflorescence* is the deposit of crystallized salts on the surface of brick masonry caused by the leaching out of the soluble salts found in bricks or mortar. Efflorescence appears as a white discoloration on the brick surface. The use of selected brick and mortar of low porosity slows down the passage of moisture through walls and hence minimizes efflorescence.

*See* M. O. Withey and C. W. Watkin, *Materials of Construction* (1954); A. P. Mills, H. W. Hayward and L. F. Rader, *Materials of Construction* (1955); G. R. Burrell, *Limes, Cements, Mortars* (1950).
(E. C. T.)

**MORTGAGE,** the securing of "money or money's worth" by making it a charge upon property, real or personal, so that if the debt is not paid by a time agreed upon by the parties, the creditor may foreclose or sell the property and pay himself from the proceeds of the sale. In the United States the mortgage typically takes the form of a formal deed of conveyance which is expressly stated to be security for a debt. In England, since the Law of Property act 1925, the mortgage of realty takes the form of a 3,000-year leasehold or a legal charge. Both in England and in the United States, security transactions which fail to satisfy the formal requirements of legal mortgages may nevertheless be recognized as valid equitable mortgages. For example, a written promise to give a mortgage, followed by a loan to the debtor, creates an equitable mortgage. Similarly, legal mortgages, defective because of lack of seal or some other technicality, may be enforceable equitable mortgages. In England the deposit of title deeds with a creditor, with the intent that the property described in the deeds shall secure a loan, frequently results in a valid equitable mortgage. In the United States, except for New Jersey and possibly New York, the mere deposit of title deeds will not result in a mortgage.

**History.**—The theory of mortgage in the common law goes back to the gage of land or chattels in the Saxon and early Norman periods, and instances of such gages are to be found in the Domesday Book of William I. A gage involved the transfer of possession to creditors for security for a debt. If the gagee-creditor retained the rents and profits from the estate to discharge the debt, the transaction was known as a "live" gage; if the mortgagee kept the income it was known as a "dead" gage (*mort-gage*). If at the time the debt was due, the gagor failed to pay, the gagee could obtain a judgment requiring payment within a certain time, or, as an alternative, foreclosure of the estate. But title was always in the gagor and he could at any time prior to the end of the term bring a legal action to oust his creditor, leaving the latter no remedy other than to sue on the debt. This lack of security eventually caused the mortgage for a term to give way to the classical common-law mortgage in the form of a direct conveyance to the creditor with payment of the debt as a condition subsequent, which if satisfied would revest both title and possession in the mortgagor. However, if the debt was not paid at the due date, the title vested irrevocably in the mortgagee. This often resulted in drastic loss to the mortgagor, since the value of the property forfeited to the mortgagee frequently far exceeded the amount of the debt. During the 17th century, courts of equity accordingly developed the mortgagor's equity of redemption, a right which allowed the debtor to get back his estate by paying the debt after the due date, even though at law he had completely forfeited his property.

In the course of the gradual development of the mortgage as a security transaction, the law of possession of mortgaged property also changed. In the early days, since the taking of interest was deemed usury and thus illegal, the only way in which the mortgagee could get a return on his money was to demand possession. Moreover, transfer of possession was in accord with the law of pledges, where chattels were held for security (*see* PAWNBROKING). However, from a practical and business standpoint, failure to leave the mortgagor in possession was a serious defect, and by the time of the Restoration the custom of the mortgagee's taking possession had been virtually abandoned. Since by this time the mortgagee was permitted to claim interest on his loan, and since he had adequate security in the right to foreclose if the mortgagor defaulted on the loan, the mortgagee usually preferred to waive his right to possession. By allowing the debtor to remain in possession, he also avoided the duty to account for rents and profits.

**Modern Law.**—Mortgages of real property in the United States have developed under two theories. Some states still follow what is generally known as the "title" theory, which retains the form and the language of the English common-law conveyance on condition subsequent. The development among the pure "title" states has been extremely diverse, the only constant factor being the right to possession in the mortgagee. But since the mortgagee is primarily interested only in the security of his debt, even in "title" states possession almost always remains with the mortgagor. Other U.S. jurisdictions follow the "lien" theory. Although under this theory the mortgage deed purports to vest title in the creditor, no title in fact passes, and the creditor, in the absence of an agreement to the contrary, has no right to possession. The mortgagee-creditor does, however, secure a lien or claim on the property described in the deed and may sell the property if the mortgagor defaults on the obligation. In the United States the gradual acceptance of the lien theory illustrates the principle that in the mortgage law of all civilized legal systems there is an evolution from the forfeiture concept to the simple security concept.

Upon default by the mortgagor, the mortgagee may assert any of several remedies. In almost all jurisdictions he may proceed as if he were an unsecured creditor, ignore his mortgage lien and sue the mortgagor directly on the debt. On the other hand, the mortgagee may elect to foreclose on the mortgaged property, in which case he must comply with the local law regulating foreclosures. Two states, Vermont and Connecticut, still permit "strict foreclosure." In this proceeding a court of equity sets a day after default by which the debt must be paid or title will vest irrevocably in the mortgagee. The mortgagor is not entitled to any surplus if the property is worth more than the debt, but if the value of the property is less than the debt, the mortgagee may sue for the difference in a separate action. In England, if the mortgagee sues on the personal obligation, the prior decree of strict foreclosure is reopened and the mortgagor is again permitted to redeem.

The most widely used method of foreclosure in the United States is a public sale under the supervision of a court of equity. This method, though it is perhaps the fairest for all parties, is both complicated and costly. It usually involves a preliminary title search, the filing of a foreclosure bill and notice in court, service of process, a hearing by an officer of the court, a court decree, notice of the sale and actual sale, proceedings for the determination of rights in the surplus, a possible redemption and a possible deficiency judgment. The sale is usually conducted by the sheriff or other officer of the court, and the mortgagee may be and often is the purchaser at the sale. If the proceeds of the sale are insufficient to discharge the debt, the mortgagee may obtain a judgment for the deficiency in the same proceedings. The judicial sale is used far less frequently in England and differs materially from such sales in the United States. The most significant difference is that the mortgagee may never become the purchaser at the sale. (In about one-third of the states, but not in England, mortgagors and junior encumbrancers are given a statutory right to redeem from a foreclosure sale. This right should be carefully distinguished from the basic equitable right to redeem from the mortgage after default but before the foreclosure sale is completed.)

The usual remedy of the mortgagee in England is a private sale under express statutory power. Such a sale is also extensively used in about a third of the jurisdictions in the United States. This method was used at an early date in England, but after the development of the equity of redemption it fell into general disuse. It was revived in the 19th century and was guaranteed by statute in 1860 and again in 1881, irrespective of whether the mortgage deed itself was silent on the point. The main feature of such a power of sale is that no court order is needed for the mortgagee to sell the property. The sale must be a fair one and the purchaser must be an unrelated third party.

Similar to the power of sale is the deed of trust mortgage which is used in about one-half of the states. The borrower conveys to a third party who holds the property in trust for the holder of the note. The third-party trustee is a fiduciary to both debtor and creditor and is subject to the rules and controls which courts generally have over fiduciaries. The trustee carries out the terms of the mortgage without going into court for either authority or directions unless he is in doubt about his duties. Upon default, the trustee's sale transfers to the purchaser all the title that the mortgagor had at the time he executed the deed of trust as security for the loan. The conduct of the sale is determined by the instrument creating the power and by statutes regulating its exercise. In England the sale is frequently private, but in the United States it is almost invariably by public auction.

Interest rates on the debt for which the mortgaged property is security is limited in almost all U.S. jurisdictions by usury laws. Many banking institutions, however, have managed to circumvent these restrictions by adding to the maximum rate of interest such items as a discount rate and service charges. The most popular repayment method is the level payment plan, in which a fixed amount is paid periodically to the creditor, a certain amount designated to principal and a certain amount to interest depending upon the balance of the loan. As the balance on the principal decreases, an increasingly larger amount is allocated to principal.

*See* also references under "Mortgage" in the Index.

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**MORTIER, ÉDOUARD ADOLPHE CASIMIR JOSEPH,** DUC DE TRÉVISE (1768–1835), French army officer, one of Napoleon's marshals, was born at Câteau-Cambrésis on Feb. 13, 1768. Joining the army as a sub-lieutenant in 1791, he served in the French Revolutionary Wars from 1792 and was made adjutant general after the battle of Hondschoote (1793). At the battle of Zürich (1799) he was general of division.

Napoleon chose Mortier, on Gen. F. J. Lefebvre's suggestion, for the command in Paris in May 1800, sent him to take charge of the occupation of Hanover in April 1803 and made him one of his first 18 marshals in 1804. In the campaign of 1805 Mortier's corps was worsted by M. I. Kutuzov's Russians at Dürnstein west of Vienna (Nov. 11). Having led the attack on the Prussian and Swedish forces in Hanover and in Pomerania from Oct. 1806 to June 1807, he joined the Grande Armée for the Friedland campaign. He was created duc de Trévise in July 1808. He brought a corps to Spain in Dec. 1808, was at Saragossa in Feb. 1809 and won a battle at Ocaña in November. In Feb. 1811 he participated in the victory on the Gebora. In the campaigns of 1812 and 1813 in eastern Europe he commanded the Young Guard. His rearguard actions in France in 1814 were brilliant.

At the first Restoration (1814), Mortier was recognized as a peer of France. In 1815, however, during the Hundred Days, he rejoined Napoleon. After the second Restoration he was in disgrace till 1819, when he was readmitted to the chamber of peers.

After the July revolution, Mortier was ambassador to Russia

from Dec. 1830 to Sept. 1831. He was minister of war and president of the council of ministers from Nov. 1834 to March 1835. On July 28, 1835, he was killed in the attempted assassination of King Louis Philippe by G. M. Fieschi.

**MORTIFICATION:** *see* GANGRENE; NECROSIS.

**MORTILLET, (LOUIS LAURENT MARIE) GABRIEL DE** (1821–1898), French archaeologist and politician, is best known as the author of the first chronological classification of the various prehistoric epochs (1869–72) and of *Le Préhistorique: antiquité de l'homme* (1883) and *Musée préhistorique* (1881), both written in collaboration with his son Adrien. He was born at Meylan, near Grenoble, on Aug. 29, 1821. Exiled in 1849 for his part in the 1848 uprisings and for publishing a socialist pamphlet, he spent most of his time in Savoie, where his early scientific activities were devoted to the geology and paleontology of the Alps; his *Géologie et minéralogie de la Savoie* was published in 1858. He founded two reviews: *Matériaux pour l'histoire positive et philosophique de l'homme* in 1864 and *L'Homme* in 1884. Mortillet became director of the Musée d'Annecy in 1864 and, in 1868, a member of the staff of the Musée des Antiquités Nationales de St. Germain-en-Laye and held the post of assistant curator for 17 years. He was mayor of St. Germain and was elected deputy for Seine-et-Oise to the national assembly in 1885. Mortillet was professor of prehistoric anthropology at the Ecole d'Anthropologie from 1876 until his death in St. Germain on Sept. 25, 1898.

*See* G. Bibby, *The Testimony of the Spade* (1956). (H. KE.)

**MORTIMER,** the name of an Anglo-Norman family which wielded great power on the Welsh marches, attained political eminence in the 13th and 14th centuries and in the 15th possessed a claim to the English throne. The Mortimers, afterward earls of March and Ulster, were descended from ROGER, lord of Mortemer-sur-Eaulne in Normandy, who fought there for Duke William (afterward William I of England) in the battle against the king of France in 1054. Roger's son, RALPH (d. *c.* 1104), followed William to England and became an important landowner in the march of Wales after the rebellion of Roger, earl of Hereford, in 1075. Many of Roger of Hereford's forfeited estates, extending into 12 counties, were granted to Ralph, among them the castle and town of Wigmore, Herefordshire, which became the chief seat of the family. Successive members of the family became involved in the political disputes of the Norman and Angevin reigns, and as marcher lords, were frequently involved in warfare against the native Welsh. Ralph Mortimer rose in rebellion in 1088 with other barons of the march, but was reconciled to William II, and later devoted much of his energy to the conquest of the Welsh lordship of Maelienydd. ROGER (d. 1214), lord of Wigmore, and his son, HUGH (d. 1227), were staunch supporters of King John in the later years of his reign. ROGER (d. 1282) at first supported the baronial opposition to Henry III, but his dislike of Simon de Montfort's alliance with Mortimer's powerful enemy, Llewelyn ap Gruffydd of Wales, soon drew him into the royalist party, and he became a leader of the marchers' growing resistance to Earl Simon. Bitter but largely unsuccessful warfare with Llewelyn occupied Roger in the years 1262–63. In 1264 he was taken prisoner by Montfort at Lewes, but was soon released, only to contrive the escape of the Lord Edward (afterward Edward I) from Hereford and to help in making the alliance between Edward and the earl of Gloucester at Ludlow. He was conspicuous in the campaign which ended with the death of Montfort at the battle of Evesham in 1265. Well-rewarded for his services, he spent much of the rest of his turbulent life in war against the Welsh. His forces were almost annihilated at Brecon in 1266, but he afterward helped Edward I to reverse the tide of Welsh fortune.

In the second half of the 13th century the power of the Mortimers was immensely increased by a series of successful marriages. Roger (d. 1282) secured the hand of Matilda de Braose (coheiress of the great Braose estates and of Richard Marshal, earl of Pembroke), a match which brought him the lordships of Radnor and Builth and lands in west Wales and Ireland. His grandson, ROGER (d. 1330), further enhanced the family fortunes by his marriage to Joan de Geneville (d. 1356), whose inheritance included the castle and lordship of Ludlow, later the family's principal seat, and the lordships of Trim and Meath in Ireland.

These accessions of strength placed the Mortimers among the greatest magnates of the realm and helped this last-named Roger to play a leading part in the troubled politics of the reign of Edward II. He devoted the early years of his maturity to an effort to obtain effective control of his Irish lordships against his wife's kinsmen, the Lacys, who succeeded to their aid Edward Bruce, brother of King Robert I of Scotland, when he was fighting to become king of Ireland. In 1316 Mortimer was defeated at Kells and withdrew to England, but afterward, as king's lieutenant in Ireland (Nov. 1316), he was largely instrumental in overcoming Bruce and in driving the Lacys from Meath. In 1317 he was associated with the earl of Pembroke's "middle party" in English politics, but distrust of the Despensers (*see* DESPENSER) drove him, in common with other marcher lords, into opposition and violent conflict with the Despensers in south Wales in 1321. But, receiving no help from the king's other enemies, Roger and his uncle, Roger Mortimer of Chirk, made their submission in Jan. 1322. Imprisoned in the Tower of London, Roger escaped in 1323, and fled to France, where in 1325 he was joined by Queen Isabella, who became his mistress (*see* ISABELLA of France). The exiles invaded England in Sept. 1326; the fall of the Despensers was followed by the deposition of Edward II, and his subsequent murder (1327), in which Mortimer was deeply implicated. Thereafter, as the queen's paramour, Roger Mortimer virtually ruled England. He used his position unscrupulously to further his own ends. Created earl of March in Oct. 1328, he secured for himself the lordships of Denbigh, Oswestry and Clun, formerly belonging to the earl of Arundel; the marcher lordships of the Mortimers of Chirk; and Montgomery, granted him by the queen. His insatiable avarice, his arrogance and his unpopular policy toward Scotland aroused against Mortimer a general revulsion among his fellow barons, and in Oct. 1330 the young king Edward III, at the instigation of Henry of Lancaster, had him seized at Nottingham and conveyed to the Tower. Condemned for crimes declared to be notorious by his peers in parliament, he was hanged at Tyburn as a traitor on Nov. 29, 1330, and his estates were forfeited to the crown.

The eclipse of Mortimer power following the death of the earl of March proved no more than temporary. Edward III's friendship with March's grandson, ROGER (d. 1360), 2nd earl of March, enabled the latter to obtain a reversal of the judgment on his father in 1354 and to recover his ancient patrimony. Royal support also lay behind a series of arbitrary decisions, thinly veiled as legal judgments, which restored to the young earl in addition many of the lands acquired by the 1st earl during his years of power, notably the lordship of Denbigh; the claims of the earl of Salisbury were ignored, and the earl of Arundel was pacified with the lordship of Clun. By then, Roger had already served with the king at the battle of Crécy (1346), and became one of the founder knights of the Garter; later he accompanied Edward to Picardy in 1355, and, as constable, rode in the van of the great host which went to France in 1359. Roger was succeeded as 3rd earl by his son, EDMUND (d. 1381), whose marriage to Philippa, daughter and heiress of Edward III's second surviving son, Lionel of Clarence, by his wife, Elizabeth de Burgh, brought him the lordship of Ulster and Connaught and added the earldom of Ulster to his style. As lieutenant in Ireland from 1379, Earl Edmund's limited success was terminated by his premature death at Cork. His son, ROGER (d. 1398), 4th earl, accompanied Richard II on the Irish expedition of 1394, and was afterward a vigorous lieutenant, but he, too, met an untimely death in a rash attack on the Leinster clansmen at Kells in Aug. 1398.

His descent from Lionel of Clarence made the 4th earl heir-presumptive to the childless Richard II. The position of his heir, EDMUND (d. 1425), 5th earl, became even more dangerous after the usurpation of 1399, for by the ordinary rules of descent, he had a better title to the throne than the new king, Henry IV (*see* PLANTAGENET, YORK, HOUSE OF). Many regarded him as the legitimate heir of Richard II, and it became the declared object of Owen Glendower and the English rebels to make him king of

England. In Feb. 1405, a bold attempt was made to abduct him and his brother, Roger, from Windsor, but they were soon recaptured. For this reason Edmund was kept under close supervision throughout Henry IV's reign, latterly by Henry, prince of Wales. Edmund seems to have rewarded Henry V with persistent loyalty, and in Aug. 1415 he revealed to the king a conspiracy formed by his own brother-in-law, Richard, earl of Cambridge, and by Henry, lord Scrope of Masham, to put him on the throne in Henry's place. He took part in the siege of Harfleur, and thereafter served in all the French campaigns of Henry V's reign. Appointed lieutenant in Ireland in 1423, Earl Edmund was carried off by the plague on Jan. 18, 1425. With the death of this childless earl, the male line of the Mortimers became extinct. His lands, his titles and his potential claim to the throne passed to his nephew RICHARD (d. 1460), son of Richard, earl of Cambridge, by Edmund's sister, ANNE MORTIMER. This Richard, 6th earl of March, became duke of York in 1426, and in 1460 laid claim to the English throne in virtue of his descent through the Mortimers from Lionel of Clarence; his son Edward became king of England in 1461.

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(C. D. R.)

**MORTMAIN,** the state of land being held by the "dead hand" (*mort main*) of a corporation. In feudal days, a conveyance of land to a monastery or other corporation deprived the lord of many profitable feudal incidents, for the corporation was never under age, never died and never committed felony or married. Statutes were consequently passed prohibiting alienation into mortmain without licence from the crown: Magna Carta, reissued in 1217, *c.* 43, and the Statutes of Mortmain, 1279, 1290, 1391 and 1531. The modern law was contained in the Mortmain and Charitable Uses acts, 1888 and 1891, and in a number of acts (notably the Companies act, 1948, s. 14) which authorized limited companies and some other corporations to hold land without licence in mortmain. An unauthorized conveyance into mortmain made the land liable to forfeiture to the crown. But the law of mortmain was out of accord with modern ideas, and so it was abolished by the Charities act, 1960, s. 38.

Mortmain legislation exists in some other jurisdictions in the British Commonwealth and in the United States.

(R. E. My.)

**MORTON, JAMES DOUGLAS,** 4TH EARL OF (*c.* 1516–1581), Scottish statesman and regent, who was executed for his complicity in Lord Darnley's murder. He was the younger brother of David, 7th earl of Angus, and succeeded to the earldom of Morton in 1548 through his marriage to Elizabeth, daughter of James, 3rd earl of Morton. Inactive during the Scottish Reformation (1560) he was appointed chancellor to Mary Stuart in 1563. Although not an extreme Protestant, he always favoured close cooperation with England and this coloured his subsequent political actions. He led the group responsible for the assassination of David Rizzio (1566), and, after being pardoned for this offense, was partially involved in plotting against Henry, Lord Darnley (1567). Resentful of the earl of Bothwell's anti-English influence, he became, with the earl of Moray, the leader of the opposition to Mary, was responsible for her imprisonment at Lochleven castle and later led the forces that defeated her at Langside (1568). During the civil war that followed he was an indispensable assistant to Moray. He himself became regent in Nov. 1572 and almost immediately effected a reconciliation with some of the queen's supporters; the remainder, besieged in Edinburgh castle, were captured in May 1573.

As regent, Morton was a thorough and efficient administrator; he built up and emphasized the power of the central government, restoring law and order throughout Scotland by effective judicial methods. Following the English pattern he encouraged the development in Scotland of a Reformed episcopacy. His foreign policy was dominated by his dream of a Protestant political alliance with England; but in this he was always rebuffed by Elizabeth I. Gradually opposition to his power developed; the excluded nobility resented the efficiency of his administration, the burgesses disliked his fiscal policy and the more extreme Protestant elements were antagonized by his support for episcopacy. Forced to resign the regency in March 1578, he shortly regained a measure of power; late in 1579 even this was undermined by the French influence of Esmé Stewart (afterward duke of Lennox) and in Dec. 1580 he was charged with complicity in Darnley's murder. He was executed in Edinburgh on June 2, 1581. He was an efficient administrator, a skilful politician, but a man with few moral principles; yet he was largely responsible for creating the conditions in Scotland that enabled Protestantism to triumph.

(T. I. R.)

**MORTON, JOHN** (*c.* 1420–1500), archbishop of Canterbury, cardinal and statesman, traditionally known as the inventor of "Morton's Fork," a casuistic device to raise large benevolences or forced gifts for the crown, was born either at Bere Regis or Milborne St. Andrew, in Dorset. Educated at Balliol college, Oxford, he graduated in canon law, practised in London, and became a master in chancery and chancellor of the duchy of Cornwall. He received ecclesiastical preferment from Henry VI, was with him at the battle of Towton in 1461 and was attainted in the first parliament of Edward IV. He went (*c.* 1463) to the court of Margaret of Anjou at Bar until 1470 and actively promoted the coalition of the earl of Warwick and George, duke of Clarence, with the Lancastrians and Louis XI which drove Edward IV from England. Morton landed with Warwick at Dartmouth in Sept. 1470, but after the battle of Tewkesbury (May 1471) restored Edward's power, he made his peace with him.

Under Edward IV he became prebendary of St. Paul's cathedral in 1472 and master of the rolls in 1473. As an ambassador he was sent to Hungary in 1474 and helped to negotiate the treaty of Picquigny in 1475. In 1479 he was consecrated bishop of Ely. He was present when Edward IV died (1483) and was an executor of his will. He was among those arrested by Richard III in 1483 as a supporter of Edward V and was sent prisoner to Brecon castle. There he became a means of communication between Henry Tudor, earl of Richmond (later Henry VII), and Henry Stafford, duke of Buckingham.

When Buckingham's rising failed, Morton escaped to Flanders and remained there as Richmond's agent during the latter's campaign in England in 1485. Shortly after the battle of Bosworth Field (Aug. 1485) he acted on the king's council and became one of Henry VII's most trusted advisers. He was made archbishop of Canterbury in 1486 and lord chancellor in 1487. In 1493 he was created a cardinal and in 1495 was elected chancellor of the University of Oxford.

His reputation for learning, wit and wisdom is expressed by Sir Thomas More in his *Utopia*. He is believed to have written the Latin history of the reign of Richard III which More translated into English. He was a benefactor of Canterbury cathedral and when bishop of Ely built "Morton's dike" across the Cambridge fens from Petersborough to Wisbech. He died at Knole, in Kent, on Oct. 12, 1500, and was buried in Canterbury cathedral.

Francis Bacon, in his *History of Henry VII*, described Morton's "fork" or "crutch" as a dilemma devised by the chancellor to exact benevolences or forced loans for the crown from the seemingly poor as well as from the rich. The tax commissioners were instructed "that if they met with any that were sparing, they should tell them, that they must needs have, because they laid up; and if they were spenders, they must needs have, because it was seen in their port and manner of living."

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(D. M. Br.)

**MORTON, LEVI PARSONS** (1824–1920), banker, vice-president of the United States and governor of New York, was born in Shoreham, Vt., on May 16, 1824. He was in business at Hanover, N.H., in 1843–49 and in Boston in 1849–54. He then

became a partner in a New York dry-goods house. He established in 1863 the banking house of L. P. Morton and Company (dissolved 1899), with a London branch which had Sir John Rose (1820–88) as its principal member. The American firm assisted in funding the national debt at the time of the resumption of specie payments in the 1870s. The London house was the fiscal agent of the U.S. government in 1873–84, and as such received the $15,500,000 awarded by the Geneva arbitration court in settlement of the "Alabama Claims" against Great Britain (*see* "ALABAMA" ARBITRATION). Morton was a Republican representative in congress in 1879–81, U.S. minister to France in 1881–85, vice-president of the United States in 1889–93 under Pres. Benjamin Harrison and in 1895–96 was governor of New York. In 1899 he launched the Morton Trust company, which was amalgamated ten years later with the Guaranty Trust company. Morton died in Rhinebeck, N.Y., on May 16, 1920.

*See* R. M. McElroy, *Levi Parsons Morton, Banker, Diplomat and Statesman* (1929).

**MORTON, OLIVER (HAZARD) PERRY (THROCK)** (1823–1877), U.S. political leader and governor of Indiana during the American Civil War, was born in Salisbury, Ind., on Aug. 4, 1823. Following a brief attendance at Miami university (1843–45), he entered law practice at Centerville, Ind. He participated in the formation of the national Republican party and in 1856 ran unsuccessfully for governor of Indiana. Elected lieutenant governor in 1860, he became governor when Gov. Henry S. Lane resigned the next year, as prearranged, and in 1864 he was re-elected. As the "war governor" of a northern border state, Morton achieved fame through his vigorous handling of elements bent on disunion. Faced with a hostile legislature in 1863, he governed for two years virtually by fiat, raising the necessary funds through private appeals. In 1867 he resigned to enter the U.S. senate. Formerly inclined to support the Lincoln and Johnson "easy peace" plans, Morton now emerged as a leader of the radical forces in congress, voting for President Johnson's impeachment and urging immediate Negro suffrage. A prominent, though unsuccessful, candidate for the Republican nomination for the presidency in 1876, he was a man of above-average talents in an era of low public morality. He died at Indianapolis on Nov. 1, 1877.

*See* W. D. Foulke, *Life of Oliver P. Morton*, 2 vol. (1899).

(W. M. A.)

**MORTON, THOMAS** (*c.* 1590–*c.* 1647), one of the most picturesque of the early settlers in colonial America, who ridiculed the strict religious tenets of the Pilgrims and the Puritans. He arrived in Massachusetts in 1624 as one of the owners of the Wollaston company, which established a settlement within the limits of modern Quincy. In 1626, when Wollaston and most of the settlers moved to Virginia, Morton stayed on and took charge of the colony and named it Merry Mount. It was inevitable that this free-living, prospering, sharp-tongued Anglican would conflict with his pious neighbours. He erected a maypole, encouraged conviviality and merriment, wrote bawdy verse, poked fun at his saintly neighbours, conducted religious services using the Book of Common Prayer, monopolized the beaver trade, and sold firearms to the Indians. The Pilgrims cut down the maypole, arrested Morton and exiled him to the Isle of Shoals from whence he escaped to England. He returned within two years and his troubles were resumed, this time with John Endecott as well as William Bradford. Morton was taken into custody again (1630) and his property confiscated. He was exiled to England where he spent several years in collaborating unsuccessfully with the enemies of Massachusetts in an attempt to get the charter of the Puritans revoked and in writing an account of the colonies under the title *New English Canaan*. Upon his return to America in 1643, he was imprisoned again, fined and exiled to Maine where he died.

Morton's life has been the subject of a short story by Nathaniel Hawthorne, "The Maypole of Merrymount," and two novels by John Lothrop Motley, *Morton's Hope* (1839) and *Merry Mount* (1849). The settlement is the subject of an opera, *Merry Mount* (1934), by the American composer Howard Hanson.

(RA. MC.)

**MORTON, WILLIAM THOMAS GREEN** (1819–1868), U.S. dental surgeon, who conducted the first public demonstration of the use of ether (i.e., diethyl ether) as an anesthetic in surgery, was born at Charlton, Mass., on Aug. 9, 1819, and studied dentistry at the Baltimore College of Dental Surgery. In 1844 he opened an office in Boston, where he gave especial attention to the improvement of artificial teeth and their means of attachment. It was necessary in many cases to remove the roots of old teeth, and in order to lessen the pain of this operation he searched for some means of deadening sensation. He became interested in anesthesia through another dentist, Horace Wells (*q.v.*), who used nitrous oxide gas in 1844. Charles T. Jackson, a Boston chemist who already had made laboratory experiments dealing with the inhalation of ether, suggested the use of this gas and demonstrated for Morton the method of inhalation. Morton first used it with success in the extraction of a tooth on Sept. 30, 1846, and on Oct. 16, 1846, he publicly administered ether at the Massachusetts General hospital while J. C. Warren painlessly removed a neck tumour by surgery. Though Crawford W. Long (*q.v.*) in 1842 had performed the first operation in which the patient was under ether, as subsequently revealed in 1849, it was Morton's independent demonstrations that first made the value of ether known to the medical world. He never benefited financially from his discovery and died in poverty in New York city on June 15, 1868.

*See* also ANESTHESIA AND ANESTHETICS: *History*.

**MORVAN,** a highland region in central France, composed of gneiss and granite, and forming a northeastern extension of the Massif Central (*q.v.*) toward the Paris basin, with which it is closely associated. The rounded summits reach culminating heights somewhat below 3,000 ft. (Bois du Roi, 2,959 ft.; Mont Beuvray, 2,690 ft.). Headwaters of the Yonne and Armançon drain much of the highland north toward the Seine, but the Arroux tributary of the Loire collects the drainage of the more southerly parts. In the shallow valleys of the impermeable upland there is much boggy ground. The soils are acid and poor, and there are still extensive tracts of woodland and heath. Woodcutting is carried on and logs are floated down the rivers. The traditional crops, rye and buckwheat, are no longer much cultivated, and the farmland is now chiefly under grass and fodder crops and is concerned especially with raising cattle, which are sent for fattening to the richer pastures of the Lias clay depression that girdles the crystalline highland. The sparse population of the Morvan live in hamlets and scattered farmsteads and are served by peripheral market towns such as Autun, Clamecy, Avallon, and Semur-en-Auxois. Seasonal migrations from the Morvan to the harvest and vintage in nearby regions such as Burgundy is a long-standing practice.

(AR. E. S.)

**MORYSON, FYNES** (1566–1630), English traveler and writer whose *Itinerary* (1617; modern ed., 4 vol., 1907–08) gives a comprehensive and lively picture of Europe and the near east. Elected fellow of Peterhouse, Cambridge, in 1584, he decided to become a lawyer. However, the travels upon which he embarked in 1589 "for the ornament of this profession" became an end in themselves. In 1600 he became secretary to Lord Mountjoy, lord deputy of Ireland, where his brother held an appointment. From 1609 to 1617 he was in England writing his *Itinerary*, which includes an eyewitness account of the earl of Tyrone's rebellion. He died on Feb. 12, 1630. He completed only four of the five parts he planned and only three were printed in his lifetime. Most of the fourth, preserved in a manuscript in Corpus Christi college, Oxford, was printed by C. Hughes as *Shakespeare's Europe* (1903), with an account of the author.

*See* H. Pearson, *Urbane Travellers, 1591–1635* (1942).

**MOSAIC,** the art and the product produced by the art of decorating a surface by means of the application of closely set small pieces, usually of an inorganic substance such as stone, mineral, glass and tile or shell. Inlay in wood (intarsia; *see* WOODWORK, DECORATIVE) and in enamel (*q.v.*) are not ordinarily embraced by the term. In a specialized sense, beyond the scope of this article, the word mosaic has been adopted as a technical term in photography and photogrammetry to denote aerial

photographs pieced together from many separate exposures.

Mosaic seems to have developed not so much from the multiplication of separate pieces of inlay as from the differential treatment of surfaces by the application of other material for the purposes of increased magical potency, enrichment and decoration. The germ of the idea might have lain in such ornaments as Old Stone Age man first created by stringing bones, teeth and shells in parallel strands, more elaborate examples of which are found in Melanesian fighting charms and necklaces. From New Guinea come the most primitive examples of mosaic—trophy skulls and masks covered with rows of small shells.

As an art form, mosaic is particularly associated with Byzantine culture and reached its culmination there during the golden age of Byzantine art (mid-9th century to 1204).

**Central American Indian Cultures.**—The art of mosaic in pre-Columbian Central America was marked by a combination of great technical skill and widespread use. The representation of a mosaic mask on a stele at Seibal, Guat., which S. G. Morley dated A.D. 590, established the early use of the technique in Maya territory, but it became best known by the few specimens surviving from the time of the Aztec empire (*c.* 1376–1521) and from descriptions of others left by the Spanish conquerors. The Mexican lapidaries worked with obsidian, garnet, quartz, beryl, malachite, jadeite, marcasite, gold, mother-of-pearl and shell, but turquoise above all constituted their favourite material; the excessive richness of the religious ceremonial gave wide range to its employment in ritual paraphernalia of all sorts. The incrustation was laid upon wood, stone, gold, shell, pottery and possibly leather and native paper and was held in place by a tenacious vegetal pitch or gum or a kind of cement.

Masks, shields, helmets, knife handles, staffs, collars, medallions, ear plugs, leggings, mirrors, animal figures and cult statues received a covering, in whole or part, of small and irregularly shaped pieces of highly polished turquoise, cut to fit tightly together so as to form a brilliant green surface, varied at times with cabochons of turquoise or other material. Museums in Berlin, Copenhagen, London, Rome and Vienna preserve most of the two dozen major specimens of the art, which alone survived the Spanish spoil; others were acquired by the National museum, Mexico City, the Peabody museum, Cambridge, Mass., and especially the Museum of the American Indian, New York city. Most striking and best preserved of their types are a mask in the British museum and a shield in the Museum of the American Indian. On the former, minute pieces of turquoise, studded with cabochon turquoises, completely cover the cedar mask and are laid in symmetrical lines around the eyes and mouth and on the nose; eyes and teeth are of shell inlay. Over the wood of the latter, one paneled and three circular borders of mosaic frame a scene which may relate to the worship of the planet Venus; it is estimated that nearly 14,000 pieces of turquoise make up the decoration. The Nahuatl story of a hall at the Toltec city of Tula, the walls of which were covered with fine mosaic, may belong to legend but a monumental use of the technique was achieved in the mosaiclike treatment of the exterior wall casing of certain buildings. Those at Mitla in the state of Oaxaca are outstanding; bands and panels of simple but striking geometric ornamentation were produced by fitting together small stones of different shapes and sizes, tenoned back into the rubble mass of the wall. Each stone was cut for the spot which it occupied and some were more deeply imbedded than others so that the designs stand out in sharp relief. The effective simplicity of design and precision of workmanship of Mitla are not matched on the elaborate Maya façades, at Uxmal and Chichen-Itza in Yucatan, for example, where, along with geometrical designs, animal forms also occur.

Another type of mosaic work, feather mosaic, was practised in Central America. This most perishable art may have had its roots in man's earliest days, for some primitive Australians still glue feathers to their bodies in patterns to form ceremonial costumes. In Aztec times it was highly developed and placed in the hands of a special guild which produced gorgeous mantles and other regalia indicative of grades of rank in religious, military or civil affairs. Hardly more than a few fragments of pre-Columbian feather mosaic are extant, but the craft survived into the early colonial period for religious pictures and vestments.

**Ancient Near East.**—In the near east only Mesopotamia developed mosaic to any extent. From its prehistoric period come slender cones of baked clay, some with the blunt ends painted red or black, the use of which was revealed in the remains of a large courtyard and columned hall at Erech (modern Warka), in the second half of the 4th millennium B.C. Red, black and white painted cones imbedded in the mud brick covered all vertical surfaces to form a highly decorative protective coating. Varied geometrical patterns drawn from textiles or rush matting were worked out on the side wall and its attached half columns while the lozenges on the eight-foot thick columns of the hall attest their palm-log origin.

In the historical period baked brick displaced imbedded cones as mural sheathing but other forms of mosaic were given architectural use in the 3rd millennium. In the elaborate little temple of A-anni-padda at al-Ubaid two palm columns flanking the entrance were incrusted with a mosaic of red and black stone and mother-of-pearl in bands of lozenges, and around the exterior walls were two friezes of mosaic inlay. The lower represented cattle and dairy scenes with each figure cut out of limestone in one piece, or out of shell in several pieces, and set in a background filled in with pieces of black stone; the upper frieze had limestone figures of birds set in a similar background. This technique the early dynastic Sumerians used also in portable objects as a costlier alternative to the shell reliefs in which the background was merely coloured black or red; cutout silhouettes with carved or incised details were set in bitumen on a wooden frame against a background of small pieces of lapis lazuli. Such plaques were applied to the sound boxes of musical instruments and to other objects; an independent example is the famous "standard" excavated at Ur which represents on one side the king warring and on the other the king feasting; the three zones of each side are framed in borders of shell strips and red limestone lozenges.

There is no evidence that this brilliant and varied use of mosaic techniques was prolonged in significant manner after about 2500 B.C. Nor did other near eastern civilizations begin to rival it. In Egypt the only approach to mosaic lies in the use of blue tiles to simulate mat wall coverings and door rolls in some rooms of the Great Tomb and pyramid of Zoser at Saqqarah. Inlay of semiprecious stones and glass in furniture and jewelry was highly developed and often gives a mosaiclike effect. The Indus valley civilization used only a simple intarsia, mostly of shell. The Aegean civilization made scant use even of inlay but in some mosaiclike fashion it combined individual faïence objects to form little scenes.

**Greek and Roman.**—A humbler technique of Aegean culture supplied the origin of all later floor mosaic. Even in the Neolithic period, floors of waterworn pebbles were laid in Crete, and in the late Bronze Age (1600–1000 B.C.) they occur on the Greek mainland as well. Doubtless it was this practice which the Hellenic Greeks elaborated and spread from the 6th to the 4th centuries B.C., when pebble mosaics with representational and nonrepresentational decoration were used at various sites in Greece (*e.g.*, Athens, Corinth, Delphi, Olympia, Olynthus), Asia Minor (Assus, Tarsus) and as far west as the Phoenician colony of Motya in Sicily. Pebble mosaic had little place in public and religious buildings where floors were usually of cut stone and the extent of its use was not suspected until excavations at Olynthus first laid bare large residential areas of a Hellenic town.

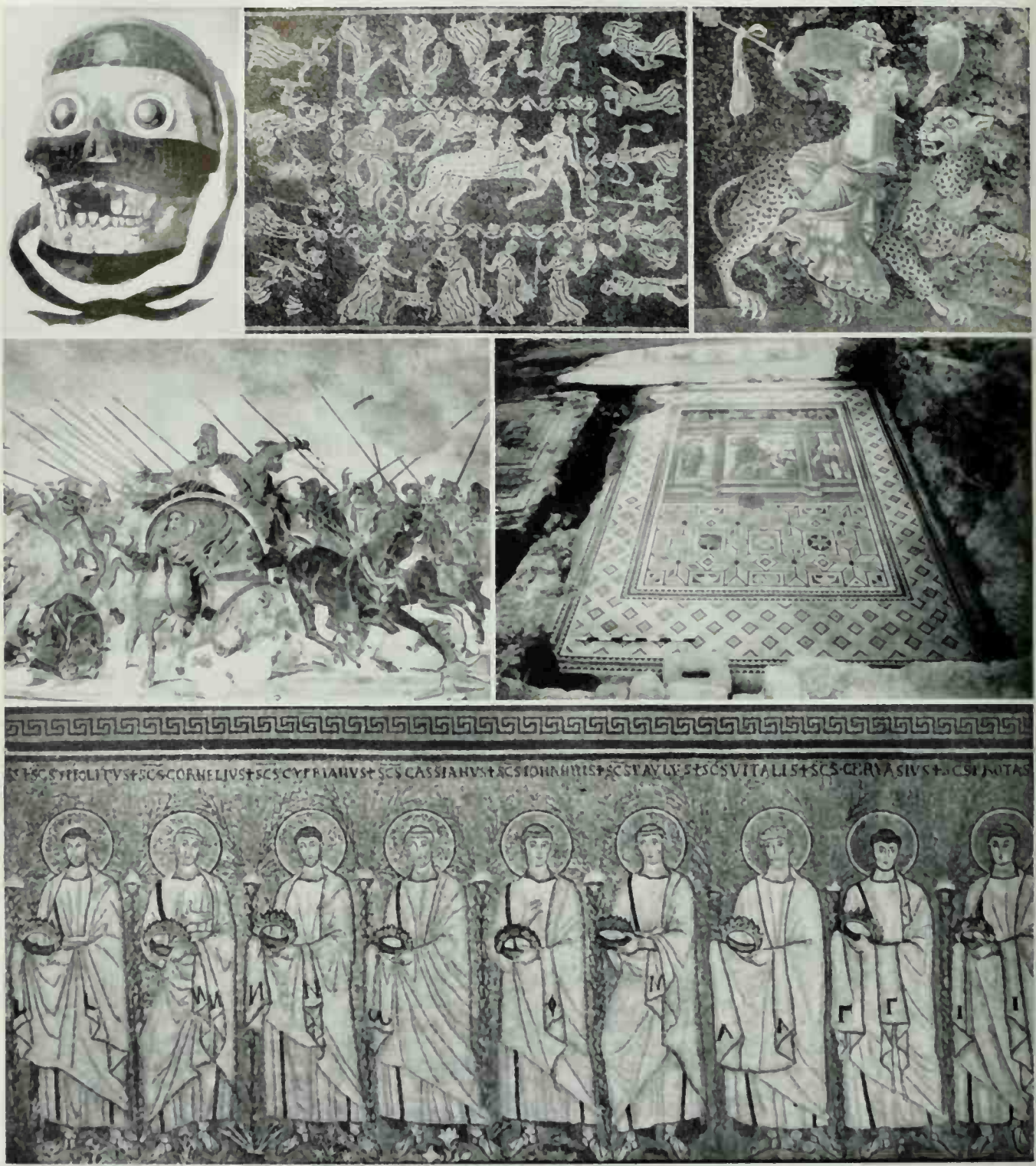
Of the more than 100 houses uncovered there, 11 had pebble mosaic floors which date within the century before the destruction of the city in 348 B.C. White designs and white figures with linear black details were set against a black background and already the usual subsequent rule was observed of centring a main scene between multiple borders, and such common later border designs as wave, meander and rinceau occur. The developed composition of these mosaics implies a strong influence or even a direct copying of figured rugs and their simple bichromy reflects the taste of the times. These pebble mosaics, with unmodeled white figures sharply visible and instantly comprehensible against the dark

BY COURTESY OF THE BYZANTINE INSTITUTE, INC.

A MEDIAEVAL BYZANTINE MOSAIC

Detail showing the empress Irene from a larger wall mosaic, the so-called John panel, in the south gallery of St. Sophia, Istanbul. This mosaic dates from the 11th or 12th centuries, when Byzantine mosaic art reached the period of its finest expression.

# MOSAIC




BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM (TOP CENTRE) DAVID M. ROBINSON, (CENTRE RIGHT) PRINCETON UNIVERSITY PHOTOGRAPHS (TOP RIGHT) ECOLE FRANÇAISE D'ATHÈNES (CENTRE LEFT, BOTTOM) ALINARI

## ANCIENT AND MEDIAEVAL MOSAICS

*Top left*: Human skull covered with a mosaic of obsidian and turquoise. Aztec

*Top centre*: White on black pebble mosaic of Dionysus from Olynthus, Greece. Before 348 B.C.

*Top right*: Polychrome tessellated (checkered) mosaic on black ground from the House of Masks, the Island of Delos, Greece. Probably from the first half of the 2nd century B.C.

*Centre left*: Detail from the Alexander mosaic from Pompeii, probably a copy of the lost painting of the battle of Issus by Philoxenus. First half of the 1st century B.C.

*Centre right*: Typical mosaic floor of a Roman villa at Daphne, a suburb of Antioch on the Orontes. About A.D. 200

*Bottom*: Part of one of the rows of saints on the walls of the church of S. Apollinare Nuovo, Ravenna, Italy. 6th century

PHOTOGRAPHS: THREE LIONS, INC.

FIFTH AND SIXTH CENTURY MOSAICS OF RAVENNA

*Top left*: Christ appearing to the Apostles. Church of S. Apollinare Nuovo. Sixth century.
*Top right*: St. Judas Zelotes. The baptistery of Neon. Fifth century.
*Centre left*: Peacock chasing a dove, detail of a mosaic in the church of S. Vitale. Sixth century.
*Bottom left*: Christ separating the sheep from the goats. S. Apollinare Nuovo.
*Bottom right*: Detail showing a dignitary in the court of Emperor Theodore of Byzantium. S. Vitale.

# MOSAIC

Mosaic murals by Harold Haydon in Temple Beth El, Gary, Ind. Left, "The Legend," 1960. Right, "The Law," 1959. Each mural is 8 ft. by 5 ft. 6 in.

A modern mosaic by Joseph L. Young in Temple Emanuel, Bever Hills, Calif.

A Greek mosaic from the House of the Faun, Pompeii

A mosaic by Joseph L. Young for the Hall of Records, County of Los Angeles, Calif.

## ANCIENT AND MODERN MOSAICS

PHOTOGRAPHS (TOP LEFT, TOP CENTRE) JOHN W. ROSENTHAL FOR HAROLD HAYDON, (TOP RIGHT) JULIUS SHULMAN, MOSAIC © JOSEPH L. YOUNG, (CENTRE LEFT) LOUIS M. FROHMAN, (BOTTOM LEFT AND R. LEE MOSAIC © JOSEPH L. YOUNG

background, are particularly effective as floor coverings. The use of pebbles other than white and black, found in some examples, adumbrates the pictorial effects soon to prevail; in the Dionysus mosaic in the Villa of Good Fortune the chariot front and reins are made of red pebbles and some yellow and green pebbles are scattered among the white and black.

The great advance in technical skill which characterized all arts in the Hellenistic period was felt early in mosaic. The first notable feature was the introduction of small cubes (tesserae or tessellae) cut from stone, or occasionally glass, to replace the pebbles. A smooth surface of closely set pieces which wore better and gave opportunity for finer work was obtained thereby. This change was accomplished before the end of the 3rd century, for Athenaeus quotes from an earlier writer the description of a ship built under Hieron II of Syracuse (270–216 B.C.), certain quarters of which had a flooring of tessellated mosaic made from a variety of stones and representing scenes from the *Iliad*. This record also serves to underline the second new feature of Hellenistic mosaic, its imitative bent; the desire to represent traditional scenes made inevitable the use of painted scenes already in existence as models.

Thus began a long servitude to the art of painting which brought the result that the best endeavour of the Greco-Roman mosaicist was often misdirected toward the imitation of paintings, when his work was technically greatest he achieved a tour de force of craftsmanship but not creative art.

In the Hellenistic period the smaller of the fine figured panels (emblemata) were made in the workshop on tiles or stone trays and set into a space reserved for them in the floor; very small tesserae were used and they were laid in straight or curved rows as the needs of the representation demanded. It has not been determined whether large emblemata were also prepared in the workshop, but in sections, or assembled on the spot. Individual representative objects or even figured panels were also worked out in floors as they were laid but their coarser quality differentiates them from the specially prepared emblemata. The general state of mosaic in a prosperous business community of the 2nd century B.C. was disclosed by excavations on Delos. Four kinds of mosaic floors occur: the earliest consists of fragments of tiles or pottery; most common is a pavement made of irregular chips of marble or stone; pebble mosaic persists but it is rare and undecorated although twice pebbles were used instead of cubes in the background of tessellated mosaics; tessellated mosaic, which alone is decorated, is neither rare nor abundant. One infers that it was just making its way into public favour. Usually the tessellated area is surrounded by a wide border of chip mosaic, hence appearing like a rug spread out on a chip floor. Although decorative elements such as the commonly found dolphins are usually dark on a white ground, the figure scenes, few in number, preserve the black ground of Hellenic pebble mosaics. Best preserved is a square panel representing Dionysus (?) riding a panther. The scene is obviously pictorial in its modeling and rich polychromy; the wide range of coloured stones is supplemented by at least red and green glass.

The history of mosaic for the next two centuries in the Greek near east remains obscure, but Pompeii shows, first, the introduction of Hellenistic mosaic into Italy and, second, the first stage of its development under Rome. Polychrome emblemata of the late 2nd and early 1st centuries B.C. are among the earliest mosaics there; in them the black ground is discarded. The famous Alexander mosaic with its amazing craftsmanship represents the battle of Issus in so completely pictorial a fashion that it is no mere guess to identify its ultimate model as the lost painting of the scene which Pliny says was done by Philoxenus about 300 B.C. With scenes such as this, or the theatre scene signed by Dioscorides of Samos, subject matter and style pass outside the realm of the history of mosaic into that of the history of painting. These figured polychrome mosaics were never common at Pompeii and with the Roman occupation in 80 B.C. they almost disappeared in favour of other types. In sectile pavements thin pieces of marble and other stones were sawed into geometrical and later curvilinear and representational shapes, and were fitted together to form what is essentially stone marquetry, not mosaic.

The lithostrotan floors, however, are mosaic, wherein larger or smaller cubes, oblong tesserae and irregular or shaped plaques of stone were variously combined to differentiate a central area from several borders. Apart from the emblemata, the tessellated floors at Pompeii were standardized into two main types, coloured and black and white, which lasted throughout the Roman empire. Most of the coloured floors are early but mark a decided development over those at Delos in the greater range of colours and of designs employed. The black and white floors, which hardly existed as an independent style at Delos, are the most characteristic of Roman Pompeii and show a considerable variety of decorative motifs which increased in numbers and complexity down to the destruction of the town in A.D. 79.

The end and earlier 3rd centuries A.D. witnessed tremendous activity in mosaic. Remains in considerable numbers, sometimes in great numbers, are found in all lands which formed part of the Roman empire. So vast a body of material cannot well be characterized briefly but these general observations may be made: the mosaics were assembled locally, for the local origin of most of the kinds of stone used in them has been proved in a number of cases; the distinction between the specially prepared emblemata and the coarser field was gradually lost; the tesserae increased in size and sometimes in irregularity of shape and were less closely set. Within a certain homogeneity of technique, planning, decorative repertory and subject matter, regional differences are evident but have only begun to receive study. Rome, for example, specialized in black and white mosaics and elaborated the rather simple black silhouettes of Pompeii into striking and effective mythological, marine and sporting scenes. At least three-quarters of the mosaics are black and white, either figured or purely decorative. Purely decorative polychrome mosaics remained rare until the second half of the 2nd century. Even polychrome figured mosaics were not common and the range of colours was usually rather limited. Several figured panels might be combined into one decorative scheme in a floor, or small insets, *e.g.*, of heads, might form part of an otherwise purely decorative pavement.

A contrast with mosaic practice at Rome is evident in the many mosaics from Antioch on the Orontes, which date from the late 1st into the 6th century A.D. Noteworthy is the absence of the black and white type and a predilection for polychrome figured mosaics, which is so pronounced in the suburban villas of the Antonine and Severan periods that the main rooms and corridors rarely lack one or more figured panels. They are composed with decorative panels and borders to accord with the use of the room, the dining rooms (*triclinia*), for example, having a figured panel in the centre and sometimes several along one side, while decorative panels form a "U" on the other three sides where the couches were placed. The earlier figured panels are the finer in workmanship but the technical disparity between the figured panels and the decorative panels and borders is usually not striking; small emblemata were found in only one house. The subjects were almost exclusively mythological. This wealth of figured panels makes the Antioch mosaics of the greatest importance in revealing the history of pictorial style in the Roman east. The figured scenes still occurred in the early Christian period (4th into 6th centuries), but they are much less frequent and differ in subject matter and treatment. Christian subjects were conspicuously absent; hunting scenes and personifications were popular and single objects, animal and vegetal, were often used as decorative motives in field and border. Composition by the accretion of rectangular panels gave way to a unitary treatment of the floor space in an allover figured scene or decorative pattern or in a radial arrangement of trapezoidal panels. The finest example of the latter type is one of the major surviving works of art of the period of Constantine the Great; personifications of the four seasons frame hunting scenes within figured and decorative borders. By the 6th century allover textile patterns showing strong Persian influence prevailed.

**Medieval.**—One returns to Italy to trace the next great stage of mosaic, the Christian wall mosaics. Already at Pompeii mosaic was applied to the walls of little fountain niches and to a few columns; the scant remains and rare literary references to wall mosaics of the 1st to 3rd centuries give the probably mistaken

impression of a very limited pagan use. With the 4th century, at any rate, wall mosaic became of first importance; floor mosaic took a subordinate role and was soon replaced by other forms of paving. The earliest surviving Christian wall mosaic is that covering the annular vault of the church of Sta. Costanza in Rome, built about 350 as the tomb for Constantine's daughter; its 11 segments, carrying vine scrolls and geometrical designs which enclose figures drawn from the pagan repertory, closely resemble pagan floor mosaics in their white ground and use of stone, not glass, tesserae.

The art-historical significance of the mosaics which survive from the late 4th century on is that they best illustrate the development of early Christian art with its confusion of styles and varying iconography. The Muslim conquest obliterated Christian monuments in the east and except for remains in four churches in Salonika, Gr., the mosaics are concentrated in Rome and in Ravenna. Basilicas ordinarily had the walls of the central aisle, the triumphal arch and the apse covered with mosaic, as Sta. Maria Maggiore at Rome, whose 5th-century mosaics are still of a rather illusionistic style, or S. Apollinare Nuovo at Ravenna, whose 6th-century rows of saints set against a gold background reveal the triumph of the other-worldly, hierarchical early Byzantine style. The early Christian period literally raised mosaic from its humble earthly position to the status of a major art, and by the development of a light but firm mortar and the exploitation of brilliantly coloured glass and gold cubes made it the chief vehicle of religious expression in the representational arts. (*See* also EARLY CHRISTIAN ART.)

It remained for the Byzantines of the 11th and 12th centuries to realize the full possibilities of mosaic. There occurred that coincidence of perfection of technique, significance of subject matter, appropriateness of style to medium and wealth of patronage which brought the art to the peak of its inherent resources. Constantinople itself preserves nothing of the period except a few scenes uncovered after 1931 in St. Sophia, but some of the rich grandeur and magnificence of an all-enveloping mosaic decoration can be felt, despite serious damaging, in the provincial churches at Daphne, near Athens, and of St. Luke in Phocis, Gr. Even individual scenes, like the Pantokrator and Annunciation at Daphne or the Crucifixion at St. Luke, are of unparalleled impressiveness; the monumental figures on the gold background are sufficiently stylized in modeling, drapery and colour to be realized perfectly as divinity in human form. For a more detailed discussion of Byzantine mosaics *see* BYZANTINE ART.

Byzantine mosaicists were called outside the empire to practise their art. Under the Norman kings of Sicily in the 12th century they produced work which survives as the greatest single body of Byzantine mosaic in existence, and which, at its best, as in the apse of the cathedral at Cefalù or in some of the scenes in the Martorana at Palermo, is comparable with that at Daphne and St. Luke in Greece. The extensive but somewhat inferior mosaic decoration in the cathedral at Monreale represents the work of Sicilian mosaicists; it is important as revealing the Byzantine iconographic scheme for the placing of the various series of scenes. The Venetians too brought Byzantine craftsmen to decorate their more sumptuous churches with mosaic. Among the earliest examples of the 11th or early 12th century is that in the cathedral of the neighbouring island of Torcello, the simple grandeur of whose apse mosaic remains unmatched. St. Mark's in Venice is a Byzantine church in all respects, and despite the restoration and replacement of much of the original mosaic of the 12th century by later work it best gives the effect of a large structure of its kind. The mosaics were begun in the second half of the 11th century and rather strict Byzantine style characterizes the work done into the 13th; in 1268 a decree provided for the setting up of a workshop of mosaic and the 14th century mosaics in the baptistery were probably done by Venetians. After the fall of the Byzantine empire the Venetian workshop carried on the craft into Renaissance and modern times, although its efforts were then spent in restoration and in the reproduction of paintings. It should be noted that almost all Christian mosaics have been subjected through the ages to more or less drastic restoration which imposes varying limits on the conclusions to be drawn from their present appearance. The Byzantines also made small, portable mosaic icons which represented individual Christian figures or scenes.

Through the 9th century mosaics in Rome retained certain individual characteristics in the use of colour despite strong Byzantine influence. Thereafter the art lapsed until the late 11th century; the revival was not marked by direct Byzantine work, as at Venice and in Sicily, but rather by a return to early Christian forms and composition within a generally Byzantinizing style. At the end of the 13th century artists' signatures began to occur, as those of Torriti and Rusuti in Sta. Maria Maggiore. The mosaics by the famous painter Pietro Cavallini in the apse in Sta. Maria in Trastevere are still sufficiently limited in pictorial quality to be effective as mosaic.

The extensive 13th-century mosaic decoration of the baptistery at Florence was begun by Venetian mosaicists working in rather pure Byzantine style and completed by local craftsmen whose work shows the influence of late 13th-century painting. At the end of the 12th century, from the example of the combination sectile and mosaic Byzantine pavements, there was developed in central Italy a stone intarsia which was widely used in pavements, to frame architecture openings and on church furniture; it was called Cosmati (*q.v.*) work.

There was no independent development of tessellated wall mosaic in Muslim hands. The elaborate 7th-century mosaics in the Dome of the Rock at Jerusalem and the Great mosque at Damascus were carried out by Byzantine craftsmen, and in the 10th century the Spanish caliph had a Byzantine mosaicist brought to decorate the mosque at Córdoba.

Apart from the elaboration and extension in use of ancient Egyptian intarsia, Islam's only significant contribution lay in a kind of sectile tile mosaic, wherein small pieces in geometrical shapes were cut from tiles glazed in different solid colours and combined to form elaborate decorative patterns on walls. From its origin in Persia in the early 14th century, this craft spread west to Constantinople and south into India.

**Modern.**—The rise of illusionistic painting in the Renaissance successfully enslaved mosaic. Workshops existed at Venice and Rome, and their activity was almost limited to these cities. The revival of interest in medieval antiquities brought a renewed and widespread interest in the 19th century. Mosaic began to be employed occasionally in the major European countries under state or religious patronage and workshops were established for a time in Russia, France and England. The work was essentially imitative of earlier styles and of necessity largely carried out by Italian mosaicists, trained in reproducing paintings; frequently the mosaics were executed in Italy from cartoons and shipped to the place of erection.

The modern movement in the representational arts and architecture and the patronage of business firms in the 20th century occasionally brought mosaic back to a significant level of achievement. For utilitarian purposes its use ranges from the plain white-tile mosaic of bathrooms to the decorated floors of large buildings where stone tesserae form borders or allover patterns which may be drawn from Greco-Roman models; a modern innovation is the insertion of widely spaced metal strips which decrease cracking of the floor and add to the decorative effect. Floor mosaic is usually assembled on a cloth or paper facing and pressed into the cement bed in strips or sections. This labour-saving practice when applied to wall mosaic of glass cubes reduces its effectiveness greatly by producing a smooth, tight surface whose hardness and lack of luminosity is then intensified by too bright lighting of the interior.

Only the wide spacing, gentle tilting and slight irregularity of hand-set cubes under subdued illumination, as in middle Byzantine work, exploit fully the resources of mural mosaic. The frank renunciation of this luminism in favour of a flat-pattern effect is more consonant with modern architectural decoration and is achieved by the use of relatively large cubes in simplified representations. A similar purpose has been attained through the adaptation of the Muslim tile mosaic technique to modern exterior and

interior decoration in figured panels by cutting tesserae in a limited number of geometrical shapes from glazed tiles. The bright but opaque tiling of distinctive texture decorates the wall, yet preserves its solidity. Such efforts may serve to prolong the life of such an aristocratic handicraft as that of mural mosaic into an age of mechanized technique and high-priced labour.

*See* also references under "Mosaic" in the Index.

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**MOSASAUR,** any of a family (Mosasauridae, order Squamata) of extinct aquatic lizards closely related to the present-day oriental and African monitor lizards. They attained a high degree of adaptation to the marine environment and became distributed round the world during Cretaceous time (about 70,000,000 to 130,000,000 years ago). The mosasaurs competed with other marine reptiles—the plesiosaurs and ichthyosaurs—for food, which consisted largely of fish and cuttlefish. Many of the Late Cretaceous forms were large animals exceeding 30 ft. in length, but the most common ones were no larger than most of the porpoises of today.

The mosasaurs had elongated, snakelike bodies with large skulls and long snouts. Fore and hind limbs were modified as paddles, with shortened limb bones and a modest to great increase in the number of finger and toe bones. The tail region of the body was long and its end slightly downcurved in a manner similar to that of the early ichthyosaurs. The backbone consisted of more than 100 vertebrae. The construction of the skull was very similar to that of the modern monitors. The jaws bore many conical, slightly recurved teeth set in individual sockets. The jaw bones are noteworthy in that they were jointed near mid-length, as in some of the advanced monitors, and connected in front by ligaments only. This arrangement enabled the animals not only to open the mouth by lowering the mandible but also to extend the lower jaws sidewise while feeding on large prey. *See* also PALEONTOLOGY; REPTILE.

*See* A. S. Romer, *The Osteology of the Reptiles* (1956). (R. ZL.)

**MOSBY, JOHN SINGLETON** (1833–1916), Confederate cavalry leader in the American Civil War noted for his exploits as a ranger, was born in Edgemont, Va., Dec. 6, 1833. In 1849 he entered the University of Virginia where he shot and wounded a fellow student in a quarrel; he was fined $1,000 and sentenced to six months in jail but the sentence was later annulled by the state legislature. After studying law he was admitted to the bar in 1855 and practised law in Bristol, Va., until the outbreak of the Civil War in 1861, when he enlisted in the Confederate cavalry. He fought at the first battle of Bull Run and the following year began scouting for Gen. J. E. B. Stuart, accompanying Stuart's cavalry on its famous ride around Gen. G. B. McClellan's army in June 1862.

Early in the next year Mosby recruited in Union-occupied northern Virginia a force of irregular troops, known as the Partisan Rangers, who provided their own equipment, raided Union outposts and supply lines and then dispersed. His men followed the practice of dividing among themselves the property they captured and were therefore looked upon as robbers by the Federal authorities. On March 9, 1863, the rangers made one of their most spectacular raids when they slipped through the Federal lines at Fairfax courthouse and captured Brig. Gen. E. H. Stoughton and some of his men. Such exploits made Mosby a hero in the South and forced the Union armies to devote a great deal of effort to hunting him down. The rangers were declared outlaws by the Union forces and in 1864 several of them were caught and hanged without trial. Mosby retaliated by hanging an equal number of Gen. G. A. Custer's cavalrymen, and the executions stopped. In Dec. 1864, when Mosby was promoted to the rank of colonel, his force consisted of eight companies. Twelve days after the surrender of Gen. R. E. Lee on April 9, 1865, Mosby reviewed his troops for the last time and disbanded them at Salem, Va.

After the war, Mosby resumed the practice of law. He entered politics as a Republican, thus alienating many of his friends in the South, and supported the candidacy of U. S. Grant for president in 1872. From 1878 to 1885 he served as U.S. consul in Hong Kong. From 1904 to 1910 he was an assistant attorney for the U.S. department of justice in Washington, D.C. He published *Mosby's War Reminiscences, and Stuart's Cavalry Campaigns* in 1887 and *Stuart's Cavalry in the Gettysburg Campaign* in 1908. He died at Washington, D.C., on May 30, 1916.

*See* V. C. Jones, *Ranger Mosby* (1944).

**MOSCA, GAETANO** (1858–1941), Italian jurist known for his writings on constitutional law and political doctrines, was born in Palermo, Sicily, on April 1, 1858. He studied law at the University of Palermo and was appointed lecturer in constitutional law there in 1885. Transferred to the University of Rome in 1888, he became professor of constitutional law at Turin in 1896. A member of the chamber of deputies from 1908, he served as undersecretary of state for the colonies from 1914 to 1916. He was made a senator for life by royal appointment in 1919. From 1923 to 1933 he was professor of the history of constitutional law in the University of Rome. He died in Rome on Nov. 8, 1941.

Mosca's most important books were: *Elementi di scienza politica,* 2nd ed. (1923; Eng. trans., *The Ruling Class,* 1939); *Sulla teorica dei governi e sul governo parlamentare,* 2nd ed. (1925); and *Storia delle dottrine e istituzioni politiche,* 2nd ed. (1937). Contrary to theories of majority rule, he asserted that societies are always ruled by minorities—whether by military, priestly or hereditary oligarchies, or by aristocracies of wealth or of merit. He showed an impartial indifference to all systems of political metaphysic: for him the will of God, the will of the people, the sovereign will of the state and the dictatorship of the proletariat were all mythical.

*See* M. delle Piane, *Gaetano Mosca* (1952).

**MOSCHELES, IGNAZ** (ISACK) (1794–1870), German-Bohemian pianist, conductor and composer, was born at Prague on May 23, 1794. He studied at the Prague conservatory and later at Vienna under J. G. Albrechtsberger and A. Salieri. In 1814 he made the first piano arrangement of Beethoven's *Fidelio.* After giving piano recitals in Germany and France he settled in London in 1821 and in 1829 took part in the first performance there of the concerto for two pianos by Mendelssohn, who had been his pupil. In 1832 he conducted the first performance in England of Beethoven's *Missa Solemnis* and later he gave Beethoven's Ninth Symphony at the Philharmonic society, of which, from 1845, he became a regular conductor. From 1846 he was principal professor of the piano at the Leipzig conservatory. He died at Leipzig on March 10, 1870.

Though Moscheles belonged to a conservative school of piano playing his explorations of the gradations of tone colour at the keyboard influenced Schumann and Liszt. He was also known for his brilliant extempore performances. His compositions include eight piano concertos, studies and chamber works.

*See* Charlotte Moscheles, *The Life of Moscheles,* Eng. trans. by A. D. Coleridge (1873).

**MOSCHEROSCH, JOHANN MICHAEL** (1601–1669), German satirist whose works give a graphic description of life in a Germany ravaged by the Thirty Years' War, was born at Willstädt, near Strasbourg, on March 5, 1601. He was educated at Strasbourg, occupied from 1630 onward various administrative

posts, and died at Worms on April 4, 1669. His reputation rests on his *Wunderliche und wahrhafftige Gesichte Philanders von Sittewald* (anagram of Willstädt) (1641–43), modeled on *Los Sueños* of Francisco Gomez de Quevedo y Villegas (*q.v.*), satirizing the customs and culture of his day from the standpoint of a stanch Lutheran patriot and containing, in the *Alamode Kehraus* (a satire on extravagant speech, dress and manners) and the *Soldatenleben* (an attack on the freebooting soldiers of the time), two outstanding examples of his satirical ability. Scarcely inferior to the "visions" is the *Insomnis cura parentum* (1643), a religious work addressed to his family and reflecting his strict Lutheran piety. Other works include *Die Patientia*, a manuscript discovered in 1897, and the *Sex Centuriae Epigrammatum* (1665). Keenly patriotic, deeply conservative, his attitude clouded by the experiences of his own unhappy life, Moscherosch wrote satire alternately witty and bitter, brilliant and tedious, full of an overpowering moral zeal and sense of mission.

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**MOSCHOPOULOS, MANUEL,** Byzantine grammarian and critic, flourished at Constantinople during the reign of Andronicus II Palaeologus (1282–1328). Little is known of his life except what can be gathered from his correspondence and a reference in a letter of Maximus Planudes who describes him as his pupil. Moschopoulos is a prominent representative of those humanist scholars active during the last revival of classical learning in Byzantium, and he is best remembered for his *Erotemata grammatika* ("Grammatical Questions," first printed in Milan, 1493), a handbook of Greek in the form of question and answer, which enjoyed great popularity among western humanists of the early Renaissance. He also compiled a lexicon of Attic Greek (*Sylloge onomaton Attikon*), and wrote treatises on mathematics and theology. He studied the works of several Greek poets and wrote commentaries on them, but his most important contribution to classical scholarship is his recension of three Sophoclean tragedies (*Ajax, Electra, Oedipus Tyrannus*) where he displays awareness of metrical problems and considerable critical acumen.

*See* K. Krumbacher, *Geschichte der Byzantinischen Litteratur*, 2nd ed. (1897); A. Turyn, *Studies in the Manuscript Tradition of the Tragedies of Sophocles* (1952). (S. J. PA.)

**MOSCHUS** OF SYRACUSE (fl. *c.* 150 B.C.), Greek bucolic poet, of whose *Bucolica* three short extracts in hexameters are preserved by Joannes Stobaeus. A longer piece, again in hexameters, translated as *Love, the Runaway*, has also survived and an elegiac epigram on Love as a plowman, included in the *Anthologia Planudea*. The attractive short epic *Europa* is assigned to Moschus in some manuscripts, perhaps correctly. The *Megara*, a dialogue between Hercules' wife of that name and his mother Alcmene, is sometimes attributed to Moschus, but on the whole seems unworthy of him.

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**MOSCICKI, IGNACY** (1867–1946), Polish scientist and statesman, president of the republic from 1926 to 1939, was born on Dec. 1, 1867, at Mierzanow, near Plock. From 1887 to 1891 he studied at the school of engineering at Riga in Livonia, specializing in chemistry. He left for Warsaw and joined the Polish Socialist party. To avoid arrest by the Russian police he fled to London in July 1892, where he met Jozef Pilsudski and other leaders for whom the restoration of Polish independence was more important than a social revolution. In 1897 Moscicki joined the staff of the Catholic university at Fribourg, Switz. In 1912 he was given a chair of electrochemistry and physics at Lwow (Lemberg). In 1922, on the partition of Upper Silesia between Poland and Germany, he successfully restarted production of synthetic nitrogen at the Chorzow plant, which the Germans had stripped.

On June 1, 1926, on Pilsudski's recommendation, Moscicki was elected president of the republic for seven years by the *sejm* and senate sitting together; he was re-elected on May 8, 1933. After Pilsudski's death (1935), Moscicki's influence increased. His part in accepting the German challenge in 1939 was decisive. After the German invasion of Poland he left the country with the government on Sept. 17 for allied Rumania, but the Rumanians interned him at Bicaz. He resigned on Sept. 29, appointing Wladyslaw Raczkiewicz his successor. In Dec. 1939 he was allowed to leave Rumania for Switzerland, whose government made him an honorary citizen. He resumed his scientific work at Fribourg and later in Geneva. He died at the village of Versoix on Oct. 2, 1946. *See* also POLAND: *History*. (K. SM.)

**MOSCOW** (MUSCOVY), **GRAND PRINCES OF,** a line of princes in Russian medieval history. During the 12th and 13th centuries Moscow was a small settlement in the Rostov-Suzdal principality. Its line of princes began with Alexander Nevski's youngest son Daniel, who ruled in Moscow from *c.* 1280 until his death in 1303. Under Daniel's successors the principality grew rapidly in size and political importance.

Situated in the centre of the Great Russian lands and at the intersection of many trade routes, Moscow was less exposed to foreign attack than most other Russian principalities. The Muscovite princes, collecting large revenues in taxes and customs, were able to extend their domains by purchase and to practise an energetic policy of colonization. In 1328 Ivan I Danilovich (prince from 1325 to 1341; *see* IVAN) obtained from the Tatar khan of the Golden Horde the title of grand prince of Vladimir, thenceforth retained by the princes of Moscow, who for a long time remained obedient servants of the khan. The khan entrusted these princes with the collection of tribute from the Russian population; and this commission strengthened their political and financial position. They began to "gather the Russian lands," not only by purchase and colonization but also by armed force (with or without Tatar help), diplomatic pressure, treaties and marriages. In 1326 Moscow became the permanent residence of the Russian metropolitan.

The short reigns of Ivan I's sons Semen Ivanovich the Proud (1341–53) and Ivan II Ivanovich (1353–59) were followed by that of Ivan II's son Dimitri Ivanovich, later called Dimitri Donskoi (*q.v.*). He felt himself strong enough to challenge Tatar authority and, with a huge army from Muscovy and its allied principalities, defeated the Tatars under Mamai in the battle of the Kulikovo plain, on the upper Don, in 1380. This victory made the prince of Moscow the national leader of Russia and the city of Moscow the Russian capital. Dimitri's successors, Vasili I Dimitrievich (1389–1425) and Vasili II Vasilievich (1425–62), continued to expand and strengthen Muscovy; and Ivan III Vasilievich (1462–1505) culminated the process of "gathering" the Russian lands. When Tatar domination came to an end in 1480 Ivan III became, legally and in fact, the sovereign ruler of Russia.

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**MOSCOW** (MOSKVA), an *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., covers an area of 18,147 sq.mi. round the capital of the Soviet Union. It was formed in 1929 and was originally called the Central Industrial *oblast*. The main feature of its relief is the Klin-Dmitrov ridge, part of the Smolensk-Moscow upland, which stretches roughly east–west across the *oblast*, just north of Moscow. This ridge represents a line of terminal moraines and reaches a height of 978 ft. Its northern slope is steep, overlooking the boulder clay plain of the upper Volga, to which the *oblast* boundary extends for a short distance at Dubno. This northern part is drained by short tributaries of the Volga: the Dubna, Sestra and Lama. South of the Klin-Dmitrov ridge is the broad, level plain of the Oka and its major tributary, the Moskva, on which the capital stands. The part of the plain east of Moscow is drained by the headwaters of the Klyazma, another major tributary of the Oka. In the

southeast the plain gradually drops to the Meshchera lowland, an area of extensive swamp. In the small area of the *oblast* south of the Oka the land rises once more toward the northern edge of the central Russian upland. The climate is continental. Winters are prolonged and cold, with January average temperatures about −10° C. (14° F.). Stable snow cover lasts from the beginning of December to April, although first snowfalls often come in early October. Summers are warm, with a July average of 19° C. (66° F.). Average annual precipitation ranges from 18 in. in the southeast to 26 in. on the Klin-Dmitrov ridge, but the variation from year to year is considerable, from 12 to 31 in. Maximum fall comes in summer.

Moscow *oblast* lies in the mixed forest zone, its natural vegetation dominated by spruce, pine, oak and birch. Past clearance for agriculture has reduced the forest area to 40% of the surface, but much forest is now protected for amenity. Grass marsh and, to a lesser extent, peat bog are found in many areas, but are particularly extensive in the Meshchera lowland. Along the Oka and Moskva are broad flood-plain meadows, with smaller belts along the minor rivers. Soils are mostly sod-podsols, with wide areas of bog or bog-podsol transitional soils. In the extreme south are grey forest soils and even small patches of chernozem.

The census of 1959 enumerated 10,908,908 inhabitants in the *oblast*, making it by far the most densely populated area of the U.S.S.R. Of this number 5,045,905 then lived in the city of Moscow itself. In August 1960 Greater Moscow was created, including within the city limits the formerly independent towns of Babushkin, Perovo, Kuntsevo, Lyublino and Tushino, and a broad green belt. A high proportion of the population is urban (78%), living not only in the capital, but also in the many surrounding towns which make up the central industrial region of the U.S.S.R., in all 65 towns and 67 urban districts. Moscow, although the administrative centre of the *oblast*, is itself administered independently. The largest of the other towns are Podolsk (pop. [1959] 123,816), Orekhovo-Zuyevo (108,297), Serpukhov (106,387), Kolomna (99,693), Mytishchi (98,606), Elektrostal (96,922), Noginsk (92,760), Lyubertsy (93,013), Zagorsk (73,578), Kaliningrad (incorporating Kostino; 71,885), Yegoryevsk (59,341), Balashikha (57,600), Pavlovski Posad (55,025) and Klin (53,322). In addition to the urban dwellers many of the 2,000,000 or more classified as rural commute to the towns and especially to Moscow. Most commuters live in the "forest-park" zone which surrounds Greater Moscow as an outer green belt. The majority of the towns are concentrated in a ring around Moscow or east of the capital along, and just north of, the railway to Vladimir. Another group (including Serpukhov, Kashira and Kolomna) lies along the Oka. In the west there are only small towns.

The *oblast* is highly industrialized. One of the major branches of industry is textile manufacture. The area, above all the east, retains its historic importance as the chief producer of cotton and woolen textiles in the U.S.S.R. The most important of many towns so engaged are Orekhovo-Zuyevo, Yegoryevsk, Serpukhov, Zaraisk and Naro-Fominsk. Besides cotton and woolen cloth, clothing and knitwear are widely made; artificial textiles are produced at Klin and silk and linen at Naro-Fominsk. The second major branch of industry is engineering, with a wide range of products, including diesel locomotives (Kolomna), rolling stock (Mytishchi), agricultural machinery (Lyubertsy and Zagorsk), boilers (Podolsk), buses (Likino-Dulevo), heavy machinery and machine tools. Some of the steel used is produced by the electric hearth method at Elektrostal. The chemical industry produces chiefly artificial fibres, plastics and fertilizers and is centred in Orekhovo-Zuyevo, Voskresensk and Lyubertsy. Old-established and still flourishing industries are glass and chinaware making, especially in the north. Other manufactures include cement and ferro-concrete items, furniture, joinery and other timber products, footwear and foodstuffs. The *oblast* is lacking in fuel resources, although some brown coal is mined in the south (most of the "Moscow" lignite field lies in Tula *oblast*) and peat is extensively dug in the east, especially round Shatura, to supply peat-burning power stations. Local fuel resources are supplemented by natural gas pipelines from the northern Caucasus, the western Ukraine and Saratov and by high-tension grid from the giant Volga hydroelectric stations. Obninsk, the Soviet Union's first atomic power station, lies just over the boundary in Kaluga *oblast*.

Agriculture plays a relatively minor role in the economy of the *oblast*, engaging only one-fifth of the employed population. Only 28% of the area is under the plow. Throughout the *oblast*, but especially round Moscow, dairying and market gardening are well developed to serve the city. In the east of the plain the emphasis is on dairy and beef cattle. Pig keeping and poultry farming are widespread. Grains, chiefly rye and oats, are not of great importance. Fodder crops occupy over half the arable. In the west and north considerable areas are under flax, the only important industrial crop. Much reclamation work continues in the swampy areas, the land so reclaimed proving excellent for potatoes or for hay and cattle pasture. There are several fur farms, mostly silver fox.

Communications are excellent. Eleven trunk railways, from all parts of the U.S.S.R., focus on Moscow, while there is a good network of electrified suburban lines. At a distance of about 24 to 40 mi. from Moscow, there is an outer ring railway, linking all the radial lines. There are also a number of short branch lines and, in peat or timber-working areas, narrow-gauge railways. There is also a radial pattern of highways and the *oblast* has the highest proportion of asphalted-surface roads in the U.S.S.R. It is no less well served by waterways, with the Moscow ship canal from the capital north to the Volga, the canalized Moskva (for smaller craft) and the Oka all giving access to the Volga system.

(R. A. F.)

**MOSCOW** (Moskva) is the capital and largest city in the U.S.S.R., capital of the Russian Soviet Federated Socialist Republic and administrative centre of Moscow *oblast*. It stands on the Moskva river at its confluence with the small stream Yauza about 400 mi. S.E. of Leningrad. Pop. (1959) 5,045,905. Since the formation of Greater Moscow by decree of the presidium in Aug. 1960, the limits of the city enclose an area of 34 sq.mi.

Moscow lies largely on the three terraces of the Moskva and on the higher ground to north and south. The Moskva, embanked and canalized, follows a sinuous course for 28 mi. through the city. Its high right bank in the southwest forms the elevation (655 ft.) known as the Lenin hills (formerly the Sparrow hills). The natural surface has been greatly modified by the long occupation by man and the "cultural layer" in the centre of the city is 30 to 50 ft. deep. The climate is continental. The January average temperature is −11° C. (12° F.), but in cold spells the thermometer may fall to −40° C. (−40° F.). Snow, which usually falls first in October, has established its cover by the end of November and may reach 4–5 ft. in depth. The city employs a large fleet of mechanical devices and many manual workers to keep its streets clear. Thaw comes in April. Summers are warm, with a July average of 18° C. (64° F.), but the maximum recorded 37° C. (99° F.) was in August. Rainfall is 23–24 in. a year, which is relatively high for the Russian plain. The maximum fall is in the summer.

With the creation of Greater Moscow the former 20 administrative divisions were reduced in number to 17 larger ones. Four are inner districts, within the Sadovaya ring road, and the remaining 13 are all radial, extending from the ring road to the town limits. In addition five previously independent towns were included: Babushkin, Perovo, Tushino, Kuntsevo and Lyublino. At the same time a "forest-park" green belt was established, surrounding Greater Moscow and covering 70 sq.mi. This zone was made administratively subordinate to the council. The 1959 census showed Moscow's population as 5,045,905, but this was before the formation of Greater Moscow. On April 1, 1961, Greater Moscow had a population of 6,208,000, or including the "forest-park" belt 7,144,000. This last figure includes the towns of Mytishchi (pop. [1959] 98,606), Lyubertsy (91,013), Balashikha (57,600) and Khimki (47,800), all within the belt. About 479,000 people within the "forest-park" zone are classified as rural dwellers. There is now an official restriction on the further growth of Moscow's population. A permit is needed for permanent residence and no new industries are being established. A satellite town to take overspill population was built in the 1960s at Kryukovo, 36 km. (22 mi.) N.W. of Moscow.

Moscow is the cultural centre of the Soviet Union. It is the home of the world renowned Bolshoi (or Great) Theatre of Opera and Ballet (1780), the Maly (or Little) Opera Theatre, the Moscow Art Theatre (MKHAT), the Tchaikovsky concert hall, 20 other dramatic theatres and a puppet theatre. There are more than 120 cinema theatres and Moscow is the main motion-picture-making centre in the U.S.S.R. It is also the chief publishing and printing centre. The Lenin State library is one of the three largest in the world, with about 20,000,000 items, including many rarities and manuscripts. (*See* LIBRARY: *U.S.S.R.*) There are more than 900 other general libraries and several thousand specialized libraries. Among the 49 museums and art galleries, of outstanding interest are the State Pushkin Museum of Fine Arts, the State Tretyakov gallery (mostly Russian art), the Kremlin museum and the Central Lenin museum. On the northern outskirts is a vast permanent exhibition of the economy of the U.S.S.R. Scientific institutions number more than 460, including the Academy of Sciences of the U.S.S.R., its botanical garden and many of its institutes; the Academy of Medical Sciences; the V. I. Lenin All-Union Academy of Agricultural Sciences; and academies of art and architecture. There are about 90 higher educational establishments (excluding military), headed by the M. V. Lomonósov state university (1755), with nearly 20,000 full-time students. Others include the "Patrice Lumumba" People's Friendship university for Afro-Asian and Latin-American students (founded in 1960), the Timiryazev Academy of Agriculture (1865), the teachers' institute for advanced training, the D. I. Mendeléyev Institute of Chemical Technology, the P. I. Tchaikovsky state conservatoire and the A. V. Lunacharski Institute of Dramatic Art. There are well over 1,000 schools. Moscow has a number of parks, the largest being Gorki park in the south and, in the northeast, Sokolniki, where exhibitions are often held.

Communications, both internal and external, are excellent. The city has a dense network of bus and trolleybus lines and tramlines, with frequent services. The Metro electric underground system, begun in the 1930s, now serves nearly 50 stations, all of which have different and highly elaborate décor. The Lenin Hills station forms the lower deck of a two-layer bridge over the Moskva. There is a good net of electrified suburban lines. Trunk railways radiate out from the passenger and freight stations to all parts of the Soviet Union. Direct passenger trains run to Vienna, Paris and the Hook of Holland. The radial lines are linked by an inner-ring railway within the city and an outer ring, about 25–40 mi. from Moscow. About 10% of the total rail-freight turnover of the U.S.S.R. is handled in Moscow. Although the original Tushino airport is now too small to be of use, Moscow has two civil airports, at Vnukovo to the southwest and Sheremetyevo to the northwest, with a third and larger airport completed in 1964. There are frequent services to all parts of the U.S.S.R., Europe, China and India. The Moscow canal gives access to the city from the Volga for seagoing ships, while the canalized Moskva can take smaller craft. Through the canal links of the Volga system, Moscow claims the title of Port of the Five Seas—Caspian, Azov, Black, White and Baltic. There are three ports, the northern or main port on the Khimki reservoir and the western and southern, both on the Moskva. Water-freight turnover is about 10,000,000 tons annually, about 77% of which are incoming cargoes. Regular passenger, cargo and pleasure cruising services use the Moscow canal.

Many of Moscow's inhabitants are engaged in the administrative, cultural and service occupations associated with a large capital, but Moscow is also of great industrial importance, with more than 1,800 undertakings. Among its wide range of engineering products are automobiles, buses and trucks (from the Likhachev and Moskvich works), bicycles, ball bearings, machine tools and instruments, including lathes and precision measuring equipment (from the Ordzhonikidze, Krasny proletari, Kalibr and Frezer plants), calculating machines, clocks, electrical and electronic equipment, including radio and television sets, refrigerators and vacuum cleaners, cables, electric gantry cranes, transformers, electric motors and lamps. Steel and alloys for these industries are made in Moscow, especially at the Serp i Molot ("Hammer and Sickle") factory, or brought from Elektrostal, 36 mi. E. of Moscow. Moscow is the largest textile centre in the U.S.S.R., and produces cotton and woolen cloth and clothing, knitwear and silk goods. The chemical industry makes paints, dyes, synthetic rubber and rubber tires, medical preparations and perfumes. Other consumer goods manufactured include footwear, soap, pianos and furniture, and the many food-processing industries supply flour and bread, confectionery, cheese, vegetable oils, margarine, sausages and other prepared meats.

Moscow draws on a wide area for its fuel and power. Natural gas is brought by pipeline from Saratov on the Volga, Dashava in the western Ukraine and Stavropol in the north Caucasus. A ring pipeline surrounds the city. Electricity is brought from the Kuibyshev and Volgograd hydroelectric plants and from the peat-burning power stations of Shatura and elsewhere around the town. Coal gas is produced at Shchekino and Rastorguyevo on the outskirts and there are several power stations in Moscow itself. Many new buildings are heated by communal central heating plants. By the mid-1960s this type of heating was serving thousands of blocks of flats and many factories. (R. A. F.)

**History and Historic Buildings and Monuments.**—Moscow was first mentioned in Russian chronicles about 1147, although, according to archaeological excavations, a settlement had existed there as early as Neolithic times. In 1156 the wooden Kremlin (citadel) was built in Moscow by Yuri (George) Dolgoruki, prince of Suzdal. The Kremlin became the centre around which Moscow has grown. It is shaped like an isosceles triangle, the southern side being parallel with the Moskva river, the northwestern with the Neglinnaya ditch, a "tributary" of the Moskva (now running underground), and the northeastern running along an artificial moat. In the 12th and 13th centuries Moscow was an important town with a trading settlement to the northeast where artisans worked, and in the latter century it became the centre of the new Moscow principality (*see* MOSCOW, GRAND PRINCES OF). About 1237–38 the city was burned by the Tatars but soon recovered from its destruction. The Tatars sacked it again in 1293. Three years later the Kremlin was encircled by a strong earthen wall and an oaken palisade. Under Ivan I Danilovich (d. 1341) the principality of Vladimir was incorporated with that of Moscow. In 1326 the residence of the Russian metropolitan was transferred from Vladimir to Moscow. In the second half of the 14th century Moscow headed the struggle against the Mongol-Tatar yoke. The general levy formed the nucleus of the Russian forces which, under Dimitri Donskoi, routed the Tatar army under the grand khan Mamai at Kulikovo on the Don in 1380. In 1382, however, after a heroic defense, Moscow was captured and plundered by another Tatar leader, Tokhtamysh, but in 1408 it resisted a Tatar attack led by Yedigei.

As Moscow increased in importance the area occupied by the city grew and its appearance changed. Ivan Danilovich widened the Kremlin area by extending its earthen and oaken fortifications to the northeast and building there the first Uspenski cathedral made of stone (1326). In 1367, during the reign of Dimitri Donskoi, the first stone walls of the Kremlin were erected, and within the area it occupied were the palace of the grand duke, the palaces of the boyars (*q.v.*), monasteries and administrative buildings. There are six gates leading out of the Kremlin: one to the Moskva river, two to the Neglinnaya and three to the northeastern side of Krasnaya Ploshchad or Red square (this is a mistranslation and should be "beautiful square," its proper name since the 17th century). In 1404 Lazar, a Serbian monk from Mount Athos, Greece, fitted the Kremlin courtyard bell tower with a clock striking the hours.

After the second half of the 15th century Moscow, having annexed most of the surrounding principalities, became a centre for the unification of a national Russian state, though it was not until the reign of Ivan III (1462–1505), who annexed Novgorod in 1478, that the prince of Moscow claimed to be "ruler of all Russia." Ivan IV, called "the Terrible" but better "the Dread" (1533–84), subdued the khanates of Kazan and Astrakhan, but Moscow suffered many disasters at this time. In 1547 two great fires destroyed the greater part of the city; in 1571 the Tatar khan of the Crimea captured Moscow and burned it again, except for

The Cathedral of St. Basil the Beatified, a complex of nine chapels surmounted by domes and spires of various shapes and colours, built 1554–60. St. Basil stands in the Red square adjoining the Kremlin walls. It is now maintained as a museum

Novodevichi, one of the monastery-fortresses built to protect the city approaches; founded as a convent in 1524, it is now a museum

The Cathedral of the Annunciation (centre), built inside the Kremlin walls, 1484–89, on the site of an older church. At right is part of the Grand palace of the Kremlin, built 1838–49

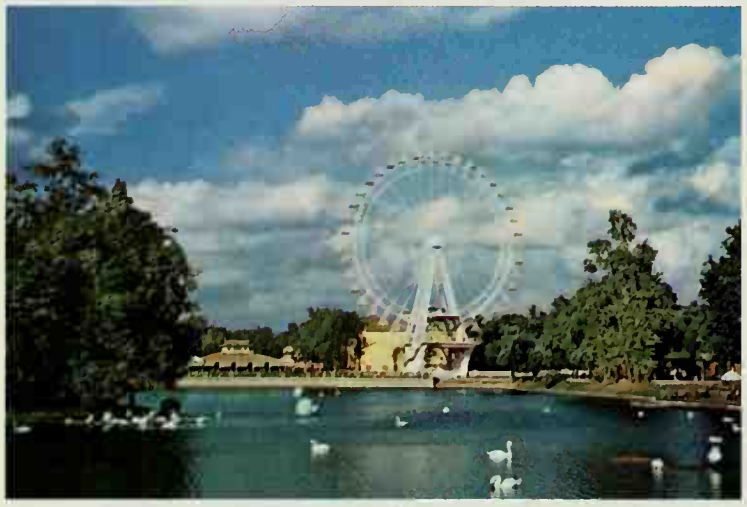
The Kremlin, viewed from a bridge over the Moskva river. First built of wood in 1156, the triangularly shaped fortress was surrounded by stone walls and towers in 1367. The Vodovzvodnaya tower is seen in the foreground

PHOTOGRAPHS, (TOP LEFT) JERRY COOKE—PHOTO RESEARCHERS INC. (TOP RIGHT) VALERIE J. FOESTS (CENTRE RIGHT) KEN HEYMAN (BOTTOM) EARL MORGAN—LIFE © 1959 TIME INC.

# MOSCOW

A view from Revolution square looking toward the Manezh (riding school), with the Lenin and Historical museums on the left. The Sobakina tower, part of the Kremlin wall, is seen in the background, rising above the roof of the Historical museum

The Moscow M. V. Lomonosev State university, located on Lenin hills, built in 1953. The university was founded in 1755 and is the largest and oldest in Russia



A view of Gorki park, one of the largest in Moscow and situated in the southwestern section of the city

Junction of Marx prospect and Gorki street in the centre of the city. In the background is the Moskva hotel

Street scene in an older quarter of Moscow, lying in the southern part of the city. In the background, the spires of one of the many Orthodox churches in Moscow

PHOTOGRAPHS, (TOP RIGHT) NOVOSTI PRESS AGENCY, (OTHERS) JERRY COOKE

the Kremlin (the annals record that of its 200,000 inhabitants only 30,000 survived); in 1591 the Tatars of the Crimea again attacked the city outside the Kremlin, the stubborn defense of which was helped by the fire-resisting brick walls and towers built in 1485–95.

Moscow's population was composed of a secular and ecclesiastical aristocracy, of merchants, artisans, small traders and serfs. The differences among the inhabitants with regard to the property owned by each, and the social conflicts, sometimes turning into open rebellions (for example in 1382, 1445 and 1547), were typical of medieval Moscow. In the city were concentrated the state businesses and workshops in which cannon were cast, gunpowder was prepared and weapons forged. The leather trade, the production of clothes and provisions, and the working of silver were important. The craftsmanship practised in 16th-century Moscow excelled in its quality and variety. The industrial character of the city was clearly reflected in the names of its suburbs: Bronnaya (armour makers), Kuznetskaya (blacksmiths) or Kotelniki (boiler workers). The centre of commercial life in Moscow was the market, adjoining Red square, where each stall traded in a certain kind of goods. This market was the largest in the land and played a big part not only in internal but also in external trade in the 16th century. The Moscow merchants traded with western Europe, especially with England and Holland, with central Asia, Transcaucasia, Persia and with such trading settlements on the Black sea as Kaffa (Feodosiya) and Surozh (Sudak). Among home products furs, for which there was a great demand in western Europe, took first place.

Moscow was also the centre of state administration. It contained the tsar's court, the boyars' *duma* (council), the assembly of the *zemstvo* (an advisory organ made up from elective representatives), the *sosloviya* (states of the country squires and burghers) and the *prikazy* (central governmental institutions controlling the separate branches of the state administration). The Moscow patriarchate was founded in 1589 with the idea of strengthening the power of the Moscow sovereign and also the powers of the church. The great importance of Moscow in the life of the Russian realm made foreigners identify it with the Russian state itself, which, in foreign writings of that time, was often called "Muscovy."

In the second half of the 15th and the beginning of the 16th century the number of stone buildings within the Kremlin increased. The old Uspenski cathedral fell to ruins in 1472 and a new one was built in 1475–79 by Ridolfo di (Aristotele) Fioravante, a Bolognese architect. It is in the Lombardo-Byzantine style, with Indian cupolas; its Italian innovations were frequently copied in later Russian churches. From the 16th century it was the church where the tsars were crowned. The Cathedral of the Annunciation (Blagoveshchenski Sobor), with its nine cupolas, was erected in 1484–89 by architects from Pskov on the site of an old church first built in 1397; the sacred pictures by Andrei Rublev (1405), on the *iconostas* (screen) of the high altar of the older church, were preserved in the newer one. The Archangel cathedral (Arkhangelski Sobor) was designed by Aléviso Novyi, a Milanese architect, and built in 1505–09 on the site of the original 14th-century cathedral. It contains the tombs of the tsars, from Ivan Danilovich to Ivan V (d. 1696), with the exception of Boris Fedorovich Godunov, whose body was removed in 1606 to the Troitsy-Sergieva Lavra (monastery of the Holy Trinity, in Zagorsk); of the later tsars only Peter II (d. 1730) is buried there.

Among the Kremlin's stone buildings of the 15th century is the Granovitaya (Faceted) palace (1487–91), all that remains intact of the original Grand Kremlin palace. It is a single-vaulted state reception hall, and there Ivan IV, in 1552, celebrated the conquest of Kazan. Opposite the Uspenski cathedral rises the lofty Ivanovskaya belfry (1505–08, completed in 1600 in the reign of Boris Godunov). Near the belfry stands the Tsar Kolokol, the largest bell in the world, which weighs 193 tons and was cast in 1733; during the fire of 1737 it fell from its scaffolding and a piece weighing 11 tons broke off. After 100 years it was raised and placed on a granite base. It has never been rung. To the east of it are two other belfries; one, erected by the Italian architect Petroche "the Little" in 1532–43, holds the chief church bell of Moscow, whose first stroke at midnight on Easter eve was later used as a signal to set the bells of the other 350 churches of Moscow ringing.

Near the Spasskiye Vorota (Redeemer gate) stands the former Voznesenski (Ascension) nunnery, restored in the 19th century; it is the burial place of the wives and sisters of the tsars. The Chudov (Miracles') monastery (14th century, rebuilt 1771) was formerly the residence of the metropolitan of Moscow and later a state prison; restorations undertaken in 1924, when the building was transformed into a museum for the objects of art from the famous Solovetski monastery on the White sea, evacuated after the civil war, revealed ancient corridors and rooms. Opposite the Chudov monastery stands the huge and ornamental Tsar Pushka (Tsar cannon), cast in 1586 and weighing 40 tons, which has never been fired.

The Red square lies along the northeastern wall and moat. It is linked with the Kremlin by three gates, of which the Spasskiye Vorota is in the centre. Behind Red square was the principal part of the old settlement, the Kitai Gorod (a name supposedly derived from the Tatar word for fortress). A small part of its wall still survives. While the Kremlin was the residence of the court and aristocracy, the Kitai Gorod was the residence of the merchants. It was enclosed by stone walls built by Petroche between 1535 and 1538. The Bely Gorod or White City—the settlement which had grown around both the Kremlin and the Kitai Gorod, north of the Moskva river—was enclosed in 1585–93 by stone walls built by Theodore I. The present boulevard ring occupies the site of these walls. Another settlement, known as Zemlyanoi Gorod (earthen city) grew up outside the White City and also on the south side of the Moskva river; it was surrounded by an earthen wall at the end of the 16th century. The site of this wall is now the green belt or Sadovaya ring. The main thoroughfares form radii of these concentric circles, cutting across the two rings and coming together at the Kremlin. Thus originated the radial-ring planning of Moscow. The city approaches were protected by a half-ring of monastery-fortresses, the two most famous being Novodevichi and Donskoi, both now preserved as museums. In the former many Communist leaders are buried.

In the 16th century the number of stone structures, religious and residential, in the settlement increased. In the years 1554–60 the Pokrovski Sobor (now a museum), better known as the cathedral Vasilii Blazhenny (St. Basil the Beatified)—named after Basil, the holy fool who was "idiotic for Christ's sake" and who was buried in the church vaults during the reign of Fedor Ivanovich (Theodore I, 1584–98)—was built in the Red square by Barma and Postnik to commemorate the subjugation of the khanate of Kazan. This cathedral is an outstanding monument of Russian national art.

Between the 14th and 16th centuries Moscow became the cultural centre of the Russian nation. The all-Russian archives as well as the archives of ecclesiastical literature were assembled there. Education made considerable advance in the 16th century, to which the growth of the book trade testifies. There existed a special book arcade and libraries which were large for the time. The first printing house was founded about 1553. Architecture, painting and applied decorative arts (wood carving, needlework and jewelry making) reached a high level. The greatest artists of Moscow were Andrei Rublev (*c.* 1360–1430), and Dionisi with his sons (15th–16th centuries).

At the beginning of the 17th century, during the *smutnoye vremya* ("time of troubles"), Moscow was seized by the impostor False Dimitri (Pseudo-Dimitri I), and in Sept. 1610 the hetman Stanislaw Zolkiewski entered the city. In May 1611 the Muscovites attacked the Polish garrison and forced the remnant of the Polish troops to take refuge in the Kremlin, where they surrendered in Nov. 1612. Kuzma Minin, a butcher, and Prince Dimitri Mikhailovich Pozharski played a great part in the liberation campaign.

In the 17th century Moscow, the greatest commercial and industrial city in the country, took on a new significance as the centre of the developing all-Russian market. The city area at this time extended beyond the boundaries of the Zemlyanoi settlement. The basic element of the population, as before, was made up of

artisans, day labourers and tradesmen who rose against exploitation in 1648 and 1662. At the time of the peasants' revolt (1667–71), under the leadership of Stepan T. Razin, the unrest of the people of Moscow was recorded. The execution of Razin in 1671 was carried out in Moscow in order to terrorize the populace.

The architecture of 17th-century Moscow underwent striking changes, taking on more and more a trim and decorative character. In the 1620s the Kremlin lost its importance as a fortress, and ornamental tent-shaped additions were made to the Spasskiye Vorota; in the 1680s similar decorations were added to other towers. In 1625 an Englishman erected the famous peal of bells in the tower above the Spasskiye Vorota. Large commercial houses and public buildings in stone occupied a still larger portion of the city. Toward the second half of the 17th century buildings sprang up which were complex, picturesque in composition and outline, and finished with ornamental brick masonry, coloured tiles, carved details in white stone, etc., the style known as "Moscow baroque." Among the surviving buildings the following should be mentioned: the Holy Trinity (Svyatoi Troitsy) church in Nikitniki, in the Kitai Gorod (1628–34); the Nativity (Rozhdestva) church (mid-17th century) in Putinki; the Holy Trinity church in Ostankino (1678–93); the buildings of the Pechatny Dvor or state printing house (1642–45) and of the Novodevichi and Simonov monasteries (1680s); and the Volkov house in the Great Kharitonovski passage (second half of the 17th century).

During the 17th century Moscow continued to play a leading role in the cultural and artistic life of the nation. It was also a centre of educational development; in 1687 the ecclesiastical Slavonic-Greco-Latin academy was founded. Russian literature and that translated from various languages was published and official chronicles were compiled.

At the same time, however, there was much disorder and internal strife. Revolts were crushed with the aid of the *streltsy*, a class of citizens and merchants rendering hereditary military service to the tsar. The spread of the *raskol* (schism), a nonconformist religious movement, led to further repressive measures. In 1698 the *streltsy* themselves revolted and were suppressed only after fearful slaughter by Peter the Great. In 1703 Peter, wearied of the opposition to his plans of reforms, of the conspiracies of the boyars and of the distrust of the masses, founded Petersburg (later St. Petersburg) to which, in 1712, the capital was transferred. Moscow's importance declined. The great fires of 1737, 1748 and 1752 caused much misery, but led to the enlarging of the streets and squares. Under Catherine II, in the 1790s, the population of Moscow was about 175,000.

Eighteenth-century Moscow remained, however, the great centre of culture and enlightenment in Russia. A large number of educational institutions were founded: the school of mathematical and navigational sciences (1701), the medicosurgical college (1786) and others. In 1755, through the initiative of the great Russian man of learning, M. V. Lomonósov, the first university in Russia was founded in Moscow. Changes in the tenor of life of the city gave rise to new types of domestic, public, commercial and industrial buildings, as special attention began to be paid to the planning and suitability of the architecture. The arsenal in the Kremlin, begun in 1701, was completed in 1736. The Menshikov tower (properly the church of the Archangel Gabriel) was built by I. P. Zarudny in 1705–07.

After an interruption, caused by the transfer of the capital to Petersburg, construction became more intensive, *e.g.*, the storied belfries of the Donskoi and Novospasski monasteries (1750s) and the church of St. Kliment in Pyatnitskaya street (1762–70), and flourished especially in the last third of the century when Russian classicism saw a brilliant development in the works of architects such as V. I. Bazhenov (1737–99) and M. F. Kazakov (1738–1812). Characteristics of the buildings of this period are monumentality of form, logical planning and harmony of composition. Among the most remarkable buildings of these years are the house of Pashkov (now the old building of the Soviet Lenin library); the building of the former Moscow senate (1776–87) in the Kremlin (now a Soviet government building); the old university building, on the corner of Mokhovaya and Herzen streets; the Golitsyn hospital in the Great Kaluzhskaya street; and many others. Typical of that period was a nobleman's town residence, usually consisting of a two- or three-storied house, standing in the courtyard or along the street front, with wings, servants' quarters and a garden. A number of smaller private detached residences were also built, together with thousands of little wooden houses, shops and workshops scattered throughout the city in a haphazard fashion.

Moscow played a significant part in the patriotic war of 1812, when the city was a large arsenal and provision depot for the Russian army. The seizure of Moscow was considered by Napoleon to be the deciding factor in winning the war and near the city the crucial battle of Borodino took place, after which Gen. Mikhail I. Kutuzov, commander in chief of the Russian army, decided to leave Moscow in order to conserve his army and be able to prepare a counteroffensive. Moscow was occupied by Napoleon from Sept. 14 to Oct. 19 (N.S.; Sept. 2 to Oct. 7, O.S.), 1812. This, however, did not save the French from rout. On the first night following the entry of the French, the city was set on fire through the carelessness of its inhabitants, and the stores in the bazaar were destroyed. The citizens fled and the city was plundered by the troops of both armies. The burning of Moscow (more than three-quarters of the houses were destroyed), however, was the signal for a general rising of the peasants against the French. The want of supplies and the impossibility of wintering in a ruined city continually attacked by Cossacks and peasants compelled Napoleon to leave Moscow, after an unsuccessful attempt to blow up part of the Kremlin.

After the liberation a great program of building was begun under the direction of the Commission for the Construction of the City of Moscow, established in 1813 with Osip Bove (1784–1834) as chief architect. The centre of the city was partially replanned. With the building of the Bolshoi theatre in 1821–24 (rebuilt after the fire in 1856), the Teatralny square took on a new appearance. Changes made in Red square included the filling-in of the moat, the building of the Torgovyye arcades opposite the Spasskiye Vorota in 1889–93 in the neoclassic style (the site of the modern G.U.M. or State Universal store), and the erection of a monument in 1818 to Minin and Pozharski. The riding school or *Manezh* was built in 1817 and the university, which had suffered from fire, was reconstructed.

In the 19th century the industry of Moscow reached its highest development up to that time and the *bourgeoisie* increased in importance. In 1837 the stock exchange was founded. After the abolition of serfdom in 1861, Moscow was rapidly transformed into the largest centre of manufacturing industry after St. Petersburg and became the biggest railway centre in the country. In 1871 its population reached 602,000. In the period from the second half of the 19th century to the beginning of the 20th century intensive construction of banks, commercial houses, railway stations, blocks of flats and industrial plants gave it the appearance of a commercial and industrial city. Among the largest buildings are the Gorodskaya Duma or town hall (1890–92, now the Central Lenin museum), the Polytechnic museum (1877) and the historical museum (1875–81). From this period date the Grand palace and Oruzheinaya (Armoury) palace of the Kremlin. The former was the scene of sessions of the supreme soviet up to 1961, and the latter houses a superb collection of treasures of the tsars. The construction, however, was carried on piecemeal, and all attempts at a rational replanning of the city met with opposition from private landowners. In the outskirts there arose all types of huts, workers' barracks and other dwellings of the poor. These districts formed a sharp contrast to the business centre and the residential districts of the well-to-do people.

In the architecture of Moscow of this period imitations of former styles and, at the beginning of the 20th century, the so-called modern style (for example, the Yaroslavl railway station, 1904–14) predominated. In a few buildings there was a harmonious blending of various architectural styles of former times, for instance, in the Kazan railway station and the great Tarasov house.

In the second half of the 19th century a progressive patron of the arts, P. M. Tretyakov, collected in his gallery the best works of Russian national art. In 1892 he gave his collection to the city

and, after 1918, this gallery was called Tretyakovskaya. In 1897 K. S. Stanislavski and V. I. Nemirovich-Danchenko founded the Moscow Art theatre.

With the appearance of the industrial proletariat in the 1870s and 1880s, workers' movements in Moscow became more extensive and many strikes took place. In the 1880s the first Marxist groups came into being. On the eve of Nov. 16 (N.S.; 3, O.S.), 1917, shortly after the successful Communist revolution in Petrograd (previously St. Petersburg), Soviet rule was set up in Moscow as the result of an armed revolt of workers. On March 10–11, 1918, the Soviet government and the central committee of the Communist party headed by V. I. Lenin moved from Petrograd to Moscow, which again became the capital of Russia, the first socialist state in the world. After the end of foreign and civil wars, during the years of the establishment and development of state economy, Moscow rapidly became an important industrial centre. Just before World War II the industrial production of the Moscow region was almost twice that of all pre-1914 Russia. In 1930 the Lenin mausoleum was erected in Red square. Considerable street widening in the centre and along the radial roads took place.

During World War I the population of Moscow grew to 1,983,700 (1915), but during the Revolution it diminished to 1,027,300 (1920). It grew to 2,029,425 in 1926 and in 1939 it passed the 4,000,000 mark. During World War II (described in the U.S.S.R. as the Great Patriotic War, 1941–45) its population diminished somewhat, especially toward the end of 1941 when the German invaders approached within 25 mi. of the capital. From Oct. 20 the city was declared to be in a state of siege. It was bombed from the air by German aircraft and fighting raged in the countryside around Moscow. The Soviet counterattack on Dec. 6 saved the city, and the Germans were forced to retreat.

After World War II the capital changed almost beyond recognition, especially in its centre. Although old wooden buildings, often in very bad condition, still remain and the great growth of population causes serious overcrowding, many of these relics of the past have been swept away and replaced by hundreds of huge blocks of flats. A number of skyscrapers in the postwar "Stalinist" style of elaborate architecture dominate the skyline, including the 32-story university building, imposingly located on the Lenin hills, in which are housed the science faculties, the humanities remaining in the old university opposite the Kremlin. Although new housing developments are found all around the city, one of the most extensive areas is near the new university, known as Cheremushki. Facing the university across the river is a new sports area, Luzhniki, with the large Lenin Central stadium and indoor palace of sport and several smaller buildings. In the centre of the town a large open-air swimming pool has been built on the site of the former Spasskaya (Redeemer) cathedral. In 1961 a new palace was completed inside the Kremlin to house sessions of the supreme soviet. The Sadovaya ring has been modified to meet increasing traffic, with overpasses (fly-overs) and underpasses. *See* also RUSSIAN ARCHITECTURE; UNION OF SOVIET SOCIALIST REPUBLICS; and references under "Moscow" in the Index.

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(X.; R. A. F.)

**MOSCOW ART THEATRE,** founded in the spring of 1897 by Konstantin Sergeevich Stanislavski and Vladimir Nemirovich-Danchenko, two intellectuals who felt that Moscow needed a playhouse to do justice to the new realistic playwrights. The cofounders were prompted by the spirit of protest against the prevailing star system, the triteness of the repertory and the routine of staging and acting. Their decision to start a new theatre amounted to a declaration of war on all existing theatrical conventionalities.

On Oct. 14, 1898, the Moscow Art theatre was opened with Aleksei Tolstoi's *Tsar Fyodor Ivanovich,* staged by Stanislavski with Meiningen-inspired devotion to historical accuracy. The decisive battles, however, were waged and won when the director and cast attempted the plays of Anton Chekhov, *The Sea Gull* in 1898, *Uncle Vanya* in 1899, *The Three Sisters* in 1901 and *The Cherry Orchard* in 1904. Maksim Gorki's *The Lower Depths* in 1902 likewise was a test of strength for the young company that gropingly discovered a new acting style of psychological realism.

After the Russian Revolution of 1917 the Art Theatre was unsuccessful in attracting the new audiences. The company was sent abroad for an extensive tour to Berlin, Prague, Paris and the United States. Before visiting other American cities the troupe played in New York city for eight weeks (January and February 1923), a highly successful engagement that revealed to American audiences the virtues of concerted ensemble-acting. (A. M. N.)

**MOSCOW CANAL** (KANAL IMENI MOSKVY), a ship canal of the U.S.S.R., links the capital to the Volga at Ivankovo, north of Moscow. Built 1932–37, the canal replaced the canalized Moskva river, which can take only small craft, as the main water access to Moscow. The boat journey to Gorki was shortened by 120 km. (75 mi.). Along its length of 128 km. (80 mi.) there are 11 locks. The minimum depth is 18 ft., while lock dimensions are 950 by 100 ft. making possible the passage of seagoing ships. The canal passes through three artificial lakes, the Khimki, Klyazma and Ucha reservoirs, which also serve Moscow's water supply and are much used for recreation by the city's inhabitants. The main port for Moscow is at Khimki on the northwestern outskirts. There are regular passenger, cargo and pleasure-cruising services along the canal and thence throughout the Volga system of waterways. Some passenger services are operated by hydrofoil craft.

(R. A. F.)

**MOSCOW FOREIGN MINISTERS CONFERENCE:** *see* WORLD WAR II CONFERENCES, ALLIED.

**MOSELEY, HENRY GWYN-JEFFREYS** (1887–1915), British physicist whose name will always be associated with his work on the X-ray spectra of the elements, was born at Weymouth, Dorset, on Nov. 23, 1887. He was educated at Eton and at Trinity college, Oxford. Immediately after graduation he was appointed lecturer in physics in Rutherford's laboratory in the University of Manchester, where he was later John Harley fellow and where he worked from 1910 until 1914, when he entered the army. His first researches were concerned with radioactivity; he then studied with remarkable success the X-ray spectra of the elements. In a series of brilliant investigations he showed that the frequencies of corresponding lines in these spectra were proportional to the squares of whole numbers which increased regularly by unity as one passed from one element to the next when the elements were arranged in order of increasing atomic weights. The atomic numbers represented the electrical charges on the nuclei of the atoms of the various elements, and Moseley's fundamental discovery was a milestone in advancing knowledge of the constitution of the atom.

Moseley's death in action at Gallipoli on Aug. 10, 1915, at the age of 27, robbed physics of one of its most promising investigators.

(D. McK.)

**MOSELLE,** a *département* of northeastern France, consists of the portion of Lorraine (*q.v.*) that was twice annexed by Germany, in 1871–1918 and 1940–44. It is bounded on the north by Luxembourg and Germany, including the Saar territory, on the east by the *département* of Bas-Rhin and on the southwest by Meurthe-et-Moselle. The population in 1962 (many German-speaking) was 919,412. The *département,* with an area of 2,414 sq.mi., extends south of the German frontier across the plateau of Lorraine from the wooded sandstone hills that flank the Rhine valley north of the Vosges to the oolitic limestone plateau that overlooks the Moselle valley in a great escarpment (Côtes de Moselle). The Lorraine plateau consists largely of clay country, above 600 ft., but it is diversified by outcrops of calcareous beds which form scarped heights. The Moselle in the west, and its tributary, the Sarre (Saar), farther east, flow from south to north in conformity with the grain of the relief. The winters are rather severe, but the summers are warm, and there is much good, if rather heavy, farm-

land, on which pasture is gaining ground at the expense of grain. Potatoes and fodder crops are extensively cultivated, and livestock products for the local mining and industrial towns are becoming increasingly important. The agricultural population live mainly in villages and there are few isolated farms in the countryside. The lower slopes of the scarped hills, especially favoured by soil and aspect, are marked by lines of villages and orchards.

The salt deposits of the Saulnois district in the Seille basin have long been worked, and are now the basis of important centres of heavy chemical industries at Château-Salins, Dieuze and Sarralbe. Clay has also been worked for centuries for making pottery, for which Sarreguemines is well known. But the most important mineral resources, iron ore and coal, have been developed only since the mid-19th century. Moselle contains the most accessible and highly developed part of the Lorraine iron-ore field, which extends westward from the Côtes de Moselle under the Briey plateau. The valleys of the Orne and Fentsch (Fontoy), left-bank tributaries of the Moselle, cut back into the plateau and facilitate exploitation of the ore, most of which is worked by adits. In the northeast of the *département*, adjoining the Saar territory, is a buried extension of the Saar coalfield, which was opened up in the 20th century. The mining area in Moselle around Forbach and St. Avold is an increasingly important source of provenance for the Lorraine iron and steel industry. Coking plants are situated on both the coalfield and the ore field. The iron and steel works are in the Moselle valley near Thionville and in the valleys of the Fentsch and Orne, which are heavily industrialized. Besides new coking plants, the post-World War II modernization plans have included the erection of new strip mills and at Richemont, by the confluence of the Orne with the Moselle, an electric power station and an oxygen works that supplies the iron and steel works by means of the "Oxylor" network of pipelines.

The Marne-Rhine canal, as well as important railways and roads, crosses the *département* from west to east, converging upon the Col de Saverne approach to Strasbourg. The Marne-Rhine canal is connected with the Sarne basin by the Canal des Houillères, but the waterways are far less important for industrial traffic than the railways. The railway along the Moselle valley provides the chief link with the Ruhr coalfield, but the canalization of the river from Thionville to Coblenz (completed by 1963) reinforces this connection.

Metz is the *préfecture* of the *département* and also the centre of the bishopric, but the *département* comes under the *académie* of Strasbourg for the administration of education, and under the court of appeal at Colmar for justice. Metz, Thionville, Boulay, Forbach, Sarreguemines, Sarrebourg, and Château-Salins are the centres of the *arrondissements* into which the *département* is divided. (AR. E. S.)

**MOSELLE RIVER** (German MOSEL), of northeastern France and western Germany, 340 mi. long, is a left-bank tributary of the Rhine. It rises in France in the granitic Vosges, flows westward down their forested slopes and turns northwestward through lower terrain, of Triassic sandstone, to Épinal. Entering the scarplands of Lorraine it turns westward at Pont St. Vincent to cross the Oolitic limestone escarpment in a deep valley. At Toul the river approaches a gap, the Val de l'Asne, in a further line of hills through which it had flowed in the preglacial era, but swings sharply away northeast to recross the Oolite. It receives the Meurthe as a right-bank tributary at Frouard and from there flows northward, in a valley floored mainly by Lias clays and overlooked by the steep eastward-facing scarps of the Côtes de Moselle, through Metz and Thionville. The Moselle leaves France below Thionville, for a short distance forms the frontier between Germany and Luxembourg, then flows northeastward through Germany. From Trier to its confluence with the Rhine at Coblenz it cuts through Devonian slates and quartzites in impressive entrenched meanders broken by falls and rock bars. In this sector of the valley (Moseltal) are the vineyards from which the famous Moselle wines are produced. The chief tributaries are the Madon, Orne and Sauer (Sûre) on the left, and the Meurthe, Seille and Saar on the right.

Above Metz the Moselle was navigable to 300-ton barges from the 19th century. It connects at Toul and Frouard with the Rhine-Marne canal. From Metz to Thionville it was navigable from 1932 to 300-ton barges moving upstream; below Thionville it was not navigable until the inauguration in 1964 of the Moselle canal from Metz to Coblenz, built to take 1,350- to 1,500-ton barges. The canal is administered by a tripartite authority, representing France, Germany and Luxembourg, with power to levy tolls. Several iron and steel plants front the waterway. Of 14 barrages with locks (11 in Germany) 12 have power plants (10 in Germany) with a total annual capacity of 800,000,000 kw.hr. (J. E. M.)

**MOSEN, JULIUS** (1803–1867), German writer, best known for his stories (*Georg Venlot*, 1831; *Bilder im Moose*, 2 vol., 1846), his political-historical novel *Der Kongress von Verona* (1842) and his poems (1836 and 1843), some of which attained popularity (*e.g.*, "Andreas Hofer"). Many of his writings, although fundamentally romantic in approach, show the influence of contemporary events. Mosen was born at Marieney in the Saxon Vogtland on July 8, 1803, and studied law at Jena and Leipzig; he traveled in Italy and in 1844 accepted the post of dramaturgist to the court theatre in Oldenburg. Soon afterward he was stricken with paralysis and he died at Oldenburg after many years of ill-health on Oct. 10, 1867. His other works include the epics *Das Lied vom Ritter Wahn* (1831) and *Ahasver* (1838) and a number of plays (*e.g.*, *Theater*, 1842, and the tragedies *Herzog Bernhard*, 1855, and *Der Sohn des Fürsten*, 1858). His collected works appeared in eight volumes (1863).

*See* H. Schuller, "Zu Mosens Georg Venlot," *Euphorion*, vol. 23 (1921); F. A. Zimmer, *Julius Mosen* (1938). (L. H. C. T.)

**MÖSER, JUSTUS** (1720–1794), German writer, a forerunner of the *Sturm und Drang* movement, was born at Osnabrück, Dec. 14, 1720. A barrister, he became virtual head of the government of Osnabrück, a Protestant prince-bishopric, displaying great statesmanship in this post. The fruit of his experience and of his love of the region was a collection of weekly papers, on the English model, *Patriotischen Phantasien* (1774–76). His *Osnabrücks Geschichte* (1768) was a pioneer work, showing the influence of folk traditions on the customs and government of a community. His contributions to the rediscovery of the past strengthened that literary revolt against foreign influence and the Enlightenment of which Goethe, who admired Möser, was the greatest figure. He died in Osnabrück, Jan. 8, 1794.

Möser's collected works were edited by B. R. Abeken (1842–43; new ed., 1945 *et seq.*); a selection was edited by K. Brandi (1921). His letters were edited by E. Beins and W. Pleister (1939).

*See* F. Meinecke, *Die Entstehung des Historismus*, 2nd ed. (1946); P. Klassen, *J. Möser* (1936).

**MOSES** (13th century B.C.), the founder of the religious community of Israel, was the leader of the Israelites in their exodus from Egypt, in the subsequent covenant ceremony at Mt. Sinai and on their journey to the promised land, although he died in Jordanian territory before the tribes entered it. The core of the traditions about Moses witness to his primary function as the prophetic founder of Israel's religion, but to ascertain the details of his life constitutes one of the most difficult tasks of modern biblical study.

**Moses in the Pentateuch.**—The introductory story of the birth and upbringing of Moses in the Pentateuch is embellished by legendary motifs. The son of Amram and Jochebed (Num. xxvi, 59), he was born when the Israelites, who had come to Egypt under Joseph, were being oppressed by the Egyptians and compelled to drown every newborn male child (Ex. i). Moses' mother, however, was determined to save him alive, so she placed him, at the age of three months, in a basket (or ark) made of bulrushes at the edge of the river where Pharaoh's daughter came to bathe. The princess took pity on the child, whom she adopted as her own and called Moses.

His origins are certainly Egyptian, for the name is of Egyptian provenance. Also there are added to the story notes of inferior historical value about Aaron being his brother and Miriam (with whom is connected the oldest piece of literature in the Bible, Ex. xv, 21) his sister. When Moses had grown up he was aroused by the oppression of his kinsmen in Egypt. Having killed an

Egyptian in their defense, he fled to Midian (south of Palestine), where the narrative begins to be more historically reliable.

*Midianite Connections.*—The story of Moses' family connections in Midian (Ex. ii, 15 ff.) is on sure historical ground. Moses married a daughter of a Midianite priest and there he also took part in Midianite worship. In spite of the fact that in later history the Midianites were Israel's enemies (Judg. vi–viii), a Midianite-Israelite cultic fellowship is evidenced (Ex. xviii, 12).

Zipporah, the daughter of Jethro (called Reuel in Ex. ii, 18), bore to Moses two sons, Gershom and Eliezer. On their leaving Midian (Ex. iv, 24 ff.) a strange incident happened: Yahweh (or, as in the Greek version, an angel) attacked Moses and threatened to kill him. By applying the flint knife in the rite of circumcision, Zipporah saved her husband's life. The story preserves primeval and obscure reminiscences of circumcision in connection with marriage.

*Moses' Call.*—The call of Moses occurs in the context of his life in Midian and fits into the theme of his Midianite ties. For that reason, and because it fits into a known pattern of religious behaviour, the story of God's call to Moses (Ex. iii, 1 ff.) must be admitted as historical evidence. While grazing the sheep of his father-in-law Moses chanced upon the sacred mountain, Sinai, which undoubtedly was a frequented place of pilgrimages. There, in a way peculiar to ancient religion, he experienced the presence of God; the blackberry bush (Hebrew *seneh*) was enwrapped in fire which did not consume it, and out of it Moses heard the words of God mediated to him by a heavenly being. In fact a new deity, Yahweh, whose name had not been hitherto known to him, appeared to Moses (*see* YAHWEH). Since, in ancient religion, the name of a person or a deity was thought to embody the being of its bearer, the revelation of the name of Yahweh to Moses was equivalent to the unfolding of the deity's nature and purpose and the instituting of the closest personal relationship between God and Moses. On the one hand, Yahweh was a new god, hitherto unknown to Moses, but, on the other hand, Moses understood him to be the same god as the one worshiped by his Hebrew ancestors, the "God of the Fathers." Thus, in his religious experience Moses received a new revelation, while at the same time the continuity of Hebrew religion was preserved.

In some ways Moses' call resembles that of later prophets; like them, for instance, he was at first reluctant to take on the exalted task offered him (Ex. iii, 11). But there is a difference; Moses was called not only to be the prophetic intermediary between God and Israel but also to be the saviour of Israel and to lead the Israelites out of Egypt. Consequently, his call is not merely a reading back of later prophetic experiences into this earlier period.

*The Exodus.*—The story of the deliverance out of Egypt depicts dramatically the sufferings of Israel under Egyptian tyranny, where they served as slaves, while the overwhelming power of the Pharaoh, in its opposition to the divine will to deliver Israel to freedom, takes on demonic colours. Moses and Aaron went before Pharaoh, demanding Israel's release, but their request was denied. The subsequent story of the ten plagues which God sent to the Egyptians represents in dramatic form the battle between Yahweh and the hostile power, the Pharaoh. After the tenth plague, in which all the first-born of the Egyptians were destroyed, Pharaoh let the Israelites escape to the wilderness under the leadership of Moses but later sent an army which overtook them at the Papyrus marsh (the "Sea of Reeds," usually called the Red sea). In Ex. xiv it is related that the waters parted to let the Israelites through to the other side on dry land but closed in on the Egyptians, who were all drowned. The miracle at the Red sea is described with poetic magnificence in the hymn of Ex. xv. The narrative of the exodus from Egypt (Ex. i–xv) is probably based on an ancient Hebrew ritual performed annually at Passover in words and dramatic action in celebration of this formative event in the religious history of the people (*see* JEWISH HOLIDAYS). The central figure is Moses (*see* also EXODUS).

*Sinai.*—The story of the journey to Sinai, which now follows, is to be seen as a part of a larger theme in the Pentateuch, that of the wanderings in the wilderness. In its midst the Sinai theme is set, relating the covenant at Sinai.

In the two Sinai passages (Ex. xix–xxiv and xxxii–xxxiv) Moses is the prophetic intermediary and ruler. In the first section the grand scene of the institution of the covenant is told. The structure of the liturgy clearly involves the following parts: the admonition to the people (xix, 4–6); the decision of the people to enter the covenant (xix, 8); the appearing of the deity, described in terms peculiar to ancient near-eastern religion, such as earthquake, lightnings, etc. (xix 16 ff.); the declaration of the divine will; the announcement of the Ten Commandments (xx, 2–17); the divine promise consequent upon the covenant (xxiii, 20); and the sealing of the covenant (xxiv) in a beautiful ceremony including sacrifices offered up by young men under the direction of Moses and the celebration of a sacramental meal, during which God himself was present in splendour upon the mountain (*see* also COVENANT: *In Religion*).

It has been suggested that this account is based on a ceremony which took place each autumn in Palestine, either at Shechem or in Jerusalem. However, it is probable that the nucleus of the narrative rests on a covenant event at Sinai. That historic event instituted "Israel" as God's people (*cf.* Deut. xxviii, 9).

The Decalogue (xx, 2–17) represents the ethical principles laid down by Moses, although in its present form it has been expanded by centuries of preaching in Israel (*see* DECALOGUE). The sabbath also, in its original form, is a Mosaic institution. But the law material which follows the Decalogue, such as the Book of the Covenant (Ex. xx, 23–xxiii, 19) and the priestly laws (xxv–xxxi), is of later origin.

The second section (Ex. xxxii–xxxiv) relates the Israelites' idolatrous worship of the golden calf made by Aaron during Moses' absence on the mountain (xxxii, 1–6). In its present form, the story reflects idolatrous practices in Israel in the 9th century. But the theme into which it is fitted, the rebellion of the people against Moses' authority, is firmly embedded in the Mosaic tradition. This rebellion brought to a head the obvious division of religious allegiance among the people. It was suppressed with much bloodshed by the Levites (xxxii, 26–29), and only after their victory was the worship of Yahweh re-established. Moses had to atone for the sin of Israel (xxxii, 30 ff.). His intercessory prayer is given in ch. xxxiii, together with the account of the tent of meeting containing the tabernacle, where Moses conversed with God "face to face." The narrative oscillates between hope and despair until it comes to rest in a proclamation of God's grace. In vehement prayer on the top of the mountain Moses receives a blinding vision in which the word of forgiveness is heard as in an oracular shout: "Yahweh, Yahweh, a God merciful and gracious . . ." (xxxiv 6 ff.). This formula, which also occurs in a similar form elsewhere (Num. xiv, 18; Ps. ciii, 8), is probably an oracular pronouncement of forgiveness used in the cult. In the following material a covenant between Yahweh and Israel is proclaimed and its commandments stipulated (Ex. xxxiv, 10 ff.). The chapter concludes with an obscure picture of Moses wearing a cultic mask ("veil," xxxiv, 33–35).

This latter Sinai section is independent of the former, but in the redactional process the two have been joined by the insertion of notes about the breaking of the first set of tables of law and the making of new tables (Ex. xxxii, 19; xxxiv, 1), so the narrative is transformed into a story of the renewal of a broken covenant. Originally, however, ch. xxxii–xxxiv constituted an independent tradition of how Moses wrestled with a rebellious people, how he won Yahweh's favour and how the covenant was established. This section, being concerned (perhaps originally) with the revelation of the name of Yahweh to Moses (xxxiii, 19; xxxiv, 6), is involved in the scene of the call (ch. iii) and the exodus theme. This lends added historical support to the narrative, which probably contains odds and ends of oral traditions about Moses' prophetic work; fragments which were conflated, as early as the oral stage, into an epic of Moses. Its central part (Ex. xxxiii, 7–xxxiv, 9) is concerned with showing how Moses was authorized as the servant of the Lord (*cf.* Ex. xiv, 31; Deut. xxxiv, 5) and the leader of Israel. He was so authorized only because he was able to lead the people on. If Yahweh accompanied Israel, it proved the authenticity of Moses' office (Ex. xxxiii, 16). Again, this trait in

the description of Moses' role indicates that it is not a reading back into the wilderness period of later prophetic material. No later parallel is available.

*The Wilderness.*—The narrative of the 40 years' wandering in the wilderness constitutes a separate theme in the Pentateuch. It tells primarily of the journey from Sinai to the oasis of Kadesh south of Palestine (Num. x, 11–xx, 13) and from there to the promised land (Num. xx, 22 ff.; Deut. xxxii, 48 ff.). The stories about the journey from Egypt to Sinai (Ex. xv, 22–xviii) also belong to this theme. Some of this material has been transposed in order to make an ordered sequence of a journey from Egypt to Sinai and from there to Kadesh and on. The original sequence was probably more complex.

The theme of the wanderings in the wilderness is expressed in a series of stories. Their action takes place against the backdrop of the people's murmurings, the most notable of which is the rebellion of Korah, Dathan and Abiram (Num. xvi, 1 ff.), and Moses' marvelous power to provide for the people's needs and lead them onward. Thus he made the water drinkable at Marah (Ex. xv, 22–25), struck water from the rock at Massah (Ex. xvii, 1 ff.; *cf.* Num. xx, 2 ff.), provided the people with manna and quails (Ex. xvi; Num. xi, 4–35) and mediated superhuman power in their battle against the Amalekites (Ex. xvii, 8–13). Moses' connections with the Midianites appear again when Israel arrives at the sacred mount (it is uncertain if this is Sinai), and Moses and his father-in-law, Jethro, the Midianite priest, offer up sacrifices and celebrate a sacred meal in common (Ex. xviii). Then Moses, on the advice of Jethro, puts the administration of justice on a regular footing, a valuable piece of historical information.

These passages, which reveal a knowledge of the localities mentioned, fill out the picture of the function of Moses. Thus, for example, the story of Moses and the Cushite woman, which is set in a narrative about prophecy in the wilderness, preserves an obscure reminiscence of the role of Moses (Num. xii); he was something more than a prophet, he was the servant of the Lord. Generally speaking, these narratives tell how Moses welded the Hebrew tribes and the rabble (Num. xi, 4) that accompanied them into one ordered community of life and worship.

The final episode of the wanderings in the wilderness is the journey around the kingdom of Edom, which denied passage to the Hebrews, and through Moab. There Moses, having commissioned Joshua as his successor, ascends Mt. Nebo, east of the Jordan river, and dies (Deut. xxxiv, 1 ff.). The Book of Deuteronomy in its present form is cast in the form of a recapitulatory speech made by Moses before his death. Toward its conclusion two later poems, the song of Moses (Deut. xxxii) and the blessing of Moses (Deut. xxxiii), are interpolated.

**Moses in History.**—Moses' impact on Israel's religion is debatable in the opinion of those modern scholars who regard the beginning of Hebrew faith as a natural growth rather than as deriving from the religious genius of an individual. But the figure of Moses as presented by the pentateuchal traditions when they are critically examined with a view to synthesis, as has been attempted above, affords the most plausible explanation of the first origins of Hebrew faith and institutions. Moses' impact, then, was to communicate a revelation of God as a redeeming power in history who makes exclusive, ethical demands on man's will, and, at the same time, to build a community around that revelation (the covenant). Having thus started a development in religious history which was to have much historical consequence, Moses remains one of the outstanding figures of all time.

In Judaism Moses is a towering figure from whom the entire religious system is derived and on whose authority it rests. In postbiblical Jewish literature Moses became an eschatological figure and a heavenly being who will appear at the end of time.

Traditionally he was regarded as the author of the first five books of the Bible, which are known as the books of Moses, and the Jewish law is called Mosaic because it was traditionally revealed through him.

In the New Testament Moses is viewed in the same way as in Jewish thought. But he is at the same time the precursor of Christ (1 Cor. x, 1 ff.) and a witness to him (John i, 45). Moses (with Elijah) appears to Jesus in the scene of the transfiguration, thus heralding the coming of the Kingdom of God in Christ (Mark ix, 4 ff.). On the other hand, Jesus (it can be inferred) is seen as the new Moses giving the new Law of the Sermon on the Mount (Matt. v–vii). Conversely, the law of Moses is contrasted with the grace of Christ (John i, 17).

*See* also references under "Moses" in the Index.

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**MOSES** of Khoren (Movses Khorenatzi) is known as the "father of Armenian literature." Traditionally held to be a 5th-century author, he has been dated as late as the 9th century. Nothing is known of his life apart from alleged autobiographical details contained in the *History of Armenia* bearing his name. His claims to have been the disciple of St. Sahak and St. Mesrop, to have studied in Edessa and Alexandria after the council of Edessa (431) and to have been commissioned to write his *History* by the governor Sahak Bagratuni (481–484) have been rejected by most serious scholars, mainly in view of anachronisms in his text. He is the only early Armenian historian to treat of events in his country long before its conversion to Christianity, and his lively style, narrative skill and diversity of interests ensure his continued popularity. A *Rhetoric*, a *Geography* (now attributed to Anania Shirakatsi) and some homilies also bear his name. (C. J. F. D.)

**MOSES, ASSUMPTION OF,** an extracanonical apocalyptic work of the Old Testament, a prophecy of the future relating to Israel, put into the mouth of Moses and addressed to Joshua just before the great lawgiver died. Founded upon the book of Deuteronomy, it contains a brief history of Israel from Moses to the messianic age. The most striking feature in this work is the writer's scathing condemnation of the priesthood, before, during and after the Maccabean period, obviously meant as an attack on the Sadducean high priests of his own time.

After the time of Herod's sons the story loses its concretion; "the times shall be ended" (vii, 1), the true Jewish religion will be persecuted by a mighty king, and a certain Taxo of the tribe of Levi shall appear, exhorting his seven sons to withdraw with him to a cave and die rather than transgress the law of God; God shall avenge them, he says. Then the kingdom of God shall be established. It has been suggested that the name Taxo is derived from the Greek *taxon* ("orderer") and is meant to render the Hebrew *mehoqeq* ("sceptre") of Num. xxi, 18, a passage that was also given an eschatological interpretation among the Dead sea covenanters, especially in the so-called Damascus document. For this and other reasons, it seems probable that the book derives from Essene or related circles.

The book is preserved in a Latin translation from the Greek, but was probably originally written in Hebrew or Aramaic. It has been assigned to a date between the death of Herod the Great and that of Bar-Cochba; but the true date appears to lie between 4 B.C. and A.D. 30. Herod is already dead (vi, 6), hence it is after 4 B.C.; and Herod's sons are to rule for shorter periods than their father, hence it must have been composed before these princes had reigned 34 years—*i.e.*, before A.D. 30. But there are grounds for assuming that A.D. 7 is probably the earlier limit. *See* also Apocalyptic Literature.

Bibliography.—*See* the edition by R. H. Charles (1897), and his article in *Apocrypha and Pseudepigrapha of the Old Testament* (ed. by Charles), vol. ii, pp. 407–424 (1913), with bibliography. Later discussion in H. H. Rowley, *The Relevance of Apocalyptics* (1944; 3rd ed. 1955), and M. Burrows, *More Light on the Dead Sea Scrolls* (1958). (R. H. Ch.; H. Ri.)

**MOSHEIM, JOHANN LORENZ VON** (1693–1755), German Lutheran theologian and founder of the pragmatic school of church historians, was born at Lübeck on Oct. 9, 1693. He studied at Kiel university, became in 1723 professor at Helmstedt and in 1747 was appointed by George II professor of divinity and

chancellor of the newly founded university at Göttingen, where he died on Sept. 9, 1755.

Mosheim was the first church historian to advocate the treatment of original sources from an objective and critical standpoint, founding the pragmatic school of church historians which later included scholars such as J. G. Walch and J. A. W. Neander. He was also the first to move away from the old method of simple narrative to an interest in wide historical movements. Among his 85 works are his *Vindiciae antiquae Christianorum disciplinae* (1720), *Institutiones historiae ecclesiasticae* (1726), *Versuch einer unpartheyischen und vollständigen Ketzergeschichte* (1748) (an objective treatment of heresies) and *De rebus Christianorum ante Constantinum Magnum Commentarii* (1753). The *Institutionum* was translated into several languages and published in an English edition (1863) by William Stubbs with a preface on Mosheim's significance.

*See* K. Heussi, *Johann Lorenz von Mosheim* (1906); E. Hirsch, *Geschichte der neuen evangelischen Theologie,* vol. ii (1951).

(C. L. A. R. H.)

**MOSHESH** (d. 1870), founder of the Basuto nation in southern Africa, was born toward the end of the 18th century near the upper Caledon river. Though his father was only a minor chieftain, so successfully did Moshesh resist repeated attacks during the disturbances initiated by Shaka, the Zulu, that he built up a large following. In 1833 he received three members of the Paris Evangelical Missionary society, who became his advisers in his dealings with the Boers and the British. The emigration of *Voortrekkers* from the Cape Colony led to competition for the fertile land on either side of the Caledon river, and it was not long before Moshesh decided that his best hope lay in British protection. In 1843 Britain accepted him as an ally and in 1848 his territory was included in the Orange River sovereignty, as annexed. But the British administration failed to resolve the conflicts which arose between Moshesh and rival African chiefs and between Basuto tribesmen and Boer settlers, and when Britain abandoned the sovereignty in 1854 it renounced the Moshesh alliance. In a war against the Orange Free State in 1858 Moshesh outmaneuvered the Boers, who were glad to have the British high commissioner negotiate a settlement. After further fighting the Boers gained the upper hand and Moshesh accepted the treaty of Thaba Bosiu (1866), which drastically reduced his territory. Sir Philip Wodehouse, high commissioner, concluded that Moshesh's reiterated request for British intervention should be granted; and on March 12, 1868, on authority from London, Wodehouse annexed Basutoland, whose boundaries with the Free State were fixed at their present limits by negotiation in 1869. Moshesh died on March 11, 1870. He had shown great skill in uniting diverse fragments of African tribes, in defending their land and in bringing them into the British empire. *See* also BASUTOLAND.

(L. M. T.)

**MOSLEY, SIR OSWALD ERNALD,** 6TH BARONET (1896– ), British politician, leader of the British Union of Fascists from 1932 to 1940 and of the "Union movement" after 1948, was born in London on Nov. 16, 1896. Educated at Winchester college, he entered parliament as a Conservative in 1918, became an Independent (1922), joined the Labour party (1924) and was chancellor of the duchy of Lancaster (1929–30). He resigned from the Labour party in 1931 to form a new socialist party, but lost his seat at the general election in October. In 1932 he founded the British Union of Fascists and, a powerful orator, roused some enthusiasm, being supported in 1934 by Lord Rothermere, who publicized the party as the only alternative to socialism. Interned in 1940, Mosley was released in 1943 on the ground of illness. After World War II he launched the Union movement on Feb. 8, 1948. He married in 1920 Lady Cynthia Curzon (d. 1933), daughter of Lord Curzon of Kedleston, and in 1936, Diana Guinness (née Freeman-Mitford), daughter of Lord Redesdale.

See *Mosley: the Facts* (1957) for a list of his publications and a statement of his views.

**MOSQUE,** a place of prayer for Muslims. The Arabic word *masjid* (sometimes *al-masjid al-jami'*, or *al-jami'* alone) means "a place of prostration" to God, and the same word is used in Persian, Urdu and Turkish. A mosque consists of an open space, generally roofed over, containing a mihrab and a mimbar (or minbar), and a minaret is sometimes attached to it. The mihrab, a semicircular niche reserved for the imam who leads the prayer, points out the *qibla* (*i.e.*, the direction of the Ka'ba at Mecca). The mimbar, a seat at the top of steps placed at the right of the mihrab, is used by the *khatib* (preacher). In the early days of Islam the rulers delivered their speeches from the mimbar. The minaret (*mi'dhana*), originally any elevated place but now usually a tower which can take various forms (*see* MINARET), is used by the muezzin (*mu'adhdhin*, "crier") to proclaim the *azan* (call to worship). A place for ablution, containing running water, is usually attached to the mosque but can be separated from it. Mats or carpets cover the floor of the mosque.

According to the Koran (xvii, 1), the Masjid al-Haram at Mecca and the Masjid al-Aqsa at Jerusalem existed before Islam, and Mohammed is said to have visited these two mosques. Probably they were old sanctuaries used by monotheists. No mosques were built during the Mecca period. After the hegira Mohammed erected a primitive pulpit and used the courtyard of his house at Medina as a praying place. Later, Mohammed was enjoined to direct his face toward Mecca instead of Jerusalem during prayer (Koran ii, 144). Usually Muslims abstained from using non-Muslim sanctuaries as mosques; Omar, the second caliph, refused to pray in the Holy Sepulchre at Jerusalem. However, some rulers who conquered non-Muslim countries by war turned their sanctuaries into mosques. An example is the Christian church of Hagia Sophia in Constantinople, which Mohammed II converted into a mosque after he took the city in 1453.

Mohammed's praying place, like the ancient Roman forum, was used for all public functions, military, political, social and educational. It served as a model for the following generations, though the mosque as such underwent architectural changes under the influence of local styles (*see* ISLAMIC ARCHITECTURE). Out of the mosque there emerged various institutions, such as the school, the ribat and the court. The ribat was originally a place where horses were assembled and kept in readiness for an expedition. Later ribats became religious and military establishments. The courts were used by judges or magistrates.

The mosque differs from a church in many respects. Ceremonies and services connected with marriages and births are never performed in mosques. The rites that are an important and integral function of many churches, such as confession, penitence and confirmation, do not exist in the mosques. Prayer is performed by bows and prostrations, with no chairs or seats of any kind. Men stand in rows, barefooted, behind the imam and follow his movements. Women may join in but they must use a separate space. Children are required to pray on reaching the age of puberty. No statues, ritual objects or pictures are used; the only decorations permitted are inscriptions of koranic verses and of the names of Mohammed and his companions. Music and singing also are not incorporated into the religious services conducted in the mosque. The Koran, however, is chanted by professional chanters (*muqri'*), who have learned the system in special schools. No discrimination is allowed; rich and poor, noble and humble people, all stand together in the same rows.

In Muslim countries mosques are subsidized by the state, hence no collection of money from the community is permitted. The ministry of *waqf* (endowment) appoints the servants, preachers and readers of the Koran. Mosques in non-Muslim countries are subsidized by individuals. They are administered by their founders or by a special fund (also known as *waqf*). A caretaker is appointed to keep the place clean. The muezzin calls to prayer five times a day from the minaret, and no bells are allowed. All mosques follow the same basic pattern of architecture and belong to the same institution. Muslims from the four schools of thought (Shafi'i, Hanafi, Maliki, Hanbali) go to the same mosque. Only heterodox (*batini*) Muslims have their own places of worship which differ in style and ritual from the mosque, but these are comparatively few.

The mosque has developed in modern times, but not radically. Its social, educational and political functions have been largely taken over by other institutions. In a few cases a *kuttab* (a primi-

tive elementary school) is attached to a mosque, mainly for the teaching of the Koran. On certain occasions the *'ulama'* (learned men) give public lectures in the mosques on religious and social subjects after afternoon and evening prayers. Men as well as women frequent the circles of these *'ulama'* and discuss various problems. During mawlids (birthdays of the Prophet and celebrated persons) and festivals the mosque becomes a central gathering place for worshipers and visitors. In modern times, however, other attractions compete with the mosques, and celebrations are directed elsewhere. Formerly, distinguished holy men were buried in mosques. This is now strictly forbidden, and cemeteries have to be established far away from mosques.

Some Islamic states are reviving the old function of the mosque by attaching to it a library and a club for social activities. Turkey, at one time, wished to introduce some basic changes, such as covering the prostration place with wood and calling for prayer in Turkish, but these innovations did not last long.

*See* also references under "Mosque" in the Index.

*See* H. A. R. Gibb and J. H. Kramers (eds.), *Shorter Encyclopaedia of Islam,* pp. 330–353 (1953). (I. M. H.)

**MOSQUERA, TOMÁS CIPRIANO DE** (1798–1878), Colombian statesman and president, was born in Popayán, on Sept. 20, 1798. Scion of a powerful family, Tomás was one of four brothers, all of whom served Colombia with distinction. From 1815 to 1830 he remained in active military service, serving in field, staff, diplomatic and politico-military posts. He began his political career as deputy to congress in 1834. Elected president in 1845 and 1866, Mosquera also headed the Liberal revolutionary government (1860–64) until elections were held in 1864 under the federal constitution of 1863. His conservative administration (1845–49) was noted for its economic measures, and his subsequent liberal administrations for hostility against the Roman Catholic Church. His conflict with the Radical and Liberal-dominated congress of 1867 led him to establish a dictatorship (April 22) which was overthrown on May 23, 1867. Impeached and exiled for two years, he returned to serve as president of the state of Cauca and as senator. He retired from public life in 1876 and died two years later in Coconuco on Oct. 7, 1878.

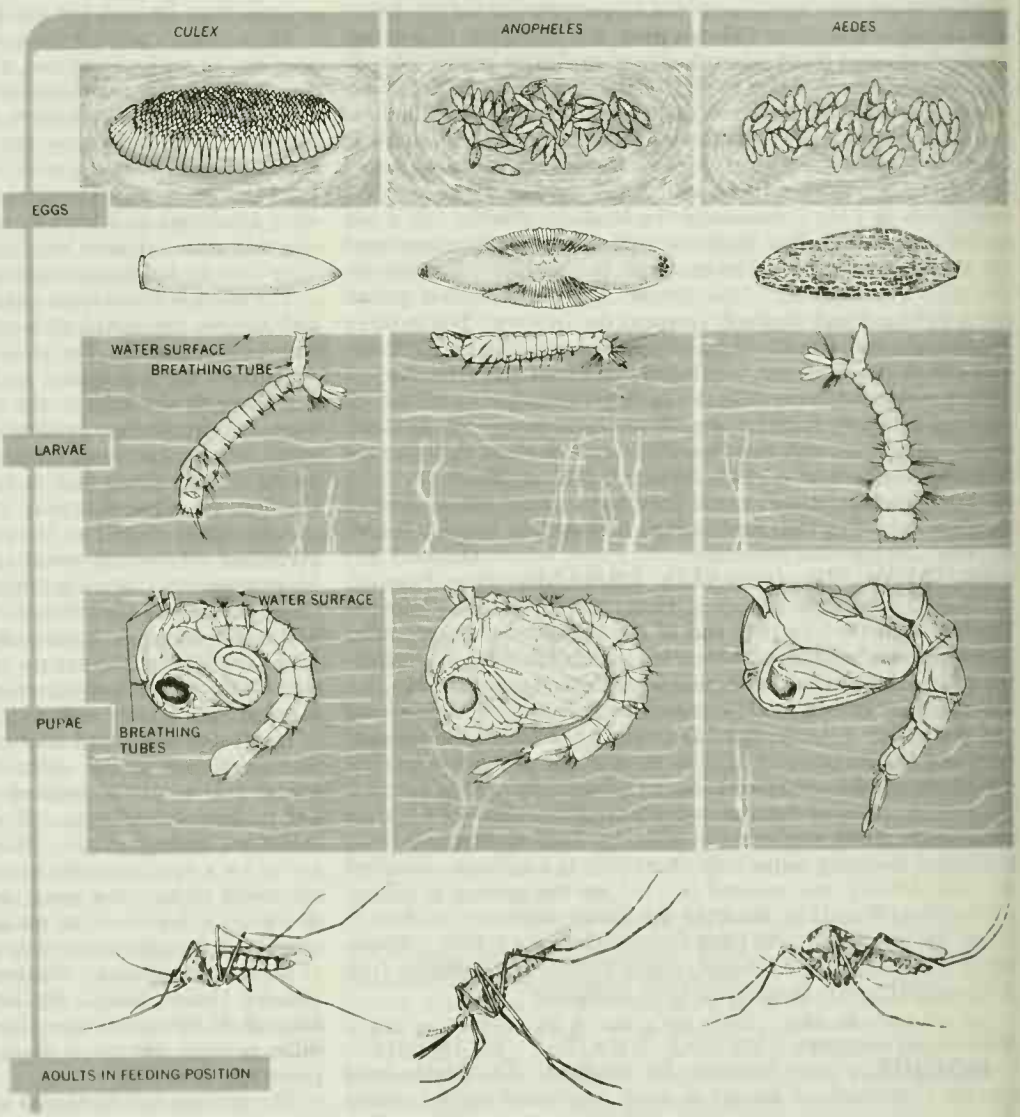
Mosquera was willful, ambitious, able, independent and vengeful. A major personality, a successful general in civil conflicts and popular in the Cauca valley, he could not be ignored by the political parties, much as they disliked and distrusted him. Although he was eager to change Colombia into a modern progressive nation, he failed to become a major influence in its development. (R. L. Ge.)

**MOSQUITO,** any of the familiar flies of the cosmopolitan family Culicidae, important in public health because of the blood-sucking habits of the females of most species: many "bite" man and some can transmit serious diseases, among them yellow fever, malaria, filariasis and dengue (*qq.v.*). The Culicidae is included in the suborder Nematocera, distinguishable from other suborders of the Diptera, or true flies, by the long, threadlike antennae. (Some authorities include the dixine and chaoborine midges in the family, but these groups are now generally separated into their own families, Dixidae and Chaoboridae; *see* also Fly.) The approximately 2,500 species are grouped into three subfamilies: Toxorhynchitinae, Culicinae and Anophelinae.

## GENERAL FEATURES

**Body Characters and Habits.**—The typical mosquito form is well known: a slender elongate body with long, fragile-looking legs. The wings are characteristically veined, the veins and margins being beset with scales. The antennae, composed of 15 segments, are generally bushier in the male. The mouthparts are contained in an elongated proboscis characteristic of the group. The males (and also frequently the females) feed on nectar and other plant juices. In most species, however, the females require a special supplement of protein in order to mature their eggs; this they derive from a blood meal. Different species show preferences and in many cases narrow restrictions as to host animals.

Adult mosquitoes exhibit maximum activity at different times of the day or night, depending on the species. They appear to be attracted to host animals largely by body odour, but other factors are undoubtedly involved. The hum of a mosquito is due to the high wing-beat frequency. The female's slightly lower frequency



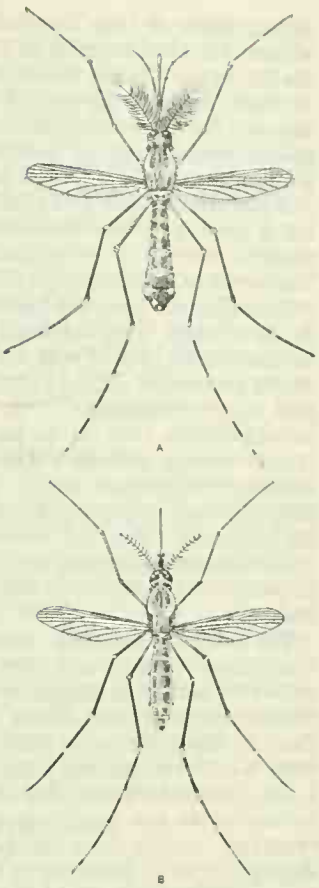

FROM W. HERMS, "MEDICAL ENTOMOLOGY"; REPRODUCED BY PERMISSION OF THE MACMILLAN CO.

FIG. 1.—LIFE HISTORIES OF THREE GENERA OF MOSQUITOES, SHOWING CHARACTERS USED IN IDENTIFICATION

produces a lower hum that seems to serve as a means of sex recognition and as an attractant for the male.

**Habitats and Life Cycle.**—The habitats or breeding-places range from small artificial or natural containers (*e.g.*, domestic utensils, rot-holes in trees, leaf bases and the joints of bamboos) to swamps and the edges of large, permanent bodies of water. Many species can withstand severely contaminated water. Thus one species breeds abundantly in hot, highly alkaline volcanic pools around Lake Edward in Uganda, while another has been found breeding in a tank of hydrochloric acid in a factory in India. The immature stages of many species can even tolerate the digestive enzymes in the fluid in "pitchers" of carnivorous plants. Saline and brackish pools are also highly productive of mosquitoes in coastal areas.

The duration of the life cycle varies greatly depending on the species; in some only one generation occurs annually; others need only about seven days from egg to adult. The adults mate soon after emerging from their pupal cases. There are four discrete larval stages and one pupal stage between the egg and the adult; both the larvae and pupae are active and free-swimming. The eggs may be laid on the surface of the water or above the waterline, to await flooding, or they may be glued to floating vegetation. In some cases they are laid at random on the wing and remain dormant until they are washed into shallow, rain-filled depressions where they hatch. The sabethine mosquito *Sabethes chloropterus* (*see* below) breeds in very small tree-holes and flips its eggs into the tree-hole from the tip of the abdomen while hovering in front of it.



BY COURTESY OF THE U.S. DEPARTMENT OF AGRICULTURE

FIG. 2.—STRUCTURAL DIFFERENCES BETWEEN (A) MALE AND (B) FEMALE AEDES AEGYPTI. FEMALE CAN TRANSMIT THE YELLOW-FEVER VIRUS

**Control Measures.**—Before the end of World War II, attempts at controlling mosquitoes were aimed at eliminating the breeding places, the sources of an otherwise diffuse and inaccessible mosquito population. Much research was therefore carried out on larval biology and on the factors governing the females' choice of site for laying eggs. Modifying the larval environment was, at that time, the principal means of control in many areas. The methods used included drainage of swamps, marshes and ditches, clearing of streams, cutting back of dense overgrowth of vegetation and removal of debris that could provide breeding pockets.

Surface films of oil have been applied to reduce the larval population by clogging the breathing tubes of wrigglers; larvicides such as Paris green, pyrethrum and rotenone have long been used to treat small ponds and ditches.

With the advent of the new synthetic organic insecticides came increased emphasis on destroying the adult mosquito in indoor situations. This results in a more economical use of insecticide and avoids some of the risks to beneficial insects, other wild life and even man, inherent in the wider dispersal of toxic substances in nature. Insecticide may be sprayed on walls and interior surfaces generally and remain lethal to resting adult mosquitoes for long periods. Such methods, however, are ineffective where habits of mosquitoes favour transmission of disease out of doors, as they do to some extent in the case of malaria and to a large extent in the case of filariasis and virus diseases.

Of limited use are the following examples of biologic control. The application of spores of the fungus *Coelomomyces*, which parasitizes insects, has been investigated and shows some promise. Several small fishes, especially *Gambusia affinis*, the mosquito fish of the southern United States, have been introduced into areas of heavy infestations, where they have substantially reduced the mosquito population; they are effective consumers of mosquito larvae and pupae and are most useful in ponds and other small bodies of water. To find out how to use the new insecticides effectively, there must be research on subjects ranging from the genetics of insecticide resistance to the age structure of mosquito populations. Much more research on the biology of adult mosquitoes is needed before the more recondite problems of disease control can be tackled.

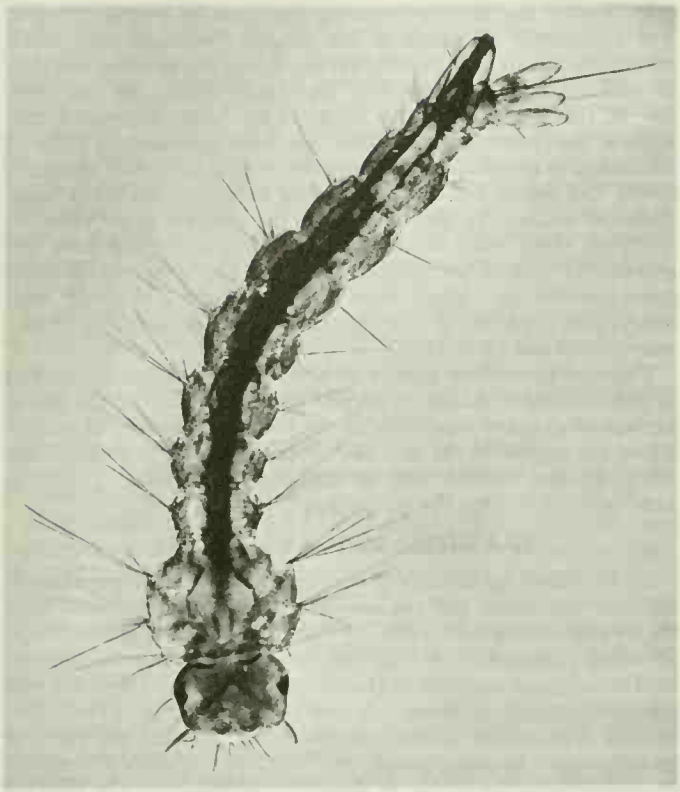
Personal protection against mosquitoes (and other biting flies as well) can be obtained for several hours at a time by the use of various proprietary repellents, in the forms of creams and lotions. These are applied to the skin and deter the insects from alighting. Bites are best treated with an anti-histamine cream applied as soon as possible after the occurrence.

## CLASSIFICATION AND SURVEY

Of the three subfamilies of Culicidae the Toxorhynchitinae is the least important and the smallest. With very few exceptions the two remaining subfamilies of Culicidae are distinguished from all other Nematocera in that the female has elongated, attenuated mouthparts enclosed in the proboscis sheath. These are well adapted for drawing blood. A few small crane flies (Tipulidae) have a superficially similar proboscis but without the piercing mouthparts. In one genus of Culicinae, *Malaya* (formerly *Harpagomyia*), the proboscis sheath is modified and the piercing parts are greatly reduced in the female, as they are in the males of all mosquitoes. In this genus the adults live on food regurgitated by ants of the genus *Cremastogaster*, the tip of the proboscis being thrust almost into the jaws of the ant. All the other genera of mosquitoes, with the possible exception of a few species, are believed to take blood. It seems, however, that more species than had previously been realized are, in part, autogenous (capable of maturing their eggs without a blood meal). In some cases probably only a part of the population can do this, the remainder being anautogenous (completely dependent on a blood meal).

**Toxorhynchitinae.**—This subfamily contains only one genus, *Toxorhynchites* (formerly *Megarhinus*), which includes, for the most part, very large and brilliantly coloured mosquitoes. They are marked by a long proboscis, bent downward and backward through more than a right angle, specialized for insertion into the nectaries of flowers. The proboscis sheath forms a sucking tube, and the mouthparts are greatly reduced. The adults of both sexes feed exclusively on nectar. Protein for the maturation of the eggs is obtained by the larvae, which are cannibalistic and prey on the larvae of other mosquitoes. For this reason species of *Toxorhynchites* have been brought from Africa and southeastern Asia to several Pacific islands with a view to reducing the numbers of disease-carrying mosquitoes that use the same breeding-places (in this case tree-holes and other organic containers). But this is unlikely to have more than a palliative effect, owing to the slow rate of reproduction of *Toxorhynchites*.

**Culicinae.**—This subfamily is divided into two tribes, the Sabethini and Culicini. The former includes three old world genera, *Tripteroides*, *Topomyia* and *Malaya*, and five new world genera, *Trichoprosopon*, *Wyeomyia*, *Phoniomyia*, *Limatus* and *Sabethes*. The old world genera are tropical except for a few species that are found as far north as Japan and as far south as New Zealand. The new world genera are confined to Central and South America and the West Indies, except for a few species occurring in the southern United States and one remarkable species, *Wyeomyia smithii*, found as far north as Newfoundland, Labrador and southeastern Canada, in company with the pitcher plant *Sarracenia purpurea* in which it breeds. The larvae of this species overwinter in the plant pitchers and are said to be capable of withstanding freezing and subsequent thawing. The South American sabethines include several known vectors of human and ani-



BY COURTESY OF THE U.S. DEPARTMENT OF AGRICULTURE

FIG. 3.—LARVA, OR WRIGGLER, OF THE YELLOW-FEVER MOSQUITO (AEDES AEGYPTI)

mal viruses, possibly including yellow fever.

The tribe Culicini contains many genera with considerably varied habits and habitats. The genus *Mansonia* (formerly *Taeniorhynchus*) is notable for the fact that the respiratory siphon of the larva and the respiratory trumpets of the pupa are modified for piercing the submersed tissues of water plants. It is in this way that oxygen is obtained for respiration. This genus includes important carriers of human filariasis in southeastern Asia. In all other mosquitoes (except the Anophelinae, discussed below) the tip of the siphon is applied to the film at the surface of the water. Oxygen dissolved in the water is also used to some extent, being absorbed through the general body surface. The so-called anal gills probably serve more for maintaining the salt balance of the larva rather than specifically for respiration.

Among the other genera of Culicinae the largest and most important medically are *Aedes* and *Culex*, each of which has a world-wide distribution and contains some hundreds of species. The most northerly records of mosquitoes are of certain species of *Aedes* (subgenus *Ochlerotatus*) from nearly 80° N. Mosquitoes of this subgenus are serious pests in arctic and subarctic latitudes, where they occur in enormous numbers. No mosquitoes are known from the Antarctic. Most of the medically important species of *Aedes* belong to the subgenus *Stegomyia*, and include the *Aedes scutellaris* species complex, the main vectors of human filariasis over much of the Pacific area; *Aedes aegypti*, the principal carrier of yellow fever among human populations; and *Aedes africanus*, which maintains the yellow fever virus in monkeys in the tree-top canopy of the African forests. In the new world the place of *Aedes africanus* is taken by mosquitoes of the related genus *Haemagogus*. Not all the carriers of the many new mosquito-borne viruses discovered in recent years have been identified, but *Aedes* (subgenus *Neomelaniconion*) *circumluteolus* is known to carry several diseases in South Africa, and viruses have been isolated from *Aedes* (*Ochlerstatus*) *scapularis* in the new world and also from species of *Mansonia* and *Psorophora*.

Mosquitoes of the genus *Culex* (and some others) differ from *Aedes* in that their eggs, instead of being laid separately, are glued together to form floating rafts. They transmit particularly certain forms of virus encephalitis, mainly diseases of domestic animals but also occurring in epidemic form in man. Examples are St. Louis, Eastern Equine and Western Equine encephalitis in North America, Japanese B encephalitis in eastern Asia and Murray Valley encephalitis in Australia. *Culex pipiens* (subspecies *fatigans*) (*C. p. quinquefasciatus* of American authors) is a common carrier of human filariasis in the tropics.

**Anophelinae.**—In this subfamily the eggs, unlike those of all but a very few other mosquitoes, are provided with individual floats by which they are maintained on the surface of the water. The larvae do not have respiratory siphons. Instead, the spiracles or breathing apertures are flush with the surface of the abdomen, the tip of which is applied direct to the surface film. These larvae are maintained parallel with the surface film by a notched organ on the thorax and special palmate hairs on the abdomen. They feed on microorganisms in the surface film; the head can be rotated through 180° for the purpose. The adults have a characteristic resting attitude. This subfamily includes two small, medically unimportant genera, *Chagasia* and *Bironella*, and the medically very important *Anopheles*. *Anopheles* is divided into six subgenera. Four of these, *Anopheles* in the strict sense, *Nyssorhynchus*, *Kerteszia* and *Cellia* (formerly *Myzomyia*) are of particular importance as they include major carriers of human malaria.

The subgenus *Anopheles* includes members of the *Anopheles maculipennis* complex and allied species responsible for the transmission of malaria in Europe and North America. As living conditions improved, the disease disappeared spontaneously from Great Britain and most of western Europe; it has been eradicated from North America and much of southern and eastern Europe in the course of a world-wide campaign against it. The principal vectors in the new world tropics belong to the subgenus *Nyssorhynchus*. Among them are *Anopheles albimanus*, *aquasalis* and *darlingi*. Species belonging to the subgenus *Kertessia*, which is also confined to the new world, breed mainly in the water that collects in the leaf bases of certain plants (bromeliads) growing on the trunks and branches of trees, often at great heights above the ground. A few other anophelines breed in tree holes or dead bamboos, but the great majority breed in ground waters of one kind or another. *Kerteszia* species are notorious malaria carriers in Brazil and in Trinidad and certain adjacent areas on the mainland. In Trinidad the disease assumed epidemic proportions when shade trees, intended for the protection of cocoa trees in the plantations, were invaded by bromeliads from the surrounding forests. On that occasion the disease was brought under control by the mass spraying of bromeliads from the ground with copper sulfate solution. The same method was later applied successfully in Brazil but proved too costly as a permanent control measure. The subgenus *Cellia* includes many highly important malaria carriers in the old world tropics, such as *Anopheles gambiae* and *A. funestus* in Africa, *A. stephensi* in the Middle East, *A. culicifacies* and *A. minimus* in India, *A. sundaicus* and *A. maculatus* and species of the *A. leucosphyrus* complex in southeastern Asia and members of the *A. punctulatus* complex in Melanesia.

*See* also references under "Mosquito" in the Index.

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**MOSQUITO COAST** (COSTA DE MOSQUITOS; MISKITO COAST), a section of the Atlantic coast of Central America comprising part of the republics of Honduras and Nicaragua, specifically a narrow strip, about 40 mi. wide, skirting the Caribbean sea for a length of about 225 mi. The name of the region comes from its ancient Indian inhabitants, the Miskito or Mosquito Indians. While the term Miskito can still be used to refer to an identifiable Indian population, a large percentage have long been mixed with Negroes.

The Mosquito Coast was first discovered by Columbus in 1502, but there were only some tentative efforts at colonization by the Spanish and for practical purposes it did not come into contact with Europeans until the rise of the buccaneers in the 17th century. After that the English established a protectorate over the Mosquito Indians. Spain, Nicaragua and the U.S. disputed this claim until the matter was finally settled with the occupation of the Mosquito Coast by the Nicaraguan government and by the Clayton-Bulwer treaty (*q.v.;* 1850) between the United States and Great Britain, later revised under the Hay-Pauncefote treaty of 1901.

The Mosquito Coast of Nicaragua is divided among the departments of Río San Juan, Zelaya and Cabo Gracias a Dios. Its principal city is Bluefields, the capital of the department of Zelaya, the principal city of the Atlantic region of Nicaragua and an important seaport (pop. [1959 est.] 11,248). Other centres are Puerto Cabezas and San Juan del Norte (Greytown). *See* also NICARAGUA. (M. F.-G.)

**MOSS,** the common name for any of the lower green nonvascular plants belonging to the class Musci, a subdivision of the Bryophyta (*q.v.*). They bear leaflike organs. Popularly, the term is often applied to a variety of unrelated organisms that superficially resemble true moss: certain red algae are called sea moss or Irish moss (*q.v.*); the green alga *Protococcus* forms the greenish film, called moss, on tree trunks, posts, stones, etc. (*see* ALGAE); certain kinds of lichen (*q.v.*) are called reindeer moss, beard moss, oak moss, etc.; a group of lower vascular plants is called club moss (*see* LYCOPODIUM); among the flowering plants is the epiphyte Spanish moss (*q.v.*); a phylum of aquatic invertebrates is so mosslike to the naked eye that it is called Bryozoa (*q.v.*), a Greek name meaning "moss-animal." Only the true mosses (Musci) will be dealt with in this article.

## GENERAL FEATURES

**Distribution.**—Although usually small and often overlooked, some mosses are conspicuous by their size or abundance. The brook moss (*Fontinalis*) may form streamers one to three feet long in flowing water. The stair-step moss (*Hylocomium splendens*) forms a dense carpet very characteristic of the northern coniferous forest. Although the greatest number of species and the greatest quantities of mosses are found in areas of high humidity (*e.g.,* the Olympic and Great Smoky mountains in the United States and elsewhere in the temperate rain forest of the tropics and the tundra), they are found also in almost all parts of the world, including the deserts.

Some common species include the cord moss (*Funaria hygrometrica*) found on wood ashes, the silvery bryum (*Bryum argenteum*) and the horn-tooth moss (*Ceratodon purpureus*) occurring on various substrata; they are common in the United States and appear to be more or less cosmopolitan in distribution. However, most are restricted in range by substratal or climatic factors or past geological events, and exhibit much the same geographical range patterns as do the flowering plants.

**Life Cycle.**—As in other bryophytes there is a very evident difference between the two generations that constitute the complete life cycle of a moss. The sporophyte is the asexual phase; the gametophyte is the sexual phase (fig. 1). The mosses multiply by branching and fragmentation, by regeneration from tiny pieces of leaves or stems or specialized bodies (propagula) and by the production of spores (minute single-celled and usually spherical structures) in the capsules (sporangia) of the sporophytes. The spore under favourable conditions germinates and grows into a branching, algalike green thread (protonema). Repeated branching may produce a mat of green felt which on exposed soil retards its erosion.

Sooner or later, from these green filaments come branches (gametophytes) with leaflike scales (phylloids) arranged alternately in spirals or, less frequently, in two rows. In most cases there are eventually formed at the tips of the branches or in the axils of the phylloids the sex organs: male (antheridium) and female (archegonium). The sexes may be represented by different plants or both types may appear in the same cluster of sex organs on one plant. The antheridium is usually shaped like

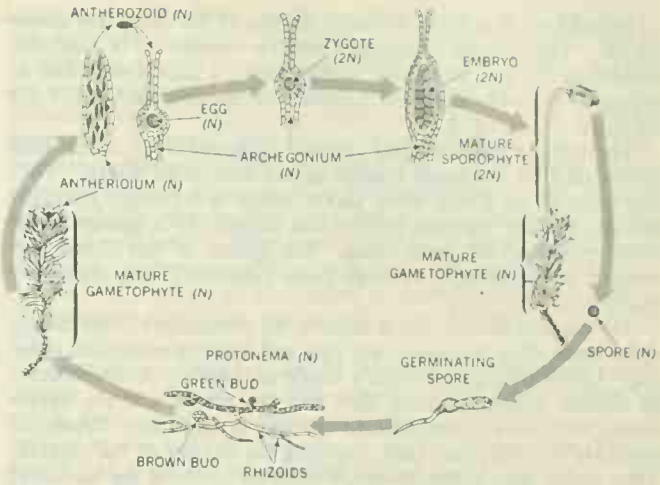
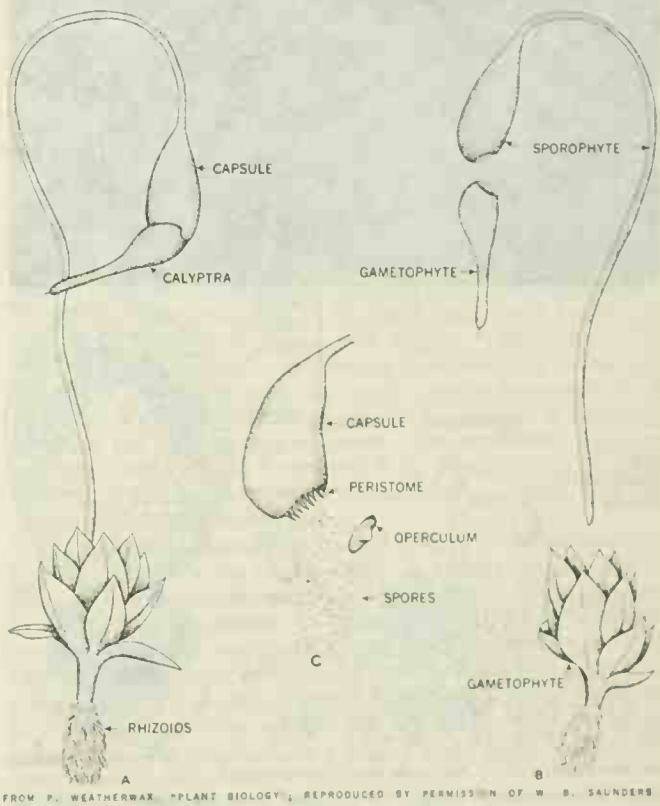



FIG. 1.—LIFE CYCLE OF A MOSS

a short sausage and is composed of a jacket of a single layer of cells enclosing a dense mass of tiny cells, each of which develops into a sperm (male gamete). At maturity the antheridium ruptures under moist conditions and the released sperms, equipped with two whiplike cilia, are capable of swimming.

The archegonium is shaped like a flask with a long, narrow neck. The egg (female gamete) is borne in the centre of the enlarged base (venter). At maturity under moist conditions the top cell of the neck breaks away and the central column of cells in the neck disintegrate, forming a canal to the egg. Sperms within close proximity swim into the archegonium but only one penetrates (fertilizes) the egg to form a zygote.

The zygote divides, forming an embryo sporophyte, which usually grows faster than the archegonium. As a result, the top part of the female sex organ is broken loose and borne aloft as a sort




FROM P. WEATHERWAX "PLANT BIOLOGY"; REPRODUCED BY PERMISSION OF W. B. SAUNDERS COMPANY

FIG. 2.—A MATURE MOSS PLANT: (A) MORPHOLOGY OF WHOLE PLANT; (B) DISSECTION INDICATING TISSUES OF THE TWO GENERATIONS; (C) MATURE SPORE CAPSULE

of pointed cap (calyptra) covering the top of the elongating sporophyte. The mature sporophyte usually consists of a foot embedded in the base of the old archegonium, a stalk (seta) and an enlarged spore-bearing head (capsule or sporangium) under the calyptra. (*See* fig. 2.)

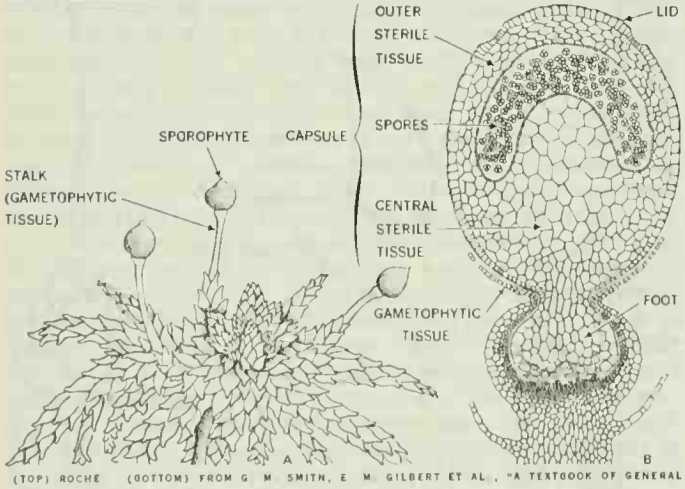
The capsule has a central column (columella) of sterile cells surrounded by the many minute spores mentioned above. They are enclosed by a thin inner jacket which is separated from the thicker, tougher exterior wall of the capsule by a spongy tissue (chlorenchyma) of green cells. The spaces in this tissue may connect to the exterior through pores (stomata) with regulatory guard cells.

The capsule usually has a definite lid (operculum) that neatly splits loose when the spores are ripe and leaves a mouthlike opening. Under the operculum is a single or double row (peristome) of slender, triangular teeth that ring the mouth and are hygroscopic and move in response to changes in moisture. When the teeth are dry, they curl back, exposing the interior of the capsule; when moist, they curve inward, effectively blocking the mouth of the capsule and thus controlling to some extent the dissemination of spores.

A few mosses have capsules that lack the operculum and break open irregularly; others may have an operculum but lack the peristome.

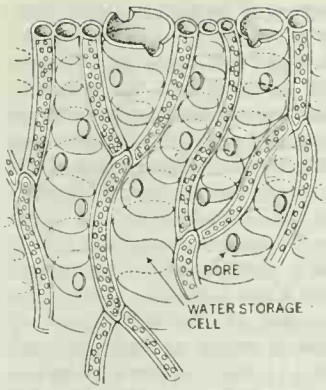
## SURVEY AND IMPORTANCE OF MOSSES

The mosses may be subdivided variously but are usually classified into three orders: Sphagnales, Andreaeales and Bryales.




(TOP) ROCHE (BOTTOM) FROM G. M. SMITH, E. M. GILBERT ET AL., "A TEXTBOOK OF GENERAL BOTANY"; REPRODUCED BY PERMISSION OF THE MACMILLAN CO.

FIG. 3.—SPHAGNUM MOSS: (TOP) CLUMP GROWING UNDER A CONIFER; (BOTTOM A) APICAL PORTION OF A LEAFY SHOOT BEARING SPOROPHYTES; (B) LENGTHWISE SECTION OF A NEARLY MATURED SPOROPHYTE. THE SPORES ARE IN GROUPS OF FOUR, EACH GROUP DERIVED FROM ONE SPORE MOTHER CELL



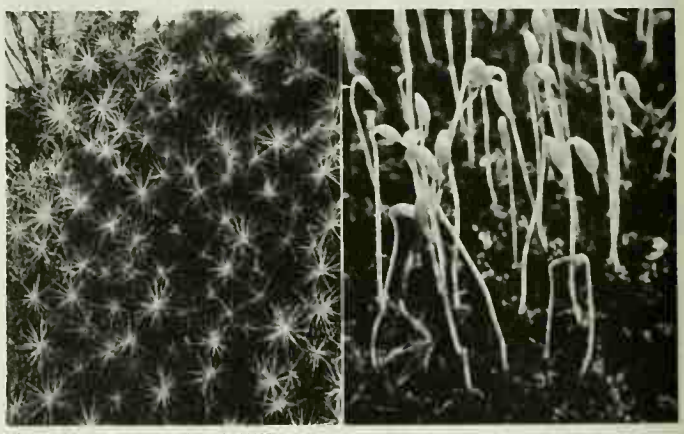

FROM H. J. FULLER AND O. TIPPO, "COLLEGE BOTANY," REVISED (1954); REPRODUCED BY PERMISSION OF HENRY HOLT AND CO., INC.

FIG. 4.—PORTION OF SPHAGNUM "LEAF" WITH NARROW CELLS CONTAINING CHLOROPLASTS AND WIDE, ELONGATED CELLS WITH PERFORATED WALLS, STRENGTHENED WITH INTERNAL RINGS AND SPIRALS

**Sphagnales.**—This order, represented by a single genus *Sphagnum*, is often the chief component of peat bogs and is usually known as bog or peat mosses. Economically, they have the greatest importance of all of the Bryophyta. In addition to being the original source of peat and some charcoal, sphagnum has been used as packing for nursery stock and cut flowers, for surgical dressings, as an additive to soil and as litter for stables and chicken houses. Because so many cells in the leaves and stems are large, empty and have porous walls (*see* fig. 4), sphagnum can absorb great quantities of liquids and odours. The plant contains a small amount of sphagnol, a phenolic compound with some antiseptic properties.

Sphagnum differs from the other mosses not only in the empty, porous cells mentioned above, but also in several other characters: a sporophyte (*see* fig. 3) without a stalk, which is raised at maturity on an elongated specialized branch (pseudopodium) of the gametophyte; a short domelike columella; spherical capsules with no peristome; long-stalked spherical antheridia; and the thalloid embryonic stages of the gametophyte.

**Andreaeales.**—Represented by a single genus *Andreaea*, the slit mosses, this order in North America has two characteristics in common with sphagnum: the pseudopodium and the initial thalloid stage of the gametophyte. But sphagnum may be over one foot long and of a pale colour while *Andreaea* is less than one inch high and is red-brown to black. The capsule opens by four slits in the lateral walls. It usually grows on nonlimy rock.



(LEFT) ROCHE; (RIGHT) GRANT HAIST

FIG. 5.—HAIR-CAP MOSS (POLYTRICHUM COMMUNE): (LEFT) A DENSE STAND OF GAMETOPHYTES; (RIGHT) SPOROPHYTES ARISING FROM THE GAMETOPHYTES

**Bryales.**—Most of the mosses belong to the order *Bryales*, although they vary considerably in size, form and habitat. Among them are found the smallest, pygmy moss (*Ephemerum*) and the longest (*Fontinalis*). Their form often gives them interesting names: tree moss (*Climacium*); wind-blown moss (*Dicranum*); feather moss (*Ptilium*); extinguisher moss (*Encalypta*); turkish-slipper moss (*Diphyscium*); and the luminous elfin-gold (*Schistostega*), the protonema of which contains lens-shaped cells that reflect golden light from the dark depths of cellars or caves.

In the past, members of this order had more economic importance, fancied or real, than in modern times, although many are still used, particularly by peasants. The pigeon wheat or hair-cap moss (*Polytrichum*) and carpet moss (*Hypnum*) have been used in stuffing bedding; the carpet moss was thought to be capable of

inducing sleep. Pigeon wheat, which often is over a foot in height, was and still is used in making brooms and dusters. The stems, stripped of their leaves and outer layers, were used in the plaiting of baskets and other articles. They have been tried in landscaping, but some prove difficult to cultivate. They are also extensively used for Christmas decorations in Latin America, where bales of mosses are shipped annually from the mountains for this purpose. Some have a retarding effect on soil erosion, and newly cut banks along roads or trails in the Appalachian mountains often are covered with green, feltlike mats of protonema of a moss (*Pogonatum pensilvanicum*) that greatly reduces erosion.

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**MOSSADEGH** (MOSADDEQ, MUSADDIQ), **MOHAMMED** (1880– ), Iranian statesman mainly responsible for the Oil Nationalization act of 1951, was born in Teheran, the son of Mirza Hidayat, a former minister of finance. After serving for a period as treasurer of Khurasan province, Mossadegh went to Neuchâtel, Switz. (*c.* 1908), where he studied law, obtaining the degree of *Docteur en Droit* for his thesis *Le Testament en droit musulman* (*secte chyite*) (Paris, 1914). On his return to Persia (1914) he was appointed governor general of the province of Fars; he showed both energy and tact in the performance of his duties. He refused to recognize the new regime established in Feb. 1921 by Sayyid Zia ad-Din and Reza Khan, but when Qavam as-Saltaneh became prime minister later in the year Mossadegh was appointed minister of finance. He introduced some much-needed reforms. In 1922 he became governor general of Azerbaijan, but soon resigned owing to differences with the military authorities. He was appointed minister of foreign affairs (1923) but relinquished that post later in the year on being elected to the Majlis as a deputy for Teheran. He opposed the change of regime in 1925 and, disliked by Reza Shah in consequence, retired into private life for a time.

In 1944 Mossadegh was again elected to the Majlis and played a leading part in opposing the U.S.S.R.'s demand for an oil concession covering northern Iran. He later occupied himself with the affairs of the Anglo-Iranian Oil company and was largely instrumental in the passing of the Oil Nationalization act in May 1951. He had become prime minister on April 30; his rigid enforcement of the act and his intractability in the resulting dispute with Great Britain led to the complete withdrawal of the Anglo-Iranian Oil company from Iran. Subsequently his failure to find markets for Iran's nationalized oil brought the country to the verge of ruin. At this time Mossadegh showed signs of what seemed to many to be emotional instability. His endeavours to obtain what amounted to dictatorial powers led to strained relations with the shah, Mohammed Reza Pahlavi. In Aug. 1953 a military coup d'état resulted in his overthrow, and he was later sentenced to three years' imprisonment for treason. After his release he led a life of complete retirement. *See* also PERSIAN HISTORY.

*See* N. Wilber, *Iran Past and Present*, 4th ed. (1958); G. Lenczowski, *The Middle East in World Affairs* (1952). (L. Lo.)

**MÖSSBAUER, RUDOLF LUDWIG** (1929– ), German physicist who received the Nobel prize in physics (1961) for his discovery and 1958 report of a phenomenon known as the Mössbauer effect (*q.v.*). Born in Munich, Ger., Jan. 31, 1929, he studied there at the Technische Hochschule (1949–55). After writing his doctoral thesis at the Max Planck institute (Heidelberg university) he was granted his doctorate in physics in 1958 from the Technische Hochschule and remained there through 1959 as a research fellow. In 1960 he was appointed senior research fellow at the California Institute of Technology (Pasadena), later becoming professor of physics. Mössbauer also received the Research corporation award (U.S., 1961), the Röntgenpreis from the University of Giessen (1961) and the Cresson medal of the Franklin institute (1961). (R. M. SN.)

**MÖSSBAUER EFFECT,** also known as recoil-free gamma-ray resonance absorption, was discovered in 1957 by R. L. Mössbauer at the Max Planck institute, Heidelberg, Ger. His discovery was of great interest to physicists, who used the phenomenon to make by far the most precise clocks known. These nuclear clocks are not useful for ordinary timekeeping because they run at such a high frequency that there is no known way to relate them to conventional time scales. However, it is easy to compare the frequencies of two of these clocks, and a careful experiment can detect a difference of as little as one part in one hundred trillion ($10^{14}$) between two clock rates. Mössbauer experiments are done with two of these nuclear clocks, a source (generating) clock and an absorber (detecting) clock; the experiment consists in observing changes of the source or absorber clock rate under the influence of various disturbances (*see* CLOCK; RADIOACTIVITY).

The nuclei of atoms are used as the clocks in Mössbauer experiments. Atomic nuclei can exist only in certain configurations, or states, and can occupy only one of these states at a time. A nucleus in one of these states has a certain energy, and this energy is the same for all nuclei of that type in that state. The least energetic and most stable state is called the ground state; all others are called excited states. If a nucleus is in an excited state, it tends to move to an excited state having less energy or to the ground state. Since energy must be conserved, the nucleus must emit some energy in this process. If the nucleus moves from a state A to a state B of lower energy, the excess energy can be emitted as a gamma ray with an energy equal to the difference between the energies of states A and B. Since the energies of the states A and B are very stable and the same for all nuclei of a given type, the gamma rays will have a very uniform energy. It is this uniform energy that supplies the accurate frequencies used in Mössbauer experiments. (Energy and frequency are equivalent terms in describing the strength of a gamma ray and will henceforth be used interchangeably.) In iron-57, the isotope most commonly used for Mössbauer experiments, the gamma rays coming from all undisturbed iron-57 nuclei have the same frequency to within about one part in $10^{12}$ (*see* NUCLEUS).

If the atomic nuclei that emit gamma rays are placed near a magnet, however, the gamma-ray frequency will change. The amount of the change is a measure of the strength of the magnet. Thus, by putting iron-57 atoms inside a solid, the magnetic fields generated by the other atoms in the solid can be measured. Experiments of this type, known as solid-state Mössbauer experiments, have revealed some failings of the classical theory of ferromagnetism (magnetism in steellike materials) that had not previously been suspected.

The best known experiments using the Mössbauer effect are those to measure the gravitational red shift. Einstein's theory of relativity predicts that two identical clocks will run at different rates if they are in different gravitational fields (*see* RELATIVITY). Since the gravitational field of the earth varies with height, the rate of a clock should change with height. This change is so small that it is impossible to measure it by ordinary means, but the gamma rays from iron-57 have such a precise frequency (clock rate) that a change in height of only 50 ft. provides a frequency shift that can be accurately measured. This experiment was very carefully done by R. V. Pound and G. A. Rebka, Jr., at Harvard university, and the results were in excellent agreement with the predictions of the Einstein theory.

The method of detecting the frequency shifts of the gamma rays is closely related to the way in which the gamma rays are generated. If a nucleus is in the ground state (state B in the previous example), it can be moved into an excited state (A) if the proper amount of energy is added. A gamma ray given off by a nucleus of the same type going from state A to state B has just the proper energy, since the energy difference between the A and B states is the same. A gamma ray that has exactly the right energy to raise the nucleus to the A state will be much more likely to be absorbed than one of any other energy; this is called resonance absorption. Gamma rays from the source go through a thin layer of absorbing material and then into a gamma-ray detector, such as a Geiger counter. If the gamma rays are of the proper frequency to be resonantly absorbed, a large proportion will be ab-

sorbed and the counter will detect relatively few. If the gamma-ray frequency has been shifted (by a magnetic field, for example), fewer gamma rays will be absorbed and the counter will detect more. Thus, the percentage of gamma rays absorbed can be used to find the frequency shift.

In actual experiments the source is set in motion at a known velocity. This velocity introduces a known frequency shift through the phenomenon of Doppler effect (the same effect that makes the horn of an approaching automobile appear to have a higher frequency than it actually does). The shift of gamma-ray frequency being produced by the disturbance under study is measured by finding the Doppler shift that is necessary to return the gamma-ray frequency to the proper value to be resonantly absorbed.

The preceding discussion must be qualified to the extent of considering the effect of the recoil of the nucleus. Just as a gun recoils when it is fired, a nucleus that emits a gamma ray recoils in the opposite direction to conserve momentum (Newton's third law). This motion of the nucleus takes up some of the energy difference between the A and B states, and thus the gamma ray has an energy slightly lower than would be expected from the oversimplified picture presented above. Similarly, the nucleus that absorbs the gamma ray recoils backward, and a gamma ray must have a slightly higher energy than the energy difference between the A and B states if it is to be resonantly absorbed. Although the recoil energy loss is only about a millionth of the gamma-ray energy, the resonance is so sharp that even this small loss will prevent the gamma rays from being resonantly absorbed.

Mössbauer discovered that under certain conditions the nuclei could be so firmly held in a crystal lattice (a regular array of atoms) that the loss of energy due to recoil was effectively eliminated, in a manner analogous to fastening a gun to the earth. (Hence the name recoil-free gamma-ray resonance absorption.) Under these conditions, the gamma rays emitted by a radioactive source have essentially the full energy difference between the A and B states and thus can be resonantly absorbed if the absorbing nuclei have been similarly held in a crystal lattice. It was this discovery by Mössbauer that made it possible to use the extreme sharpness of the gamma-ray resonance.

The sharpness of the Mössbauer resonance is limited primarily by Heisenberg's uncertainty principle, which states that there will be an inherent uncertainty in the gamma-ray energy related to the half-life of the A level (the half-life is the time it takes for half of the nuclei in the A state to decay to the B state). By choosing nuclei which in the A state have a long half-life, the energy uncertainty can be made very small. For example, in iron-57, which in the A state has a half-life of a ten-millionth of a second, the uncertainty in the gamma-ray energy is about one part in a trillion. Other isotopes with still smaller uncertainties are available, but they are extremely difficult to use because the resonance is so critical that the slightest vibration or other disturbance will destroy it (*see* UNCERTAINTY PRINCIPLE, THE).

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**MOSSI PEOPLES** (also called MOSHI, MOLE or MORE), the inhabitants of a large area south of the river Niger, stretching roughly between the 11° 30′ and 13° 30′ N. parallels and from 2° to 5° W., and forming the core of the population of the Republic of Upper Volta. In 1960 they numbered approximately 1,500,000, and an additional 500,000 were estimated to live in other parts of west Africa. Their language, Mole, belongs to the Gur group and is akin to that spoken by the Mamprusi and Dagomba of northern Ghana, from whom the ruling estate trace their origin.

According to tradition, the first Mossi ruler was one Widraogo, the offspring of Yennenga, daughter of a Mamprusi chief from Gambaga, and a Busansi (Mande-speaking) hunter called Riale. Widraogo's sons, Diaha, Raoua and Zungurana, are said to have conquered the areas covered by the kingdoms of Fada N'Gourma, Yatenga (capital, Ouahigouya) and Tenkodogo respectively, and it is to them that the present rulers trace descent. Zungurana's son, Oubri, was sent out to establish the fourth of these major kingdoms founded by the Mossi conquerors, that of Ouagadougou. In Fada N'Gourma, the rulers adopted the speech of the indigenes (Gurma), but in the other areas they imposed their own language upon the previous inhabitants.

The establishment of these states apparently precedes the 14th century, for a 17th-century chronicle, the *Tarikh es Soudan*, records that in 1333 Mossi troops sacked Tombouctou, a town of great importance as a terminal in the trans-Saharan trade. The whole area became subject to French administration with the entry of the latter into Ouagadougou in 1896 and received its independence as the Republic of Upper Volta (*q.v.*) in 1960.

The country is rolling savannah and, though it receives a low rainfall, supports a population of up to 70 per square mile. Although there are a number of part-time specialists, such as smiths, leather workers and weavers, the Mossi are essentially hoe agriculturalists, whose main food crops are pennisetum and sorghum. Some cattle, sheep and goats are kept.

The population is divided into royalty, nobles, commoners and, formerly, slaves; in addition, Muslim groups wield some influence. However, the religious system of the majority of the people places a strong emphasis on the cult of the ancestors and the cult of the Earth. The Earth priest plays a significant part in local affairs, filling a complementary role to the village chief. At the top of the hierarchy of each kingdom stands the paramount ruler, the senior of whom is the Moro Naba of Ouagadougou. This ruler is assisted by divisional chiefs who also act as electors, although it is usually his eldest son that succeeds.

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**MOST** (Ger. BRÜX), a town in Usti nad Labem *kraj* (region), northwestern Bohemia, Czech., lies on the north bank of the Bilina river, a tributary of the Labe (Elbe), and is about 150 km. (93 mi.) N.W. of Prague by rail. Pop. (1961) 45,417. It is mentioned by its German name in early 11th-century documents. Both forms of the name mean "bridge" and appear to derive from the structure built and maintained to cross the marshy ground near the old town. Traces of the town's older appearance remain in the Renaissance belfry in the town centre and in the late Gothic church of St. Mary. Most has long been the chief town of a region of active lignite mining and is the headquarters of the state lignite mining authority. Some lignite seams are nearly 100 ft. thick and are largely suitable for opencast mining. The annual yield is about 38,000,000 tons. The production of steel and ceramics is also important. Four miles to the north lies Zaluzi, with the largest chemical combine in Czechoslovakia; synthetic petrol is an important product. (H. G. S.)

**MOSTAERT, JAN** (*c.* 1475–1555/1556), Dutch painter, who is said to have spent 18 years in Brussels and Mechelen as painter to Margaret of Austria, regent of the Netherlands; other evidence, however, suggests that he worked chiefly in his native town, Haarlem. His chef-d'oeuvre is the "Deposition" triptych in the Brussels gallery; other notable works are an "Adoration of the Kings" (Amsterdam), a "Tree of Jesse" and a curious West Indian landscape (in private collections), and some portraits (Brussels, Copenhagen, Paris, Liverpool, Sarasota, Fla., etc.). Mostaert's style, though not unaffected by the more modern manner of Quentin Massys or Joachim de Patinir (*qq.v.*), is essentially that of a belated follower of Geertgen, tot Sint Jans (*q.v.*); his pictures are assembled from much phlegmatically observed detail and have the smooth finish and crystalline brightness of an older generation of Netherlandish painters. (D. Kc.; X.)

**MOSTAGANEM,** a town and seaport of Algeria, on the edge of the coastal plateau 80 km. (50 mi.) E.N.E. of Oran by road,

is the headquarters of the Mostaganem *département* created in 1956. Pop. (1960) 64,786, of whom about 20,000 were Europeans. Divided by the ravine of the Ain Sefra river are a large modern quarter on the left bank and the compact Muslim quarter Tidgit (dominated by two *marabouts*, or shrines) on the right. The modern town has wide streets and tall buildings, and there is a large public garden. The port area is west of the town. Farther west are bathing beaches at La Salamandre and Les Sablettes. Mostaganem is linked with Oran by rail. The surrounding district is mainly cultivated; there are vineyards and the port exports wine, vegetables, citrus fruits and kieselguhr (diatomaceous earth). A gas pipeline from the Sahara to Mostaganem and to the Algerian coastal areas runs from Hassi Messaoud via Hassi R'mel.

Mostaganem was known in the 11th century as Murustuge. The *bordj* (bastion) al Mehal (the old citadel, now a prison) is attributed to the Almoravid amir Yusuf ibn Tashfin (reigned 1062–1106). Conquered in 1516 by the sea rover Arouj Barbarossa, the town passed to his brother Khair ud-Din and enjoyed great commercial prosperity. It was garrisoned by the French in 1833.

(Fr. D.)

**MOSTAR,** the capital of Hercegovina region of the Peoples Republic of Bosnia and Hercegovina, Yugos., lies on the Neretva river just south of the famous Neretva defile, among gaunt and rugged mountains. Pop. (1961) 35,242. Immediately upon their conquest of Hercegovina, the Turks chose it as a military base. They built the Neretva bridge in 1566 in a stone arch, 90 ft. wide and 60 ft. high. Mostar (Serbo-Croatian "old bridge") is on the road and railway from Sarajevo to Dubrovnik. In 1875 the Hercegovinians started an uprising against the Turks, which ended with the Austrian occupation. Under Austrian rule (1878–1918) Mostar was the centre of the Serbian patriotic movement. Some of the best-known poets in Serbian literature worked there. Mostar is the seat of the district court and of both a Roman Catholic and an Orthodox bishop and has a large Orthodox cathedral. There are a gymnasium, a theatre, state schools of viticulture and horticulture and a state stud farm. The principal industries are textiles, wine and tobacco. The district is well known for its tobacco, which was formerly smoked at both the Istanbul and Vienna courts. Good wines, *blatina* and *zilavka*, are produced in the neighbourhood, and fruit, vegetables and walnuts are grown. Within a few miles of the town are the sources of the Buna, a small affluent of the Neretva, which issues from a cavern amid scenery of wild grandeur. Anthracite is found in the district. (V. De.)

**MOST-FAVOURED-NATION TREATMENT** is best defined as equality of trading opportunity. Attempts to guarantee such equality were incorporated into the provisions of commercial treaties and agreements at least as early as the beginning of the 17th century. The most-favoured-nation clauses in such treaties did not grant special favours but guaranteed treatment equal to that of the most-favoured nation. Since every state sought this guarantee, the effect was to establish equality of trading opportunity among states. The principle had been formulated in various ways for more than two centuries before its adoption in the Anglo-French treaty negotiated in 1860 by Richard Cobden and Michel Chevalier established it as standard practice.

Most-favoured-nation treatment is therefore both a principle of public international law and an instrument of economic policy. It establishes the sovereign equality of states in respect of trading policy, and it provides a treaty basis for competitive international transactions. Imposed unilaterally upon weaker powers, such equality of trading opportunity has been called the "open door policy." Negotiated between independent states, it has generally consisted of a broad covering clause in commercial treaties, supplemented by specific clauses applying the principle in detail to a constantly increasing variety of subjects. It confers two main rights—a guarantee against discriminatory treatment, and equal participation in concessions made by either contracting party to the citizens of any other state.

The primary application of most-favoured-nation treatment has always been in respect of the duties charged on imports, but specific provisions have extended the principle to a wide variety of international economic contacts. These include the establishment of nationals of one country in the territory of the other; navigation in territorial waters; real and personal property rights; intangible property rights such as patents, industrial designs, trademarks, copyrights and literary property; import entry, duties and quotas; government purchases; foreign exchange allocations; and taxation. In all these fields the right to equality of treatment has been elaborated in considerable detail which varies from treaty to treaty.

Most-favoured-nation treatment often has been advocated and attacked as a device to extend free trade. Theoretically it can be used either by a protectionist or by a free-trade country since it merely guarantees treatment equal to that enjoyed by any third state. In practice it has operated to generalize the lowest rate of duty and the most favourable treatment enjoyed by any state to all other trading states having commercial treaties incorporating most-favoured-nation clauses. The Cobden-Chevalier treaty of 1860 was the model for many similar agreements in subsequent decades. These built up a set of interlocking tariff concessions, all of which, by most-favoured-nation treatment, were extended throughout the trading world. The United States in 1934, under the leadership of the secretary of state, Cordell Hull, modeled the Reciprocal Trade Agreements act upon this practice. The use of most-favoured-nation treatment in the executive agreements subsequently negotiated was strongly attacked by protectionists. Its application was somewhat limited by following the practice of granting concessions to the principal supplier country in an effort to get reciprocal concessions.

**Conditional Form.**—From its first commercial treaty with France in 1778 until the practice was formally abandoned in 1923, the United States insisted upon the conditional form of most-favoured-nation treatment. The argument was that the contracting parties did not guarantee to each other all concessions made to third parties, but only those made gratuitously or upon the same or equivalent conditions if the concessions had been bargained for. An attempt was made by the United States to obtain for each extension of most-favoured-nation treatment to a third party a concession equal to that obtained from the original contracting party. This conditional form was embodied in most of the commercial treaties entered into by the United States before 1922. A typical wording, in the 1911 treaty with Japan, was: ". . . in all that concerns commerce and navigation, any privilege, favour or immunity . . . to the citizens or subjects of any other State shall be extended to the citizens or subjects of the other Contracting Party gratuitously, if the concession in favour of that other State shall have been gratuitous, and on the same or equivalent conditions, if the concession shall have been conditional." By contrast, the unconditional form provided that "any privilege, favour or immunity . . . shall be extended immediately and unconditionally to the subjects or citizens of the other Contracting Party."

Even where the language of a treaty was in the broad unconditional form, successive administrations in the United States insisted upon a conditional interpretation. This was essentially a development from the law of contract. It was argued that for a contract to be binding there must be a consideration. A succession of judicial decisions in U.S. courts, of which the leading cases are *Bartram* v. *Robertson*, 122 U.S. 116, and *Whitney* v. *Robertson*, 124 U.S. 190, upheld this legal argument. Authoritative opinion among international jurists was divided. L. F. L. Oppenheim (*International Law*, 6th ed., rev., vol. i, p. 750 [1945–47]) and Sir Thomas Barclay (*Problems of International Practice and Diplomacy*, p. 383 [1907]) disputed the U.S. interpretation, but F. de Martens (*Traité de droit international*, vol. ii, p. 509 [1883–87]) and J. Westlake (*International Law*, part i, "Peace," p. 294, 2nd ed. [1910]) approved it.

Other governments from time to time attempted, under nationalist and protectionist pressure, to use the conditional form or to invent devices which might achieve the same effect. Thus in 1892 France enacted minimum and maximum tariffs in an attempt to secure a range of bargaining; but in practice other countries invoked their most-favoured-nation privileges to secure the minimum tariff. In 1919 France adopted the conditional form used by the United States, but was unable to implement its adoption. More

successful efforts at evasion have been made by many countries primarily by reclassification and minute definition of items in the customs tariff so that a duty concession, while general in form, applied in practice only to one country. Thus, in the reciprocal trade agreement between the United States and the United Kingdom in 1938, the United States subdivided the item "building stone" and made a concession on "Cornwall building stone." The best-known illustration of a classification designed to confine a tariff concession to imports from one country without breaking the most-favoured-nation clauses in treaties with other countries occurred in the German tariff of 1902. Item 103 of this tariff admits at a special rate "large dappled mountain cattle or brown cattle, reared at a spot at least 300 metres above sea level, and which have at least one month's grazing each year at a spot at least 800 metres above sea-level."

**Unconditional Form.**—After more than a century of effort to make effective use of the conditional form of most-favoured-nation treatment, the United States reverted to the unconditional form which had been common elsewhere. A thorough study conducted by the U.S. Tariff commission, published in 1918 as "Report on Reciprocity and Commercial Treaties," revealed the fact that additional concessions obtained from other countries by insisting upon a specific price for each extension of most-favoured-nation treatment had been negligible. The United States had been involved in incessant disputes contesting its interpretation of the principle. Great difficulties had arisen in defining what constituted an equivalent concession. Many countries had penalized U.S. imports. The legalistic attempt to enforce reciprocal concessions for each extension of most-favoured-nation treatment had backfired in discriminatory treatment of U.S. exports. Moreover, the composition of these exports had changed. During World War I it became clear that the United States was changing from an agricultural-exporting to a manufacturing-exporting country, and this weakened its bargaining position to secure equivalent concessions.

Pres. Woodrow Wilson included adoption of the unconditional form of most-favoured-nation treatment in the third of his 14 points offered to Germany as a basis for peace negotiations. The first application of the unconditional principle was in an exchange of notes with Brazil on Oct. 18, 1923. On Nov. 30, 1923, in an address at Philadelphia, Charles Evans Hughes, then secretary of state, stated that "in our commercial relations the United States is seeking unconditional most-favoured-nation treatment in customs matters." Thereafter, all commercial treaties and executive agreements under the Reciprocal Trade Agreements act, 1934, included the unconditional clause. In 1945 the United States published its "Proposals for the Expansion of World Trade and Employment" which were developed at conferences at London, Geneva and Havana into an international trade charter. In all these negotiations, the United States was the leading advocate of unconditional most-favoured-nation treatment. The charter was abortive, but the unconditional principle was included in the 1948 General Agreement on Tariffs and Trade (G.A.T.T.).

Exceptions are recognized in respect of frontier traffic, of fish caught in contiguous waters and of preferential arrangements between metropolitan countries and their colonies. The latter has been interpreted to include the preferential arrangements among the self-governing states of the Commonwealth of Nations, as well as those between the United States and Cuba and the Philippines. Attempts to extend this exception to cover preferential arrangements between neighbouring countries were resisted in the period between World Wars I and II. Groups of European states wished to foster mutual trade but were unwilling to create a customs union by abandoning all tariffs on imports from each other. These attempts to form regional preferential groups failed when other states, including the United States and the United Kingdom, insisted upon their most-favoured-nation rights.

**New Devices for Control of Trade.**—Following the World Economic conference of 1927, the Economic committee of the League of Nations developed (1929–31) an elaborate codification of most-favoured-nation treatment. The economic depression of these and succeeding years nullified this work. No government adopted the code. New devices of trade regulation, notably import quotas, exchange control and state trading, became greater obstacles to trade than tariffs. The League code and successive reciprocal trade agreements negotiated by the United States included clauses intended to apply most-favoured-nation treatment to these new devices, but the discretionary and often arbitrary administration inherent in their nature rendered impossible any specific guarantee of equality of trading opportunity. All that can be written into a treaty is an assurance in general terms that the governments will not discriminate against each other in administering these devices. Various formulas have been experimented with, such as quotas proportioned to imports in a previous period, but none established equality of trading opportunity in the former competitive sense. Quotas, exchange control and state trading were in fact devised to give governments a means to control imports more directly and flexibly than by tariffs permitting price competition. Necessarily these devices involve discrimination, which is the antithesis of most-favoured-nation treatment. They often are advocated on this ground by nationalists and protectionists. Whenever international price discrepancies are exaggerated by currency depreciations the differences between the productivity and therefore the living levels of trading countries are emphasized. Then protectionist attacks are directed against most-favoured-nation treatment on the ground that it is a freer-trading device advantageous to the economically strongest country. Discrimination is defended as essential to the welfare of less competitive economies, and methods of trade regulation are adopted which circumvent the pledge of equality of trading opportunity.

A concerted attack on the principle of equality of trading opportunity was made at the Conference on Trade and Development convened by the United Nations at Geneva, Switz., in March 1964. Breaches had been made in the principle earlier by special arrangements designed to associate the former colonies of various European states (Belgium, France, Germany, Italy, the Netherlands) with the European Economic Community. As the E.E.C. was legally a customs union, reduced duties—leading ultimately to elimination of tariffs—between its members were a recognized exception to most-favoured-nation treatment. The British system of Commonwealth preferences had also been accepted, though not without protest. Not all the former European colonies applied for association with the E.E.C., but most of the new states in French Africa and some other ex-colonies did so and thus received preferential treatment. Special arrangements were made also with Denmark and Greece. Many of the less developed countries attending the Conference on Trade and Development asked preferential treatment for their exports, but these requests were opposed by the United States and other industrial nations.

Concurrently with the Conference on Trade and Development, negotiations opened on May 4, 1964, among the signatories to the General Agreement on Tariffs and Trade. These negotiations were popularly known as "the Kennedy round" because they followed the Trade Expansion act passed in 1962 by the U.S. congress upon the urging of President Kennedy. The Conference on Trade and Development questioned, while the G.A.T.T. conference was based upon, the principle of equality of trading opportunity.

*See* also COMMERCIAL TREATIES; FREE TRADE; SUBSIDY; TARIFF.

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**MOSUL** (AL MAWSIL), a *liwa* (province) and the most northerly of the administrative units of Iraq. Area 19,645 sq.mi.; pop. (1960 est.) 756,482. Formed after 1924 from the old vilayet of Mosul which also included the *liwas* of Irbil, Kirkuk and Sulaymaniyah, the *liwa* consists essentially of a section of the main valley of the Tigris river, which is defined to the east by a series of low ridges, the chief being the Jabal Qarah Chawq and Jabal Batiwa; west by an irregular upland forming part of Al Jazirah (*see* IRAQ: *Physical Features*). The southern boundary is arbitrarily taken at 35° N. lat. Mosul *liwa* thus has three distinct types of terrain: from west to east Al Jazirah culminates

in the north at the Jabal Sinjar (about 4,700 ft.), and slopes down from an average altitude of 1,200–1,500 ft. in the north to 700 ft. in the south, where there are numerous shallow basins mostly filled by salt pans (*sabkhat*) that become marshy in spring; the riverine zone itself is narrow with the Tigris sometimes deeply incised into a narrow channel and sometimes flowing in more open, flatter country; eastward the land rises to form a series of ridges aligned northwest-southeast which are the first outliers of the Zagros mountain system, and there the *liwa* boundary follows the Great Zab river northeast toward the Turkish border.

There are no large settlements other than the city of Mosul, and economic life centres on trade and communication with the neighbouring regions, together with the exploitation of oil. In 1939 deposits were discovered at 'Ayn Zalah to the north of the city (though production did not begin until 1952), with a second centre at Butmah, each having four wells and together ranking as the third field in order of production within Iraq. Oil also exists in quantity at Qayyarah on the Tigris, but high gravity and sulfur content have so far inhibited exploitation. A little cultivation occurs near the Tigris, but large numbers of the population are still nomadic herders, chiefly of sheep, goats and some cattle. Many of these people are of Kurdish origin, and there is extensive seasonal movement either over the Jazirah or to and from the hill country of the north and east. The *liwa* of Mosul is in a special way an intermediary for contact with adjacent lands and has more distinctiveness and individuality than many other areas of Iraq.

(W. B. Fr.)

**History.**—The area witnessed the birth of the Assyrian empire (*see* Babylonia and Assyria) and within Mosul *liwa* are the archaeological sites of the ancient capitals Ashur, Nineveh and Nimrud (*qq.v.*). The later history of the *liwa* is inseparably bound up with that of Mosul city. Refounded by the Muslims under the Omayyad caliphate on a site opposite Nineveh long occupied by a Sasanian and almost certainly by a far earlier town, Mosul became, in and after the 8th century A.D., a spacious, rich, walled and fortified city with excellent markets, mosques, hostelries, baths, Christian convents and spreading gardens. It was an important Kurdish and Arab tribal centre and became under the Abbasids the capital of Al Jazirah province and the greatest city of northern Mesopotamia. This status generally persisted throughout Abbasid times (*i.e.*, until 1258), including those periods when the city and district fell under the temporal power of independent dynasties (which acknowledged, however, the spiritual overlordship of the caliph of the time). These dynasties, which were far from contemptible in their wealth, power and high Islamic civilization, arose almost continuously from the mid-10th century onward to dominate Al Jazirah province and often much wider areas. Some were of Kurdish or Arab tribal origin (*e.g.*, the Hamdanids of Mosul and Aleppo, and the Ugailids of Mosul); some were from Persia (*e.g.*, the Buyids); others (in the 11th and 12th centuries) were established by the formidable incoming Seljuk Turks, or (in the 12th and 13th centuries) by their captains and successors, the atabegs. Some of the latter dynasties (the Zangids of Mosul, the Ortukids of Diyarbakir, the Begtiginids of Irbil-Mosul) occupied for years the seats of power in northern Mesopotamia. Particularly powerful was the atabeg Zangi, founder of the Zangid dynasty, whose influence extended far beyond the boundaries of the Mosul area (*see* Crusades). The famous Saladin (*q.v.*) was himself a native of the immediate vicinity of Mosul. Throughout this long and politically confused period, with changing temporal but an abiding religious overlord, Mosul with its thickly populated plain and its foothill and mountain dependencies passed through a protracted period of prosperity and relative internal stability.

This ended, there as throughout Mesopotamia, with the horrors of the Mongol conquest (1258) under Hulagu (*q.v.*), the wholesale desolation of city and countryside alike and the feeble distracted rule of the subsequent short-lived Mongol, half-Persian and Turkmen states which succeeded to power, or at least to pretensions of power, in Al Jazirah (*see* Mesopotamia). By the time of the brief occupation (1508) of Mesopotamia by the Persian Safavid conqueror Ismail I and its subsequent occupation by the Ottoman Turks (1534–1918), Mosul had fallen to a sad level of shabby and defenseless poverty from which nothing, until the 20th century, could rescue it. Under Turkish rule the city served as headquarters of an *il*, covering wide Kurdish as well as Arab districts; it was long (1726–1834) the seat of a line of Jalili pashas from a prominent local family. It was besieged by Nadir Shah of Persia (1743) and knew plague, flooding, drought, locust visitations and fierce civil and interfamily strife. Relations with the Kurdish chiefs were always close, and French influence among the local Christians, based on Syria, grew notably in the 19th century.

Under the British occupation (1918–20) and mandate, and during and after the period of the independent kingdom of Iraq, Mosul remained a provincial capital and the leading northern city. Its inclusion in Iraq, disputed by the Turkish republic during 1923–25, was, after a long diplomatic struggle and the visit of a League of Nations mission to Iraq, confirmed in 1926. Since then the city and surrounding area, with its rich oil wells, has been greatly developed and modernized.

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(S. H. Lo.)

**MOSUL** (Al Mawsil), a city of Iraq and the administrative headquarters of the *liwa* (province) of the same name, lies on the right bank of the Tigris river, opposite the ruins of Nineveh, 225 mi. N. of Baghdad. In later Ottoman times Mosul was the headquarters of the Mosul region, which comprised the modern *liwas* of Mosul, Irbil, Kirkuk and Sulaymaniyah. Pop. (1957) 179,646.

The population, comprising several communities, is composed mostly of Arabs with some Kurds and Turkmen. The majority are Sunni Muslims, but Mosul is also the seat of the Uniate Chaldean patriarch of Babylon, the church to which most of the 30,000 Christians of the city belong. The Monophysite (Jacobite) and the Uniate Syrian Catholic churches are represented by bishops. Smaller communities include Armenians (Orthodox and Catholic), Old Chaldeans (Nestorians) and Protestants.

The ancient walled city is about one square mile in area. The characteristic material used in the better class of construction is a gray alabastrine marble which lends itself to decorative carving. Many of the older Muslim buildings, both religious and secular, are associated with the Zangid atabegs of Mosul (A.D. 1127–1233) and with Badr ad-Din Lu'lu' who ruled, first as regent and then independently, from 1218 to 1259. Deserving of special mention are the Great mosque with its leaning minaret; the Red mosque or shrine of Khidr on the site of an earlier mosque near the river; the mosques of Nabi Jarjis and, on the left bank of the Tigris, Nabi Yunus (Prophet Jonah); the shrines of the imams Yahya and Aun ad-Din; and the ruins of Badr ad-Din's palace, the Qara Saray. The mosque of Nabi Shith (Prophet Seth), a modern building, is remarkable for its cluster of fluted spires. The principal Christian churches also date in parts from the Zangid period; those of Mar Shimun as-Safa and Mar Gorgis (Chaldean), Mar Toma (Jacobite) and At-Tahira (Syrian Catholic) are of especial interest.

Several thoroughfares cut through the old city, and of these Nineveh street, running approximately from west to east, and Faruk and Nabi Jarjis streets, from south to north, are the most important. Suburban extensions since World War II include a municipal housing estate. Notable among modern buildings are the royal hospital, the educational centre (comprising the technical, agricultural and teachers' training colleges) and the museum which houses a small but important collection of objects from Nimrud and Hatra (al Hadr).

Mosul owed its ancient importance to its location on the main caravan route from Aleppo to Persia, in the middle of a fertile plain where numerous secondary roads converge, and on a river suitable for cheap raft traffic downstream. Developments in the 20th century seem likely to restore its position as a great commercial centre. The oil field of Ayn Zalah lies 60 mi. to the north. Most of the converging roads have been metaled (hard surfaced) for motor traffic. The last link of the railway connecting Baghdad

with Mosul and the Syrian and Turkish systems was completed in 1940. The old bridge of boats was replaced in 1933 by a girder bridge, and the King Faisal II bridge of five spans (1,130 ft. in length), with dual carriageway and footpaths, was completed in 1958. There is an airport from which service is maintained with Baghdad.

The principal traditional exports are cereals, livestock, wool, hides and textiles. The old established light industries have been supplemented by a modern cotton-textile factory, a sugar factory and, nearby, a cement plant and a bitumen refinery, all inaugurated by the governmental development board. The main imports are machinery of all kinds, building materials and the usual consumer goods.

*See* H. C. Luke, *Mosul and Its Minorities* (1925); *Annual Reports on the Operations of the Iraq Development Board.* (C. J. E.)

**MOSZKOWSKI, MORITZ** (1854–1925), German pianist and composer known for his Spanish dances, was born at Breslau, Aug. 23, 1854, of a Polish father. He studied the piano at Dresden and Berlin, where he gave his first concert in 1873. His two books of *Spanische Tänze,* opus 12, published in 1876 for piano duet and later in many different arrangements, were long popular as an example of national music in a light style. Other attempts with national idioms were less successful. His opera, *Boabdil* (1892), was known chiefly for its ballet. He also wrote concertos and chamber music. He lived in Paris from 1897 and died there, March 4, 1925.

**MOTACILLIDAE,** a family of perching birds comprising two genera, the wagtails (*Motacilla*) and pipits (*Anthus*). *See* Wagtail; Pipit.

**MOTALA,** a town situated on the northeast of Lake Vättern, 20 mi. W.N.W. of Linköping in the *län* (county) of Östergötland, Sweden. Pop. (1960) 27,170. It was incorporated in 1881; the name signifies "the temple [sacrificial place] where the roads meet." Motala is a summer resort with open-air bathing at Varamobaden on Lake Vättern. It is the eastern terminus of the Göta canal and has good road and rail connections with the rest of Sweden. The town is also a centre of heavy industry; manufactures and exports include hydraulic presses, crankshafts, diesel and electric locomotives, stainless-steel sinks, refrigerators, wireless and television sets, tape recorders and record players. Motala is the site of a radio-transmitting station and a hydroelectric plant.

**MOTET,** a basically medieval style of composition that has undergone numerous transformations throughout the ages. It began as an application of new text, that is to say words (Fr. *mot*), to old music; a line of music thus put into text was called *motetus*. Sometimes two or even three parts were each given a text, and although these were usually Latin there are numerous examples of bilingual motets (French-Latin, English-Latin). From the original 13th-century motet there was a development in the use of instruments to accompany the texted part or parts and an eventual simplification that left text and music in the uppermost part and instruments below. This was in effect a song form, used for liturgical music as well as for ceremonial occasions. By the second half of the 15th century there was a return to the former ideal of text in all voice parts but with identical, not dissimilar, texts, even though the syllables and words would not necessarily always be vertically aligned. The text was audible as such only in homophonic sections, and this eventually gave rise to the solo motet of the baroque era when the stress was on one voice and one text. Many so-called motets are in fact clearly defined liturgical forms, such as antiphon, hymn, responsory and gradual; these motets would have been used as a polyphonic elaboration of the plainsong of Mass and Office in the appropriate feast.

The most important kind of motet is the type written for a particular holy day. Such motets are sung between the Credo and the Sanctus of the Mass, or at Vespers. They are often founded on the Gregorian chants of their texts, and the Mass is founded on the same themes, thus giving the whole service a musical unity that has never since been approached in any church music even under Bach. When a motet was not founded on Gregorian chants it was still possible for the composer to design a Mass on the same themes, and the titles of 16th-century Masses, when they do not indicate a secular or diplomatic origin, indicate either the motet or the plainsong on which they are founded.

Sometimes one composer founded a Mass on another composer's motet; thus Francisco Soriano's fine *Missa nos autem gloriari* is based upon a motet by Giovanni Palestrina, and Palestrina's *Missa quem dicunt homines* is on a motet by Adriaan Willaert. When a motet was in two movements the second movement always ended with the last clauses of the first, both in text and in music, producing a distinct impression of *da capo* form.

In later times the term motet came to indicate any piece of church music of clearly single design, regardless of language or of place in a liturgy. (D. F. T.; D. W. St.)

**MOTH:** *see* Butterfly and Moth.

**MOTHER OF GOD, CLERKS REGULAR OF THE** (Ordo Clericorum Regularium a Matre Dei; O.M.D.), a small Roman Catholic order founded in 1574 by St. John Leonardi (d. 1609) at Lucca and confirmed in 1595. Its small size was a matter of the founder's policy; the order never had more than 15 churches and only one house was established outside Italy. Its members have been distinguished for their learning. John Leonardi was canonized in 1938, and his feast (Oct. 9) was added to the calendar in 1941. *See* Orders and Congregations, Religious.

**MOTHER'S DAY,** a holiday celebrated on the second Sunday in May, in honour of all mothers, was instituted in the United States in 1907. The festival, recognized by the United States congress in 1914, is generally observed in the United States and to some extent elsewhere. (A. McQ.)

**MOTHERWELL AND WISHAW,** a large burgh of Lanark, Scot. Pop. (1961) 72,794. It lies near the right bank of the Clyde, 12 mi. S.E. of Glasgow by road, in the centre of a coal-mining area. Motherwell (from a well dedicated to the Virgin) has been the seat of a Roman Catholic bishop since 1947.

The burgh has iron, steel and engineering works and manufactures clothing, confectionery and preserves. Motherwell and Wishaw were united into one burgh in 1920.

**MO TI** (Mo-tzu) (470?–391 B.C.?) was an important ancient Chinese philosopher and founder of a religion. His name was actually Mo Ti; Mo-tzu was the name that was popularly applied to him in a complimentary manner to mean "Master" or "Teacher" Mo. He is also sometimes referred to as Micius by western writers.

Mo-tzu was born a few years after Confucius' death, and lived as a contemporary of Socrates. By this time, the system of feudalistic hierarchy instituted at the beginning of the Chou dynasty had degenerated into a period of warring states, and the pressing problem confronting all thinkers was how to bring political and social order out of chaos. For approximately two centuries, Confucianism and Moism were linked as the eminent schools of the day.

Mo-tzu was widely read and well versed in the common literary tradition of the age that has come to be known as the Chinese classics. It is said that he was at first a follower of Confucianism but later became a renegade because of the burdensome code of rituals and its reticence on matters concerning positive religion. Except for a brief period as holder of a public office, Mo-tzu spent most of his life traveling from one feudal state to another in the hope of meeting a receptive prince to put his teachings in practice and the world in order. Since no such prince was at hand, he had to be contented with maintaining a school and recommending his disciples for administrative positions. He led a very simple life and his teachings even suggested ascetic practices.

Mo-tzu was a teacher who took his own teachings seriously. For example, in the *Mo-tzu,* the work that bears the philosopher's name and contains records of his sayings and doings, there is a chapter on "Condemnation of Offensive War." In the same volume there are also records of his journeying to distant states to prevent the outbreak of a war when he had heard of such a possibility. On one of these journeys, the record tells, he had to walk for ten days and ten nights and tear pieces of cloth from his gar-

ments to wrap round his feet. An ancient critic said of Mo-tzu, "Despite all personal hardships, he held fast to his ideas—a man of distinction indeed!"

One outstanding characteristic of Mo-tzu as a thinker is his insistence on methodology. In an age of a "hundred philosophers," it should be easy to see why he insisted that "some standard of judgment must be established." He himself came near to being a pragmatist, and his yardstick may be summarized as the threefold test and the fourfold standard. The threefold test concerning a proposition evaluates its basis, its verifiability and its applicability, while the fourfold standard is applied to the resulting benefits to the country and the people. These are measured in terms of enrichment of the poor, increase of the population, removal of danger and regulation of disorder. To Mo-tzu these tests and standards were indispensable: "To make a proposition without regard for the standard is similar to determining the directions of sunrise and sunset on a revolving potter's wheel." Six chapters in the *Mo-tzu* deal with such logical problems as definition, inference, etc., and they must have been the work of his disciples if not of Mo-tzu himself.

Universal love is the cornerstone of Mo-tzu's system. The world was in chaos, and, in the Moist analysis, this was due to selfishness and partiality. As to the cure, "Partiality should be replaced by universality." When everyone regards the states and cities of others as he regards his own, no one will attack the others' state or seize the others' cities. The same is true concerning the welfare of the family and the individual. The peace of the world and the happiness of man lie in the practice of universal love. Many objections were raised against this new doctrine—its impracticability, its neglect of the special claims of one's parents, etc.—but Mo-tzu demonstrated that the principle of universal love had in it both utilitarian justification and divine sanction. He spoke of "universal love and mutual profit" without embarrassment or apology, and he was convinced that the principle was both the way of man and the way of God.

Mo-tzu's stand on religion makes him exceptional among Chinese philosophers. He might be said to be a revivalist, a champion of the anthropomorphic orthodoxy. To Mo-tzu there is Heaven, Heaven has a will, and this will of Heaven is to be obeyed by man and accepted as the unifying standard of human thought and action: "What is the will of Heaven that is to be obeyed? It is to love all the people in the world universally." Heaven not only "desires righteousness and abominates unrighteousness," but also metes out reward and punishment accordingly. To Mo-tzu it is a fact beyond doubt that Heaven loves all the people, teaches them all, claims all, just as it accepts sacrifices from all.

The system of Mo-tzu, with its gospel of universal love and the ascetic discipline as exemplified by his own life, soon after the master's death became embodied in an organized church with a succession of elder masters and a considerable body of devotees. At one time, it was said, as many as 170 followers were ready to die at the command of the master, but this religion was short-lived and is no more. In fact, Mo-tzu and Moism have been all but completely eclipsed by the more popular doctrines of Confucianism and Taoism (*qq.v.*) in China for the last 2,000 years. One ancient writer made the observation, "Mo-tzu was blinded by utility and did not know refinement." It was not until the 20th century that Mo-tzu was rediscovered and his worth reappraised. *See* also CHINESE PHILOSOPHY.

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(Y. P. M.)

**MOTION,** in law, an application to a court for a rule or order. Motions may be made either on notice to the other party or *ex parte*, that is, on the application of one party alone, and either orally or in writing. They may be based on facts of record in the action or as established by supplemental affidavits or oral testimony. *See* PRACTICE AND PROCEDURE. (C. E. CL.)

**MOTION, PRINCIPLES AND LAWS OF.** This article is concerned primarily with the meaning of motion in physics and the historical evolution of the principles and laws that describe it.

So great has been the preoccupation of physical scientists with motion as the most obvious and simplest of all changes in the flux of human experience that even in the case of phenomena in which no motion is directly observed a tendency has grown to interpret what goes on in terms of the motion of unobserved particles; *e.g.*, the molecules of the kinetic theory of gases. This explains the paramount place which mechanics holds in all physical science. For practical purposes motion may be defined as change of position of a particle or body with respect to some suitably chosen reference system; *e.g.*, the earth or the stars.

**Ancient Views on Motion.**—The views of the ancient Mediterranean peoples about motion were largely enshrined in the *Physica* of Aristotle (384–322 B.C.), a work that dominated western European physical science during the later middle ages and indeed until the 16th century. Aristotle contented himself with the common-sense classification of all observed motions into natural motions and violent motions. Natural motions are those which take place without the obvious intervention of human beings, such as the circular motions of the incorruptible heavenly bodies and the rectilinear motions of freely falling or rising bodies on the surface of the earth. According to Aristotle the natural motion of the heavenly bodies is circular because this is the most perfect form of motion. The natural motion of a terrestrial object is rectilinear since this is the best way for it to reach its proper place or position of equilibrium. Heavy bodies (*e.g.*, solids and liquids) fall because they desire to get as close as possible to their proper position at the centre of the earth; light bodies (*e.g.*, flames and gases) rise since their proper sphere is above the earth.

In Aristotelian mechanics, motion produced by human agency is called violent motion; an example is the throwing of a ball. This motion may be neither entirely rectilinear nor entirely circular, but in any case must always be some combination of the two. This conclusion was of course wrong, since it was discovered later that the motion of a projectile on the surface of the earth, neglecting the effect of wind and air resistance, is parabolic.

Acting on the basis of his common-sense classification, Aristotle was led to enunciate his "law" of motion: that in any motion, whether violent or natural, the velocity attained is the ratio of the applied force to the resistance which the medium offers to the motion. At first thought this seems sensible enough, and yet this law caused even Aristotle some moments of puzzlement; he was forced to conclude from it that there is no such thing as a vacuum since in a vacuum there would be no resistance to motion and hence even for the smallest force the velocity attained would become infinitely great, a thing never observed. Even more difficult to understand from Aristotle's law is the fact that a body set in violent motion by the hand, for example, continues to move when the hand no longer is in contact with it and is therefore exerting no further force on it. To meet this difficulty Aristotle was forced to assume that the air or other medium through which the motion takes place continues somehow to push on the object as well as to resist it. Finally Aristotle was led to the conclusion that in the same medium, heavy bodies fall faster than light ones, which common-sense observation confirms in the case of a heavy stone and a feather but not at all in the case of two stones of the same size and shape but with different weights. (R. B. L.)

**Medieval Theories of Mechanics.**—Medieval views on motion take their points of departure from Hellenistic mathematics and from the works of Aristotle, particularly from his *Physica* and *De caelo*. The most precious legacy from Greece to medieval statics consisted of mathematico-deductive proofs, the form of which originated about the time of Euclid and Archimedes. Medieval authors also inherited theorems that became the foci of medieval and early modern statics; for example, the general law of straight and bent levers. Also the idea of a nascent principle of virtual work came indirectly and ultimately from the *Mechanica* attributed to Aristotle and the *Mechanics* of Hero of Alexandria. The mathematician Jordanus de Nemore in *De ratione ponderis* (early 1200s) applied this principle (in a new form emphasizing vertical rather than areal weight displacement) to mathematical

proofs of the general law of the lever; and to a theorem concerning the equilibrium of weights on oppositely inclined planes. The latter theorem led to a correct procedure for resolving forces into components. Jordanus' proofs essentially show that either the law of the lever and the inclined-plane theorem hold or the principle of virtual work is violated. Thus he took a dynamic approach to statics that is characteristically modern (*see* STATICS).

Medieval dynamics significantly changed the Aristotelian idea that velocity is proportional to the ratio of force to resistance. John Philoponus (*q.v.*) advanced views leading to the notion that velocity follows the arithmetic excess of force beyond resistance, later expressed mathematically by Thomas Bradwardine in *De proportionibus velocitatum in motibus* (1328). Bradwardine himself held that an arithmetic increase in velocity follows a geometric increase in the original ratio of force to resistance. Despite its lack of empirical support this view held for almost a century.

Much more fruitful for dynamics was a theory by Jean Buridan (*q.v.*) in *Questiones in libros physicorum* (*c.* 1340) to explain continuing projectile motion after the initial force of projection ceases, and the acceleration of falling bodies. Aristotle's view of the ambient medium as the continuing motor in projection had already been rejected (largely on empirical grounds) by Philoponus, who proposed that the initial mover impressed an incorporeal kinetic force that kept the object in flight until the force was destroyed by projectile weight and by air resistance. Buridan (and in some respects Avicenna and other earlier Arabic authors) developed a new form of impressed force theory conventionally known as the impetus theory. For Buridan and Philoponus impetus was a force impressed into the projectile. (Schoolmen in the middle ages had not abandoned the Aristotelian idea that motion was a process arising conjointly from force and resistance; *i.e.*, motion was not conceived as a state). But Buridan clearly described impetus as permanent; unless it was destroyed by contrary inclination or resistance he held it would tend to continue indefinitely. This made impetus a kind of analogue to inertia (*see* DYNAMICS) particularly when Buridan suggested that the continuing motion of the heavens could arise from the impression of impetuses by God. Furthermore Buridan quantified impetus in terms of quantity of matter and of imparted velocity. These are similar to quantities that define momentum in Newtonian mechanics. Buridan also used impetus theory to explain the acceleration of falling bodies. He supposed that the weight of the body continually impressed more and more impetus and thus greater and greater speed, a theory to which Giovanni Battista Benedetti still adhered in the 16th century. When impetus came to be seen not as a force but rather as an effect (like momentum), the Newtonian second law of motion and definition of force were not far off. For such a meaning of impetus indicates a continuing force (gravity) directly producing acceleration.

Medieval schoolmen also began to discuss kinematics in detail. Greek authors (including Aristotle) made simple proportionality statements comparing completed movements in terms of the spaces traversed in equal times or in terms of the times necessary to traverse some given spaces. Ancient authors did not assign velocity a magnitude; however, from the time of Gerard of Brussels' *Liber de motu* (13th century), schoolmen began to do so, although the magnitude still was not defined as a ratio of unlike dimensions (space and time).

At Merton college, Oxford (1328–50), substantial advances were made in kinematics by contemporaries of Bradwardine, especially William Heytesbury and Richard Swineshead. The important concept of instantaneous velocity was defined mathematically by the space which would be traversed if a body were moved for a given time at the velocity it had at the instant. Precise definitions of uniform speed ("the traversal of equal spaces in any equal periods of time") and uniform acceleration ("the acquisition of equal increments of velocity in any equal periods of time") led to the Merton rule (theorem): the space traversed in a given period by a body with uniformly accelerated motion is the same as if the body moved uniformly at its speed for the middle instant of the period. This theorem, first enunciated by Heytesbury (*c.* 1335), was proved geometrically by Nicole Oresme (*q.v.*) who represented qualities and motions as two-dimensional figures. Oresme's proof showed the equality of a right triangle representing the uniform acceleration and a rectangle representing the uniform motion. Apparently Oresme held that the velocity of falling bodies was directly proportional to time, but he did not apply the Merton theorem to the acceleration of falling bodies. This was haltingly done by the Spanish scholastic Domingo de Soto (16th century). However, it was Galileo, starting with one form of the Merton theorem, who developed his law of distance traversed in free fall (*see* below). Thus it was particularly in kinematics that medieval discussions exerted their greatest influence on Galileo. (ML. CT.)

**Galileo.**—The modern theory of motion was largely the creation of the Italian scientist Galileo Galilei (1564–1642). Dissatisfied with the views of Aristotle, which in spite of their apparent common-sense approach were not successful in predicting accurately the results of even simple experiments, Galileo decided to examine with meticulous care the special case of freely falling bodies to see whether he could make an assumption about their fall which would lead by direct mathematical reasoning to a result he could verify by experimentation. He was finally able to do this and in so doing he not only provided the foundation for the science of mechanics which has endured since his time but also established the fundamental method for the description of experience which characterizes the whole of modern physics. Specifically, Galileo showed that by assuming that the acceleration (or rate of change of velocity) in free fall is constant he could deduce that the distance traveled by a body falling from rest is proportional to the square of the elapsed time. He verified this latter conclusion with sufficient accuracy by experiments on the motion of bodies rolling down inclined planes. It is appropriate to emphasize that this mathematical deduction of Galileo's was a genuine law of motion in the sense that it provided a precise and quantitative description of how freely falling bodies on the surface of the earth really move. As a description of a regularity or routine of physical experience it meets the test of what later came to be called a law of nature.

Galileo also introduced a radical change in Aristotle's views on violent motion. He developed a strong feeling that horizontal motion on the earth's surface (neglecting friction), unlike vertical motion, is not affected by the earth; hence, motion in this direction with any particular velocity should persist unchanged. He verified this ingeniously by performing experiments in which a ball was allowed, starting from rest, to roll down one inclined plane and on reaching the bottom was immediately permitted to roll up another. He showed that in every case, independently of the length of the horizontal projection of the second plane, the ball rose to practically the same height as that from which it originally started; hence, the horizontal velocity was retained unchanged in each case no matter how great the horizontal distance. Galileo therefore concluded that the velocity of a moving body not under the influence of a net, unbalanced force (*e.g.*, gravity) will not change. This was the discovery of the law of inertia, the real foundation of the modern theory of motion. Implicit in this is the idea of force as something which can change motion; *e.g.*, from rest into motion or from motion into rest.

**Newton and the Principles of Motion.**—The century following Galileo's death in 1642 saw the firm establishment of the principles of motion along the lines initiated by him. This was the work of several great minds, but the most definite systematization was performed by Sir Isaac Newton (1642–1727) whose *Philosophiae Naturalis Principia Mathematica* was published in 1687. Newton's famous three laws of motion (*see* MECHANICS) stated that: (1) every particle continues in a state of rest or motion with constant speed in a straight line unless compelled by a force to change that state; (2) the net unbalanced force producing a change of motion is equal to the product of the mass and the acceleration of the particle; (3) all forces arise from the mutual interaction of particles and in every such interaction the force exerted on the one particle by the second is equal and opposite to the force exerted by the second on the first, or as it is usually expressed: action and reaction are equal and opposite.

These ideas are essentially hypotheses or principles of motion and not expressions of routines of experience like Galileo's law of falling bodies. All special cases of motion, however, are derivable from them, provided only that one makes a fortunate guess as to the nature of the relevant force. The first law is obviously Galileo's principle of inertia and the second law was also effectively applied by Galileo. The third law was Newton's own particular contribution to the theory of motion. It appears fairly reasonable in the case of two bodies in collision, like billiard balls, or two bodies joined by a spring. However, it required more imagination to apply it to two bodies separated by a relatively great distance like the earth and the moon between which there is no visible connection. Here Newton saw the necessity of introducing some force of interaction and postulated his celebrated law of gravitation (*q.v.*), namely, that any two particles of matter in the universe attract each other with a force varying directly as the product of their masses and inversely as the square of the distance between them. By introducing this law of force into the second law of motion, and assuming that this was the proper equation of motion for the planets of the solar system, Newton was able to derive theoretically the laws which J. Kepler (1571–1630) had discovered about 1600 by direct observation of the heavenly bodies. According to these laws each planet moves in an elliptical orbit with the sun at one focus; moreover, in its path it sweeps out equal areas in the plane of its motion in equal times. Finally the square of the time for each revolution around the sun (one year in the case of the earth) is proportional to the cube of the major axis of the orbit; *i.e.*, the distance between the point of closest approach to the sun (perihelion) and the farthest point from the sun (aphelion). Newton verified his theory for the case of the motion of the moon.

Mathematical astronomers of the 18th century and after showed that his law of gravitation, taking into due account the perturbing influence of the attraction of the planets for each other as well as their attraction by the sun, accounts very accurately for the observed motions with one possible exception—the motion of the planet Mercury. This discrepancy was accounted for during the 20th century by Einstein's theory of general relativity.

The Newtonian formulation of the principles of motion was marred by certain logical difficulties. Newton was never able to give an adequate definition of mass, though it entered vitally into his idea that motion is always connected with the interaction of bodies. He was aware that it was intimately connected with inertia, but made little use of this in his applications of the laws of motion, being content to use weight (the force with which the earth attracts an object) as proportional to mass. Another difficulty Newton encountered was the fact that motion has no meaning except in relation to some chosen reference system. For rough practical purposes we do not worry about this, since we use the earth as a reference frame, but since the earth also moves (relative to the sun, which may itself move away among the stars) the problem arises as to whether there is any such thing as absolute motion.

Newton felt constrained to introduce an absolute space with respect to which all motion would be absolute. He also felt the necessity of introducing an absolute time, but this actually played a small part in his theory of motion, since in all derived equations the quantity representing time had to be replaced by numbers taken from clocks which were calibrated in terms of the earth's rotation on its axis or its revolution around the sun. Newton recognized that his laws of motion would keep precisely the same form for all frames of reference moving at constant velocity relative to each other, provided the forces employed were functions of the mutual separation of the bodies involved, as is true of course, for the force of gravitation. Frames of reference of this character are usually called Galilean or inertial frames. An important result of the form of Newton's laws is that by no mechanical experiment can one detect absolute motion of a Galilean frame. For example, when we play ball on the deck of a ship moving at constant velocity with respect to the shore, the motions of the ball and all aspects of the game proceed precisely as if the game were being played on shore. As far as any mechanical (*i.e.*, motional) effects are concerned it is just as correct to say that the ship is standing still and the shore is moving as it is to say the ship is moving and the shore is standing still. This result of the form of Newton's laws is usually called the Newtonian theory of relativity. It is interesting to note in this connection that the earth as a rotating body does not constitute a Galilean or inertial frame of reference. As a result when a particle moves on the earth's surface it is subject not merely to the ordinary acceleration of gravity but also to the well-known centripetal acceleration associated with motion in a circle, as well as the so-called Coriolis acceleration. For a freely falling particle the latter is an acceleration directed perpendicular to the meridian plane in which it starts to fall. It is always directed toward the east and is equal in magnitude to twice the product of the velocity of fall, the rotational velocity of the earth and the cosine of the latitude. As a result of this acceleration, any freely falling body always lands a short distance east of the plumb line from the point from which the body was dropped. At latitude 45° N., for example, the deflection is about 0.1 ft. for a drop from a height of 500 ft. The Coriolis acceleration is responsible for the production of cyclonic wind movements on the earth's surface, since because of it, a wind starting in any direction is always deflected toward the right in the northern hemisphere and toward the left in the southern hemisphere.

The logical difficulty concerning mass inherent in the Newtonian theory was removed in the late 19th century by the Austrian physicist and philosopher Ernst Mach (1838–1916) and his contemporaries. Mach showed that one can readily define the ratio of the masses of any two interacting particles as the negative inverse ratio of their accelerations with respect to the same inertial frame. This makes it possible to choose a standard particle, label it as our unit of mass and determine (ideally, at any rate) the mass of every other particle in the universe by allowing it to interact with the standard mass. This permits a logical verification of the use of the balance as the practical method of comparing masses on the earth's surface. It also provides an easy way of grasping the significance of the readily deduced principle of the conservation of momentum which says that when any set of particles are interacting with each other the sum of all products of mass and velocity for each particle remains constant, even though the individual velocities may change with time. The illustration of a gun's recoil after discharge immediately comes to mind: the mass of the gun multiplied by the recoil speed equals the mass of the bullet multiplied by its speed. This principle is the basis of all jet propulsion and the launching of rockets and artificial satellites.

**Relativity.**—We have already commented on the inability of the Newtonian principles of motion to detect the absolute motion of an inertial system. In the late 19th century it was believed that this might be done by optical means; *i.e.*, by flashing light signals from one moving object to another. If light is a wave propagation in a medium and this medium (sometimes called the luminiferous ether) can act as a reference frame for light as the air does for sound, the detection of motion with respect to it (a kind of absolute motion) should be possible. All attempts in this direction failed however; finally, A. Einstein (1879–1955), H. Poincaré (1854–1912), H. A. Lorentz (1853–1928) and others set up in the early 1900s a more drastic theory of relativity than that of Newton; namely, that no physical effect whatever is competent to detect the absolute motion of an inertial frame. This theory has had widespread consequences in the 20th century; one of its consequences is that the scale of time measurement must differ from one inertial system to another in contradiction of the Newtonian idea of absolute time. Moreover the mass of a particle is no longer constant but increases with its velocity to a degree which, while unnoticeable at the speeds of ordinary terrestrial objects, can become very perceptible with such atomic particles as electrons and protons. These effects of the theory of relativity must be taken into account in modern devices such as cyclotrons and betatrons (*see* ACCELERATORS, PARTICLE) for the production of very high-speed particles possessing energy sufficient to produce changes in the nuclei of atoms.

In 1915 Einstein extended the theory of relativity to derive a new theory of gravitation, essentially by treating gravitation as a kind of geometrical property of space and time (space-time structure). This theory was successful in removing the difficulty in accounting for the motion of the planet Mercury encountered by the Newtonian theory. The Einstein theory has been the starting point for elaborate 20th-century theories of cosmology. (*See* COSMOGONY; COSMOLOGY; RELATIVITY; SPACE-TIME.)

**Quantum Mechanics.**—The elementary particles which constitute the atoms of the 20th-century theory of the constitution of matter have motions obeying laws quite different from the classical uses of Newton. In fact, their behaviour inside the atom—if it can be described at all in terms of what we think of as motion in the large-scale world, a possibility which is becoming increasingly more doubtful—would appear to be more akin to wave motion in a continuous medium than to the motion of particles. This point of view was introduced by L. V. P. R. de Broglie (1892– ) and E. Schrödinger (1887–1961) in the middle 1920s and was materially extended by W. K. Heisenberg (1901– ), P. A. M. Dirac (1902– ) and others. The original foundation was laid by N. H. D. Bohr (1885–1962) in 1913. The theory is now known as quantum mechanics since it employs the fundamental idea introduced in 1900 by M. K. E. L. Planck (1858–1947) of the essentially discrete character of all atomic processes, even radiation. (*See* ATOM; QUANTUM MECHANICS.)

**Motion of Continuous Media and Wave Motion.**—The foregoing discussion of the principles of motion has referred primarily to the motion of particles. Physics also is concerned with the motions of continuous media; *e.g.*, the flow of liquids and gases, as well as wave propagation in fluids and solids. It is important to note that the same fundamental principles of motion apply to these cases. *See* HYDROMECHANICS; AERODYNAMICS; WAVE MOTION; SOUND. *See* also references under "Motion, Principles and Laws of" in the Index.

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**MOTION PICTURES.** The main sections of this article are as follows:

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  1. Photography
  2. Sound
  3. Colour
  4. Wide Screens
II. The Art of Motion Pictures
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  2. Historical Origins
  3. Addition of Sound
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## I. HISTORY

The motion picture first emerged from the laboratories of abstract science on April 14, 1894, with the introduction of Thomas A. Edison's Kinetoscope, a coin-in-the-slot peep-show device that permitted individuals to glimpse about 15 seconds of film showing people and objects in wonderfully lifelike movement. By the end of 1895, motion-picture projection had been achieved in London, Paris and New York. The public presentation of Edison's projector, the Vitascope, as the climax of a vaudeville program at Koster and Bial's music hall in New York on April 23, 1896, might be termed the true dawn of motion pictures as a popular entertainment medium. The success of the Vitascope was immediate; Edison sold 80 of his projectors between April and November of 1896. The Lumière Cinématographe, which had been introduced in Paris on Dec. 28, 1895, made its American debut on June 18, 1896, at Keith's 14th Street theatre, New York. The Biograph, Edison's strongest American competitor, was installed at Hammerstein's Olympia music hall soon after. Before the year was over, numerous other machines had appeared, both in the United States and abroad, to supply the sudden demand for the novelty of living movement reproduced in black-and-white shadows. The motion picture was quickly incorporated into vaudeville and music hall programs and also became a feature of the then-popular wax museums and traveling fairs.

Behind this seemingly overnight phenomenon lay almost 75 years of research, experimentation and invention on an international scale. The scientific study of optical characteristics of objects in motion had begun with the investigations of Peter Mark Roget in England, resulting in a paper presented by him before the Royal society in London on Dec. 24, 1824, under the title, "The Persistence of Vision With Regard to Moving Objects." Roget's paper inspired several scientists, among them Sir John Herschel and Michael Faraday, to engage in various experimental investigations. In Europe, Joseph Antoine Plateau, of the University of Ghent, and Simon Ritter von Stampfer, of Vienna, simultaneously discovered a method for viewing a series of pictures representing phases of motion. The pictures, hand drawn, were mounted in sequence on the rim of a disk and observed through slots in a similar disk mounted on the same rotating shaft. Baron Franz von Uchatius, an Austrian artillery officer, in 1853 combined the disk device with the magic lantern and projected the pictures upon a screen. The capacity of the machine was obviously limited to a very short cycle of movement. The work of Plateau and Stampfer gave rise subsequently to the invention of the Zoetrope, or "wheel of life," a familiar parlour toy in which bands of drawings of clowns, jugglers or frisking animals were brought to life when viewed through the slits of a rotating cylinder. More elaborate was the Praxinoscope of Emile Reynaud, although the principle was much the same. Small mirrors at the core of the cylinder replaced the slits; the band of pictures was reflected into the mirrors, and when the apparatus was set in motion the images seemed to flow from one mirror to the next. Reynaud continued to elaborate on his invention until, in 1892, he opened his Théâtre Optique in Paris, combining hundreds of his little drawings of phases of movement into story films 15 or 20

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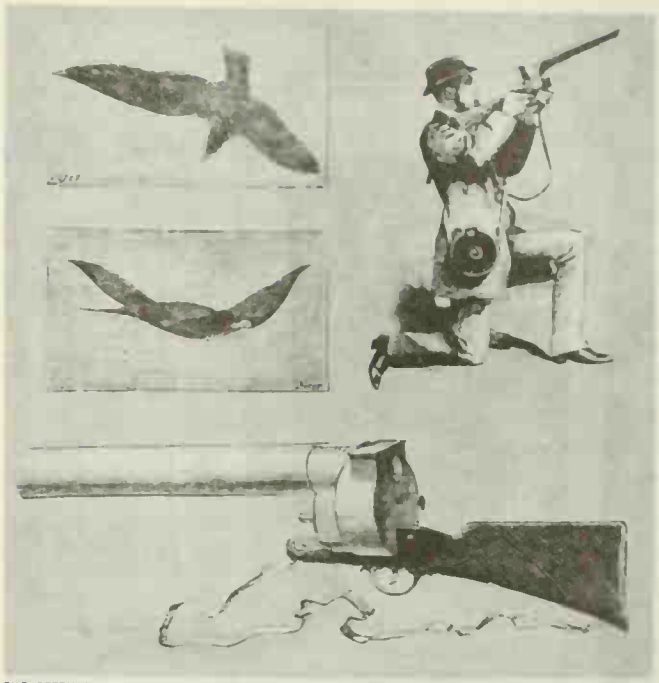
PRAXINOSCOPE AND PROJECTION MATERIAL MADE BY EMILE REYNAUD, *c.* 1890

minutes in length. He continued to show his pictures there until 1900, when competition from true motion pictures drove him out of business.

**1. Photography.**—Even while Roget was conducting his researches into the nature of vision in England, work was proceeding in France that was soon to lead to the invention of practical photography. In 1822 Joseph Nicéphore Niepce had succeeded in producing a crude but permanent photograph. Joined by Louis Daguerre, he continued his experiments until, in 1839, the two men were able to outline and demonstrate a complete, practical photographic process. Although their sensitized plates were far too slow for motion pictures, it was still possible to obtain photographs of posed phases of movement. That same year in England, Henry Fox Talbot introduced a negative-positive process that was to become the basis for modern photography. In Philadelphia, Pa., in 1860, Coleman Sellers, a mechanical engineer, made the first known attempts to relate photography to the principle of the Zoetrope. He posed his sons in a series of photographs showing them, in successive phases of a cycle of action, driving a nail into a box. The photographs were mounted on the blades of a paddle wheel, which, when revolved from a given point of view, produced the effect of animation. The machine was patented Feb. 5, 1861, as the Kinematoscope. The Sellers method of photographing posed phases of motion was applied to a projecting zoetropic device by Henry Renno Heyl, an engineer and inventor, who presented his Phasmatrope before an audience of 1,600 at the Philadelphia Academy of Music on Feb. 5, 1870. It carried photographs of six poses of a waltzing couple, repeated three times, giving a capacity of 18 pictures. The wheel on which these photographs (glass plate transparencies) were mounted was actuated by a ratchet and pawl mechanism that gave each image a brief period of rest on the screen, a method and principle that had to be rediscovered a quarter of a century later. Provisional patents for similar devices had been granted in England in 1868 and 1869.

In 1872, and without any intended relation to motion-picture development, Leland Stanford, a California railway magnate and sportsman, wished to investigate the gaits of the horse. Stanford assigned the problem to photographer Eadweard Muybridge (*q.v.*), who, with John D. Isaacs, an engineer on the staff of the Central Pacific railway, contrived a battery of 12 cameras with electrical shutter controls. The shutter mechanisms were improved, and the speed of photographic materials was increased, making possible by 1877 the first real photographs of objects in rapid motion. Exposures as brief as $\frac{1}{2,000}$ of a second were made. Word of Muybridge's pictures reached the French painter Jean Louis Meissonier, then engaged in a heated controversy with French academicians over the postures of the horses in his pictures. He not only confronted his colleagues with the proofs contained in the California photographs but, as a final proof, arranged to have them shown as projected transparencies on the Zoöpraxiscope, a machine similar to Heyl's Phasmatrope.

The photographic method devised by Isaacs and operated by Muybridge required the triggering of 12, and later 24, separate cameras. Clearly, the next step toward motion pictures was the creation of a single camera capable of high-speed, instantaneous photography—particularly since the Muybridge photographs, when projected, gave the illusion of an object moving in a single spot while the scenery ran past. The first success in this direction occurred in 1882 in France, where Étienne Jules Marey, a physician, physiologist and early authority on the nature of movement, developed a "photographic gun." It was shaped like an ordinary rifle with a disk of photographic paper inserted into the chamber and exposed by successive squeezes of the trigger. During the next decade, with the assistance of George Demény, he evolved a series of clumsy but original and practical cameras, culminating in 1888 with his Chronophotographe, which could take as many as 60 pictures per second on a roll of film that passed horizontally before the lens aperture. Because Marey used coated paper as his film base, his pictures could not be projected, but this was of small consequence to the inventor, who was interested in them solely for scientific purposes. The commercial exploitation of



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"PHOTOGRAPHIC GUN" INVENTED IN 1882 BY ÉTIENNE JULES MAREY TO PHOTOGRAPH MOVING OBJECTS. WOODCUT, 1885

cinematography was to come from other sources.

In the decade between 1885 and 1895, dozens of inventors throughout the world turned their attention to the problems of combining photography with motion. In England, beginning in 1889, William Friese-Greene (*q.v.*) patented a series of machines, cameras and projectors alike, although there is doubt that he ever produced practical, working models. Similarly, in 1889 Wordsworth Donisthorpe obtained patents on a camera-projector combination but lacked the funds to produce a working model. As early as 1888 the French-born Louis Le Prince patented in France, England and the U.S. a camera and projector involving multiple lenses and using strips of perforated celluloid as a film base; he and his plans disappeared mysteriously from the Dijon-Paris express in 1890. Independently of Marey, George Demény in 1893 developed a camera and projector; in the same year Ottomar Anschütz patented a practical projector, also in France. Commercial success, however, waited upon Edison's invention of the peep-show Kinetoscope.

Edison began his researches into the problems of motion-picture photography in the autumn of 1887, at a time when his phonograph was nearing completion. He had already seen Muybridge's photographs and felt that the two could be successfully combined. Indeed, his first motion-picture machine recorded spirals of tiny pictures on a cylinder, in the pattern of a phonograph groove. The pictures were given an intermittent motion and viewed under a microscope. The results were inadequate, however, and Edison determined upon larger images to be handled on a tape or belt. With the aid of his talented assistant, William Kennedy Laurie Dickson, he built a device for this purpose and experimented with various materials, including films made of collodion varnish coated with photographic emulsion. The material was unsatisfactory. In Aug. 1889, George Eastman, of Rochester, N.Y., began the manufacture of photographic film on a nitrocellulose base, a material evolved to meet the mechanical problems of "roller photography" for the Eastman Kodak box camera. Dickson employed samples of this material, and in 1890 a workable camera—the Kinetograph—was developed. To view the pictures so produced, the Kinetoscope was devised.

The Kinetoscope was a machine approximately 4 ft. high and 2 ft. wide in which the film ran with a continuous movement between a magnifying lens and a light source; a revolving shutter made it possible to view each individual frame momentarily. The

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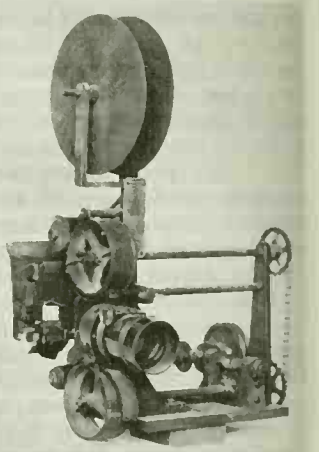
**EDISON'S KINETOSCOPE, PATENTED MARCH 1893, OPENED TO SHOW ENDLESS BELT OF FILM DRIVEN BY A MOTOR THROUGH A ROLLER SYSTEM**

capacity of the machine was limited to 50 ft., the length of the tables on which the film was manufactured; the images sped past the peephole at the rate of 48 frames per second, and the entire show lasted about 13 seconds. (This was later reduced to 16 frames per second, the rate that was to remain roughly the norm throughout the era of silent films; for sound film the speed is 24 frames per second.) The width of the film (35mm.), the shape of the image and the arrangement of the sprocket holes by which the film was driven in that first machine continued as the standard for motion pictures right up to the advent of the wide screens and wide films in 1952. Edison patented his Kinetoscope on July 31, 1891, but apparently thought so little of his invention that he failed to pay the additional $150 that would have granted him an international copyright, a circumstance he was to regret within a very few years.

The machine stood idle in the Edison laboratory until 1894, when, on April 14, the first of several Kinetoscope parlours in the U.S. was opened at 1155 Broadway, New York city. That autumn several machines were exported. From these sprang the final development of the motion picture in England and Europe. They provided answers to problems that had vexed the European inventors. In England, Robert W. Paul was hired to copy the Edison machine, then went on to produce a hand-cranked, portable camera of his own design. In Berlin, Max and Emil Skladanowski, also inspired by the Edison novelty, created their Bioskop. In France, Louis and Auguste Lumière, photographic manufacturers at Lyons, saw the Kinetoscope and conceived the idea of combining it with the kind of projected image then being presented in Reynaud's Théâtre Optique. Where Edison, fearing that a projected image would soon exhaust the novelty of moving pictures, had confined his attention to a peephole mechanism, the Lumières proceeded immediately to the problems of projection. Their Cinématographe, which they patented on Feb. 13, 1895, was a combination of camera, projector and printer. From Edison they borrowed the concept of sprocket holes at either side of the film, but they developed their own form of claw mechanism to move it past the aperture and also reduced the speed of the frames from 48 to 16 per second. The first public presentation of the Cinématographe took place on Dec. 28, 1895, at the Grand Café, Boulevard des Capuchines, in Paris. Within a few months, Cinématographes were taking pictures and giving shows throughout Europe; in June 1896 they invaded the United States to compete with Edison's invention.

Edison himself was forced to develop a projecting Kinetoscope to counter the numerous attempts of other American inventors to show his Kinetoscope pictures on a screen. On Feb. 22, 1895, Woodville Latham, of Virginia, whose two sons were Kinetoscope exhibitors, gave a New York press exhibition of his Pantoptikon, projecting a Kinetoscope subject; it was placed on public exhibition on May 20 but proved highly imperfect. A second version of this device had a brief international career under the name of Eidoloscope. Dickson, who had been Edison's assistant, joined forces with the American Mutoscope and Biograph company to make pictures move by a completely different system from the Kinetoscope. Jean Le Roy and Eugene Lauste also introduced cameras and projectors of independent design. In June 1895, Thomas Armat, of Washington, D.C., discovered a principle used in the modern projector; it differed from the Edison and Lumière devices in that it used a film movement based on an escape mechanism shaped like a Maltese cross that gave each successive image a period of rest and illumination greater than the period of movement from image to image. It also incorporated a loop in the film as a means of easing the strain as it passed through the apparatus. This machine, using Kinetoscope pictures, was first shown publicly at the Cotton States exhibition, Atlanta, Ga., in Sept. 1895. It became known as the Vitascope.



BY COURTESY OF THE SMITHSONIAN INSTITUTION

**VITASCOPE MOTION PICTURE PROJECTOR INVENTED BY THOMAS ARMAT, FIRST PATENT ISSUED MARCH 1897**

It was this Armat machine, manufactured by Edison, that was presented as the Edison projector at Koster and Bial's music hall in April 1896. Raff & Gammon, Edison's agents for the Kinetoscope, sensing the growing demand for moving pictures on a large screen, had independently investigated the Vitascope. They approved of what they saw and persuaded Edison, for the sake of expediency, to come to terms with Armat. Although Edison continued to make improvements on the apparatus after its theatrical debut, he acknowledged that the basic patents belonged to Armat. Other inventors were not so fortunate, as a protracted series of bitter law suits subsequently revealed. Meanwhile, European audiences were viewing other inventions. In London, for example, Birt Acres projected his pictures publicly in Jan. 1896; the Lumières demonstrated their apparatus on Feb. 20, 1896; and Robert Paul showed his films in March 1896, first at Olympia and then at the Alhambra theatre.

The first films, both in the United States and elsewhere, retained the conventional 50 ft. length, less than a minute of screen time. One important difference arose immediately, however. Edison, concerned as ever with the application of electricity to his every invention, had constructed a battery-driven camera, the Kinetograph, of approximately the size and weight of a small upright piano. To house it, he built near his West Orange, N.J., laboratories the world's first movie studio, the tiny tarpaper-covered "Black Maria," at a cost of $637.67. Acts were brought to this studio—vaudeville turns, circus performers, wild west, even moments from successful New York plays. The Europeans, however, were content with relatively light, mobile, hand-cranked cameras. Their cameramen could go anywhere and photograph anything. As a result, the first screens were soon crowded with brief glimpses of parades, trains drawing into stations, street crowds and folk dances. The accent was on actuality; if it moved, it was suitable for filming. In 1896 Edison bowed to the competition and prepared a portable version of his Kinetograph.

BY COURTESY OF THE SMITHSONIAN INSTITUTION

"BLACK MARIA," FIRST MOTION PICTURE STUDIO, BUILT BY THOMAS A. EDISON AT WEST ORANGE, N.J., FEB. 1892

Although bits of theatrical lore continued to come from the "Black Maria," the Edison catalogue was soon as well stocked with actualities as those of any of his competitors.

Because motion pictures made their theatrical debut as part of a vaudeville show, the capacity of the projectors was fixed at 1,000 ft. of film (sufficient to provide the equivalent time of the average stage turn), thus establishing the existing standard film unit of one reel. At first, the reel was made up of about a dozen assorted subjects; indeed, many of the short films on the early programs had been made for the peep shows. Within a short time, however, the novelty value of pure movement began to wear thin. Producers began to search for more ambitious, or at least more original, film material. Perhaps the first attempt to tell a story on film took place in 1897, when R. G. Hollaman, of the Eden Musée in New York city, produced a Passion play in three reels with a cast of actors and dramatically arranged settings. In Paris, Georges Méliès, a magician and proprietor of the Théâtre Robert-Houdin, began a long series of subjects exploiting the trick possibilities of the camera. By 1899 he was combining his short lengths of film to form episodes in a connected story. Méliès' fertile, fantastic imagination crowded the screen with charming tableaux and historic recreations that found favour everywhere. In England, shortly after 1900, the so-called Brighton school of film makers became intensely active and quickly established themselves in the forefront of creative film making. But the real birth of the narrative film took place in 1903 when Edwin S. Porter, a director for the Edison company, presented his *The Great Train Robbery*. Its single reel (about eight minutes) contained the seed of modern editing techniques, while its immediate popularity launched the era of the nickelodeon. In the truest sense, *The Great Train Robbery* marked the beginning of both the art and the industry of motion pictures.

**2. Sound.**—Through the first quarter of the 20th century, the motion-picture industry prospered and grew. Its films became longer, its equipment more costly and complicated, its techniques more refined. Basically, however, nothing had changed. The problem was still one of constructing an illusion of reality out of black-and-white shadows on a screen. Subtitles, introduced about 1907, helped explain action too subtle or involved for pantomime. But the idea of linking sound with the images had been present in the minds of inventors from the outset; Donisthorpe, in England, had made the suggestion as early as 1878, and Edison from the start had envisaged the camera as an adjunct of his phonograph. In France, Léon Gaumont had produced before 1900 a series of short sound films featuring such notables as Constant Coquelin and Sarah Bernhardt. In all of these devices, the concept was simply to synchronize a moving picture with an ordinary phonograph record. Synchronization seemed the basic problem, and many ingenious schemes were worked out to overcome it. One inventor actually tied the phonograph to the projector motor through a system of belts and pulleys that ran the length of the house from booth to screen. By 1912 sufficient interest had been aroused to induce Edison to produce several reel-length talking pictures, while in England, Eugene Lauste had made, patented and demonstrated the basic method for recording sound on film.

Around 1912, however, exhibition began expanding beyond the nickelodeon stage. As theatres grew larger, it quickly became obvious that the problems of sound films included not only synchronization but amplification as well. Neither Lauste's equipment nor the early phonographs, with their needle and diaphragm, could supply the volume of sound necessary to fill an auditorium of any size. This deficiency was soon met, however, in the so-called audion amplifier, a selenium vacuum tube developed by Lee De Forest (*q.v.*) shortly before World War I. Its immediate application during the war years lay in long-distance radio and telephone communications, since it could step up the volume of sound for message relays. De Forest assigned his patents to the Bell Telephone company, but when the war was over, he turned his attention to talking pictures. Unlike his predecessors, he had little faith in the phonograph-motion picture combination. The system created mechanical difficulties of synchronization, and, in fact, synchronization became impossible if either the record or the film was damaged. De Forest confined his experiments to recording sound directly on film. By 1923 De Forest was exhibiting his Phonofilms as an "extra added attraction" in theatres in the United States. They were brief vaudeville turns, involving such top personalities of the day as Eddie Cantor, Phil Baker, and Weber and Fields, but their novelty value was negligible. The public was not yet ready to accept sound. Nevertheless, De Forest had uncovered the basic means of transcribing the varying impulses of sound waves into varying impulses of electricity that could be photographed in terms of black and white upon a strip of celluloid; and then the film, when passed around a photoelectric cell in the projector, could transform these images back to natural sound. Although there were to be variations in detail, fundamentally De Forest's methods were duplicated by such subsequent sound-on-film systems as the Movietone (developed for William Fox by Theodore W. Case, a former assistant to De Forest) and Russia's Shorin sound, and they were anticipated in Ger-

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VITASCOPE AND PHONOGRAPH PARLOR, SPRING STREET, LOS ANGELES, CALIF., 1896

many, where the Tri-Ergon system of recording was demonstrated in 1919 and 1920.

In the meantime, the Bell Telephone laboratories persisted in the effort to combine the phonograph with the motion picture. By 1926 they had prepared a special turntable synchronized to the projector motors that could handle 13- to 17-inch disc-type records, large enough to accommodate a full reel of sound. This was the system that Warner Brothers, then on the verge of bankruptcy, grasped as a last hope. As the Vitaphone, it was introduced on Aug. 6, 1926, in a program that comprised several talking and musical shorts and featured John Barrymore in *Don Juan,* a silent film but with a synchronized symphonic accompaniment. For more than a year (during which Fox also began to release sound-on-film shorts, the Movietone newsreel and synchronized scores for his more important features), the novelty created no great stir. But suddenly, on the night of Oct. 6, 1927, the sound revolution began. The occasion was the Vitaphone presentation of Al Jolson in *The Jazz Singer,* a silent picture with four talking or singing interludes. These were enough. The linking of sound with a dramatic feature—plus the electric personality of Jolson—at once tore down the public's apathy. Within the year, any picture of importance was produced as a talkie, or at the very least a part-talkie. By 1930, silent films had become a thing of the past. Late in that year, Warners reluctantly conceded that sound-on-film was superior to sound-on-disc and gave up the latter system (although not the Vitaphone trademark). Bitter litigation over rights and patents was conducted between the Radio Corporation of America and the Western Electric company, the two largest manufacturers of sound equipment, and between them and Warners and Fox, the two pioneers in the production of sound films; court settlements were reached in 1935.

The period between 1930 and 1952 can best be described as one of technological improvement but without basic changes in sound techniques. Methods to remove extraneous noise from the sound tracks were devised as early as 1931. Microphones, recording equipment and loudspeaker systems were perfected; numerous devices—sound readers, multichannel recording panels, magnetic tape—were introduced to simplify the problems of handling sound or to enhance sound quality. What went onto the film, however—and what, in most instances, still goes onto the film—was an optical band about $\frac{1}{4}$-in. wide running along the right side of the image; this band was a photograph of the electric impulses derived from each sound's characteristic, captured in either minute striations of gray or varying areas of light and dark.

With the introduction of wide screens in 1952, however, new forms of sound recording quickly made their appearance. Where sound formerly had issued from a single set of speakers strategically placed behind the screen, Cinerama introduced the concept of a whole battery of speakers spread not only behind the screen but also into the auditorium so that a sound could always be physically linked to its visual source. (Directional or stereophonic sound had been demonstrated by Bell Telephone as early as 1933 and employed by Walt Disney in 1940 for his *Fantasia.* Impressive as these experiments were, their limited usefulness on the small screen did not warrant the expense of reequipping both studios and theatres at that time.) Cinerama, on the other hand, boasted an image both wider and higher than anything seen before; it needed an equally wide-ranging sound. For it Hazard Reeves, a sound engineer who had pioneered in the use of magnetic tape for recording, developed a seven-channel system in which each track powered a separate set of speakers. The tape was synchronized to the film but was separate from it.

Cinerama's sound set new standards of fidelity and flexibility in the motion-picture field, standards that subsequent wide-screen processes attempted to equal or at least approximate. CinemaScope, introduced in 1953, also used directional sound on a magnetic strip on the film but for economy's sake compromised on a four-channel setup. But the magnetic strip, whether placed directly on the film or handled on a separate reel, created special problems for the producer and added expenses for the exhibitor. As an alternative, M-G-M engineers in 1954 brought out an optical, three-channel system called Perspect-A-Sound. The process used a single, standard-sized, optical sound track, but in the final recording stage three low-frequency, *i.e.,* below the audible range, cuing signals were included to switch the sound to three sets of speakers behind the screen. In addition to the three sets of amplifiers and the three sets of stage speakers, as used for magnetic CinemaScope, the Perspect-A-Sound units also required an integrator, a relatively low-cost electric device that picked up the cuing signals and effected the switching operation.

**3. Colour.**—The quest for colour motion pictures antedates the motion-picture era. A complete motion-picture system was patented in France in 1864 by Louis Ducos du Hauron; a few years later, he described a colour monopack, or integral tripack, film; *i.e.,* one in which emulsions sensitive to different colours are combined on one base. Materials of his day, however, were inadequate to the task of putting those ideas into practice. During the first years of the 20th century, the films were coloured by hand. Dozens of girls, each with her own tint, followed the tiny images from frame to frame; but in 1905 Pathé introduced a semiautomatic stencil system that persisted until about 1930. Since film was sold by the foot in the early days of the industry, the exhibitor, for a few additional pennies, could buy his pictures in full, if wavery, colour.

The first important advance toward the mechanical reproduction of colour on the screen came in England, where, in 1906, the producer Charles Urban and the inventor G. Albert Smith patented Kinemacolor, a two-colour process. It used ordinary black-and-white film running at 32 frames per second. During photography, however, and again at the point of projection, alternate red and green filters passed before the lens, supplying a realistic if not always accurate colour. Urban was primarily a promoter, and between 1908 and 1914 he vigorously exploited his novelty, even using it in the production of feature-length films. Among his most famous subjects were the Delhi durbar of 1911 and the many nature studies of F. Percy Smith. His Kinemacolor pictures, widely shown in the United States, Germany and France, inspired a host of imitations. Most prominent of these was Biocolour, invented by Friese-Greene, which eventually broke Urban's monopoly through a patents suit that was decided in Dec. 1913. The following year, both companies ceased operations because of World War I.

One of the chief drawbacks of Kinemacolor, and all processes that have attempted to reproduce colour through similar mechanical means, was the difficulty of ensuring perfect registration. The tones were not only false (inherent in any two-colour process) but they also flew behind any moving object. Audiences were attracted by the novelty of colour but tended to laugh at its inadequacies. In any case, the suggestion of colour had been present on the screen since 1905 in the form of tinted stocks (blue for night, red for fires, etc.) and, a bit later, in the practice of toning the image with a contrasting hue (blue toning for sea combined with a pink tinting for sky, etc.). Tinting and toning persisted up to the introduction of the sound track, when the need for a uniform film base made such leaps from blue to salmon to amber impracticable. A relic of the process can still be seen, however, in an occasional sepia-toned feature.

Inventors concerned with the reproduction of true colour turned their attention meanwhile to the development of colour-sensitized emulsions. The chief difficulty, it soon became apparent, was that while there are three primary colours the film base could conveniently accommodate only two. Technicolor, begun in 1915 by Herbert T. Kalmus and a team of physicists from the Massachusetts Institute of Technology, Cambridge, made a first step toward solving this problem by using a prism that split the light beam into two parts as it entered the camera, one beam favouring the red-orange end of the spectrum, the other the blue-green. Each image was captured simultaneously on a separate band of film. The two strips were then developed separately and printed, after which the prints were passed through their appropriate dyes; when laminated together, they produced a reasonably faithful approximation of natural colour (although favouring, of course, red-orange and blue-green). Technicolor made its commercial bow in

*The Toll of the Sea* in 1922 and was used in the climactic sequences of such spectacles of the 1920s as *The Ten Commandments, The Phantom of the Opera* and *Ben Hur*. The most notable colour film of the silent era was Douglas Fairbanks' *The Black Pirate* (1926), in which the tints appreciably enhanced the romantic flavour of the story.

Technicolor came at just the right time. Because so many of the films of 1929–30 were musical comedies, revues and operettas, colour was especially appropriate. Technicolor moved into a period of unprecedented prosperity. Indeed, so heavy was the demand that the laboratories fell far behind in supplying prints, and those supplied were frequently so badly processed that the images appeared fuzzy and blurred. The enthusiasm of audiences and producers alike quickly tapered off. Even the announcement of a three-colour process—a process for full natural colour—failed to generate interest in the studios. Only Walt Disney, producing animated cartoons, liked what he saw well enough to sign a contract; his *Flowers and Trees* (1932) became the first film made in the three-colour system. Eventually, in order to exploit the process in live-action feature films, an independent production company, Pioneer Pictures, was organized by John Hay Whitney, with *Becky Sharp* (1935) as its first major release. Although other studios made an occasional colour feature thereafter, not until the success of *Gone With the Wind* (1939) was colour seriously considered a significant box-office attraction.

Technicolor continued to dominate the colour scene virtually unopposed in the United States for more than a decade thereafter. (The sole competitor was Cinecolor, a two-colour process used primarily in low-budget westerns and shorts.) Technicolour, Ltd., an arm of the parent company, was established in England and became noted for the greater subtlety of its colouring. In the European market after World War II, however, the process was in direct competition with such relatively low-cost and flexible processes as the German Agfacolor, the Belgian Gevacolor and the Italian Ferraniacolor, all based on substantially different monopack methods of producing colour on the screen. On the other hand, the U.S. firm of Eastman Kodak, which had introduced a three-colour monopack process, Kodachrome, in 1935, confined its activities to the amateur field. Even its commercial Kodachrome, introduced in the mid-1940s, was made available at the outset solely in the substandard 16-mm. width.

The coming of the wide screens changed all that. With the larger, heavier cameras required by Cinerama, CinemaScope, VistaVision, Todd-AO and Cinemiracle, it was no longer possible to cope with the additional strips of film required for Technicolor. Both Eastman Kodak and its competitor, Ansco, leaped into the breach with full-colour monopack processes that, as De Luxe Color, Metrocolor or WarnerColor, quickly superseded Technicolor not only in the wide-screen films but often in normal screen films as well. Eastmancolor soon penetrated as far as Japan; *Gate of Hell* (1954), photographed in the process, revealed nuances in the psychological handling of colour that made directors the world over increasingly aware of colour as a dramatic, rather than purely a decorative, element in their pictures. By the mid-1960s, over half the pictures produced by Hollywood—and a considerable proportion of films made elsewhere—were being shot in one or another of the many colour processes available, while Technicolor was used increasingly for the preparation of prints.

**4. Wide Screens.**—In 1947 the U.S. motion-picture industry was enjoying the greatest prosperity it had ever known. But by the end of 1948, danger flags were flying. Television, freed of wartime restrictions, had captured the movies' audiences and was holding them glued to the small screen in the living room. As attendance in motion-picture houses continued to decline, the studios searched for a means of bringing the public back to the theatres. They found an answer in the autumn of 1952 when Cinerama, independently developed by Fred Waller, made its bow on Broadway. Its wide, curving picture, a composite of three separate strips of film, and its seven-channel stereophonic sound produced an astonishingly realistic effect. A few months later, stereoscopic movies—3-D (three dimensional) with glasses—were revived in a low-budget action feature, *Bwana Devil*. (In one form or another, stereoscopic movies had been presented since the early 1920s, generally with red and green gels to achieve the necessary separation of images. The process used in *Bwana Devil* had been demonstrated at the New York World's fair of 1939.)

Both Cinerama and 3-D were so enormously popular that the studios immediately investigated. Cinerama, they quickly discovered, was highly complicated, extremely expensive and would require drastic innovations in both studio and theatre equipment. 3-D, on the other hand, needed only a special camera equipped with light-polarizing lenses and, in the theatres, an inexpensive adapter to lock together the two machines required to project the dual images—plus, of course, the polarizing viewers for the audience. Most of the studios plumped immediately for Natural Vision, the trade name for the polarizing process, rushing into production a series of cheap horror films and melodramas designed to exploit the twin novelties of depth and of objects flying out from the screen. Before the end of 1953, the producers realized that they had backed the wrong horse. Audience apathy—even antipathy—to this rash of low-budget pictures convinced them that it was more prudent to release as conventional pictures some of their more elaborate productions, even though they had been shot in 3-D.

Cinerama, on the other hand, continued to attract crowds. In patent imitation, many theatre owners simply enlarged their screens and overmagnified their pictures. But in the fall of 1953, 20th Century-Fox introduced CinemaScope, a true wide-screen system that approximated the Cinerama effect through a revolutionary, if not precisely new, technique. CinemaScope was, quite simply, the trade name given to an anamorphic process developed in France by Henri Chrétien and demonstrated there as early as 1928. Special distort lenses squeezed into the normal 35-mm. frame an image almost twice the normal width; when the picture was screened in a theatre, complementary lenses on the projector opened it out again to an aspect ratio of 2.5 to 1 (the relation of width to height). Again with an eye to Cinerama, this was accompanied by a three-channel stereophonic sound system. The whole installation—lenses, screen and sound equipment—was made available to theatres at about $20,000. To assure a flow of quality films, Fox arranged to lease the process to other studios at the moderate price of $25,000 per picture or $75,000 per year. The first CinemaScope feature, Lloyd C. Douglas' *The Robe*, proved so enormously successful that within the next few years virtually every theatre in the United States, and most of the larger theatres in Europe and Asia as well, had acquired CinemaScope installations.

CinemaScope was dubbed from the outset "the poor man's Cinerama." It aped its rival in adopting a curving screen and directional sound (although neither so curved nor so directional as Cinerama's). But other processes were soon introduced that sought not merely to approximate but to duplicate Cinerama's effect through other, less complicated means. In the fall of 1955, for example, Michael Todd introduced his Todd-AO with an adaptation of the Rodgers and Hammerstein musical *Oklahoma!* Developed for Todd by Brian O'Brien of the American Optical company, it produced a wide-screen effect by using an ultrawide, 70-mm. film base—the first important departure from standard 35 mm. since Edison's Kinetoscope experiments of 1890. (There was a brief flurry of wide-screen enthusiasm in 1929–30 when the studios sought to introduce widths from 56 to 70 mm.; the sturdy opposition of the exhibitors kept these from coming into all but a handful of houses.) Cinemiracle, sponsored by National Theatres, strongly resembled Cinerama in that it continued to use three projectors to fill the wide, curving screen. A system of angled mirrors, however, made it possible to operate all three machines out of a single booth, thus cutting down drastically on the costs of installation and operation. Cinemiracle made its debut in the spring of 1958 with the documentary *Windjammer*.

Paramount refused to go along with any of the ultrawide-screen systems, arguing that they were both aesthetically unacceptable and difficult to adapt to the shape and size of many theatres. Instead, Paramount technicians developed VistaVision, a system that permitted great extremes of magnification without graininess or

graying, thus permitting theatres to enlarge their screens without overaccenting the horizontal. VistaVision cameras used the ordinary 35-mm. film, but the negative passed the aperture horizontally rather than vertically, and the aperture was widened to 70 mm. (twice the usual width). Each double frame was then reduced and swung 90 degrees in the printing process, thus producing normal 35-mm. release prints that could be shown on all standard theatre projectors. Because the original negative held twice as much picture information, the photographic quality of these prints was exceptionally high; they could be blown up on the largest screens without loss of detail. VistaVision was introduced in 1954. Paramount hoped to induce the larger theatres to install new projection equipment to show 70-mm. contact prints, *i.e.*, prints made directly from the negative, the pictures feeding into the projector horizontally; but once again the theatre owners balked. They had just spent large sums to install new screens, new sound equipment and new lenses. They drew the line at purchasing new projectors as well. The same fate befell CinemaScope 55 (using a 55.625-mm. film base) and M-G-M's Panavision (65 mm.); in both instances, films shot in these processes were reduced to 35 mm. for general release.

Technirama, developed in 1957 by Technicolor, combined the squeeze principle of CinemaScope with the horizontal negative of VistaVision; consequently, it was possible to produce a negative that could be printed in any desired aspect ratio on any width of release print—70 mm., 35 mm. or even 16 mm.—in squeezed or unsqueezed images. Other processes in the United States—Superscope, Vistarama, Thrillarama, Vidoscope, Vistascope, Delrama—borrowed in one way or another from the principles of Cinerama, CinemaScope, VistaVision or Todd-AO. In Europe, Cinepanoramic and CameraScope were virtually identical with the CinemaScope system, while Russia produced a process, Kinopanorama, that literally duplicated Cinerama. Indeed, the only radical departure from any of the four basic systems described above would seem to be the Dynamic Frame, developed in England by Glenn Alvey, Jr., an American inventor. Compatible with any of the existing wide-screen processes, it introduced the concept of changing the shape of the screen, and the position of the image on the screen, in harmony with the composition or psychological intent of each shot. Sponsored by the British Film institute, it made its debut in a short experimental film, *The Door in the Wall,* early in 1956. (A. Kt.)

## II. THE ART OF MOTION PICTURES

**1. Attempts at Definition.**—All speculation about the arts must wait upon the artist and is a form of wisdom after the event. Nor does any evaluation of the past prepare for subsequent events. Thus art is in a large measure unpredictable. It does not progress according to established laws; rather, it accumulates, informed by a spirit that bloweth where it listeth. From this it must be at once apparent why it has been said of the cinema that it is much less an art than it should be and that it cannot, in its present condition, fulfill its true function as the supreme weapon of the poet. It cannot afford the unpredictable. Therefore it seeks the security of successfully established formulas. In other words, the industrialization of the cinema and the high cost of production call for the kind of planning that will ensure the stockholder a maximum return for his investment. A premium is put on profits, and to secure them the cinema industrialist must find as wide a market as possible for his product. Even under these conditions there is no intrinsic reason why the cinema should not have developed the status of a true, popular art. It simply has not done so. The motion-picture industrialist prefers to think of himself as a showman rather than as any kind of an artist; he also views his concern as being with entertainment, not art. His aim is toward happiness, not beauty; toward the moral rather than toward the aesthetic. He has a commercial desire to secure the greatest happiness of the greatest number. This is not a new problem and was long ago dramatized in Goethe's *Faust.* The prelude shows the poet, his eye on posterity, arguing with the impresario and the actor whose preoccupations are economic and whose eyes are on the waiting crowd. The solution offered by the impresario still guides the showman. He must win the masses with mass, providing a little of everything, so that there will be something for all. The motion-picture showman, however, goes further. His ideal product is aimed at a world population. The limitations thus imposed are at the heart of almost all the problems of cinema and have largely dictated its development. This is particularly true of the subject matter. His aim being directly and uncompromisingly euphoric, the cinema industrialist must concern himself with those things that are thought to bring happiness to everyday life. This calls for the widest insistence on romantic love and prosperity, on the happy solution to every problem and the moral satisfaction of justice triumphant. Even this is not incompatible with art in the cinema. All too frequently, however, the industrialist, while playing for safety and the worldwide audience, underestimates the taste and intelligence of that audience.

The artist cannot always be denied, and he has, from time to time, escaped from the prison walls of industry to give the cinema moments of greatness. Nor are all problems of the cinema economic in nature. Some derive from the time in which the problem was born. Among these must be counted the cinema's association with the theatre and the resulting confusion over its functions as a medium in its own right. Censorship of many kinds hems it in. Again, the multiplicity of its legitimate uses militates against a unanimous agreement on what is or is not cinema and, so, against any final definition of the art of motion pictures. As good a way as any to examine the nature of this art is under the headings of form and content.

*Form.*—The form is the result of the operation of three principal agents: camera, sound and editing. On the surface the roles of the first two are clear enough, though some persons still deplore the introduction of sound, at least in the form of dialogue. Editing may be explained briefly as the process by which the images on the strips of film are cut and arranged together, in due sequence of timing and rhythm. Because of the control thus given to the film maker, editing has been called the foundation of the art of motion pictures. Certainly it distinguishes cinema both from theatre, even when it is little more than a photographed stage play, and from live television, with its restricted form of editing through the camera.

*Content.*—By content is meant whatever is conveyed by the images, according to the sum of their order. This may be purely reproductive, as in a newsreel or a travelogue or in the record of a flight of birds; or it may be some form of selective reenactment. This reenactment may be either by men or women concerned in events and actions of their everyday lives or by actors enacting a drama. These various enactments may take place in their natural setting or before a reproduction of a natural setting. Generally speaking, the lines of the development of motion pictures have lain within these categories or within some combination of them.

**2. Historical Origins.**—*France.*—The motion-picture camera appeared in a world already sharply divided over the aesthetics of the still camera. Theatre and the plastic arts, it was held, creatively transmute reality in the process of what Aristotle called mimesis (variously rendered as imitation or reproduction). The process of photography seemed to be significantly different. The still camera, and the motion-picture camera even more so, was thought to reproduce reality literally, so to speak, without any transmutation or poetic rendering. The concern of photography was therefore with truth, not beauty, and its realm was science, not art. As long as the camera remained fixed in front of the moving object and merely reproduced it, there appeared to be some basis for this argument. However, the cameramen of the Lumière brothers, who were the forefathers of all realism in the cinema since they ordered their crews to film the world about them, soon had the camera moving. The first recorded traveling shot was made in Venice in 1896 when a cameraman, in an attempt to film the city more effectively, strapped his camera to a moving gondola. The principle of the mobile camera, thus early established, was at first more honoured in the breach than in the observance. Georges Méliès, impresario, magician, inventor and enthusiastic frequenter of the Lumière film showings, saw in this new apparatus the means of realizing his highly imaginative dreams. He took it back into

the studio. Immobilized, it became the eye of the spectator in a theatre. In Méliès' own words, he "set the cinema along the path toward theatrical spectacle and introduced the extravagant costume film, imposing décor, historical reconstructions, dramas, comedies, opera. . . ." The commercially fruitful yet basically uneasy union of camera and theatre was thus effected, and the cinema became a composite; its identity as a medium in its own right, while not lost, was increasingly obscured for approximately a quarter of a century, when it was finally reaffirmed by Robert Flaherty in his *Nanook of the North*.

*England.*—At the time that the motion picture was being immobilized and theatricalized by Méliès in France, the scope of the cinema was being extended, in England, by the Brighton school. G. A. Smith and James Williamson, the best known of this group, were both photographers, Smith a professional and Williamson an enthusiastic amateur. Thus they tended to give importance to facial expression, being thereby led to the use of the close-up. Smith, alternating close-up and full view, anticipated the selective juxtaposition of images that later came to be known as montage. Accepted as normal procedure a few years later, this innovation was found at first too puzzling for audiences. Smith therefore resorted to circling the faces or objects he wished to emphasize, after a fashion then common in the illustration of books or on magic lantern slides. In these and in a number of other ways the Brighton school anticipated both Edwin S. Porter and D. W. Griffith in the U.S. by their early use of the chase, simultaneous action, exterior shooting and subjects with social implications. The most richly promising of their films, *Attack on a China Station*, made by Williamson in 1900–01, is an unmistakable forerunner not only of Porter's *The Great Train Robbery* but even of Griffith's *The Birth of a Nation*.

*United States.*—At first ashamed of working in the new medium, which seemed to offer little beyond a temporary livelihood to a man who aspired to be the Shakespeare of the American theatre, Griffith developed its existing techniques to a point beyond which, in many respects, they have not since progressed. As early as 1908, Griffith's first year in motion pictures, it was evident to one perceptive critic that his films ". . . have got down to the root idea of a moving picture. . . . Their photographs are not mere snapshots or rapidly taken groups of small parties of puppets moving about on the stage. . . . They are active photographs of thinking men and women. . . . He puts his camera near the subjects . . . and you see what is passing in the minds of the actors and actresses." To the already established mobility of the camera he added movement within the individual scene, thereby giving greater vividness. To this he added an intensified form of parallel cutting, which, when integrated with the chase, carried the suspense of the audience almost beyond endurance. (*See* also GRIFFITH, DAVID [LEWELYN] WARK.)

*Russia.*—This process of editing as developed by Griffith was taken still further by the Russian film makers, notably Sergei Eisenstein and Vsevolod Pudovkin (*qq.v.*). Their colleague, Lev Kuleshov, had laid down the principle that film art begins ". . . not when the actor acts or a scene is shot . . . but from the moment when the director begins to combine and join together the various pieces of film. By joining them in various combinations in different orders he obtains different results." Nor need these various pieces of film have any intrinsic relationship. Indeed, the more conflicting their relationship and the more explosive their coming together, the richer the creative result. "Editing derives its power," Kuleshov continued, "not merely from the fact that by breaking up a scene into shots it can be represented more vividly and realistically but also from the fact that a succession of shots involves a complex set of relationships between them, relationships of ideas, of duration, of physical movement and of form, by the skilful manipulation of which an audience could be most powerfully affected." That the Soviet film makers should seize upon and elaborate this powerful cinematic device can be readily explained by the analogy it can be made to bear to the Hegelian process of dialectic with its insistence on the importance of relationship. It is in this light that Eisenstein explains the structure of *Potemkin;* the word montage might well be used to describe the Hegelian universe. Even the relationship known as audience participation is seen by Eisenstein as a part of this organic total.

**3. Addition of Sound.**—The coming of sound into motion pictures was one further instance of the seemingly arbitrary evolution of a medium centrally dominated by economic considerations. Introduced by the financially threatened Warner Brothers in 1926, it was soon accepted by the public. The filmed stage play came into its own, and the spectacular musical was not long delayed. The cinema seemed to have lost its dynamism and to be again a mere form of recording. Nor were protests wanting. The commercial results quickly reconciled the industrial film maker, but the others, wedded to a well-developed and universally expressive medium, resisted. Some are still not reconciled. The Russians, while accepting sound as such, rejected synchronized sound in the form of dialogue as a return to the stage play and as a threat to montage and to the universal quality of the silent film. By way of pointing up the importance of the moment, Eisenstein and Pudovkin embodied their views in a manifesto. Synchronization had come to stay, however, and step by step the same ingenuity that raised the problem did something toward removing part of it—by making the microphone mobile.

**4. Reappraisal in the 1930s.**—By the early 1930s, the film maker was in possession of his full kit of tools, and the motion picture had again to attempt to find its true self. From time to time crises have given occasion to the endlessly experimenting engineer, and the results have seemed to threaten established practices. The various forms of wide screen, for example, threatened to strike at the vital process of editing, since their size made adjustments to the established flow and rhythm more difficult. Filming on tape bade fair to revolutionize all aspects of production. Whatever the pattern for the future may be, the past, for all its conflicts and confusion, can be seen in some measure of ordered perspective.

**5. Fluctuations: Reality *v.* Theatricalism.**—There have been two commercial peaks, one in silent films at the end of the 1920s and the other in sound films at the end of the 1930s. The artistic fortunes of the cinema, on the other hand, have fluctuated everywhere according to the success or failure of the film maker in his struggle with the economics of commercial production. By 1908 there were studios in almost all European countries, and production had started in Japan. A glance back over the years would seem to establish a fact that may ultimately help point the way along which the future of the cinema may lie. Success of an artistic kind, whatever the concomitants of the theme, seems invariably to have been achieved in proportion to the degree that the films have been uncompromisingly rooted in reality and, adhering adamantly to the intrinsic necessity of the dramatic fact, have included only what should be a part of the whole, rejecting the synthetic or the compromise. This would seem to justify the assertion that the affinity of the camera is directly with the drama of reality, and not indirectly through theatrical conventions. This does not at all mean that the camera is concerned only with externals. On the contrary, it reaches into the heart and the soul. However, it achieves its insight into man more profoundly in his natural habitat, in the field or in the street, where a lifetime of associations, of relationships and attitudes exposes him to the lens as he is. Valid exceptions are exceptions of such genius as the created images of Jean Cocteau (*q.v.*).

*France.*—The distinction thus established between the reality of the cinema and the convention of the theatre was not always clear. What Méliès began was perfected by two groups: (1) those who saw money in making the play-on-film available to a wide public; and (2) those who believed that cinema could become an art only by being married into the respectability of the theatre. So, the *film d'art* was born. Not every French film maker, however, was willing to film plays. The comedian Max Linder, who strongly influenced Charlie Chaplin, was teaching himself the cinematic art of revealing a whole world in a gesture, and Louis Feuillade was busy with the detective serial and the adventures of *Fantomas*. After World War I, theatricalism was finally swept into the background on a surge of new ideas stirred by a group of intellectuals that included Guillaume Apollinaire, Pablo Picasso and the surrealist André Breton. In the U.S., the films of Thomas Ince,

Mack Sennett, Chaplin and, later, for some, Erich von Stroheim, seemed to reveal the real nature and potentialities of the screen even more than the French pictures did.

An aesthetic of the film began to be formulated. The influential French critic Louis Delluc, who at the outset had been hostile to motion pictures, began to report them favourably and finally turned to making them. At his prompting, the public began to distinguish between what was and what was not cinema. An early tendency toward impressionism and fantasy gradually gave way to a use of natural settings, with the French Abel Gance and Jean Epstein contributing an out-of-doors poetic realism. Inevitably the French cinema had its avant-garde and its moments of surrealism, since the cinema, with its freedom of juxtaposition, was a most apt medium for such experiments. The young directors of the post-World War I period, among them René Clair and Jean Renoir, saw clearly that the task of the cinema, as Cocteau later described it, is to express ideas that cannot be adequately expressed by any other means. Of the more forceful directors of the post-World War II period in France, Robert Bresson was particularly alive to the special powers of the camera, which he has used like an X-ray machine to examine the human heart, by way of the face.

*Scandinavia.*—The intense spiritual quality of Bresson's work induces comparisons with the outstanding figure of the Danish cinema, Carl Dreyer. In searching for the soul in the face, Dreyer was criticized for an exaggerated use of the close-up. His *The Passion of Joan of Arc*, made in 1929, was dismissed by some as merely a series of portraits and not cinema. After entering into motion pictures in 1912, Dreyer dominated the Danish screen with his usually important and always controversial work. His major post-World War II film, *Day of Wrath*, which deals with witch-hunting and religious persecution, is no exception to this rule. The interest of the Danish government in motion pictures tended to emphasize documentaries and subjects dealing with the realities of social problems.

Norway's output has been small and has likewise emphasized the documentary. Its major production, however, an adaptation of Knut Hamsun's *Growth of the Soil*, indicated a preference for the realities. Sweden tended all along to dominate the Scandinavian scene, in part because of the fame of her actresses, from Asta Nielsen and Greta Garbo to Ingrid Bergman, but mostly because of the fine Swedish directors. Among the earliest of these were Victor Sjöström and Mauritz Stiller. Their work was characterized not only by a love of national traditions but also by a combination of moral values and a deep love of nature. The search for moral values has characterized the entire Scandinavian output and has earned for it the title of the Biblical school. After World War II, producer Alf Sjöberg and writer-director Ingmar Bergman joined forces to give a new, though no less serious and realistic, orientation to the Swedish cinema. In *Frenzy* and subsequent films, there is manifest a deep concern for, and understanding of, the sufferings and problems of adolescence in a difficult world. Nor are the remarkable natural-life films of Arne Sucksdorff without certain significances beneath their faithfulness to their natural settings.

*Germany.*—Up until World War I the German screen was dominated by the Scandinavian film. For another decade or more, until the dictatorship of Hitler, it flourished on its own, reflecting, naturally enough, certain national characteristics. It was a composite of the mystically romantic and the grimly realistic, and it went hand in hand with a readiness to experiment. The expressionism prevailing in German art at the close of World War I found a new form in the strange sets and stranger action of *The Cabinet of Dr. Caligari.* With *Nosferatu,* a grim species of dark-tower romanticism, began the Dracula series. Then, with *The Joyless Street* and his subsequent works, G. W. Pabst introduced a powerfully grim realism, while E. A. Dupont with *Variety* produced a masterpiece of camera virtuosity that disturbed Hollywood by seeming to threaten its supremacy. In *Metropolis*, Fritz Lang turned to a fanciful parable to present the problems that threatened future capitalist-worker relationships in a totally industrialized world; with this film, the last vestiges of expressionism disappeared. No parallel development became apparent in Germany after World War II.

*Great Britain.*—In the period between the two world wars the outstanding craftsmen and actors of British motion pictures, like the creative spirits of the German cinema, found themselves in Hollywood. Whether for this or some other reason, England, after the brilliant promise of its earliest beginnings, offered nothing new till the 1930s. Nor did this contribution come from the established studios; it came instead from a group of men who wished, in the interest of economic and social development, to show Britain to herself and to the world. They turned the camera on men at work, with something of the poet's eye of Flaherty but mostly with a propaganda purpose, using to this end the ostensibly so-called objective eye of the camera of Ziga Vertov. Out of this came the name documentary film, which was fought over endlessly. These discussions at least made it generally clearer that the camera is particularly suited to find drama in reality. Its effects and influence likewise were felt in the commercial cinema, and comedy blossomed for a splendid moment in the realistic settings and situations at the Ealing studios. This feeling for reality, bolstered on all sides, reemerged in England in the late 1950s in what was called free cinema.

*Russia.*—The Soviet cinema, once a world of masterpieces, seemed to die of too much control both from within and without. Montage could be and has been made to say anything. Thus, the sterilizing hand of authority, allocating art to the realm of ideology as a weapon of the class struggle and of itself without any value, killed the promise of Russian film genius, even making it reverse itself and reaffirm the kinship of cinema and theatre. Socialist realism made the masses the arbiters of elegance, thus subjecting the cinema to the same fate as the arbitrament of the box office of the commercial cinema of the free world. The cinema in the remaining "iron curtain" countries apparently developed somewhat more freely.

*Italy.*—In contrast with the cinema in Germany, much was heard of the Italian cinema after the passing of its dictator. Its neorealism was in a measure a revolt against the regime of Mussolini, who was obsessed with the desire to make elaborate historical reconstructions that showed a parallel between his reign and the splendour of ancient Rome. Historical reconstruction was nothing new in the Italian cinema. The Italians have always had a powerful and justifiable sense of their past. Their early films set the fashion for the spectacular with the first *Quo Vadis?* and the elaborate *Cabiria*, the latter with subtitles by Gabriele d'Annunzio. The end of fascism brought a sense of the realities of the situation and a desire to express them, in *Open City, The Bicycle Thief* and in other works of Roberto Rossellini, V. de Sica, Cesare Zavattini, Federico Fellini, Michelangelo Antonioni and others.

**6. Neorealism and the Truth.**—Neorealism stirred up a general realization of its widespread ancestry and of the presence of its essential qualities wherever true cinema has flourished. Sharp eyes outside the film world had examined the motion picture and noted an affinity for reality. Henri Bergson said of it that it should be an invaluable record of our times. Thomas Mann failed to see it as an art but nevertheless saw it as narrative "in its nature epic." It was, he thought, "too genuine to be theatre." Tolstoi insisted that "it is necessary for the cinematograph to record Russian reality in all its many-sided developments. Russian life must be shown as it is, instead of continuing to chase after fabricated subjects."

Subsequent developments, notably the "New Wave" in France, the films of Antonioni and later of Fellini in Italy, and of the Spaniard Luis Buñuel, filming mostly in Mexico, confirmed the wisdom of waiting for theories of art to follow the practice of the artist. Wherever their influence is felt, whether in the Greek films of Michael Cacoyannis or in the developing cinema of South America, there is evidence of the capacity of the motion picture to transcend sensible reality and discover images expressive of that unstable composite of ambiguities and conflicts in action, the human person.

Japan, in the cinema it sends abroad, has seemed, through its history, to be presenting the inner reality of its national soul to the

world in exquisitely coloured compositions. In them there is especially to be found that most cine-dramatic quality that attaches to the manners of everyday life derived from age-old tradition, and it is revealed in certain bodily attitudes and expression of the face, a fact early realized by the Brighton school. It is to be found, too, in a surviving symbolism that, it is hoped, will never be destroyed where it still exists, although it has been destroyed in the industrialized west. It is this same quality that is caught in some works exported from India, notably the *Pather Panchali* of Satyajit Ray, in which the ceremonial, the communication by gesture and the daily practice of ritual of Bengali life seemed made for the cinema.

Such things are in a measure pantomime, that rich contribution of early comedy to cinema; its first master was Max Linder. It reached perfection in Chaplin, whose contribution to the motion picture was above all himself. Comedy dominated even the first little episodes from daily life filmed by the Lumière brothers. In all its physical manifestations comedy seems made for the camera. It is a conflict with the facts of life and nature; almost all comedy of the silent films was an application of this principle, after the different fashions of Buster Keaton, Harold Lloyd, Laurel and Hardy, and others. Sound brought verbal comedy. Dialogue meant character, and character individualizes. This was the change it wrought, even in Chaplin. Slow to accept the cinema, he was even slower to accept sound and only gradually developed from the impersonal but universal little man of *The Gold Rush* to the individual of *Limelight*.

The relationship to things that is so much a part of comedy is also, due to the close-up and to editing, an integral part of all cinema. Thus the dramatic object is as cinematically valuable as the actor. Yet, on the other hand, what dramatized object can equal the dynamic exuberance of a Douglas Fairbanks, Sr.? Which is the more cinematic? The answer, with any finality, is not yet forthcoming. An attempt has been made here to do no more than show where true cinema has always been found and where it is increasingly being sought. It will certainly not be found by anyone who has no taste for the truth. Truth in cinema, as elsewhere, is nevertheless not without powerful enemies. However, a glance at the titles of the peak days of the 1930s does show a praiseworthy attempt by Hollywood to treat subjects reflecting the violence and social problems left over from prohibition, along with a certain awareness of the threat to democracy posed by the dictators. But the post-World War II period brought crises, among them television, that set the fight for survival above all other considerations. The original story on which the hopes for the development of the cinema might be built is of necessity ruled out in favour of the insurance guaranteed by an already successful Broadway play or best-selling book. In a situation where the very survival of the industry is at stake, it would seem almost irrelevant, if not hopeless, to be concerned with the art of the motion picture. The showman is always convinced of one thing: that he knows what the public wants. Since there is no hope of convincing him that he does not, the only alternative is to set the artist up, modestly, in business and to find some form of audience for him. In either event, the aim of the cinema will always be, as Griffith said, "to make you see." Thus we are back again with the individual artist and his vision. Without it he has nothing to show, and we have nothing to see. (H. J. Gr.)

## III. FILM PRODUCTION

By far the greater majority of full-length films are fiction films. The fiction film is created from a screenplay, and all the resources and techniques of the cinema are directed toward the successful realization on the screen of the screenplay. Any treatment of motion-picture production will naturally and logically begin, therefore, with a discussion of the screenplay.

**1. The Screenplay.**—The screenplay, which is sometimes known, also, as the scenario or film script, resembles the blueprint of the architect. It is the verbal design of the finished film. In studios where films are made in great numbers, and under industrial conditions, the writer prepares the screenplay under the supervision of a producer, who represents the budgetary and box-office concerns of the front office, and who may be responsible for several scripts simultaneously. Under ideal conditions, the screenplay is prepared by the writer in collaboration with the director. This practice, long the custom in Europe, has become more common in the United States with the increase of independent production. Indeed, not infrequently, the writer may also be the director.

In its progress toward completion, the screenplay normally passes through certain stages; these stages have been established over the years and depend on the working habits of those engaged in writing it. The practice of these years has come to establish three main stages: (1) the outline; (2) the treatment; (3) the screenplay. The outline, as the term implies, gives the essence of the action or story and may present either an original idea or, more usually, one derived from a successful stage play or novel. The outline is then built up into the treatment. This is a prose narrative, written in the present tense, in greater or less detail, that reads like a description of what will finally appear on the screen. This treatment is broken down into screenplay form, which, like its stage counterpart, sets out the dialogue, describes the movements and reactions of the actors and at the same time gives the breakdown of the individual scenes, with some indication of the role, in each scene, of the camera and the sound. It likewise serves as a guide to the various technical departments: to the art department for the sets, to the casting department for the actors, to the costume department, to makeup, to the music department, and so on.

The writer, who should be as skilled in the dialogue of images as of words, must have the capacity to anticipate, visually and in detail, the finished film. The detailed screenplay, prepared ahead, not only saves time and money in production but also enables the director to hold securely to the unity of form and to the cinematic structure of the action, while leaving him free to work intimately and concentratedly with the actors.

Unlike the screenplays of today, the first scripts had no dramatic form, being merely lists of proposed scenes, and their content when filmed was strung together in the order listed. Anything that called for further explanation was covered in a title.

Step by step, as the form and scope of the film developed, the screenplay grew more and more detailed. The pioneer of these detailed screenplays was Thomas Ince, whose remarkable capacity for visualizing the finally edited film made a detailed script possible. In contrast were the talents of D. W. Griffith, who contributed more than almost any other single individual to the establishment of the technique of film making, and who never used a script.

By the early 1920s, the writer was meticulously indicating every shot, whereas today, when the scenarist writes less in images and gives more attention to dialogue, leaving the choice of images to the director, the tendency is to confine the script to the master scenes, so called because they are key scenes, covering whole sections of the action, as distinct from individual camera shots. This practice also follows on the increasingly common use of the novelist to adapt his own books; he is likely to be unfamiliar with the process of detailed dramatic and cinematic development. The dramatist, on the other hand, called on to adapt his play, is usually found to be more naturally disposed to do the work effectively. However, the scenarist is faced with a more difficult task than the dramatist. While the latter is, indeed, called upon to sustain the interest of an audience for three acts, these acts are broken up by intervals during which the audience can relax. The screen writer is faced with the task of holding the attention of the audience for an uninterrupted two hours or longer. He must so grip their attention that they will stay on, held from scene to scene, till the climax is reached. Thus it is that, because screen writing must build the action continuously, the stage dramatist, used to the building of successive climaxes, will tend to make a better film scenarist.

Sequences must never peter out but must carry the action forward, much as the car of a ratchet railway is carried forward, cog by cog. This is not to say that film is either theatre or novel. Its nearest parallel is the short story, which is as a rule concerned to sustain one idea and ends when the action has reached

the highest point of the dramatic curve. A novel may be read at intervals and with interruptions; a play has breaks between the acts; but the short story is rarely put down and in this it resembles the film, which makes a unique demand for uninterrupted attention upon its audience. This unique demand explains the need for a steady development of a plot and the creation of gripping situations arising out of the plot, all of which must be presented, above all, with visual skill. The alternative is interminable dialogue, which must inevitably send a cinema audience to sleep. The most powerful means of gripping attention is suspense. It can be either the suspense inherent in a situation or the suspense that has the audience asking, "What will happen next?" It is indeed vital that they should ask themselves this question. Suspense is created by the process of giving the audience information that the character in the scene does not have. In *The Wages of Fear,* for example, the audience knew that the truck being driven over dangerous ground contained dynamite. This moved the question from, "What will happen next?" to, "Will it happen next?" What happens next is a question concerned with the behaviour of characters in given circumstances.

In the theatre, the performance of the actor carries the audience along. Thus dialogue and ideas suffice. This is not so in the motion picture. The broad structural elements of the story on the screen must be cloaked in atmosphere and character and, finally, in dialogue. If it is strong enough, the basic structure, with its inherent developments, will suffice to take care of the emotions of the audience, provided the element represented by the question "What happens next?" is present. Often a successful play fails to make a successful film because this element is missing.

It is a temptation in adapting stage plays for the screen writer to use the wider resources of the cinema, that is to say, to go outside, to follow the actor offstage. On Broadway, the action of the play may take place in one room. The scenarist, however, feels free to open up the set, to go outside more often than not. This is wrong. It is better to stay with the play. The action was structurally related by the playwright to three walls and the proscenium arch. It may well be, for example, that much of his drama depends on the question, "Who is at the door?" This effect is ruined if the camera goes outside the room. It dissipates the dramatic tension. The departure from the more or less straightforward photographing of plays came with the growth of techniques proper to film, and the most significant of these occurred when Griffith took the camera and moved it in from its position at the proscenium arch, where Georges Méliès had placed it, to a close-up of the actor. The next step came when, improving on the earlier attempts of Edwin S. Porter and others, Griffith began to set the strips of film together in a sequence and rhythm that came to be known as montage; it took the action outside the confines of time and space, even as they apply to the theatre.

The stage play provides the screen writer with a certain basic dramatic structure that may call, in adaptation, for little more than the dividing up of its scenes into a number of shorter scenes. The novel, on the other hand, is not structurally dramatic in the sense in which the word is applied to stage or screen. Therefore, in adapting a novel that is entirely compounded of words, the screen writer must completely forget them and ask himself what the novel is about. All else—including characters and locale—is momentarily put aside. When this basic question has been answered, the writer starts to build up the story again.

The screen writer does not have the same leisure as the novelist to build up his characters. He must do this side by side with the unfolding of the first part of the narrative. However, by way of compensation, he has other resources not available to the novelist or the dramatist, in particular the use of things. This is one of the ingredients of true cinema. To put things together visually; to tell the story visually; to embody the action in the juxtaposition of images that have their own specific language and emotional impact—that is cinema. Thus, it is possible to be cinematic in the confined space of a telephone booth. The writer places a couple in the booth. Their hands, he reveals, are touching; their lips meet; the pressure of one against the other unhooks the receiver. Now the operator can hear what passes between them. A step forward in the unfolding of the drama has been taken. When the audience sees such things on the screen, it will derive from these images the equivalent of the words in the novel, or of the expositional dialogue of the stage. Thus the screen writer is no more limited by the booth than is the novelist. Hence it is wrong to suppose, as is all too commonly the case, that the strength of the motion picture lies in the fact that the camera can roam abroad, can go out of the room, for example, to show a taxi arriving. This is not necessarily an advantage and it can so easily be merely dull.

Things, then, are as important as actors to the writer. They can richly illustrate character. For example, a man may hold a knife in a very strange way. If the audience is looking for a murderer, it may conclude from this that this is the man they are after, misjudging an idiosyncrasy of his character. The skilled writer will know how to make effective use of such things. He will not fall into the uncinematic habit of relying too much on dialogue. This is what happened on the appearance of sound. Film makers went to the other extreme. They filmed stage plays straight. Some indeed there are who believe that the day the talking picture arrived the art of the motion picture, as applied to the fiction film, died and passed to other kinds of film.

The truth is that with the triumph of dialogue, the motion picture has been stabilized as theatre. The mobility of the camera does nothing to alter this fact. Even though the camera may move along the sidewalk, it is still theatre. The characters sit in taxis and talk. They sit in automobiles and make love, and talk continuously. One result of this is a loss of cinematic style. Another is the loss of fantasy. Dialogue was introduced because it is realistic. The consequence was a loss of the art of reproducing life entirely in pictures. Yet the compromise arrived at, although made in the cause of realism, is not really true to life. Therefore the skilled writer will separate the two elements. If it is to be a dialogue scene, then he will make it one. If it is not, then he will make it visual, and he will always rely more on the visual than on dialogue. Sometimes he will have to decide between the two; namely, if the scene is to end with a visual statement, or with a line of dialogue. Whatever the choice made at the actual staging of the action, it must be one to hold the audience.

**2. Direction.**—Film direction was born when for the first time a man held a motion-picture camera and turning it on his friend said, "Do something." This was the first step in creating movement for the camera. To create things that move for the camera is the aim at all times of the storytelling director.

Documentary direction is different. Its directors are primarily editors or, rather, discoverers. Their material is provided beforehand by God and man, noncinema man, man who is not doing things primarily for the camera. On the other hand, pure cinema has nothing in itself to do with actual movement. Show a man looking at something, say a baby. Then show him smiling. By placing these shots in sequence—man looking, object seen, reaction to object—the director characterizes the man as a kindly person. Retain shot one (the look) and shot three (the smile) and substitute for the baby a girl in a bathing costume, and the director has changed the characterization of the man.

It was with the introduction of these techniques that film direction departed from the theatre and began to come into its own. Still more is this the case when the juxtaposition of images involves a noticeable change, a striking variation in the size of the image, the effect of which is best illustrated by a parallel from music, namely in the sudden transition from a simple melody played on the piano to a sudden burst of music by the brass section of the orchestra.

The essence of good direction then is to be aware of all these possibilities and to use them to show what people are doing and thinking and, secondarily, what they are saying. Half the work of direction should be accomplished in the script, which then becomes not merely a statement of what is to be put before the camera but in addition a record of what the writer and director have already seen as completed on the screen in terms of fast-moving rhythm. This, because it is a motion picture that is visualized and not a play or novel—an adventure carried along by a central figure. In a play, the action is moved forward in words.

The film director moves his action forward with a camera—whether that action is set on a prairie or confined to a telephone booth. He always must be searching for some new way of making his statement, and above all he must make it with the greatest economy and in particular the greatest economy of cutting; that is to say, in the minimum of shots. Each shot must be as comprehensive a statement as possible, reserving cutting for dramatic purposes. The impact of the image is of the first importance in a medium that directs the concentration of the eye so that it cannot stray. In the theatre, the eye wanders, while the word commands. In the cinema, the audience is led wherever the director wishes. In this, the language of the camera resembles the language of the novel. Cinema audiences and readers of novels, while they remain in the theatre or continue to read, have no alternative but to accept what is set before them.

Then comes the question of how they are to see what they are shown. In a mood of relaxation? Not relaxed? It is how the director handles his images that creates the state of mind, of emotion, in the audience. That is to say, the impact of the image is directly on emotions. Sometimes the director goes quietly along in a mood of simple, normal photography, and the eye is pleased as it follows the story. Then suddenly the director wishes to hit hard. Now the pictorial presentation changes. There is a bursting impact of images, like a change in orchestration. Indeed, orchestration is perhaps the best simile for a film, even to the parallel of recurrent themes and rhythms. And the director is, as it were, the conductor.

Given the skill that permits a man to direct, skills shared in varying degrees, perhaps the most significant and individually important thing about a director is his style. This style is evidenced by both his choice of subject and his manner of directing it. Important directors are known for their style. The record speaks of Ernst Lubitsch as having a style characterized by cinematic wit, or the pictorial quip. Charlie Chaplin is spoken of as having a style, and it is interesting to notice that it was his incursion into dramatic direction in *A Woman of Paris* that seemed to crystallize this style.

On the whole, style was slower to manifest itself in U.S. pictures, always excepting the extravaganzas of C. B. deMille and the works of Griffith and Ince. In the early 1920s the Germans gave great evidence of style. Whether or not it was something imposed by the studios, or individual to the directors, it is clearly in evidence in the work of Fritz Lang, F. W. Murnau and many others. Some directors are more concerned with style and the treatment of the content than with securing new themes. This is to say that, for the director, as often as not, what is important is the manner of telling his tale. The more original will revolt against the traditional and the cliché. They will want to show contrast, to present melodrama in a revolutionary way, to take melodrama out of the dark night into the bright day, to show murder by a babbling brook, adding a touch of blood to its limpid waters. Thus the director can impose his ideas on nature and, taking what savours of the ordinary, can, in the way he handles it, render it extraordinary. So there emerges a kind of counterpoint and sudden upheaval in the ordinary things of life.

Motion pictures would be a source of much richer enjoyment, as is the case in other arts, if the audience were aware of what is and what is not well done. The mass audience has had no education in technique of cinema, as they frequently have in art and music, from their school days. They think only of story. The film goes by them too fast. The director, then, must be aware of this and must seek to remedy it. Without the audience being aware of what he is doing, he will use his technique to create an emotion in them. Suppose he is presenting a fight—the traditional fight in the barroom or elsewhere. If he puts the camera far enough back to take in the whole episode at once, the audience will follow at a distance, and objectively, but they will not so really feel it. If the director moves his camera in and shows the details of the fight—flaying hands, rocking heads, dancing feet, put together in a montage of quick cuts—the effect will be totally different and the spectator will be writhing in his seat, as he would be at a real boxing match.

Styles in direction can be individual; they can show trends or fashions. In recent times, the Italian directors have worked in the manner or style known as neorealism. They were concerned with the hardships of World War II as currently manifested in the life of the man in the street. There was a style, too, in German films in the silent days. More recent films from Germany show little new development. The French directors are well served by their cameramen and their art directors, who have great originality and a fine understanding of the cinematic. In the United States, there has been a movement in the direction of realism, but in the key areas of photography and settings the director is still forced to work in an atmosphere of artificiality. The plush architecture of Hollywood militates against a pure atmosphere and destroys realism. Only gradually is the situation changing, and it is not so long ago that the artist was shown to be starving in an attic as large and as luxurious as the living room of a wealthy house.

Sets, lighting, music and the rest are of immense importance to the director, but everything, as Ingmar Bergman has said, begins with the actor's face. It is to the features of this face that the eye of the spectator will be guided, and it is the organization of these oval shapes within the rectangle of the screen, for a purpose, that exercises the director. What figure is to be shown—and how? Near to—or at a distance? Often it is wiser for a director to save long shots for a dramatic purpose. He may need them, for example, to express loneliness, or to make some other verbal statement. Whatever his choice, the content of the pictorial frame must have an impact. This is the real meaning of the word dramatic. It signifies that which has emotional impact. So it may be said that the rectangle of the screen must be charged with emotion.

At all times the director must be aware of his intention. What is his purpose, and how can he effect it in the most economical way? Not only must he provide images that add up to a language; he must also know what it is that makes it a language.

The most apparent and, to the outsider, the main function of the director is the actual staging of the action of the film. From a director's point of view, this staging is best described as the mechanical process of setting up the action so that the actors can move in and bring their emotions to bear, not spontaneously, however, but under his strict supervision.

In the theatre, albeit after long and intensive rehearsal, the actor is finally free and on his own, so that he is able to respond to the live audience. In the studio, he responds to the director, who is staging the action not only piecemeal but, as often as not, out of sequence. The director controls every movement of the screen actor, working for the most part intimately and closely upon him.

The amount of action contained within a frame should convey neither more nor less than what the director wishes to convey. There must be nothing extraneous. The actor, therefore, cannot operate at will, spontaneously improvising. The restrictions that this imposes on the actions of the body are readily seen.

Certain special considerations apply to the face. In this regard, the chief requisite for a good screen actor is the capacity to do nothing—well. Furthermore, the director must bear in mind that the audience is not absolutely sure of the precise significance of the expression until it has seen what causes it. At the same time, this reaction must be made with the greatest measure of understatement.

In a world of images, in which both actors and things are alike capable of such significant statements, what is the role of dialogue? The answer is that the introduction of dialogue was an added touch of realism—the final touch. With dialogue, that last unreality of the silent film, the mouth that opens and says nothing audible disappeared. Thus, in pure cinema, dialogue is a complementary thing. In the films that for the most part occupy the screens of the world, this is not the case. As often as not, the story is told in dialogue, and the camera serves to illustrate it.

And so it is that the last infirmity of both writer and director, when invention fails, is to take refuge and perhaps relief in the thought that they can "cover it in dialogue," just as their silent predecessors "covered it with a title."

**3. Production Methods.**—*Sets and Art Direction.*—The staging of the action by the director draws on all the resources of the medium. Of first importance among these are the skill and knowledge of the art director who plans the sets, and the dresser who furnishes them.

Originally, film sets were neither so complete nor so elaborate as they are today. Usually, they were bits and pieces constructed for single scenes and always planned as part of the scene. The sets built today are usually large and complete. The result is that the proscenium arch of the theatre is virtually restored. The mere building of a room does not build it for the camera, and this should be the aim of all construction. The set is a kind of shorthand. It gives an impression of locale and as often as not by means of a stock shot: Washington is a view of the Capitol; New York, a skyscraper. To use an unfamiliar view would confuse the audience.

An art director must have a wide knowledge and understanding of architecture. On the other hand, he must be able to distinguish between what characterizes a type of dwelling and what individuates the inhabitant of that dwelling. The profession of a man may be characterized by what is on his walls. His untidiness, however, will be personal to him. Indeed, it is only the more imaginative aspects of art direction that require the art director to depart from the letter of his research. His basic information is not the answer to the actual requirements of a character or a scene. Increasing awareness of the capacity of the camera to show reality, to set the action in real streets under real trees, created the demand for reality even in interior sets. Therefore the woodwork and the lath and plaster of sets, no matter how manifestly artificial from behind, must face the camera with all the appearance of visible reality.

With the increasing cost of materials and labour, sets become a very serious budgetary consideration. Their construction calls upon the resources of machine shops, carpenter shops, plasterer shops, the paint shop, in short, upon all the resources needed for housebuilding, so that the audience may be given the reality it demands. One of the results of this has been the discovery, over the years, of an amazing variety of ways to circumvent this problem by the use of models of all kinds, of trick work and of various special effects, or trick shots, all of which are realistic substitutes for a reality beyond the resources, both financially and otherwise, of any studio.

The most intelligent place to be economical is at the script-writing stage, and the preparation of the script should be well advanced before any artwork is begun. The main factor to be borne in mind in art direction, as in other areas of film making, is the complete control that can be exercised not only over what the audience sees or does not see on the screen but even over the actual movements of the eye.

*Lighting.*—The lighting of the sets is the concern of the photographer and not, as is commonly supposed, the concern of the designer. Originally he was referred to as the cameraman. Today he is more commonly referred to as the lighting expert, the actual working of the camera being carried out by an operator under his supervision. In addition to supervising the work of the electricians and the camera operators, he functions by adding creatively to the mood and cinematic value of the scenes. The common impression that the sets are designed for lighting is incorrect. In theory, it should be possible to plan lighting ahead, at the set construction stage, but the actual lighting of a scene is a specific and particular operation demanding a fine, on-the-spot sense of light and shade and of composition.

*Camera.*—All uses of the camera, whether it be used straight on or at an angle, whether it be stationary or moving, must be directed to one and only one thing, namely to the dramatic impact of pictorial images that are to be cut together to reveal the progress of an action or story. The movements of the camera come under two main headings:

1. Movement in relation to the movement of the characters. Here the camera follows a character, dollying ahead or following in profile, because the character is walking. The ideal to be aimed at here is that the audience should never be aware of the camera moving. Thus there always must be complete co-ordination between the movement of the camera and the movement of the character. If the two movements are out of synchronization at any time, so that the camera is moving while the character is still, the effect is not obtained.

2. Dramatic movement, movement of the camera—that is, with the character in repose, and always for a dramatic purpose. For example, the camera may dolly up to the face of the character for emphasis, or dolly away at the end of a scene to reveal a lonely figure standing by himself in the centre of a room. So used, the camera may be said to make a statement. The film, like the novel, is the sum total of these statements.

*Sound.*—The principal adjustment that had to be made between the technique of talking pictures and that of the silent screen was in the respective roles of image and word. The written word, when brought to the moment of filming, may turn out to be redundant, the expression of the actor conveying the meaning with equal force.

Sound has many other uses, however. It can serve very effectively to denote the progress of the action. Or it may be used for a stream of consciousness over an unspeaking mouth. It is likewise of great help in expressing the mental processes of the characters. The screen shows the face of a girl. Over it comes the sound of a school bell, thus revealing that she is reminiscing. It is in its own way, then, an image maker and has been used as such from the first in a variety of ways.

*Music.*—Though it is entirely possible to see a silent film and become so engrossed in it as to be oblivious of the absence of sound or accompanying music, there have never been public showings of films without music. From the beginning there was at least the single piano, improvising; and later the orchestra, sometimes with specially composed scores. Sound has tended to increase the importance of music, and regularly over the years composers of the highest standing have written scores that, while serving to add a dimension of mood and atmosphere to the film, have also stood by themselves as compositions.

The presence of music, then, is perfectly in accordance with the aim of the motion picture, namely to unfold an action or to tell a story, and thereby stir the emotions.

*Colour.*—Colour, like sound, is to be used dramatically, when needed. Its values are never realistic and often are merely for embellishment or for decorative purposes. Thus, like the wide screen, its use belongs to the realm of showmanship. It can also serve an aesthetic purpose when the subject, whether the face of a woman or of a landscape, is enhanced by its use. It can likewise be used for spectacular or emotional purposes, as in battle scenes or in displays of pageantry or splendour, such as occur in historical or epic tales. Its range of uses is from the mood of décor to the clothes of a star. However, until such time as the realism of truly natural colour is achieved, the use of it is primarily as an embellishment.

*Wide Screen.*—The development or at least the use of the wide screen in public theatres really belongs, like colour, to the realm of showmanship. In its most common form, namely CinemaScope, it requires a rectangular screen. This shape, with a very low ratio of height to width, is now generally regarded as unsatisfactory, and some studios, by lopping off the ends of the screen, narrow down its excessive width.

*Editing.*—Editing, or, as it is sometimes called, montage, has been described as the foundation of the art of making films. Basically, it is the placing of the strips of film in the order and sequence deemed best to unfold the action or story. Initially, the strips of film were joined in a simple sequence. Even pioneers of the photo-drama, such as Georges Méliès, made no attempt to do more than follow the story quite simply, as seen from the point of view of a camera, the position of which was fixed and central. Other pioneers, in particular the Englishman G. A. Smith and his associates in the Brighton school of film making, and Edwin S. Porter, working in the U.S. for Edison, began to experiment with what were the rudiments of editing and montage. The Russian film makers, Eisenstein, Pudovkin and their contemporaries, in the late 1920s developed creative editing, or montage, as they called it, by way of the juxtaposition not just of sequences but also of individual

shots or frames, to illustrate character, to convey ideas or even to create motion by the juxtaposition of static objects.

Methods of editing vary according to the preferences of the director. In most cases, the material is assembled as the film is in progress, by an editor working from the screenplay. The director who plans the editing at the screenplay stage makes his decision as to the coverage of the scenes and characters at that stage and then shoots as planned.

Whatever method is used, it is used with the realization that everything in cinema is a visual statement and the images are its language. Film, therefore, like any language, has its own syntax, which, as the word implies, is a lining up or ordering of images to create the maximum effect.

*The Machinery of Film Making.*—Serving the film makers is the machinery of production, and in treating methods of film production it is necessary to distinguish between what is needed to bring one film and what is needed to bring a hundred films to the screen. In other words, it is necessary to distinguish between individual and mass production. A single production, planned by an independent film maker, carries with it no overhead costs and needs space only during the time of production. It can be made anywhere that there is space to be rented, and it employs only the personnel required for the project. Equipment is also hired, as are the services of the laboratories and printing establishments that are available in any production centre.

The independent producer, then, whose increasing emergence in the decade following World War II was a significant feature of the changes that have continued to overtake film production, notably in Hollywood, is, in theory, much freer to concern himself with the quality of his film. The 20 years between World Wars I and II saw Hollywood studios at the height of their productivity, under executives like Marcus Loew, Carl Laemmle, Adolph Zukor, Jesse Lasky, Louis B. Mayer, Joseph Schenck, Samuel Goldwyn, the Warner brothers (Harry M., Samuel L., Albert and Jack L.) and others who brought their organizing ability, developed in other fields, to bear on the making of motion pictures. They took over the entertainment of the people and put melodrama, comedy and musical plays on an industrial footing. They put large sums into the improvement of techniques and encouraged the development of new devices for camera, sound, editing, the recording of music, and three-dimensional and wide screen; all were calculated to give glamour to the film on the screen, to attract back a wavering audience by the novelties and the devices of showmanship.

A basic method of production has survived from those days and begins with sending the script to the production department. There it is broken down into its physical requirements. These are estimated and a budget drawn up.

After the script is approved and the budget passed, copies are sent to all departments for each to prepare its contribution to the production against the day set for shooting, according to the schedule drawn up by the unit manager.

The organization of film making in the United States still centres for the most part around a producer. This arrangement originated in the need to co-ordinate the mass production of films; at one time the whole responsibility was so much in the hands of the producer, and so little in the hands of the director, that the latter would be handed a script that was complete, with a cast already chosen. At one time, indeed, the production method was for the producer himself to put the film together after the director had completed the shooting. This system has now virtually died out, and the independent producer is as often as not his own director, or perhaps his own star, since the actor-producer has become a commonplace, along with the producer-director and the writer-producer-director.

**4. Economic Considerations.**—While the changes in methods and circumstances of production have resulted, in part, from a desire among writers and directors for greater artistic freedom, they have received their two greatest impulses from the economic situation: (1) increases in income tax, which cripples the salaried film maker; and (2) the economic decline of motion pictures, beginning a few years after World War II and caused by rivalry from television, combined with a general falling off in the entertainment quality of the films. Indeed, in 1957 Hollywood was described in a report prepared for the American Federation of Labor Film council as being at the crossroads. In the ten years between 1946 and 1956, the attendance at theatres in the U.S. fell off 50% at a time when the national economy was strong and growing stronger. The number of U.S. features released in the American market declined by 28%, while the number of imported features increased by 233%. Then, in 1948, by a decree of the supreme court of the U.S., the major studios, whose security had been based on their producer-to-consumer organization, were ordered to dispose of their theatres as a result of complaints by independent theatre owners.

The situation deteriorated more or less steadily up to 1958. Then in 1959, the tide seemed to turn as a result of a general reorganization and a new policy mapped by executives from New York. Fewer pictures were made, but those made were produced on larger budgets and were given longer runs. There were sales of old motion pictures to television, and the renting of studio space both to television companies and to independent film producers. The returns of the major companies all showed a profit, and the theatres showed a healthy rise in attendance.

**5. Theatre Management and Promotion.**—The changing conditions of the cinema have called for changes in the running of the theatres and the promotion of films. Prior to the coming of sound, there had to be a certain amount of personal and individual effort in the presenting of films in the theatres.

Then, suddenly, everything arrived in cans—picture, music and sound. All that was needed now was to set up the projection system. With that, something living went out of theatre management and presentation. The effect of this was not apparent during the 1930s and 1940s. Only gradually, in the late 1950s, was it realized that with fewer films being made the exhibitor must give special attention to each film. With the so-called rehousing of the big, expensive productions, on a twice-a-day showing booked in advance, the tide began to turn. Films began again to be presented importantly, with big advertising campaigns and a new element—the personal appearance of stars and directors—to give a flesh-and-blood contact back to audiences.

With the continued development of these methods, a phrase that epitomizes the old approach to cinema going will fittingly disappear from the language, namely, "This is where we came in."

Television helped in changing the approach to film making and film presentation by taking away the audience for what is called the "grind policy"; *i.e.*, the continuous performance with a double feature program, changed twice weekly.

There is evidence of other changes, too. There is a tendency to decentralize production, and Hollywood is said to be located round the world. There are several reasons for this, in spite of the fact that, technically speaking, production is still easier and better in Hollywood. The need for special location, for example, is clear enough. Again, if the script calls for a number of supporting actors for a foreign story, then it is an advantage to go to the country in which the story is set.

A further, and comparatively recent, development has been the drive-in theatre. This exists as a matter of social convenience. Young couples can see a film and yet enjoy a sense of being alone. Families unable to get a baby-sitter, or to afford a sitter as well as a film, can take their children with them and put them to sleep in the car. The drive-in also gives a feeling of being a place; less than the theatre, but more than television at home. It thus satisfies the urge to go out—a deep-seated urge, which will prevent television from being a final threat to the picture theatre.

(A. J. Hi.)

## IV. EXHIBITION AND DISTRIBUTION

**1. Early History.**—On April 14, 1894, Thomas Edison's newest invention, the Kinetoscope, was first shown to the public at a phonograph parlour located at 1155 Broadway in New York city. A viewer dropped a coin in a slot and glued his eye to a small peephole. He could see such animated objects as two men boxing, a girl dancing or a baby being bathed. Despite the primitive nature and quality of these earliest subjects, they created a

sensation, and the Kinetoscope almost immediately became the major attraction in the penny arcades of the larger U.S. cities. The front doors and windows of vacant stores were removed so as to afford greater visibility and easier access. Blaring music boxes, garish posters and leather-lunged barkers called the attention of passersby to the extraordinary attractions on display. Thus at the outset of its career the picture industry identified itself with the circus tradition of superlative and sensational advertising to which it has since consistently adhered.

Since only one person could look at a peep show at a time, ambitious arcade proprietors realized that profits would be substantially increased if the Kinetoscope could be combined with a magic lantern so that pictures might be projected on a large screen. Thomas Armat discovered the basic principle of the modern projector with its intermittent movement, and Edison consented to sell it under the name of the Edison Vitascope. Its world *première* on April 23, 1896, at Koster and Bial's music hall in New York city constitutes a landmark in the history of motion-picture exhibition. (The theatre was located at 34th street and Herald square on a site now occupied by Macy's department store.) When the waves were first seen dashing against Dover on the British coast, patrons in the front rows instinctively ducked, exactly as they reacted 56 years later to the first showing by Cinerama of the Coney Island roller coaster. The pictures exhibited, according to the *New York Times*, "were wonderfully real and singularly exhilarating," and the Edison organization and a few imitators were promptly inundated with orders from vaudeville theatres in all parts of the United States.

The use of movies as an adjunct to vaudeville was greatly accelerated by the actors' strike of 1900. In order to keep their theatres open, many vaudeville managers presented programs consisting solely of Vitascope subjects. To their surprise these shows were well attended. In this fashion the early "living pictures" became known to theatre audiences in all important U.S. cities long before they became equally well established in England or on the European continent.

The heads of vaudeville, however, lacked the imagination to grasp the vast potentialities inherent in the new device. As soon as the strike was over, they relegated the Vitascope to the humble position of a "chaser" designed to empty the theatre for the next performance. The active exploitation of the medium fell to the penny arcade proprietors, many of them drifters from carnivals, county fairs and medicine shows whose sole interest was in making a "quick buck" out of what they, like Edison, regarded as a passing fad. A few enterprising young men, largely from New York's lower east side, rather than leaders in the world of commerce, arts or entertainment, first recognized the possible impact of moving pictures on the American scene and had the courage to stake their future on that vision. Such men as Adolph Zukor, Marcus Loew and William Fox relinquished hard-won footholds in the fur and garment business and through their energy, business acumen and instinctive showmanship became the leaders of the new industry in its unprecedentedly rapid expansion.

They and their competitors purchased projection machines discarded by vaudeville theatres, partitioned off the rear of their arcades, equipped them with 50 to 200 chairs (frequently borrowed from a neighbouring undertaker), hung a rudimentary screen on the wall and pasted enough film together to provide a show lasting from 15 to 30 minutes. The low admission price of ten cents threatened at first to prove a boomerang. The public, conditioned by P. T. Barnum and other circus proprietors to exaggerated ballyhoo, was skeptical as to what, if anything, it would see for a dime in a dark rear room. To set their minds at rest, Thomas Tally, a former cowboy who had promptly sold his horse when he saw his first motion picture, cut a hole through the partition in his Los Angeles arcade so that prospective customers could catch a brief but intriguing glimpse of animated figures on an illuminated screen. This practice was widely copied by other exhibitors, and in a short time public comment was so favourable that the manufacturers of film and equipment could not keep pace with the demand for their products.

**2. The New Audience.**—Up to the advent of motion pictures only 10% to 20% of the U.S. public, at best, had any firsthand acquaintance with theatrical entertainment. The price of admission for the spoken drama or musical comedies, even for burlesque, vaudeville and ministrel shows, put them beyond the reach of the working classes. Many in the middle income brackets who occasionally could have attended were restrained by the disapproval of some religious denominations, the scarcity of road attractions and the unwillingness of producers to cater to what they regarded as the low taste of the masses. The ten-cent theatre, located in the congested city areas, tapped a vast new audience, itself only dimly aware of its hunger for dramatic entertainment. The low admission price and the even lower demand on literacy made these first motion pictures particularly appropriate for children and for the immigrants who were pouring into the United States in the early 1900s. The captions, as subtitles were then called, proved an ideal way of learning English. Respectable citizens and sophisticates looked down their noses at the "movies," as motion pictures came to be called in the United States, but the common people loved and patronized them from the outset.

The subjects most appealing to this audience were humble people like themselves—workingmen, housewives, farmers, the poor and the inconsequential. The primitive action scenes of the peep shows were replaced by short skits, with themes indicating the proletarian sympathies and the theatrical naïveté of the onlookers. What could be better entertainment than comic cops unsuccessfully chasing a tramp or the unexpected arrival of a wife in her philandering husband's office just as he is about to kiss his secretary?

Moreover, with the rapid improvement in picture making and exhibiting techniques, it was soon possible to promptly display current news events, such as President McKinley's inauguration and the Spanish-American War. The early pictures, in spite of their crudities, reflected the interests and activities of their patrons and helped mold their opinions and their way of life.

So great was their appeal that in 1902 Thomas Tally once again led the procession by discarding all other forms of amusement in his arcade and transforming the entire store into a theatre auditorium. Other exhibitors followed his example, but the transition on a national scale to exclusive movie houses did not occur until 1905, when John P. Harris and Harry Davis remodeled a storeroom in McKeesport, Pa., recessed the front, purchased a Lumière Cinématographe and equipped the auditorium with 92 seats and a piano so that musical accompaniments to the screen attractions could be played. They opened with Edwin S. Porter's *The Great Train Robbery*, which, although it was not, as frequently claimed, the first U.S. narrative picture, was certainly the first to clearly establish the storytelling capacity of the cinema. A continuous show ran from 8 A.M. until midnight, and to publicize the fact that the price was only five cents the theatre was called a nickelodeon.

The catchy name, the low admission price and the popularity of the opening feature proved so compelling that within four years there were at least 8,000 nickelodeons in the U.S. Eager entrepreneurs from all walks of life, with little or no experience or capital, remodeled empty stores by equipping them with sidewalk box offices, small lobbies and flamboyant advertising displays. Very often the nickelodeons were family businesses, with fathers running and repairing the projector, mothers and daughters taking tickets and sons ushering the patrons and trying to maintain a reasonable degree of order. Popcorn, peanuts and candy were hawked up and down the aisles, and music publishers furnished song pluggers to sing popular tunes in which the audience was urged to join. There were illuminated slides reading, "You Would Not Spit On The Floor At Home. Do Not Do It Here"; or, "Ladies, We Like Your Hats, But Please Remove Them." There were as yet no carpeted floors, upholstered chairs, symphonic orchestras or uniformed ushers, but the prototype of the modern motion-picture theatre was now established.

**3. Difficult Days.**—Further development was impeded, although never brought to a standstill, by forces both without and within the industry. Such opposites as saloons and churches found their attendance reduced by the competition of the nickelo-

An early (1887) series of photographs by Eadweard Muybridge, an English pioneer in motion photography

Fred Ott, who worked in Thomas A. Edison's laboratory, is shown in *Edison Kinetoscopic Record of a Sneeze, January 7, 1894*, the first motion picture copyrighted in the U.S.

May Irwin and John Rice in *The Kiss* (1896), a filmed scene from a current play, *The Widow Jones*. This short film scandalized audiences and produced the first demands for screen censorship

## 19TH-CENTURY MOTION PICTURES

*Lunch Hour at the Lumière Factory*, the first film shown in France (1895) and England (1896), showed workers leaving the Lumière factory at noon

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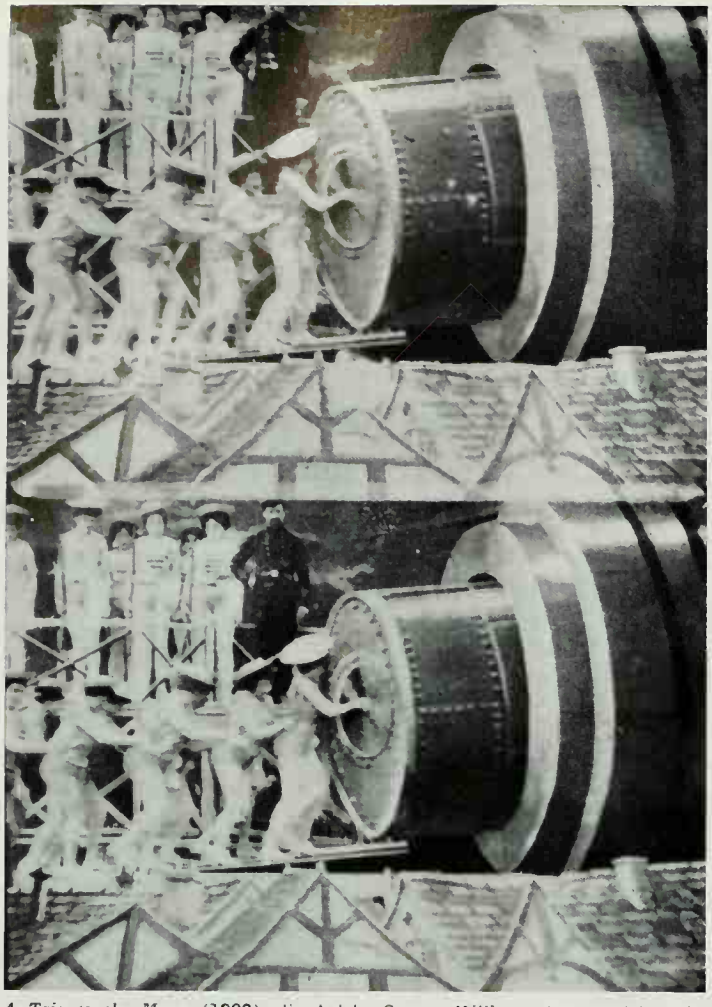
# MOTION PICTURES



*A Trip to the Moon* (1902), directed by Georges Méliès, a stage magician who made elaborate and imaginative screen fantasies

George Barnes in *The Great Train Robbery* (1903), directed by Edwin S. Porter, one of the earliest U.S. attempts to tell a story on film

## EARLY 20TH-CENTURY FILMS

Méliès' *Illusions* (1909), like most of the earliest films, was primarily a stage production performed before a stationary camera

Sarah Bernhardt in the French *Queen Elizabeth* (1912), the first feature-length film shown in the U.S.

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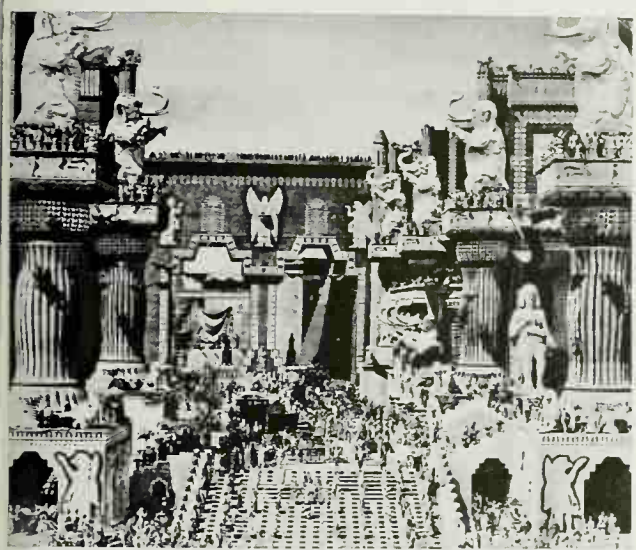
*Birth of a Nation* (1915), directed by David Wark Griffith, established motion pictures both as entertainment and as art. Griffith's camera work and technical innovations freed films from the narrow confines of the stage



D. W. Griffith's *Intolerance* (1916), an opulent and ambitious historical film. The vast set for the temple of Babylon sequence shows the breadth of Griffith's vision

*Quo Vadis?* (1912), an early Italian epic and the longest film of its time, running almost two hours

*The Cabinet of Dr. Caligari* (1919), a German film noted for its odd camera angles and bizarre sets, was the first horror film and the first to win serious critical acclaim

## DISTINGUISHED SILENT FILMS

Charles Chaplin, perhaps the best-known comedian in screen history, as the little tramp in *Sunnyside* (1919)

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# MOTION PICTURES

## EISENSTEIN AND THE MONTAGE

*Potemkin* (1925) by Sergei Eisenstein deals with a mutiny aboard the Russian cruiser "Potemkin" during an abortive antitsarist uprising in 1905. The above series of stills illustrates the montage technique that Eisenstein made famous. By juxtaposing hundreds of shots the director heightened the sense of outrage he wanted the audience to feel. The camera shows: (1) the crowd in Odessa assembled on the harbour steps to cheer the "Potemkin" anchored offshore; (2) the Cossack regulars firing into the helpless crowd; (3) the carnage after the first volley; (4) the shock and fury of a student onlooker; (5) the relentless advance of the Cossacks; (6) the defiant anguish of a mother holding her slaughtered child

BY COURTESY OF THE MUSEUM OF MODERN ART FILM LIBRARY

Zasu Pitts in *Greed* (1924), directed by Erich von Stroheim

*Variety* (1926), directed by E. A. Dupont and photographed by Karl Freund, was a pattern-setting and highly popular tour de force of German film technique

## OTHER NOTABLE SILENT FILMS

*The Andalusian Dog* (1929), a Surrealist film by Salvador Dali and Luis Buñuel

Carl Dreyer's *Passion of Joan of Arc* (1929), emphasized the close-up for dramatic effect

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# MOTION PICTURES

William S. Hart in *The Aryan* (1916), directed by Thomas H. Ince, one of the first of a series of taut, unsentimental films about the U.S. west

Mack Sennett's Keystone Cops. The Sennett studio produced hundreds of fast-paced and hilarious films, developed scores of fine comedians and actresses

## EARLY SCREEN FAVOURITES

Rudolph Valentino, the first and most fervently acclaimed screen lover, in *The Four Horsemen of the Apocalypse* (1921)

Theda Bara, the first screen vamp, as *Cleopatra* (1917)

BY COURTESY OF (BOTTOM LEFT) METRO-GOLDWYN-MAYER PICTURE CORPORATION, (OTHERS) THE MUSEUM OF MODERN ART FILM LIBRARY AND (BOTTOM RIGHT) 20TH-CENTURY FOX FILM CORP.

Al Jolson in one of the song sequences from *The Jazz Singer* (1927), the first feature-length film to employ synchronized sound

## MOTION PICTURES LEARN TO TALK

Greta Garbo (shown here in an early Swedish film) was one of the few silent stars who successfully made the transition to sound

*Blackmail* (1931), the first British talking film, was directed by Alfred Hitchcock, master of suspense and camera technique

*A Nous la Liberté* (1931), a French film by René Clair, used controlled, selected sound to heighten the director's satiric intent. Many early films used sound merely for its novelty

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# MOTION PICTURES

Edward G. Robinson (centre, with revolver) in *Little Caesar* (1930), one of the first gangster films

Massed chorus from *Broadway Melody of 1936*, one of a succession of elaborate, frothy musical comedies popular during the Great Depression

## SOME FILMS OF THE 1930S

Peter Lorre in Fritz Lang's *M* (1931), a German film about a psychopath

W. C. Fields as Mr. Micawber and Freddie Bartholomew as *David Copperfield* (1935)

Charles Chaplin in *Modern Times* (1936), a sophisticated satire on industrialism

BY COURTESY OF (BOTTOM LEFT, TOP RIGHT) METRO GOLDWYN MAYER INC., (OTHERS) THE MUSEUM OF MODERN ART FILM LIBRARY AND (TOP LEFT) WARNER BROTHERS PICTURE CORP., (BOTTOM RIGHT) UNITED ARTISTS PICTURE CORP.

*Rashomon* (1951), a complex Japanese film directed by Akira Kurosawa, combined oriental dramatic conventions with Western film technique

Satyajit Ray's *Pather Panchali* (1955), the first part of a trilogy on Indian life

## FILMS FROM EUROPE AND ASIA

*Orpheus* (1950), a bizarre film, partially autobiographical, by the French poet Jean Cocteau

*La Strada* (1954), directed by Federico Fellini, blended neorealism and poetry

*The Seventh Seal* (1956), a Swedish film by Ingmar Bergman, dealt with the great moral questions that have long fascinated and inspired Scandinavian directors

BY COURTESY OF THE MUSEUM OF MODERN ART FILM LIBRARY AND, (TOP LEFT) DAIEI MOTION PICTURE CO., (TOP RIGHT) EDWARD HARRISON, (CENTRE LEFT) BRANDON FILMS, INC., (CENTRE RIGHT) LES FILMS DU CENTAURE, (BOTTOM) JANUS FILMS, INC.

# MOTION PICTURES

Gary Cooper in Stanley Kramer's classic western, *High Noon* (1952)

## SOME DISTINGUISHED U.S. AND BRITISH FILMS OF THE 1950S

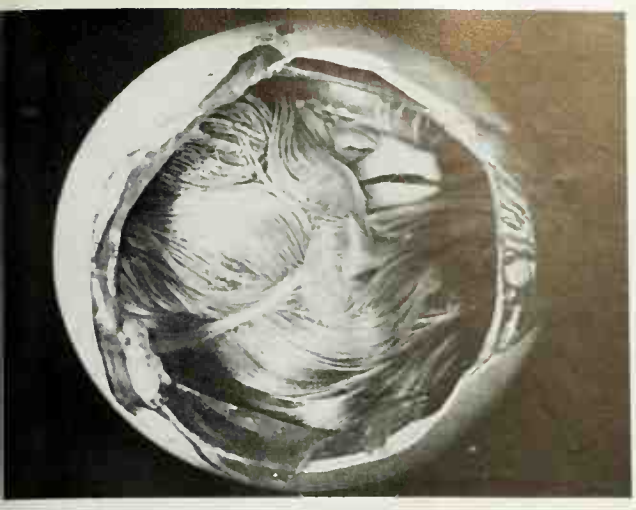
Laurence Olivier in title role of *Richard III* (1956), one of a series of brilliant Shakespearean characterizations by the British actor

Marlon Brando (left) and Lee J. Cobb in *On the Waterfront* (1954), a realistic story of violence on the New York docks, directed by Elia Kazan

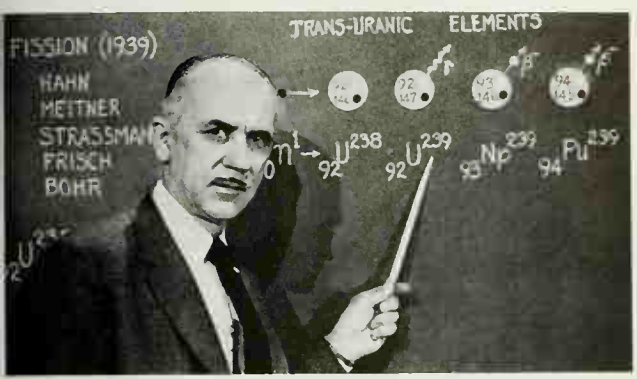
Alec Guinness (left) as the intrepid naval officer in *Kind Hearts and Coronets* (1950), one of several roles he played in this macabre British comedy

Humphrey Bogart and Katharine Hepburn in *The African Queen* (1951), directed by John Huston

BY COURTESY OF THE MUSEUM OF MODERN ART FILM LIBRARY AND (TOP LEFT, BOTTOM LEFT, BOTTOM RIGHT) UNITED ARTISTS FILM CORP., (TOP RIGHT) COLUMBIA PICTURE CORP., (CENTRE RIGHT) EALING FILMS LTD.



Unhatched chick inside its shell; from *Secrets of Nature* (1926), an early British series of educational films




Dr. Harvey E. White lectures in *The Introductory Physics Series* of 162 half-hour films designed to supplement daily high-school lessons and enrich classroom teaching. Series made by Encyclopædia Britannica Films

*Indonesia—New Nation of Asia* (1959), made by Encyclopædia Britannica Films for use in social studies classrooms

## EDUCATIONAL AND WAR-TIME PROPAGANDA FILMS

*Triumph of the Will* (1936), an official film of the Nazi propaganda ministry, directed by Leni Riefenstahl, chronicled the first Nazi party congress at Nurnberg by way of eulogizing Adolf Hitler

*Desert Victory* (1944), showed allied campaigns in north Africa during World War II; made by film units of the British army and the Royal Air Force

BY COURTESY OF (TOP LEFT) THE BRITISH FILM INSTITUTE, (TOP RIGHT, CENTRE LEFT) ENCYCLOPÆDIA BRITANNICA FILMS, (BOTTOM LEFT, BOTTOM RIGHT) THE MUSEUM OF MODERN ART FILM LIBRARY AND 20TH-CENTURY FOX FILM CORP.

# MOTION PICTURES

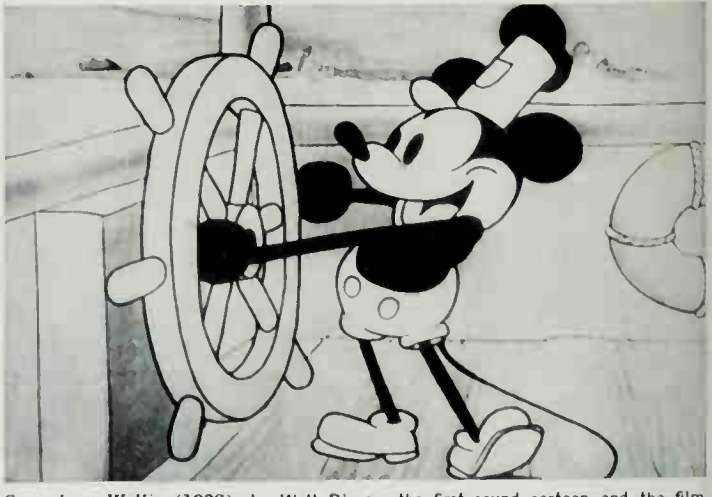
*Drifters* (1929), a documentary made by the British Film Board and directed by John Grierson, told the story of British herring fishermen in the North sea

Robert J. Flaherty's *Nanook of the North* (1922) showed the rugged life of the Eskimo and set the form for the documentary film

*The Plow That Broke the Plains* (1936), directed by Pare Lorentz and made for the U.S. Resettlement administration, chronicled the neglect that led to human misery in the Dust bowl during the 1930s

## DOCUMENTARY FILMS AND THE BEGINNINGS OF ANIMATED CARTOONS

*Gertie the Dinosaur*, animated by Winsor McCay, was one of the first cartoons



*Steamboat Willie* (1928), by Walt Disney, the first sound cartoon and the film that introduced Mickey Mouse

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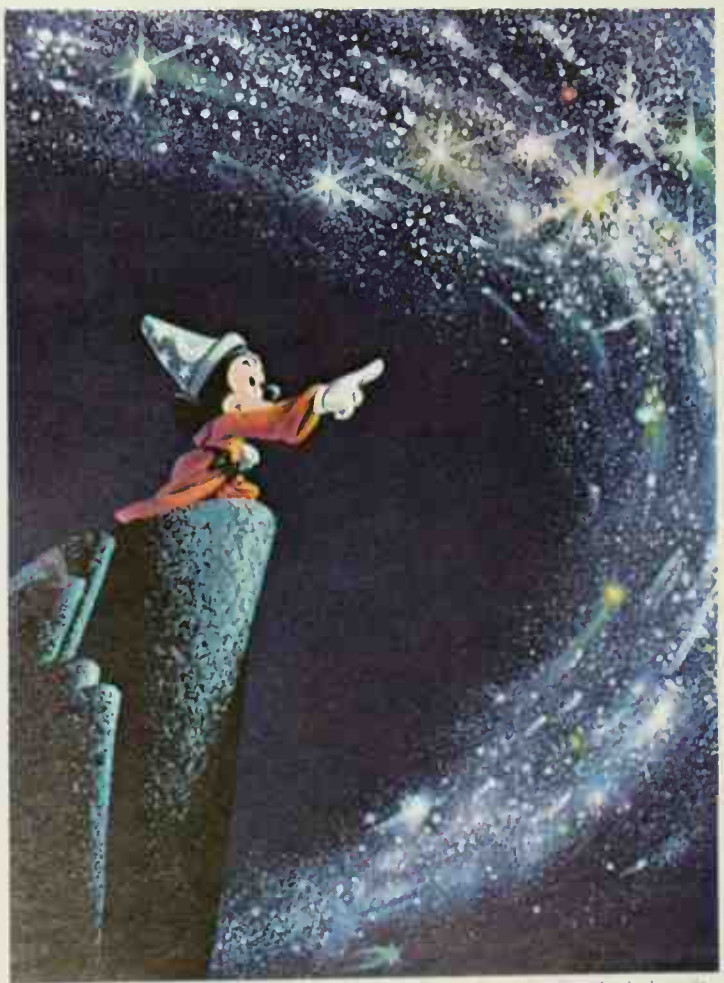
*Flowers and Trees* (1932), by Walt Disney, the first colour cartoon

*Snow White and the Seven Dwarfs* (1938), by Walt Disney, the first feature-length cartoon

## ANIMATED CARTOONS IN COLOUR

*Gerald McBoing Boing* (1951), based on a story by Theodor Seuss Geisel (Dr. Seuss) and made by United Productions of America

*The Jungle Book*, a Disney adaptation of the book by Rudyard Kipling



*Fantasia* (1940), by Walt Disney, combined cartoon animation with classical music

BY COURTESY OF (CENTRE LEFT) UPA PICTURES INC., (BOTTOM LEFT) © 1951 WALT DISNEY PRODUCTIONS, (OTHERS) © WALT DISNEY PRODUCTIONS

# MOTION PICTURES

*Gone With The Wind* (1939), one of the most popular films ever made, established colour as an important factor in motion picture production. This epic about the U.S. Civil War starred Clark Gable and Vivien Leigh

*Tom Jones* (1964), directed by Tony Richardson and starring Albert Finney in the title role, employed muted colour to depict Restoration England

## COLOUR IN MOTION PICTURES

*Lawrence of Arabia* (1962), directed by David Lean and starring Peter O'Toole as T. E. Lawrence, was filmed chiefly in the Jordan desert; colour was used to dramatize the heat and vastness of the setting

BY COURTESY OF (TOP LEFT) METRO-GOLDWYN-MAYER CORP., (TOP RIGHT) UNITED ARTISTS CORP., (BOTTOM) COLUMBIA PICTURES CORPORATION

deons and sought to discredit them in the public esteem. The *Chicago Tribune* declared, "There is no voice to defend the five cent theatre . . . its influence is wholly vicious." However, Jane Addams, the famous social worker, raised her voice to reply that motion pictures "rightly conducted are a benefit and not a menace to the poorer classes," while the People's institute maintained that the much-maligned "poor man's show" might well prove his university.

Meantime the Motion Picture Patents company, consisting of the ten producing companies authorized to use the original Edison patents and fortified by additional patents of their own, sought to establish a movie monopoly. All theatres were classified and assessed a fixed rental for film service. In addition they were charged a $2 weekly licence fee and restricted to the use of film and projection equipment manufactured by members of the trust. Seeking to establish "regularity and stability" in the business, the combine, which sold film by the foot rather than on the basis of quality, fought to prevent the development of the star system. At first the businessmen, lawyers and engineers who headed it insisted that one-reel subjects, and subsequently two reelers, were all that the low mentality of moviegoers could comprehend. Like many of their successors, these early production heads underestimated the intelligence of their audiences. They also underestimated their willingness to pay for improved entertainment. They ruled that a nickel (this later was raised to a dime) was the maximum admission that could be charged.

In Europe, however, where Edison for reasons of economy had neglected to patent his invention, producers, unhampered by shortsighted exhibition and distribution restrictions, were already turning out pictures running five to ten reels. While Great Britain followed the U.S. pattern of one- and two-reel pictures, mainly melodrama, ambitious producers in France, Germany, Denmark and Italy turned to the classics for material and made films of an elaborateness undreamed of in the United States. A French company, the Film d'Art, was formed to bring quality theatrical entertainment to the masses: now such classical actors as Constant Coquelin and Jean Mounet-Sully could be seen by all, now Sophocles would be available to the lowliest goatherd. In Italy, vast pageantlike films, operatic in style, utilized the ruins of antiquity and massed thousands of extras to create the prototype of the modern film spectacle. Both the French and Italian pictures were popular throughout Europe—the French were the first to penetrate the Russian market—and soon began to influence U.S. films. *Quo Vadis?*, a spectacular Italian feature nine reels in length, was imported into the U.S. by George Kleine and opened at the Astor theatre, New York, on April 21, 1913, at $1 admission. The engagement proved so successful that by the middle of the summer 22 road shows were exhibiting the picture throughout the U.S. and Canada. Adolph Zukor, who the previous year had defied the trust by importing from France the four-reel *Queen Elizabeth*, starring Sarah Bernhardt, decided that the time was ripe for equally ambitious U.S. projects. He organized his own company, Famous Players in Famous Plays, to bring to the screen distinguished plays or books acted by well-known Broadway performers in features running an hour or longer. Even before the Motion Picture Patents company was dissolved in 1917 by court order, Famous Players, its American and foreign imitators and the "feature craze" had destroyed the stranglehold of the monopoly. Its component companies had nearly all disappeared by 1917.

European features thus gave the impetus to growth in this country. They might also have continued to share a sizable portion of the U.S. market, as they did from 1905 to 1914, but for the outbreak of World War I. Cellulose nitrate, then the base of film stock, is an important ingredient in explosives, and the production of motion pictures therefore was reduced drastically as a wartime necessity. Short of product, the infant European distributing and exhibiting organizations also disintegrated. Yet, as the war wore on, the need for cheap escapist entertainment grew greater and greater. The rising U.S. companies filled the gap, flooding Europe with films that proved popular with world audiences. The U.S. firms also organized their own distributing systems, and by the end of World War I the U.S. motion-picture industry was dominant throughout the world. Try as they did, the national film industries of Great Britain and Europe never recovered the leadership they had enjoyed before 1914, in spite of governmental subsidies to native production and restrictions on the importation of U.S. films. Language barriers, relatively small home markets and other factors—including, decidedly, the character of the films produced—confirmed U.S. domination.

**4. The 1920s and 1930s.**—Obviously the days when the movies catered primarily to working men and women had come to an end. The younger generation of the middle and well-to-do classes became the mainstay of motion-picture attendance, dictating profound changes both in the operation of theatres and in the nature and ideology of the films presented. This younger generation in the years following World War I was generating vast changes in the social and economic tempo of American life. Armed with hip flasks, short skirts and a lack of reverence for the established mores, so-called flaming youth revolted against what they regarded as the inhibited, unexciting lives of their parents. They demanded greater freedom of speech and sex relations. Pictures reflected and, in the process, intensified their preoccupation with cars, petting parties and new dances like the Charleston. The public, old as well as young, wanted to see how the wealthy lived, dressed and misbehaved, and skilful directors, such as Cecil B. deMille, helped educate an entire nation in boudoirs, lingerie and riotous living. The worship of the stars reached delirious proportions. Theda Bara was succeeded by a bevy of seductive ladies—Pola Negri, Gloria Swanson, Clara Bow, Mae Murray and many more. The males who, to the delight of feminine audiences, eventually mastered such charmers included Douglas Fairbanks, Sr., John Gilbert and, most irresistible of all, Rudolph Valentino. Some of these public idols survived the coming of sound in 1927, and some were replaced by younger performers with better diction or voices. The movies themselves, however, although temporarily threatened by the rise of radio in the early 1920s, swept on to ever increasing popularity. Even the depression of 1929 failed to affect the box office until 1932. As long as the average American family had any available spending money, it regarded picture going as a necessity rather than a luxury.

So vast and luxury loving a public required theatres as elaborate and pretentious as the pictures. "Cathedrals of the cinema," as they were called, were erected downtown in all important U.S. cities and subsequently in the neighbourhoods and suburbs. Never before had the average patron encountered anything to rival the opulence of their lobbies and auditoriums or the comfort of their cooling plants, rest rooms and meticulous service. The Roxy theatre, for instance, which opened in 1927 in New York city, with a 6,250 seating capacity, cost $8,000,000 and in one week grossed $144,267.

The program in these motion-picture palaces was not confined to a feature picture, newsreel and short subjects. It also included elaborate "presentations" consisting of dancing, singing and vaudeville acts that utilized many of the country's best-known performers and name bands. Smaller theatres—any with fewer than 1,500 seats soon became regarded as small—made up for the absence of presentations by offering double features. If quality was lacking, exhibitors were determined to compensate for it with quantity. Where double features proved inadequate to attract business, recourse was had to dish nights, bingo parties, lotteries and contests of every variety.

Major companies, such as Paramount, Fox and Warner, sought to control playing time by acquiring the ownership of large theatre circuits; pictures were sold in groups (block booking) rather than individually; films were rented prior to their being screened for exhibitors (blind buying); and excessive clearance between the first and subsequent showing of films (protection) was required. In 1950, after 12 years of litigation, these and other trade practices were declared in restraint of trade and ordered discontinued, and the producers were instructed to divest themselves of their theatre properties.

**5. Effect of Television.**—In the meantime, however, the rise of television was creating havoc with motion-picture patronage. Weekly attendance in U.S. theatres declined from a probably

overestimated 90,000,000 in 1947 to an average of about 42,000,000 in the 1950s and 1960s. Gross receipts fell from an all-time record high of $1,565,000,000 in 1947 to a yearly average of about $1,200,000,000 in the 1950s. This average rose slightly in the 1960s. In 1945 there had been 20,355 movie houses; by the 1960s they had dwindled to 11,300. Viewing capacity, however, had probably increased through the construction of 4,700 drive-in theatres, which, through their elimination of the baby-sitter and parking problems, quickly became so popular that they soon accounted for close to 25% of movie attendance.

The worldwide investment in motion-picture theatres in the mid-1960s was believed to be at least $7,000,000,000, of which $2,555,000,000 was in the United States. A large share of the receipts of most U.S. theatres, rising to considerably more than 40% in drive-ins, came from the sales of concessions, such as candy, popcorn and soft drinks.

To meet the threat of television, movie producers in the 1950s introduced a large variety of wide-screen, three-dimensional processes, such as Cinerama, CinemaScope, VistaVision and Todd-AO. Among these, CinemaScope expanded with the greatest rapidity. By the mid-1960s it had been installed in about 30,000 theatres throughout the world.

All of the new processes were adapted to elaborate spectacular productions. Some, such as *This Is Cinerama, The Robe, The Ten Commandments* and *Around The World In 80 Days,* achieved fabulous box-office grosses. With a few exceptions, such as *Marty,* however, admissions on B pictures and even average A pictures shrank steadily. Indeed, by 1959, these formerly standard productions had almost disappeared, and with them the previously prevalent habit of nearly automatic, nonselective movie attendance. As *Variety,* the industry trade journal, phrased it, pictures were either "boffo or busto." More cultured commentators maintained that a steady diet of formula films and stereotyped productions, rather than television, had alienated all except the most adolescent and undiscriminating public—for whom, by the way, Hollywood had begun to supply, in addition to the very expensive productions, a series of very cheap ones, mostly horror films of the *I Was A Teenage Werewolf* variety. The industry, however, continued to place its major reliance on strictly escapist, supercolossal attractions calculated to appeal to a large mass audience, not only in the U.S. but also in other countries. The number of pictures produced annually in the U.S. was reduced by more than half to approximately 250, but such a large proportion of these were mammoth westerns, historical and biblical pageants, and elaborate musicals with negatives costing anywhere from $2,000,000 to $8,000,000 that budget outlays exceeded all previous records. These increased costs resulted in higher film rentals, longer runs and the need for theatres large enough to profitably show such so-called epic attractions.

This tendency ran counter to the development in the early 1950s of smaller and more intimate theatres in the U.S. About 600 of these less imposing but frequently better designed houses specialized in the showing of British, foreign-language and unusual U.S. pictures. They were located in 70 large cities and college communities and catered primarily to audiences seeking more adult fare than was usually furnished in the strictly commercial theatres. Although in the mid-1960s they contained less than 3% of the total number of theatre seats in the U.S., they served as a disproportionately effective catalytic agent on public taste and the aspirations of the more creative artists and technicians.

(A. L. Mr.; R. Gh.)

## V. EDUCATIONAL FILMS

Many things are learned from many kinds of motion pictures. The educational film, however, is one deliberately designed to make its audience remember something, do something or feel differently toward something as a result of the showing. Such films may range from the narrowly didactic to the highly dramatic, from a simple "how-to-do-it" film to one on the complex problem of race relations. In either case, the truly educational film must maintain objectivity of idea and accuracy of factual content.

Significant in the history of the motion picture are early attempts to use film for research and educational purposes. Eadweard Muybridge in the U.S. and E. J. Marey in France were making studies of animal locomotion in the 1870s and 1880s. Thomas A. Edison, who had little faith in the commercial possibilities of the invention he pioneered, predicted that films would replace textbooks. In 1897 Oskar Messter made an instructional film for the German navy, and later he took motion pictures from a balloon. In England, F. Percy Smith developed the technique of time-lapse photography during the early 1900s, and the U.S. department of agriculture filmed a flight of the Wright brothers in 1908.

By 1910 a number of broadly educational films made in France, England and the United States were indexed by George Kleine, who published a *Catalogue of Educational Motion Pictures,* pointing out that films present "the works of textbooks without their dryness, and yet impart a knowledge which cannot be gained by mere reading."

Between 1900 and 1920, the educational film movement developed considerable impetus in France, Sweden, Germany and in certain Latin-American nations, such as Chile. In 1917 the signal corps of the U.S. army made several instructional films, including one on venereal disease control that became the subject of an early study on the effectiveness of film in education. The Yale University press produced *The Chronicles of America Photoplays* in 1919, a series of dramatic enactments of episodes in American history that was widely shown in the schools of the United States.

There were pioneers in many countries. In England, for example, James Fairgrieve and G. Patrick Meredith were among the first to see the possibilities of motion pictures in education. In 1919 H. Bruce Woolfe established British Instructional Films, which produced several hundred short nature and science films in a series called *Secrets of Nature.* In 1933, British Instructional films became part of Gaumont-British Instructional, Ltd.

The Soviet government, recognizing in film a significant medium for indoctrination and education, placed the entire motion-picture industry of the U.S.S.R. under the commissariat of propaganda and education in 1919. A number of now-classic films were made between 1925 and 1930 to acquaint the peasant with the objectives of the Russian Revolution; these films demonstrated the potential of the motion picture as a medium of mass communication with persons of little or no educational background.

Early films were produced on inflammable, 35-mm. cellulose nitrate base. Because of the danger of fire, and because the so-called portable projection equipment was clumsy, heavy and expensive, the use of films in the classroom was adopted slowly. Several types of small projectors using 20-mm., 17.5-mm. and 9.5-mm. film had been exhibited at the Paris exposition of 1900, and the 9.5-mm. film had become the nontheatrical standard in France and other parts of Europe.

In 1923 the Eastman Kodak company developed a 16-mm., noninflammable cellulose acetate film base and a portable 16-mm. projector that provided new and practical means for expanding the use of films in schools. At an international film conference held in Rome in May 1934, Germany, Italy, England, France and the United States agreed on 16-mm. film and equipment as the international standard for classroom use.

Until 1933, educational films were silent, with subtitles. With the development of sound-on-film by Electrical Research Products, Inc., a subsidiary of the Western Electric company, a slow trend began toward the production of educational films with sound. However, a preference for the silent film continued to prevail in many educational systems throughout the world because it was felt that the teacher's prerogative might be usurped by the impersonal commentary of a mechanical sound track.

The concept of the educational film was significantly enriched by the documentary film movement, fathered by Robert Flaherty in the United States and by John Grierson in England. These and other documentary film producers influenced a whole generation of film makers and further impressed educators with the potential of film in public education. In 1939, for example, through the efforts of Grierson, the National Film Board of Canada was estab-

lished to produce and distribute educational films as a kind of supplementary system of national education.

During World War II, the production of classroom films was virtually halted as top educators and film producers were recruited to produce films related to the war effort. Motion pictures of great motivational force emerged from the British ministry of information, the Soviet Union, the U.S. Office of War Information, the propaganda ministry of the third *Reich* and from the Luce studio in Rome, which had been set up in 1925 as the central agency for the production of educational and propaganda films for Fascist Italy.

In the postwar period, hundreds of classroom films were produced in the United States by organizations like Encyclopædia Britannica Films, Coronet, and the text-film division of the McGraw-Hill Book company. Excellent science films also were made in Japan, in the reorganized Luce studio in Rome and in some of the Latin-American countries, such as Uruguay. The production of educational films was largely in the hands of independent producers, universities or private groups in England, France, Japan and the U.S., while in the U.S.S.R., Poland, China, Hungary, Czechoslovakia and elsewhere both the production and distribution of films for schools remained under national control.

The value of certain entertainment or theatrical films in formal education was brought to a focus in this same era. Portions of Hollywood features were excerpted for school use by Teaching Film Custodians, Inc., established in 1939 with the co-operation of the Motion Picture Association of America. Walt Disney and many other theatrical film makers began to make their films available for educational purposes. In England, Mary Field did notable work in the production of theatrical films for children. The sensitivity of Jean Benôit-Lévy in France, Jiri Trnka in Czechoslovakia and Arne Sucksdorff in Sweden further contributed to the concept of drama in the educational film.

By the mid-1950s commercial and religious sponsorship increased the production of broadly educational films, especially in the United States, where about 90% of the advertising and business films produced were described by their sponsors as being intended for school and college audiences.

Organizations like the National Education association's department of audio-visual instruction, the American Library association, the University Film Producers association, the Educational Film Library association, the National Audio-Visual association and the short-lived Film Council of America were but a few of the forces expediting the use of educational films and other audio-visual materials in the United States, where an estimated 750,000 16-mm. projectors were in use by schools, churches and other community organizations by the mid-1960s. In England, both the Educational Foundation for Visual Aids, organized in 1948, and the British Film institute served to stimulate the use of films in the schools. The International Scientific Film association was formed in 1947 under the direction of Jean Painlevè, and in 1950 the International Council for Educational Films was organized to facilitate the production and exchange of educational films on a worldwide scale. However, despite these and other international agreements, and the efforts of the United Nations Educational, Scientific and Cultural organization (UNESCO), the free exchange of educational films continued to be inhibited by import-export and currency exchange problems, print costs and the expense of local adaptation or translation.

Research on the effectiveness of films in the teaching of skills, the shifting of attitudes and the conveying of information, begun in the early 1930s, was intensified following World War II. These investigations showed, among other things, that students learn and remember at least as much from a good film as from a traditional lecture on the same subject, and that the more intelligent students learn more from films than do poorer students. Motion pictures, it was found, could significantly affect emotions and behaviour, although the degree and direction of the change was not always predictable.

Educational films were increasingly based on learning theory, with the age and educational levels of specific audiences clearly defined. They came to be more directly integrated with the curriculum, textbooks and other teaching materials. There was closer collaboration between the producers and the subject-matter specialist in the preparation of such films. The films tended to be shorter and more specific and to make more effective use of sound, colour, animation and dramatization.

The educational film took a variety of forms, including: (1) the single-concept film, often silent, which dealt with a single phase of a process in a minute or two of film time; (2) the open-ended film, which posed a problem but left the solution to the audience; and (3) the iconographic film, a variation of the U.S. navy filmagraph in which still pictures or photographs were converted to motion-picture form by camera movement, cutting and other cinematic effects.

A significant revival of the 8-mm. film began in the U.S. in the 1960s. It was accompanied by the appearance of automatic cameras, cartridge-loading projectors, 8-mm. magnetic sound film and experiments with optical sound on 8-mm. film. As a result, students and teachers became able to produce films at relatively low cost. Professionally produced films continued to be made in 35-mm. or 16-mm. sizes and in some cases were reduced to 8 mm.

The advent of educational television stimulated the production of simple demonstration and lecture films, usually in a series. Whole courses were put on film, as in the case of the high-school physics course produced in 1957 by Encyclopædia Britannica Films. Television suggested new distribution possibilities for educational films by means of a closed circuit and opened the way to wide international exchange as well.

Many educators, wary of the growth of automation in education, cautioned against what appeared to be a predominance of mass media presentations both inside and outside the classroom, with the consequent depersonalization of the teacher-pupil relationship. But far from displacing the teacher, films, when used in formal education, seemed to be making the instructional job more complex, placing greater responsibility on both the educator and the film makers. Despite these and many other problems, a growing understanding of how people learn, and significant research into human motivation and communication, promised new and exciting developments in the field of educational films, whose full potential is yet to be realized.

*See* also AUDIO-VISUAL EDUCATION. (R. W. W.)

## VI. ANIMATED CARTOONS

**1. Early History.**—The history of the animated cartoon dates back to the earliest era in the development of motion pictures. In 1831 the first efforts were made to show motion pictorially with a device called the phenakistoscope, invented by Joseph Antoine Plateau, of Ghent. The device consisted of two disks mounted on a shaft; one disk carried the drawings, which were viewed through slits around the outer edge of the other disk. A similar device was made by Simon Ritter von Stampfer, of Vienna. These devices were followed by the daedaleum, or "wheel of life," invented in 1834 by William George Horner in England and introduced in the U.S. in 1867.

The commercial possibilities of animation were first realized by a Frenchman, Emile Reynaud, in 1877. With a complex machine involving mirrors and lanterns called the Praxinoscope, he projected moving drawings onto a screen. His Théâtre Optique in Paris attracted one-half million patrons during its run from 1892 until 1900. A countryman, Emile Cohl, pioneered the cartoon in motion pictures with his imaginatively created Phantasmagoria.

The first U.S. animated cartoon drawn specifically for motion-picture film was made in 1906 by J. Stuart Blackton for the Vitagraph company and was titled *Humorous Phases of Funny Faces*. This was followed, beginning in 1911, by the *Little Nemo* series, produced by Winsor McCay for Vitagraph. The Little Nemo character first appeared in a comic strip in the *New York Herald* in 1908, and the practice of adapting newspaper comic strips to films soon became widespread after McCay toured the vaudeville circuits with his cartoons. In 1913 J. R. Bray patented certain animation processes and started his *Col. Heeza Liar* series, the first to be released commercially through movie theatres. That same year,

another cartoon series, *Old Doc Yak,* created by Sidney Smith, came into being. Earl Hurd, producer of the *Bobby Bump* series, and Bray combined their patents in 1917. Their chief competitors were Wallace Carlson, with his *Dreamy Dud* series; Paul Terry, who made the *Farmer Al Falfa* series; and the Bud Fisher Films corporation, which produced *Mutt and Jeff,* released by the Fox Film corporation. Considerable improvement was made by the International Film Service, Inc., in 1916 and 1917. It issued such cartoon series as *Jerry on the Job, Katzenjammer Kids, Bringing Up Father, Happy Hooligan, Krazy Kat* and *Silk Hat Harry.* Other animated cartoons of this period were *Terry Cartoon Burlesque,* released by the Kay company, and the *Zippy* cartoons of Sterling pictures. In 1922 Max Fleischer introduced his *Out of the Inkwell* series, the first picture combining photography with a cartoon character.

**2. Walt Disney.**—Walt Disney began making animated cartoons in Hollywood in 1923, one series of that year being based on *Alice in Wonderland* and another on *Oswald the Rabbit.* Disney produced the first animated sound cartoon, *Steamboat Willie,* in 1928, starring Mickey Mouse in his first role. Disney's first colour cartoon, *Flowers and Trees,* was released in 1932. To him goes the credit for the first feature-length animated cartoon, *Snow White and the Seven Dwarfs* (1938). This cartoon, four years in the making, consisted of approximately 477,000 photographed drawings and was translated into 13 foreign languages.

After World War II the scope of the animated cartoon was extended in such diverse ways as the abstract work of Norman McLaren in *Begone Dull Care* and of Mary Ellen Bute in *Color Rhapsodie* and *Polka Graph,* and the popular *Gerald McBoing Boing* and *The Nearsighted Mr. Magoo* cartoons of Stephen Bosustow's United Productions of America. With the advent of the wide screen, Disney produced the first CinemaScope cartoon, *Toot, Whistle, Plunk, and Boom,* in 1953. He also produced the first feature-length CinemaScope cartoon, *Lady and the Tramp,* released in 1955.

Cartoon production costs spiraled over the years. The early cartoons seldom cost more than $2,000, sometimes less than $1,000. Disney's *Lady and the Tramp* had a multimillion dollar budget, as did his *Sleeping Beauty,* which was filmed in the Technirama wide-screen process.

**3. Technique of Production of Animated Sound Cartoons.**—Animation is a cartoon in motion. The illusion of movement in the cartoon is achieved by photographing a cartoon character or characters against a mobile background.

The entire process begins by laying out a brief story plot in a series of coloured-pencil action sketches pinned in sequence on a huge board. When the story is worked out satisfactorily, the board is moved from the rooms of the story crew to those of the director assigned to the cartoon. He calls in the musician, layout man, background artists and animators and briefs them on their various tasks.

The animator does not begin to draw a sequence of action until the background layouts are finished and the dialogue, sound effects and music have been recorded. The animator must watch the scene layouts carefully so that he will not have his characters walking through such objects as furniture, buildings or trees. After the dialogue track is recorded, it is turned over to the cutting department, where it is analyzed and a chart is prepared to show, in terms of single frames of film, the length of each word, the intervals between words, the vowel and consonant sounds, accents, inhalations and exhalations. The dialogue track governs the pattern, to which the animator must work, for timing and action. If the character says, "hello," for instance, and the cutting department reports that this word, when recorded, occupies eight frames of film, the animator must produce a sequence of eight drawings in which the lips of the character move to form the word, plus whatever bodily accent may have been decided upon.

The animators have assistants who help develop the action. While an animator draws the most difficult and important points of action, his assistant follows through along the course indicated by the animator. The animators work on a transparent drawing board illuminated from below so that after one drawing has been completed a second can be placed on top of it and the new drawing varied just enough to make the movement smooth. A completed series of drawings is photographed and returned to the animator, who runs the film on a small projection machine, called a movieola. The director views the film and approves—or disapproves—the drawings.

When the drawings are approved, they are sent to the inking and painting department. There the drawings are transferred to sheets of transparent acetate by department employees who outline the characters with pen and ink so that they retain the charm of the original drawings. Other employees apply the chosen colours of paint to the reverse side of the transparencies so that the inked outlines are accented. After the acetates are finished, they are sent to the camera department. Each transparency is placed over the correct background and photographed. Transparencies are photographed at the rate of approximately eight feet of film per hour. It requires about two weeks to photograph the average 700-ft. cartoon. About 45,000 setups are used in photographing a reel of film. There are 16 frames to a foot of film, which runs through the projector at the rate of 90 ft. per minute, or 24 frames per second.

After a production is filmed, the final processes are similar to those used for a live-action motion picture. The sequences are placed together and previewed for audience reaction. The picture is then released as it stands or is returned to the studio for further editing.

The animation technique for a feature-length cartoon is essentially the same as for a short cartoon, since the short cartoon is basically comparable to one sequence of a full-length production. A feature-length cartoon may have as many as six directors, although three is usual, with each directional unit responsible for the making of several sequences of the picture.

Some changes in production technique are required in wide-screen cartoons. Animators' drawings must conform to the 2.55 to 1 ratio of CinemaScope, for example. The movieolas, too, must have a wide-screen lens to enable the animators to view their rough tests in the proper CinemaScope dimensions. The backgrounds for CinemaScope cartoons are twice as long, and layout men have to redesign and restage all their action to meet this changed format. In addition, the transparencies used in the inking and painting process call for minimum dimensions of 30 × 13 in. to maximum dimensions of 90 × 13 in., instead of the regular 16 × 13 in. (J. P. Re.)

## VII. DOCUMENTARY FILMS

The term documentary film was adapted by John Grierson, about 1924, from the French word *documentaire,* previously used in Europe to describe travelogues and other factual films. Grierson, a Scottish educator then studying mass communications in the United States, was seeking an English term to describe the special dramatic quality of the film *Moana* (1926), by Robert Flaherty (*q.v.*). In the course of his studies, Grierson became one of the first to see that the motion picture and other mass media were swiftly replacing the home, the school and the church in shaping the attitudes toward life of the majority in the industrial democracy. He wished to use the power of these media to "bring alive," as he put it, the actual structure of modern society, the actual political, economic and other forces that govern and determine everyday living; he proposed, in effect, that the film medium should be used deliberately for education for citizenship. After his return to England in 1928, he found a sympathetic ally in Sir Stephen Tallents, who urged the use of mass media for the purposes of British propaganda, and a sponsor in the Empire Marketing board (E.M.B.), a national government commission supporting the then-current "Buy British" campaign. (Sir Stephen was at that time head of the propaganda division of the E.M.B.) To his sponsors Grierson pictured the future of his documentary idea in terms of the record already achieved by the Soviet propagandist films, the U.S. epic westerns and especially the work of Flaherty. To show what he meant, in 1929 he made for the E.M.B. his only personally directed film, *Drifters.*

The object of *Drifters* was to show the ordinary man that the herring on his breakfast plate did not arrive there either by accident or by magic; that it was, in fact, a product of the daily toil and the daily heroism of the men of the North Sea fishing fleet. Despite this humble theme, the picture achieved a beauty and power that clearly rose from the fact that its ardours and heroisms were actual, not the product of studio synthesis. *Drifters* was a theatrical success, but Grierson did not attempt to repeat it. Instead, with characteristic generalship, he concentrated on attracting highly skilled persons to join what came to be known throughout the world as the British documentary film movement; these persons included teachers, writers, musicians, painters, poets, scientists and others who felt that their traditional crafts gave them inadequate scope and inadequate influence in the modern world and who, like Grierson himself, wanted to use the force of the screen to project their ideas about social reform and social progress. Among the many talented persons who worked on British documentary films were Paul Rotha, Sir Arthur Elton, Basil Wright, Sir William Coldstream, Harry Watt, Alberto Cavalcanti, W. H. Auden, Benjamin Britten, Alistair Cooke and Pat Jackson.

The early British documentaries were dramatic and simplified descriptions of the complex processes of industrial society. For example, after the film unit of the E.M.B. was transferred in 1933 to the general post office, Auden, Britten, Cavalcanti and Watt in 1936 made *Night Mail*, a lyric description of the nightly journey of the "Postal Special," a mail train that ran between London and Edinburgh; its poetic sound track hymned the meaning of mail for the man in the street. Later, not only the processes but also the problems of the machine age were surveyed, and for films about the latter Grierson sought financial support from heavy industry; thus, the British Commercial Gas association sponsored *Housing Problems* (1935), a survey of the human consequences of British slums. By the late 1930s, the British documentary film had become world famous, and all in Britain, whether in government departments or the public relations branches of big industry, who wanted their enterprises to be associated in the public mind with the advanced, the progressive, the socially responsible were eager to sponsor documentaries, which grew in number year by year.

In the United States the first documentaries were made under Soviet rather than British influence, reflected the thinking of the extreme left wing and were little noticed. Then, in 1935, Louis de Rochemont and Time, Inc., originated *The March of Time* film news feature, which, in its combination of newsreel material and specially staged scenes and interviews, rightly called itself "a new kind of pictorial journalism" and was far in advance of the old newsreel. Its influence was immediate and worldwide. In the following two years Pare Lorentz, a movie critic, made under federal auspices *The Plow That Broke the Plains* (1936), about the "dust bowl," and *The River* (1937), about flood control. These were and remain brilliant and compelling films, and they seemed to set the stage for the development of a U.S. documentary film movement as deeply rooted in national life as the British. Two factors prevented this development: (1) Congress vetoed the establishment of a U.S. government film service analogous to the one Grierson had successfully urged on the various British government departments; and (2) U.S. industry, more accustomed to direct advertising than to the public relations concepts that flourished in Britain, was cold to the prospect of sponsoring films that did not directly sell the product. The U.S. academic community was interested in the documentary idea, but funds were hard to find. Only a few academically sponsored films, such as the remarkable *The City* (1939), by Willard Van Dyke and Ralph Steiner, reached the screen.

World War II transformed the situation. The urgent need for military and civilian propaganda, and for military and civilian training in the special skills of war, required the fullest use of the mass media in a hurry, and the trained documentarians on both sides of the Atlantic were absorbed into the war effort overnight. With virtually unlimited funds and a mandate of urgency, the documentary form developed rapidly under wartime conditions, especially in the U.S. when Hollywood talent was added to that of the documentary veterans. Innovations were represented by Frank Capra's *Why We Fight* series (1943–45) of army films, which shaped newsreel stock footage from all over the world into clear, compact and dramatically exciting films detailing the causes and the progress of the war. Britain's documentaries, such as *London Can Take It* (1940), *Target for Tonight* (1941) and *Desert Victory* (1942), moved toward a new intimacy and emotional involvement in telling the story of the British war effort. As the war neared its end, there seemed no limit to the documentary future, and it was freely predicted that films of this kind would supersede the conventional teaching of history and other subjects in the schools.

Events proved otherwise. From 1945 until the early 1950s, the documentary movement was in a slough throughout the world. The people of the Allied countries, suffering from what was called ideological fatigue, reacted against films that called for mental effort. The economy of Great Britain could no longer support such expensive experiment on the frontiers of education. The U.S. congress made known its emphatic opposition to the use of public funds for this purpose, except for propaganda overseas. Moreover, the postwar documentary had no viable outlet. Wartime documentaries had been seen by millions, but their peacetime distribution through theatres was unprofitable, and the 16-mm. nontheatrical market was too small to serve as a substitute. The pioneer documentarians saw the instrument they had forged apparently discarded by a world whose conditions no longer fostered optimism about social progress.

Again the situation was transformed overnight, in the early 1950s, by the rapid growth of television. Here the broadcasting tradition of free sponsored shows easily accommodated the documentary idea. In the U.S. the documentary also is an obvious way of discharging television's public service obligations as defined by the Federal Communications commission. The nature of television itself permits exciting new technical possibilities, notably that of mixing filmed footage with live material, especially the spontaneous, unrehearsed interview. Beginning in 1952 with the series "Victory at Sea," the wartime tradition of the stock footage compilation film was vigorously resumed, refined and extended in such series as the National Broadcasting company's "Project Twenty" and the Columbia Broadcasting system's "20th Century." Indeed, the doyen of all television public service programs, "Omnibus," in its freely experimental form and in its expert popularization of complex matters, was conceived in the original documentary spirit. These programs and series, filmed and live or both, were seen and accepted by many millions who in all probability would never have had contact with the documentary under any other conditions than those broadcasting makes possible.

Since the pioneering days of Grierson and Flaherty, documentary films, in one form or another, have been made in nearly every country, including the totalitarian countries. The survey in this section has dealt exclusively with U.S. and British developments, because the documentary film was originally visualized as an extension of democratic education to meet the expanding terms of modern life. This remains its essence and its promise.

(R. GH.)

## VIII. FILM FESTIVALS AND AWARDS

The first film awards remain the most famous. They are the Academy awards, presented yearly since 1927 by the Academy of Motion Picture Arts and Sciences, founded in that same year in Hollywood. The academy performs many professional, technical and public relations services for its members and for the motion-picture industry, but it is best known for presenting the series of annual awards, known as Oscars, to the best film production and to persons in the industry who are considered outstanding in any given year. Awards are made in about 25 categories; those that receive the greatest popular attention, in addition to the award for the best production, are those for best performances by an actor, actress and director. Nominations for the awards are made by members of the appropriate craft (such as actors, film editors or sound men), while final balloting is conducted among the entire membership of the academy, which includes most persons

working in the U.S. motion-picture industry. When outstanding achievements do not fit into the standard categories, special or honorary awards are created to grant recognition. Consistent achievement over a long period also receives special attention.

The Academy awards are perhaps not always scientific assays of the work of moviemakers by their fellow craftsmen; they may include aspects of a popularity test with its reverse implications; but there is no doubt that they reflect the honest and often the impassioned views of the men and women who make movies. Almost as impassioned is the reception of the awards by some segments of the American public. Outside the U.S., however, the awards are less highly regarded, though widely publicized. The criticism is made that the Hollywood Oscars are conventional choices compared with those of the European film festivals, and that those who award the Oscars are insufficiently alert to the emergence of new and original talent.

Although the Oscars have their counterpart in Britain in the annual awards of the British Film academy, the giving of film awards outside the United States is generally not based on institutions of film makers but instead has grown out of the practice in Europe, Asia and South America of holding annual film festivals. The first of these was founded at Venice, Italy, in 1932 with the aid of the Fascist regime. It remained unique until the end of World War II, when a festival was established at Cannes with French governmental and industry sponsorship. These two festivals remain dominant in the public eye but many others—some of them ephemeral—sprang up. In fact, these events proliferated to the extent that the International Federation of Film Producers' Associations sought to persuade its members to confine support to a limited number of recognized festivals. This attempt at limitation by trade self-discipline has not been fully successful, but the international federation continues to advise its members as to which festivals are deserving of support.

Among the better established festivals, other than Cannes and Venice, the most important are probably those held at Berlin, Moscow and Karlovy Vary, Czech., the latter two taking place in alternate years. Edinburgh, in Scotland, once regarded as the leading festival for short and documentary films, has to some extent given way to Mannheim and Oberhausen, both in Germany, and to Tours, in France, at which many short films, which tend to be overshadowed by full-length films at the major film festivals, receive their need of recognition. The London Film festival, associated with the National Film theatre in London, which has adopted a formula of selecting from the other festivals those films considered to be the best of the world's film output for the year, rounds off the European festival season. The Southeast Asia Film festival, held annually at various places in that region, features films often unknown to the rest of the world.

The competitive festivals on the whole follow one pattern. Producers throughout the world are invited to submit fiction, documentary, "experimental," scientific and instructional films to the festivals, where they are shown both to general audiences and to private juries consisting of individuals thought to be qualified to judge the films in each category. Appropriate awards and honourable mentions are then bestowed. Eminent directors, stars, producers and other motion-picture workers are invited to attend, to appear at public gatherings, to socialize with their peers and generally to lend prestige and glamour to the event. These celebrities in turn attract tourists to the festivals, and they, together with the avid film fans who come from all over the world, constitute the festival public. Those who come to ogle, to shop and to eat and drink are important to the festivals, since festival costs usually are borne by the municipalities involved, except when they are met by government or industry subvention.

The value of the festivals is hotly debated among moviemakers. The cost of sending films and delegations of stars, and of necessary entertainment, is great. Some producers maintain that films made primarily for commercial purposes are judged on quite different standards and that, while the winning of an award is often of no great financial advantage, the losing of it under certain circumstances can be disproportionately damaging. Festival jurors sometimes are actuated by personal, political and nationalistic motives, as well as by the written standards by which they are supposed to judge. The multiplication of festivals and awards has diluted their public impact. Nevertheless, it is widely agreed that the festivals serve the purpose of focusing a virtually continuous spotlight on the motion picture and on motion-picture personalities, and that function, at present, is too valuable to be ignored.

Commercial considerations apart, the awards made at the major festivals, notably at Venice, carry genuine prestige for serious film makers, and, in Europe at least, the Venice Golden Lion and other awards carry some influence with critics, film societies and the discriminating audiences of specialized and repertory cinema.

*See* also entries under "Motion Pictures" in the Index.

(R. Gh.; S. W. Re.)

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For the most recent figures on production and related information, *see* the *Britannica Book of the Year.*

**MOTION SICKNESS,** a term popularized by Sir Frederick Banting in 1939, replacing the more familiar but less general term seasickness. Since man took to the sea, many persons have experienced discomfort varying from a slight feeling of uneasiness to extreme prostration during rough weather. The common symptoms of motion sickness are pallor, cold sweating, nausea and vomiting. As other types of locomotion evolved, the symptoms have been recorded as train, swing, car and airplane or airsickness.

The balancing organ, or labyrinthine portion of the internal ear, is disturbed by out-of-level movements and by sudden turning movements. The former, said to be the more upsetting, result from changes of position of the head in relation to gravity and centrifugal force (the force that deflects a rotating object away from the centre). On the other hand there is evidence to show that even slight turning movements of the head in a plane other than that in which the body as a whole is moving may cause severe loss of balance. It has been suggested that some of the beneficial effects of lying down during motion sickness result because the head is thereby fixed in relation to the body.

Persons who have lost both labyrinths from disease are not susceptible to motion sickness. Animals that previously could be made motion sick were no longer susceptible following destruction of both labyrinths. Some persons become resistant to motion sickness—develop their "sea legs," so to speak.

In addition to the disturbing effects of motion, there are a variety of contributing factors such as unpleasant sights and smells, anticipation from past experiences, etc.

The wartime transportation of large numbers of troops both by sea and air led to study of the causes and prevention of motion sickness by participating governments. It is important that a combatant be free from motion sickness during transportation, yet it is absolutely essential that he be alert and not drowsy when going into action. Likewise a pilot guiding a plane must be in full possession of his faculties. Most remedies for motion sickness (including the popular patented remedies) contain some form of sedative or quieting drug. It has been found that many of the antiallergic drugs lessen the tendency of the average person to succumb to motion sickness. Most of these drugs, however, have some sedative or other undesirable side effects. *See* also EAR, ANATOMY OF; EQUILIBRIUM, ANIMAL; AVIATION MEDICINE.

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**MOTIVATION** is a term used to cover explanations of why a person behaves as he does. It is not synonymous with "causation" because it is generally restricted to only one class of events determining behaviour. For example, it is commonly contrasted with ability, another important determinant of behaviour: a person may be able to play a game of tennis, but he may not want to; *i.e.*, he is not motivated to play. Or on the other hand he may want to and not be able to. Both ability and desire jointly determine what he actually does. Motivation is ordinarily indicated by such words as want, wish, desire, need and strive.

Students of psychology have from earliest times identified a desiring element in human personality. In the Bhagavad Gita the mind is described as being composed of three parts: *sattva*, or knowledge; *tamas*, or ignorance; and *rajas*, or passion. The passionate element is compared with a volcano that threatens to erupt and engulf the person in a life of greed and selfish desire unless it is brought under the control of reason or knowledge. In classical Greek thinking the soul is again divided into three parts: reason and two motivational elements, spirit (or will), which underlies courage in battle, and desire, which includes the basic biological needs for food, water and sex. Subsequently in the west, both within the Christian tradition and outside it, there was general acceptance of the notion that reason should be distinguished from desire and in fact was often in opposition to it. To the medieval Christian, reason alone was not strong enough to control the baser human urges represented so graphically in Dante's *Inferno*. It was necessary to invoke a higher type of motivation of divine origin (based on faith and grace) which would control the instincts. The notion that there are two opposing motivational forces and a third mediating force, reason, persisted in psychoanalysis (*q.v.*), which has had a very wide influence on psychiatry, psychology and humanistic descriptions of the nature of man. To Sigmund Freud the id represented the baser motives of man, which are opposed by the superego, representing the moral drives; whereas the ego (*q.v.*), representing roughly reason, mediates between the two opposing forces. Thus Freud regarded motivation as all-important, and the role he assigned to the ego functions, to realistic perception, to past experience and to reason was very small; later psychoanalysts from the 1940s to the 1960s, however, turned their attention increasingly to such matters.

Experimental psychology initially was much less concerned with motivation than was psychoanalysis. It had its origins in the school of psychology which argued that the mind was made up of nothing but a series of more or less complicated associations among ideas and between ideas and action. The mind was like a machine which would run automatically, once started, in accordance with the associations built up through experience. This view was modified, however, particularly in the United States, by its contact with the equally influential notion popularized initially by Charles Darwin that organisms struggle for survival and that in that struggle certain basic biological needs have to be satisfied. Thus, while U.S. experimental psychologists disavowed any interest in the subjective motivational forces of interest to psychoanalysis, they too turned their attention to the study of the basic needs such as hunger, thirst and sex which activated the organism in its struggle for survival.

By mid-20th century two widely influential but opposed psychologies of human motivation had developed. One, the simpler of the two, grew out of experimental work with animals, particularly by U.S. psychologists interested in studying the learning (*q.v.*) process. They found, for example, that if they deprived a white rat of food it would learn to run a maze more rapidly to get to a food reward; if it was well fed and all its other bodily needs were satisfied, it would run very little, if at all, in the maze. These psychologists reasoned that under the latter circumstances the rat was not motivated to run. Food deprivation disturbed a state of equilibrium by introducing a strong persistent inner stimulus which made the animal active until it had located some food; eating the food removed the inner stimulus and restored equilibrium. The persistent stimulus produced by deprivation had obvious survival value in that it led the organism to be active, which increased the probability that it would find something that would do away with the deprivation and allow the animal to live. Anything which produced a strong stimulus—extremes of heat or cold, physical injury, lack of water—was conceived as a source of motivation. More complex social motives were thought to develop out of means of satisfying the primary biological needs. This school has not been conspicuously successful in accounting for complex human motives, but U.S. psychologists have widely believed that it would be able to do so by carefully building on an understanding of the way in which the simplest biological needs operate. Its most particular weakness has been in measuring individual differences in human motivation, since it has been concerned primarily with biological needs in other animals, and these are short-term and easily satisfied in contrast to the stable, enduring dispositions in the human adult.

The other view of human motivation, represented in its most extreme form in psychoanalysis, begins precisely with the problems the experimental psychologists have had so much difficulty in handling—with motives as enduring forces in the person. The reason for the difference is not hard to find. Psychoanalysis grew out of the clinic and the consulting room rather than out of the animal laboratory. Its practitioners had to deal with the complex strivings of adult neurotics. They struggled to discover the motivational forces that lay behind the bewildering variety of symptoms they encountered. Freud's own theory of motivation underwent many changes, but perhaps it can best be summarized by saying that he was primarily concerned throughout his long

life with three major forces: the sex instinct (or libido), which was for him a kind of life force including a large variety of components only one of which was genital sexuality in the narrowest sense; the death instinct, which encompassed all of man's aggressive urges; and anxiety, which was not conceived as an instinct with an aim like the other two but which certainly motivated behaviour as it arose out of fear of the other two instincts and out of conflicts in their aims. Freud's theorizing has been criticized as unscientific and as failing to consider a number of motives which are important in normal as opposed to abnormal personalities, such as the need for achievement or for self-actualization. Certainly if experimental psychology attempts to explain human motivation with too few simple but carefully quantified drives, psychoanalysis attempts the same task with too many *ad hoc* motivational interpretations which do not follow the ordinary scientific canons of parsimony, quantifiability and predictive power.

While the two schools differ in subject matter and method, they do agree on a number of points. They both accept the fact that motives may be unconscious, whereas the man in the street may feel that he is aware of his motives if he only takes the trouble to think about them. Both argue that motivation is an important determinant of behaviour but only one determinant, the others being variously defined as ego functions in psychoanalysis or as habit and realistic perception in experimental psychology. Both tend to conceive of man as motivated primarily to reduce tension aroused by biological needs or instincts. Motives are, so to speak, disturbers of the peace, and human activity is devoted to trying to remove the disturbance.

There are of course many psychologists who do not fit clearly in either school, who try to reconcile the two points of view or to emphasize some aspect of motivation not stressed by either. The non-Freudian psychoanalysts like Carl Jung or Alfred Adler disagree with Freud primarily on his contention that the basic life urge is sexual in nature; the neo-Freudians like Karen Horney, Erich Fromm and Harry Stack Sullivan stress the importance of cultural as opposed to biological factors in shaping basic human motives. Other psychologists (such as Kurt Goldstein, Abraham Maslow and Carl Rogers) have argued from their clinical experience that the psychoanalysts have overstressed the negative, crippling human urges and not given enough credit to the creative drive for self-actualization. Still another group of psychologists, headed by Henry A. Murray, believes that it is too early to oversimplify human motivation in terms of a few basic urges and that it is necessary first to study the variety of human motives as they actually are found in the life histories of normal adults. Finally, some students of personality, such as Kurt Lewin and Gordon Allport, have had doubts as to whether it will ever be possible to find categories of human motivation which will apply equally to all people; rather the problem is to discover what uniquely motivates this person at this particular time. In general the wide variety in points of view as to the ultimate nature of human motivation reflects the fact that scientific knowledge about the subject is still extremely limited.

**Methods of Studying Motivation.**—All theories of human motivation must ultimately be based on observations of human behaviour, defined broadly to include thoughts or actions. Systematic observation of one's own thoughts, commonly called introspection, has been widely used as a method of studying motives but it has the weaknesses of all self-reports listed in the next section. Fortunately among psychologists there is much greater agreement as to what observations are relevant to motivation than there is as to the ultimate nature of motives. These observations may be divided into two classes: those having to do with ways of getting the organism to do something it would not otherwise do; and those dealing with behavioural peculiarities pointing to the presence of motives as opposed to other determinants of behaviour. In the first class are included all those techniques by which psychologists have experimentally aroused motives in animals or human beings. They may be grouped under four headings:

1. Deprivation. The organism is typically deprived of something it needs for biological survival, such as food or water, for varying lengths of time, and the effects on behaviour are noted.

2. Strong stimulation. Electric shock is most commonly used for this purpose, but air blasts, immersion in water and needle-point showers have also been used to motivate both nonhuman and human subjects to action.

3. Special lures. Among all the stimuli to which an organism is sensitive, certain particular ones seem to evoke innately either approach or avoidance responses. For example, kittens will chase small moving objects. Chimpanzees fear snakes, disentangle simple puzzles and spend time watching a moving object such as an electric train. Human infants will reach for toys and between the ages of three and six months will smile at any moving facelike object. Various psychologists have used such natural lures as a means of studying the motivational processes.

4. Special instructions. It has been demonstrated that human subjects can be motivated by verbal appeal to various motives, such as the desire to do well, to please the experimenter and to be liked by others.

By all four of these techniques the psychologist attempts to manipulate the strength of the induced motivation experimentally and to measure its effects on either symbolic or overt behaviour. There is a fifth technique which is similar to these except that the differences in motivation are produced not by actions of the experimenter but by the past history of the individuals concerned: one may compare a group of clergymen with men in general and assume that the former have a higher average level of religious motivation; or one may assume that a group of champion athletes has a higher competitive drive than a group of less successful athletes. The difficulty with this method is that since the motivational difference is not under experimental control, the two groups may differ in other ways than in the motive in question, and peculiarities of behaviour may be attributed to a motivational difference when they should be attributed to some other factor.

The second class of observational procedures starts not with what is done to the subject to produce motivation but with covert or overt behaviour displayed by the subject that is supposedly indicative of the presence of motivation. There are two ways in which behavioural signs of the presence of motivation have been identified. One is by observing the effects on behaviour when motivation is induced by any of the techniques mentioned above; the other is by determining the characteristics of behaviour that cannot readily be accounted for in terms of any of the other major determinants of behaviour. Both methods have been used to derive the three main effects that motivation is thought to have on behaviour as listed in the table below. The effects have been placed in the left-hand column with two illustrations set out in parallel columns to the right. The first illustration is drawn from the experimental laboratory and shows the three ways in which a rat's overt behaviour is different when he is hungry from what it is when he is not hungry. The second illustration, drawn from the motivational interpretations of dreams and associative sequences common among psychoanalysts and clinically oriented psychologists, is taken from the story of Jonah in the Bible as analyzed by Erich Fromm. It is included to show how analysis of covert behaviour or associational sequences (sometimes by introspection) can parallel interpretations of overt behaviour or action. The Bible story simply tells how Jonah tries to escape from his responsibility to God by taking ship at Joppa. When the ship is at sea a great storm arises, Jonah falls asleep in the ship's hold, the men decide by lot that Jonah is the cause of the storm and cast him overboard into the sea, where he is swallowed by a whale. Jonah repents and the Lord causes the whale to cough him up on dry land. Fromm argues that the story is actually like a dream sequence in which a number of improbable events are actually tied together by Jonah's need for security. That is, he escapes from the Lord first into the ship, then into the ship's hold, then into sleep, then into the ocean and finally into the whale's belly, where he discovers that his efforts to escape have been so confining that he repents and goes back to his duty. The example is included here to demonstrate that while this kind of motivational interpretation is commonly rejected as incautious by experimental psychologists, it in fact relies upon the same criteria that experi-

mental psychologists rely on in working with animal motivation (with one exception to be noted later).

The first unique effect that motivation apparently has is to activate the organism—to keep both the rat and Jonah on the move. It is unique in that without motivation the organism will often not respond even though past behaviour has demonstrated its ability to do so. For instance, a child may know his name perfectly well and may have given it in response to requests on many previous occasions, but on a given occasion he may refuse to give it or say he does not know it. His past behaviour will not readily account for his present refusal, so the concept of motivation is invoked. It is said that he is not motivated to respond.

Motivation also operates to select out certain responses for repetition—namely, those that lead to satisfaction of the motive. The rat repeats those turns which get him to food, Jonah repeats those actions which give him security from the wrath of the Lord,

| A motive | For a rat in a maze, hunger | For Jonah, need for security from the Lord's wrath |
|---|---|---|
| 1. Drives behaviour | makes him persist in his efforts to find food, | makes him persist in his attempts to flee by hiding, |
| 2. Selects behaviour | leads him to repeat those turns which got him to food, | leads him to try one method of hiding after another (in ship's hold, in sleep, in whale's belly), |
| 3. Directs behaviour | organizes his successive acts into a correct sequence | ties his successive acts into an organized attempt to escape |

at least temporarily. In this sense motivation is the key to understanding how many new responses are acquired.

Finally motivation directs or organizes behaviour. Somehow it enables the rat to tie together his turns in the maze into a smooth uninterrupted correct sequence. In Jonah's case, the inference that he has a need for security that ultimately defeats itself ties together or organizes a series of what otherwise would appear to be unrelated or improbable acts. The directive function of motivation is seen even more clearly if other motives are involved. For example, rats can be trained to turn right if they are hungry or to turn left if they are thirsty. If Jonah had been hungry when he entered Joppa, rather than frightened and running away, he undoubtedly would have directed his attention toward the market rather than toward the ship in the harbour. Motivation serves to make certain aspects of the environment especially significant, directing attention toward them and organizing behaviour in terms of them. In this case, too, it would be difficult to explain such a focusing of activity in terms of past habits or abilities.

Although the two examples are similar, they differ in one important respect. In the case of the rat the motive had been induced by food deprivation and the effects on behaviour observed. In the case of Jonah the presence of the motive is inferred on the basis of effects similar to those observed in the rat in the maze. The first approach gives information only on temporarily induced changes in simple biological needs, while the second deals with a significant need in the life of an individual; but the experimental method helps establish the criteria used for the diagnosis of individual motivation, so that the two approaches are actually complementary.

**Measuring Human Motives.**—One problem of major interest to psychologists is how to assess the strength of a particular motive in a person and to compare his behaviour with that of another person who has less or more of the motive in question. For example, does a person with a strong motive to achieve work harder than other people? Is he more likely to work harder in some situations than others? Is the need for achievement generalized or specific to a particular activity like winning at cards? When and how are particular motives laid down in childhood? To answer such questions as these it is necessary to have sound, carefully derived measures of adult human motives. In general, psychologists have pursued three different methods of getting such measures.

1. The first method simply involves asking a person to report his motives, and in its most elaborate form employs a long and detailed questionnaire about motives, interests and values. The responses a subject makes are then searched either logically or statistically for groupings which hang together consistently, and the score on a group of such items is given a name in accordance with the meaning of the items. For example, a person who says that he likes a wife who is less intelligent than he is, that he usually initiates conversation with strangers and that he asks questions after public lectures may be given a high score on the need for dominance. Such questionnaires for assessing individual human motives or needs have some serious flaws. In the first place the subject may not know very well what his interests or motives are, simply because he has not paid much attention to the problem; his answers to the questions then may reflect momentary sets or influences which come up in the course of answering. In the second place, and more seriously, most psychologists have become convinced by the work of Freud and other psychoanalysts that people repress many of their most important motives, particularly the asocial ones, and conscious reports reflect merely rationalizations of those motives which may even be the direct opposite of what the person consciously wants; thus a person who says that he dominates in a variety of social situations may in fact do nothing of the kind and may say so simply as compensation for a deep feeling of inferiority.

2. As a correction for the distortions introduced by conscious reports, psychologists have commonly employed another method in which an outside observer infers what the subject's motives are from observation of many aspects of his behaviour—his dreams, free associations, conscious reports of motives and actual overt actions. This is the method employed by psychoanalysts, and it has been refined by such psychologists as Henry A. Murray who have asked observers to report their motivational inferences on rating scales of relative strength and more than once on the same person to check the reliability of such judgments. The reliability of independent judges, if they are well trained, has often been quite high, indicating that people can agree as to a person's motives. Many psychologists feel that such ratings represent the best measures of human motives that can be obtained. However, they too have some serious drawbacks. In the first place a judgment is necessarily an impure measure of motivation since it represents a synthesis of many different aspects of the person's behaviour, only some of which involve motivation. For example, many judges would agree that a person who both works hard and dreams about great achievement has a higher achievement drive than a person who only dreams about great achievement; yet the motive to achieve may be equal in the two cases, and the fact that the first person works hard may be due to some other factor in his personality. In the second place, ratings unfortunately are determined by the point of view, training and personality of the judges as well as by the behaviour of the person being judged. It has been shown for instance that judges who themselves have a strong need for aggression tend to overemphasize the need for aggression in others. Using many judges will correct for bias only if all the judges do not have the same bias, and frequently they do because they have had the same kind of training; all of them may see the motivation they have been trained to see.

3. Still a third method of measuring human motives which attempts to get around the difficulties implicit in the other two methods has been employed. It involves arousing certain motives, such as the need for achievement and the need for affiliation, experimentally in subjects by instructions, and searching for the unique effects of the motives in standardized samples of fantasy (usually stories written to pictures) collected from the subjects. Unique effects are discovered by comparing the stories with those

written by another group of subjects in whom the motive in question is not aroused. The method has the following advantages: It starts with no preconceptions either in the subject or in the observer as to how the motive will show itself. It employs the kind of behaviour (fantasy) which has been shown to be most readily influenced by motivation. Since the subject ordinarily does not know that his motivation is being tested, he cannot control what he says to make his motives appear favourable or consciously block out certain motives altogether as in the method of conscious report. The method is not influenced by the bias or training of the judges, since the coding of the fantasy material is done objectively by counting the frequency with which certain thoughts appear which are unique to the motive in question. Once the effects on fantasy of a given motive have been determined, those effects are used to diagnose the strength of that particular motive in a person under normal testing conditions. The method has been applied largely to the development of measures of the need for achievement, the need for affiliation and the need for power.

The three methods of measuring motivation do not yield identical results, perhaps because the first two methods have the defects mentioned.

**Effects of Motivation on Behaviour.**—In considering the observational basis for inferring the existence of motivation, some very general effects of motivation on behaviour were listed above. The development of methods of measuring individual differences in human motivation, however, has made it possible to go further and find more precisely how motives influence other aspects of behaviour.

*Motivation and Performance.*—One of the most studied problems of this sort is the relation between motivation and performance. Does higher motivation always lead to better performance? The answer in general is "yes," but with several important qualifications. If sheer response output is the measure of performance, it probably varies directly up to some physiological limit with increases in the strength of motivation. If efficiency in learning is the measure of performance, it increases up to some moderate level of motivation and then decreases as motivation goes still higher. In common-sense terms the person becomes overexcited, more fixed on his goal and therefore less flexible and efficient. Furthermore, an increase in any motive will not increase efficiency on any problem; the problem must be related to the motive. For example, subjects with high need for achievement will work harder on a task if it is to count for their record, but not if it is simply to gain time off from work or to please the experimenter. A hungry rat will not run a maze faster unless there is food at the end; *i.e.*, unless solving the problem is relevant to its need. To turn this observation around, the same act may be performed for a variety of motives—to gain food, to achieve or to please someone. So it is definitely not safe to try to infer a person's motive from what he is working hard at. It would be an error to conclude that, for example, a person who studies hard and does well in school must have a high need for achievement. He may study hard for a variety of reasons, and it is necessary to search beyond his actual performance to find them.

*Motivation and Cognition.*—Another area of considerable interest to psychologists has been the effects of motivation on perception, memory and belief. Is the wish father to the thought? Does a person remember only what he wants to remember? Or are his values perhaps mere reflections of his unconscious motives? Psychological research has not yielded definitive answers to all such questions, but two points are well established. (1) First, a motive sensitizes the person in cognitive areas related to the motive. If a person has high need for achievement he tends to recognize achievement-related words quickly when they are briefly flashed on a screen; if he has a high need for affiliation he is likely to recognize pictures of people more quickly than he does pictures of objects; if he is poor he is more likely to see or remember coins as being larger in size than he does if he is rich; if he is hungry he is apt to judge food stimuli as larger than other stimuli. In other words, motivation makes certain aspects of the environment particularly salient for the individual, and he may well tend to exaggerate them. If his motivation is to avoid an anxiety-producing stimulus, he may demonstrate in reverse the salience of such a cue by seeing it more slowly than he does neutral stimuli, although evidence is less clear on this point. (2) Second, the sensitization effect is maximal when stimulus conditions are ambiguous or when reality factors determining memory, perception or belief are minimal. Ordinarily a person sees what is "out there," and remembers what really happened to him, regardless of his wishes in the matter. It is only when his information is poor that motivation begins to take over and determine what he sees, remembers and believes. In other words, wish may be father to the thought only when there is little or nothing else to be father to it. It has been demonstrated, for example, that a high need for achievement will lead subjects to estimate that they will get high grades on a final examination only if they have no good basis in their past performance for knowing what they will get.

*Motivation and Occupation.*—A third area of interest to psychologists is the extent to which motives influence the choices a person makes as to how he will spend his time. Again, research points to a very simple generalization: a motive will lead a person to engage in those activities in which he is most likely to satisfy that motive. Exactly what those activities are for various motives is only beginning to be worked out. For example, a person with a high need for affiliation will tend to choose a friend rather than an expert as a working partner, presumably because friendship is more important to him than solving the problem quickly. A person with a high motive to achieve will do exactly the reverse. He will also engage in more community activities in college and in later life in order to increase the opportunities for a sense of accomplishment. For the same reason he seeks out situations involving moderate risks, where success is neither pure luck nor a sure thing. He remembers uncompleted tasks better, presumably because they represent an unfulfilled challenge for him. Even more interesting is the way in which the preference for certain activities leads a person to choose one occupation or another. It has been worked out in some detail, for example, how a high need for achievement is most likely to be satisfied in a business entrepreneurial occupation, where there is clear-cut knowledge of results, a sense of personal responsibility and the challenge of moderate risk. Furthermore there is some evidence that as the level of need for achievement rises in a culture, more and more of its members enter entrepreneurial occupations, and the general level of economic development advances so that the growth of civilization may, in part, ultimately depend on the level of achievement motivation among its people.

*Conflicts of Motives.*—Psychologists also have been interested in the effect of conflicts of motives on behaviour. Much depends on the kind of conflict involved. A conflict relatively easy to solve is one between two approach motives, two desires to do something pleasant at the same moment (as the donkey caught between two piles of hay); usually the person vacillates awhile and then chooses one or the other. A much more serious conflict arises when the same activity elicits both an approach and avoidance motive. A rat may want some food but be blocked from approaching it by an electric shock. He is then more or less trapped in a permanent state of conflict between trying to approach and avoid the same object. Such conflicts as this are at the basis of neuroses. A person may want independence from the domination of his mother and yet fear that very independence; he is thus caught with no easy solution possible.

Experimental psychologists, notably Neal Miller, have attempted to determine what a person will do under such circumstances as the strength of the approach and avoidance tendencies are systematically varied. For example, Miller was able to deduce the commonly observed fact that psychotherapy may increase a person's anxiety before he improves. The reason lies in the reduction by therapy of the person's fear of his neurotic difficulty. Before therapy a weak avoidance tendency would keep him from approaching it. After some therapy he approaches it more closely until it elicits a much stronger avoidance or anxiety reaction than formerly.

Clinicians have been concerned with the varieties of defense mechanism a person adopts in handling such approach-avoidance conflicts. For example, he may repress the conflict, deny one side of it, attempt to rationalize it away, develop some bodily symptom which reflects it or attempt to sublimate it in some substitute activity. In general, defense mechanisms may be grouped according to whether they involve an attempt to avoid the motive conflict, to attack and solve it directly, to convert it into something else or to find a substitute means of satisfying one or the other of the two motives. Ultimately an understanding of how conflicts of different motives lead to various defense mechanisms in different kinds of persons is essential to the understanding of neurosis and psychosis (*see* DEFENSE MECHANISMS).

**Origins of Motives.**—Explanations of the origins of human motivation involve both biological and social factors.

*Biological.*—On the biological side there are two schools of thought. The first follows the Darwinian position in placing its major emphasis on simple biological needs and stimuli which become associated with them. It contends in effect that the most complex human motives are nothing but elaborations through learning of the primary biological needs. As an example, take mother love. During the first months of life the human infant is relatively helpless and subject to all kinds of primary drive stimuli—thirst, hunger, pain—which it cannot relieve by itself. The mother, on the other hand, is regularly associated with reducing those needs and hence acquires the power to reduce these discomforts by her mere presence. That is, she is not satisfying in herself at the outset, as food is, but acquires her value as a reward through regular association with satisfaction of the infant's needs. Furthermore the child soon learns to associate absence of the mother with discomfort and anxiety over not being able to reduce his needs, so absence of the mother eventually leads him to do things that he hopes will bring the mother to his side. The child then acts as if he loves his mother, although in fact, he wants her because she has symbolic reward value; *i.e.*, the capacity to reduce his anxiety. While many U.S. psychologists have felt that such a scheme has an engaging simplicity and is perhaps particularly useful in explaining the origin of anxiety, they have also felt that it is not adequate for explaining more complex human motives, particularly those which give no indication of being related to biological needs or anxiety reduction.

The second biological point of view places greater emphasis on species differences in instinctual responses. U.S. psychology lost interest in instincts at about the beginning of the 20th century because of the great stress psychologists were then placing on the adaptability and flexibility of the organism. They demonstrated that nearly all behaviour could be modified by experience and found little place in their thinking for the rigid unvarying type of behaviour they thought characterized instincts. A dominant view was that all animals, including man, were endowed by nature only with a few simple biological needs, and the rest of behaviour was due to learning. By the 1940s and 1950s reaction had set in, particularly under the influence of biologists interested in the behaviour of lower animals. Investigators such as Konrad Lorenz, N. Tinbergen and Harry Harlow demonstrated by careful studies that different species of animals were differentially responsive to certain distinctive cues in the environment. The complex sequence of such cues which leads a male stickleback fish through its elaborate courtship behaviour or which enables a honeybee to learn from the "dance" of another bee at what distance and in what direction honey lies has been worked out. The difference between these studies and earlier ones of instinct lies in the fact that they put more stress on the invariant nature of the "signs" in the environment which automatically evoke certain responses than they do on the invariant nature of the responses themselves. They also pay more attention to species differences in responsiveness to "sign" stimuli. A kitten will pursue and attack a small moving stimulus whereas a white rat will not. A chimpanzee will disentangle a puzzle while a kitten will not. While all species may have similar hunger drives, they differ very much in their innate responsiveness to other stimuli. (*See* also ANIMAL BEHAVIOUR; INSTINCT.)

How about the human species? Are there cues in the environment to which man responds selectively? One notion is that there are indeed many such stimuli but that the human being responds not with a specific overt response but with a diffuse pleasurable reaction to one class of stimuli and with diffuse signs of discomfort to another class of stimuli. Motives then may be associations based on these primary states of positive or negative affect. David McClelland and his co-workers have attempted to state the class characteristics of those stimulus situations which yield positive or negative affect. They suggest that small variations in stimulation over what the organism is "tuned to" or expects are innately pleasurable, whereas large discrepancies are innately unpleasurable. The chief advantage of such a theory is that it provides a changing base for the acquisition of new motives depending on how the "tuning" of the organism is altered by biological or social conditions. Motives are not exclusively tied to simple, unchanging biological needs. Such a view represents a return to older theories that motives are based on pleasure and pain, but with the important difference that more precision is provided as to what innately produces pleasure and pain.

*Social.*—The social origins of motives may be conceived in terms of general conditions which favour the development of one motive or another. For convenience, conditions arising out of the physical environment, the economic structure of the society, the family, religion and culture will be considered in turn. In terms of the general theory of the development of motivation given above, social conditions may be thought of as providing certain regular experiences for individuals which lead them to expect certain things. The difference between what they expect and what they experience then yields positive or negative affect, providing the basis for motivation.

Several scholars, notably Ellsworth Huntington and Arnold Toynbee, have argued that geography is a major determinant of human motivation in the extent to which it stimulates man to action. Both men were impressed by the fact that most major civilizations seem to have developed in the temperate zone, and Toynbee has developed the notion that just the right amount of challenge from the environment is necessary to produce the most creative response from mankind. Too much challenge, as in the arctic regions, or too little, as in the tropics, will not motivate man optimally. Such theories do not stand up under close factual examination. For example, Maine, which Toynbee finds less stimulating than Massachusetts, has about the same climate as northern Ireland, which he finds more stimulating than southern Ireland. Or the climate of southern Australia appears to have been particularly challenging to the Australians while the same climate in the southern part of the United States he conceived as not very stimulating. Huntington makes a case for desert conditions producing certain motives in the Arabs who inhabit the Sahara region, but he fails to note that the same motives do not occur among the Navaho who also inhabit a desert region in the United States. If climate has an effect it is marginal, operating through social institutions.

Social theorists have been particularly apt to point to the economy as a source of many of man's major motives. Karl Marx developed a whole theory of history based on the profit motive, on the need of the *bourgeoisie* to exploit the workers in order to make more money. Other theorists have spoken of conditions such as population growth, inflation or scarcity of goods which supposedly have motivated men to work harder or less hard. While such factors are undoubtedly of importance in a particular cultural context (especially the west), psychologists urge caution in interpreting them as universal sources of particular motives. Population growth may motivate one people to work harder to get food for the extra mouths; it may produce apathy and hopelessness in another people. Economic conditions operate in terms of existing motives and values in the group. One of the few instances in which the economic situation seems to have been the primary determinant of motivation of a people is provided by the case of southern Negroes in the United States. When slaves were brought into the south they were effectively "decultured" by being mixed with other persons of different cultural backgrounds.

In this situation their economic dependence on their white masters became of overriding importance in determining their motives, since no common cultural values existed to alter the significance of their economic condition.

The family influences motives in part by the way parents rear their children and in part through its structure. Much detail has been gathered by psychologists on what particular parental attitudes and practices affect given motives, and at what ages. For instance the children of authoritarian parents are likely to have greater needs for dominance and also for submission; their motivation, in other words, is centred around power, to be wielded or yielded to. Parents who stress achievement, particularly at an early age, on the other hand, are likely to produce children with stronger need for achievement. In general these studies support the view that the early formative years are more important for the development of basic motives than are the later years, which exert more influence on beliefs and values.

The structure of the family has been considered of special importance by psychoanalysts, who have emphasized the fact that many of the male child's motives develop out of the competition he feels with his father for his mother's love (the so-called Oedipus complex). The way in which the boy handles his jealousy of his father may be of major significance in determining his motivational pattern throughout the rest of his life, although there is not as yet a great deal of objective evidence on this point.

Religion also plays a role in the development of motivation. The German sociologist Max Weber argued at about the turn of the 20th century that Protestantism had infused a new spirit into its adherents which led them to engage in a more vigorous type of capitalistic enterprise than had been characteristic up to the time of the Reformation. He found that such unusual energy could not readily be explained in terms of the minority status of Protestants in many countries, since in England Catholics, who had a minority status, did not appear to be motivated in the same way. Weber felt instead that it was the nature of Calvinism itself which drove its adherents to ever greater efforts to prove their perfection and to demonstrate thereby their predestined inclusion by God among the elect. Empirical studies in the 1950s by McClelland and his co-workers showed that there may have been a connection between Protestantism, early achievement training, higher achievement motivation and greater and more successful entrepreneurial activity. Here is a clear case where the values of the parents coming from their religious background influence their attitudes toward child rearing, which in turn affect children's motives. Studies of this kind are still few in number and need to be pursued further to demonstrate the interconnectedness of social influences on motives.

Finally, other traditional influences affect motivation. For example, French-Canadians appear to have a lower average level of achievement motivation than do Italians, even though the groups are matched for the physical environment in which they live (New England), their socioeconomic status, family structure and religion. The difference must be attributed to some cultural factor not yet clearly understood. It is especially noteworthy that cultural differences in the average level of motivation have been empirically demonstrated by the objective methods of measuring human motives discussed above. Such differences in motivational level among peoples have frequently been assumed in prescientific psychology but have been just as often discredited by psychologists, partly because there was no objective evidence for the differences and partly because they were often linked to racist theories of human nature. There is increasing objective evidence, however, that cultural differences in motivation do exist, though there is no evidence that they are due to heredity. The reason is simple. Historical studies have demonstrated that the same culture or racial group (*e.g.*, the British) may have a high average level of motivation (*e.g.*, need for achievement) at one period in its history (*e.g.*, about 1925) and a lower level not long after (about 1950). The logical inference is that motivation level cannot be attributed to racial inheritance (since it could not have changed in so short a time) but must vary with changing economic, social and religious conditions in the culture. *See* EMOTION; PERSONALITY; PSYCHOLOGY; PSYCHOLOGY, EXPERIMENTAL; PSYCHOLOGY, PHYSIOLOGICAL.

*See* also references under "Motivation" in the Index.

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**MOTIVATION RESEARCH:** *see* PSYCHOLOGY, APPLIED; PUBLIC OPINION.

**MOTLEY, JOHN LOTHROP** (1814–1877), U.S. diplomat and historian best remembered for his celebrated work *The Rise of the Dutch Republic*, was born at Dorchester, Boston, Mass., on April 15, 1814. He spent two years at the experimental Round Hill school run by George Bancroft and J. G. Cogswell and graduated from Harvard in 1831. He then studied law at Göttingen and Berlin, returning to Boston in 1835. In 1837 he married Mary Benjamin. He was secretary to the U.S. legation in St. Petersburg for a few months in 1841 and was later minister to Austria (1861–67) and Great Britain (1869–70).

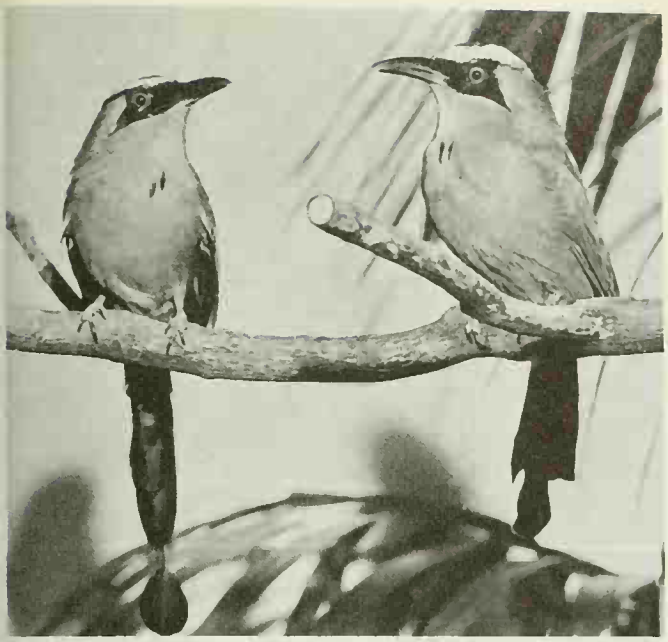
After 1846 Motley became increasingly interested in Dutch history, studying first in Boston and then in the archives at Dresden, The Hague and Brussels. He published *The Rise of the Dutch Republic* in 1856. This remarkable work of amateur scholarship quickly gained a high place among the literary classics of 19th-century popular historical writing, and it familiarized many people with the events of the Dutch revolt. As a classic it endures, although as history it has long been superseded. In Motley's view religious persecution was the ultimate cause of the Netherlands' revolt from Spain. The conflict was, for him, between Protestantism, tending toward democracy, tolerance and rationalism, and the Catholic absolutism of Spain. His narrative stressed drama and characterization, and he judged the issues in terms of 19th-century liberal values. Contemporary Dutch historians (R. J. Fruin and Bakhuizen van den Brink) criticized him sharply for failing to understand the environment and inner structure of the events and personalities he described. More recently the notion of religion as the basic cause of the revolt has been modified to include constitutional and economic factors.

Motley planned to carry his history down to 1648, but he died (May 29, 1877, at Dorchester, Dorset, Eng.) before he could complete his work. By then he had published *The History of the United Netherlands, 1584–1609*, four volumes (1860–67) and *The Life and Death of John of Barneveld*, two volumes (1874).

*See* C. P. Higby and B. T. Schantz, *John Lothrop Motley, Representative Selections* (1939); D. Levin, *History as Romantic Art* (1959); R. Wheaton, "Motley," in *New England Quarterly*, vol. xxxv, pp. 318–36 (1962). (R. WH.)

**MOTMOT,** the name for several species of beautiful tropical American birds constituting the family Momotidae (order Coraciiformes), most nearly related to todies, kingfishers and rollers (*qq.v.*). These quiet birds of dense shady forest or thickets are striking in appearance, being chiefly green with bluish and black markings. The excessively graduated tail of round-ended feathers in most species is long and peculiarly shaped; the middle pair is much longer than the next, and devoid of web subterminally for one inch or more, so that the tips are racket shaped. These feathers are entire in the young, but brittle in the stem region, where the web breaks off easily as the bird preens with its jay-like but saw-toothed bill.

Motmots are solitary. They fly in shallow undulations or perch oddly on branches of trees, occasionally twitching the long tail from side to side like a pendulum or angling it in an unusual attitude. They feed chiefly on insects caught on the wing, and on small reptiles and fruits, becoming omnivorous in captivity. Like the kingfishers and todies, motmots excavate holes in banks of streams, in some species seeking caves or rock crevices, and lay three or four white eggs. The Mexican motmot (*Momotus mexicanus*), 12 in. long, of which 6 in. is tail, inhabits thickets over arid western



BY COURTESY OF THE NEW YORK ZOOLOGICAL SOCIETY

LESSON'S MOTMOT (MOMOTUS LESSONII LESSONII). TAIL RACQUETS COMPLETELY DEVELOPED ON BIRD AT LEFT

and southern Mexico to interior Guatemala. The blue-crowned motmot (*M. momota*), 15 in., tail 9 in., is one of the largest and most common; it ranges in tropical forests from northeastern Mexico to eastern Brazil and northwestern Argentina. The turquoise-browed motmot (*Eumomota superciliosa*), 14 in., from southern Mexico to Costa Rica, is green above and on the breast, and has a black throat and cinnamon sides and belly. The keel-billed motmot (*Electron carinatum*) ranges from Veracruz to northwestern Costa Rica, the broad-billed motmot (*E. platyrhynchum*) from eastern Honduras to northern Bolivia. The red-throated motmot (*Aspatha gularis*), 10 in., from southern Mexico to Honduras, has no tail rackets. The tody motmot (*Hylomanes momotula*), about 7 in. long, ranging from southern Mexico to northwestern Colombia, has shorter tail feathers, also without rackets. (G. F. Ss.; X.)

**MOTOR, ELECTRIC,** a device for converting electrical energy into mechanical energy. It is the complement of the electric generator, the two devices together providing the link between electrical and mechanical systems. All generators may act as motors and, conversely, all motors may act as generators; they differ only in some construction details and in their auxiliary equipment. (*See* MAGNETOHYDRODYNAMICS.)

The principal phenomena that may provide a coupling between electrical and mechanical systems are: (1) electromagnetic, in which forces are established as a result of an interaction between magnetic fields created by the stationary and moving parts; (2) electrostatic, in which forces are produced by the interaction of electric fields created by the stationary and moving parts (*see* ELECTRICITY: *Electrostatics*); (3) magnetostrictive, represented by the deformation of materials subjected to magnetic fields (*see* MAGNETISM: *Stress and Magnetostriction*); (4) piezoelectric, represented by the deformation of certain crystals when subjected to an electric field (*see* PIEZOELECTRICITY); and (5) magnetohydrodynamic, or the production of a force when a stream of charged particles is discharged or impinged upon a collector. By far the most commonly exploited phenomenon is the electromagnetic, because it makes possible the conversion of more energy per unit weight, volume and cost. Electric motors, which utilize this phenomenon, may range in output from a fraction of a watt (0.0001 h.p.), for use in instrument control systems and servomechanisms, to several thousand horsepower, for pumps and wind tunnel drives.

## BASIC PRINCIPLES

According to the Hamilton-Lagrange principle, as applied to electromagnetic devices such as the electric motor, a mechanical force is established when there is a change in magnetic field energy with movement. Thus, to have a unidirectional average force, the average change in energy with displacement must be positive, and in a motor the net average power input (after satisfying the losses) must be positive.

Two more familiar (but less general) principles are those of Ampère and Faraday. Ampère's law says that a conductor will experience a force if a component of current in that conductor flows at right angles to a magnetic field. Faraday's law states that a potential difference will exist between the ends of a conductor if that conductor is given a component of motion perpendicular to the magnetic field. These relationships are illustrated in fig. 1; it should be noted that the induced voltage (fig. 1[B]) opposes the voltage that would be necessary to force the current $i$ through the conductor of fig. 1(A).

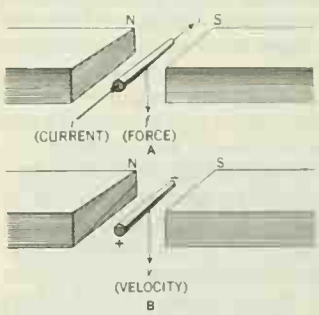



FIG. 1.—CURRENT AND POLARITY RELATIONSHIPS ASSOCIATED WITH (A) AMPÈRE'S LAW; (B) FARADAY'S LAW (*see* TEXT)

To exploit these principles and convert electrical energy into mechanical energy, motors must consist of two parts—a rotor and a stator. The rotor is the moving portion and contains conductors to establish and shape the magnetic fields that will interact with those produced by the stator. The rotor also comprises a contacting device (slip rings or commutator) to connect it electrically with the stator, together with a supporting shaft and bearings, an integral blower for cooling, etc. The stator consists of similar magnetic and electrical conductors to establish and shape the magnetic fields, as well as the frame to support the whole machine. The manner in which the conductors are arranged (and in which the magnetic fields are controlled) determines the type of motor and its characteristics.

## INDUCTION MOTORS

An induction motor has two sets of insulated-wire windings: one (usually on the stator) is connected to an external power source; the other, on the rotor, consists of continuous wire loops. The magnetic field established when currents flow in these conductors is concentrated in a narrow air gap between the stator and the rotor. The purpose of the windings connected to the external energy source is to produce a rotating field that interacts with the induced currents in the rotor conductors, thereby establishing forces on those conductors.

To set up a rotating field, there must be at least two windings carrying currents whose phase relationships are not the same. Fig. 2(A) illustrates two alternating currents whose amplitudes are the same but whose phase relationship is 90°. Fig. 2(B) shows schematically a stator on which four coils have been wound; coils 1 and 3 are so connected that if the current $i_1$ is in the direction shown, the polarities of the magnetic field at the stator surface will be north at the upper and south at the lower coils; when the current $i_1$ reverses, so do the polarities of the fields. Coils 2 and 4 are also connected so that a current $i_2$ produces a similar field. As shown in fig. 2(A), at a given instant of time $t_1$, $i_1$ is a maximum and $i_2$ is zero. Under these conditions the field situation is as shown in fig. 2(C). A quarter-period later, at $t_2$, the current $i_1$ is zero and $i_2$ has risen to a positive maximum. The resulting field conditions are now as shown in fig. 2(D). At a third instant, $t_3$, $i_1$ has advanced to a maximum, but in the negative sense, while $i_2$ has fallen back to zero from a positive maximum. The field situation is now that of fig. 2(E). Finally, at $t_4$, $i_1$ has again become zero and $i_2$ has reached a negative maximum, and fig. 2(F) shows the resulting fields. The north pole is found to travel around the periphery of the stator, making one complete revolution while the current goes through one cycle. Hence a revolving field is produced, and its speed depends solely upon the geometry of the coils and the time required for one cycle. For a 60-cycles per

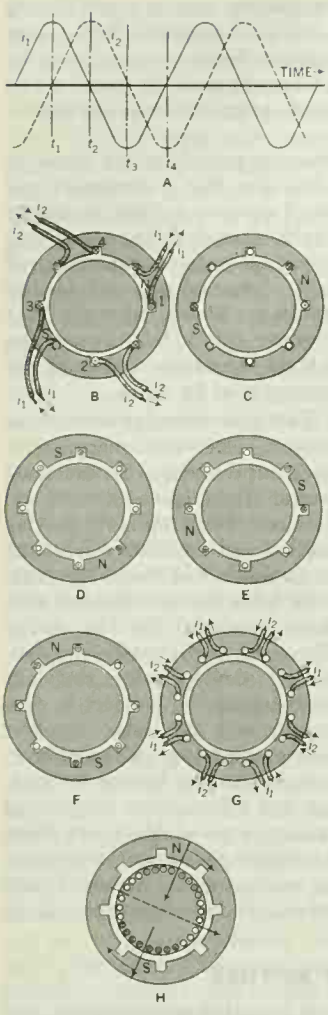



FIG. 2.—INDUCTION MOTOR FIELDS AND THEIR INTERACTION WITH ROTOR AND STATOR CONDUCTORS: ⊙ CURRENT DIRECTED TOWARD VIEWER, PERPENDICULAR TO PAGE; ⊙ CURRENT DIRECTED AWAY FROM VIEWER

second (c.p.s.) power supply, 60 revolutions will be made in one second, or 3,600 revolutions in one minute. The speed of the revolving field is known as the synchronous speed.

If each coil is reduced in size so that it spans just one-half the stator surface (fig. 2[G]), the revolving field will travel only half as far for each cycle of the supply current and the speed of the revolving field will become 1,800 r.p.m. for a 60-c.p.s. supply. The coil arrangement of fig. 2(B) is said to produce a two-pole motor, since at any instant there are but one north and one south pole. The arrangement of fig. 2(G), on the other hand, will produce two north poles and two south poles at any instant and therefore is a four-pole stator. It is not uncommon to have as few as 2 or as many as 100 poles in a motor. The speed of the revolving magnetic field in revolutions per minute in any motor is $120 f/p$, where $f$ is the frequency in cycles per second and $p$ is the number of poles.

In a practical motor the stator will have more coils than indicated here, and these will be distributed around its periphery in equally spaced slots. This arrangement makes better use of the available space than does the concentrated-coil arrangement described above, but the result is still the same—a revolving field is established.

If a set of conductors is uniformly spaced around the periphery of a rotor, as shown in fig. 2(H), and if the rotor is stationary and a two-pole revolving field is located in the position shown, a voltage will be induced (according to Faraday's law) in a direction out of the page in the upper conductors and into the page in the lower conductors. If these conductors are now short-circuited through an end ring, currents will flow in the same directions as the induced voltages. These currents in turn will produce their own magnetic field, and its direction will be as shown by the dash lines in fig. 2(H). The north pole of the rotor and south pole of the stator will attract each other, and a torque will be exerted on the rotor tending to turn it in the direction of the rotating field.

If the rotor is traveling at the same speed as the revolving field, there will be no induced voltage in the conductors, no current flow and no torque. Hence, at synchronous speed the torque drops off to zero. If the rotor travels faster than synchronous speed, the motor is serving as an induction generator.

**Construction Features.**—The rotor and stator are built up of laminations of 0.25% to 3.50% silicon steel, from 0.025 to 0.014 in. thick. The laminations are sometimes coated with an insulating varnish to reduce eddy-current losses. Uniformly distributed slots are punched in the steel to receive windings.

The coils connected to the external energy source (usually the stator coils) may be preformed and insulated and then inserted into the machine, or the conductors may be placed directly into the slots and the insulation applied afterward. The former technique is used for motors rated at more than 600 v, or about 100 h.p. Fig. 3 shows slot cross sections for the two types of windings.

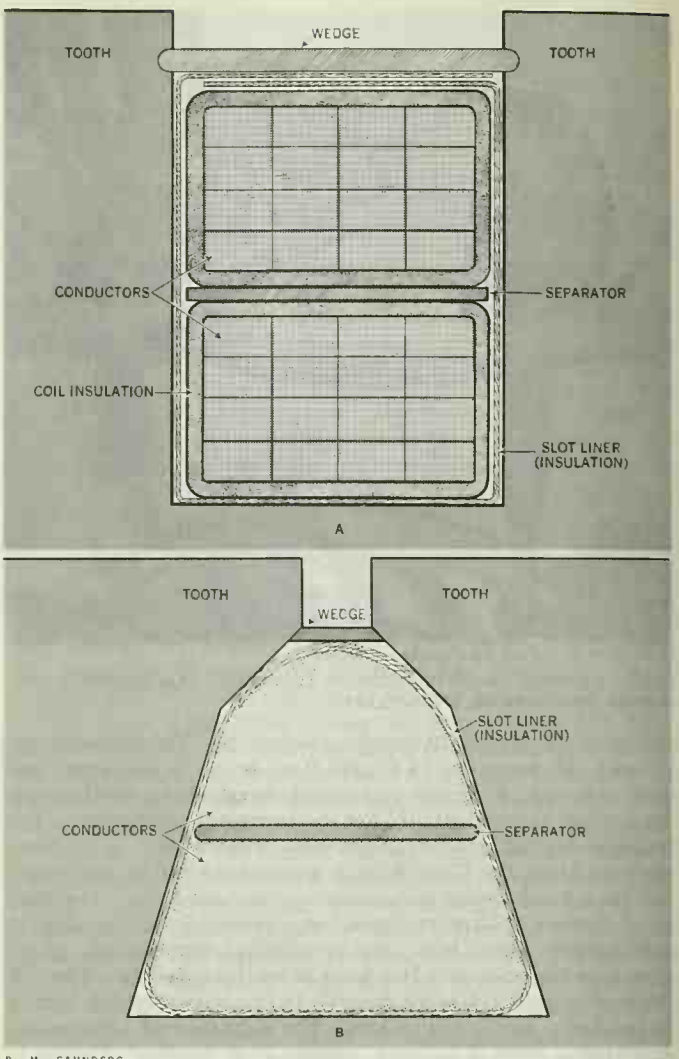
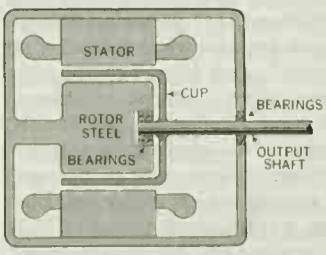



FIG. 3.—MOTOR COIL WINDINGS: (A) COIL CONDUCTORS PREFORMED AND INSULATED BEFORE INSERTION IN STATOR SLOT; (B) CONDUCTORS WOUND DIRECTLY IN SLOT ("MUSH" WINDING) AND THEN INSULATED

The conductors that form the secondary winding may be of three types: wound, squirrel-cage or solid. To make the wound type, a two- or three-phase winding is placed in the rotor slots and some of the terminals brought out to slip rings, which are insulated brass or bronze rings on which carbon brushes ride to provide an electrical connection to the rotor coils.

The squirrel-cage winding may be either cast from aluminum or copper or built up from copper or brass bars welded to a common end ring. To cast such a winding, a stack of rotor laminations is inserted in a centrifugal casting machine and molten aluminum or copper is introduced. The result, after the metal solidifies, is an integrally cast set of longitudinal conductors and two end rings. The cast winding is used for standard production line motors in sizes under 100 h.p. For larger motors the welded bar type is used.

An example of the solid or continuous winding is the drag-cup motor (fig. 4), which consists of a piece of copper or brass rotating independently of the "rotor" steel, which actually is stationary. A solid copper sheath shrunk on the rotor steel will also provide a continuous conductor. The continuous-winding rotors are used principally for servomotors.




FROM R A BRUNS AND R M SAUNDERS, "ANALYSIS OF FEEDBACK CONTROL SYSTEMS," 1955 REPRODUCED BY PERMISSION OF MCGRAW-HILL BOOK COMPANY

FIG. 4.—CROSS SECTION OF A DRAG-CUP SERVOMOTOR

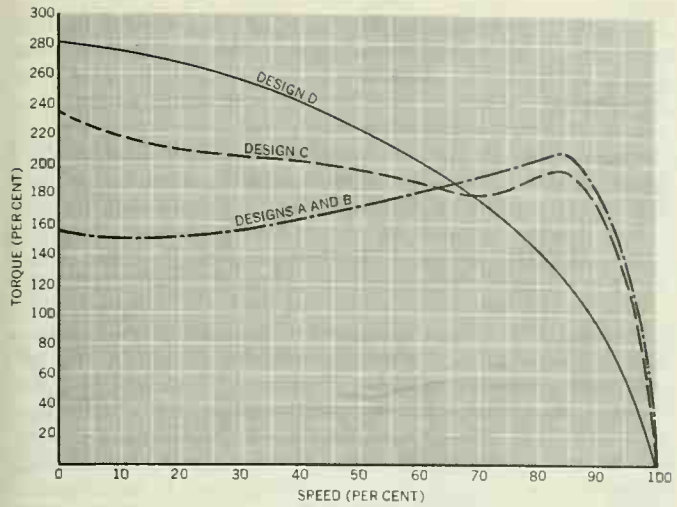



FIG. 5.—SPEED-TORQUE CURVES FOR INDUCTION MOTORS

**Polyphase Induction Motors.**—The three-phase stator connection is by far the most common, because most industrial power distribution systems are three-phase. In this type of motor the revolving field is produced by three different currents whose phase relationships are 120° instead of the 90° shown in fig. 2(A).

Both squirrel-cage and wound-rotor motors may be used in polyphase service; however, the latter are usually reserved for speed-control applications. Squirrel-cage motors may also be classed in terms of their starting current and their speed-torque curves. Fig. 5 shows typical speed-torque curves for commercially available induction motors.

**Single-Phase Induction Motors.**—In describing how a revolving field was produced it was pointed out that a necessary condition was that there be at least two currents out of phase in time and flowing in coils displaced in physical position from one another. While it is possible to satisfy the spatial requirement when a single-phase supply is used, it is more difficult to satisfy the time relationship for the currents flowing in the two sets of coils. The most common ways of solving this problem are described below.

*Capacitor-start, Capacitor-run Motor.*—For this type of motor the stator is built as for a two-phase motor; *i.e.*, with windings spaced 90° apart in a two-pole case. The main winding is connected directly across the power line and an auxiliary winding is connected to the line through a suitable capacitor. The electric field in the capacitor tends to overcome the effect on the circuit of the magnetic field in the motor so that the current flowing in the auxiliary winding (containing the capacitor) is out of phase with that in the main winding and the necessary theoretical conditions are satisfied. One difficulty with this arrangement is that the 90° phase relationship is obtained only for one condition of load at the rated speed. To obtain satisfactory characteristics during the starting period, another capacitor is placed in the circuit to retain the 90° phase relationship; the second capacitor is then taken out of the circuit at about 80% of rated speed by means of a centrifugal switch. Fig. 7 shows the speed-torque curve for a motor of this type.

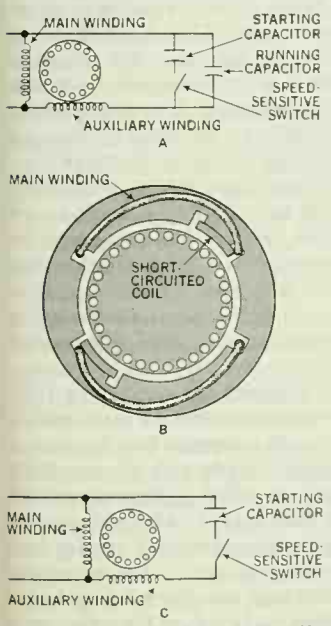



FIG. 6.—SINGLE-PHASE MOTOR CIRCUITS: (A) CAPACITOR-START, CAPACITOR-RUN; (B) SHADED-POLE; (C) CAPACITOR-START

*Shaded-pole Motor.*—If a permanently short-circuited coil is placed over a portion of the main field coil, thus "shading" it as shown in fig. 6(B), the result will be a field similar to that produced by two out-of-phase currents. Because the winding cannot be displaced 90° and the currents cannot be 90° out of phase in time, this type of motor has a low speed-torque curve and is used principally for fans, phonographs and household appliances.

*Other Types.*—Another group of motors employs a revolving field only during the starting period and then runs on a pulsating field, which may be regarded as two counter-rotating fields of equal magnitude. If the rotor response was the same to both fields, the net torque would be zero and the motor would not run at all. However, the rotor impedance can be made higher to the field rotating in the reverse sense than to the field rotating forward; thus, less reverse current flows in the rotor bars and a net forward torque results. However, at a standstill the forward and backward torques are equal, and the motor will not start unless some special provision is made. For example, an auxiliary field may be put into the circuit for starting and then switched out when the motor attains about 80% of its rated speed; or internal connections may be provided that in effect make the motor a different type for starting (*e.g.*, the repulsion-start motor), after which the connections are changed automatically so that the motor runs on the pulsating field.

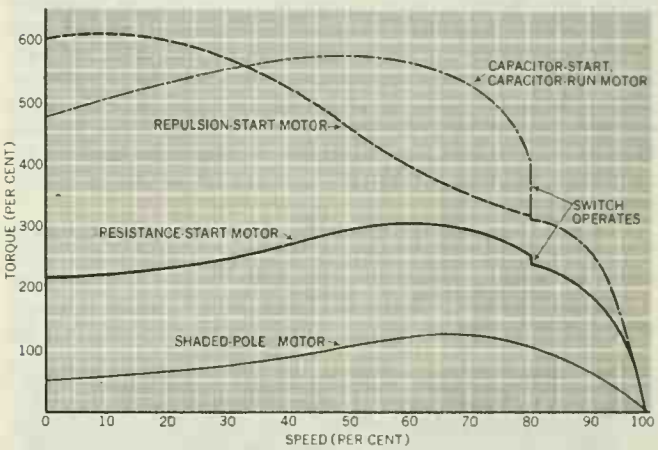



FIG. 7.—SPEED-TORQUE CURVES FOR SINGLE-PHASE INDUCTION MOTORS

Of the auxiliary field types the capacitor-start motor is very common; its circuit is shown in fig. 6(C). In the resistance split-phase motor the capacitor is omitted, and consequently there is lower starting torque, since the currents cannot be shifted 90° out of phase. Repulsion-motor principles are also used for this purpose; during the starting period the motor operates as a repulsion motor until a centrifugal switch short-circuits the repulsion winding, and the machine operates thereafter as an induction motor.

Capacitor-start motors are used for refrigerators, compressors and other equipment in which the starting torque requirements are high. Resistance split-phase motors are used for light tools and other equipment starting unloaded. Repulsion-start motors have been largely replaced by capacitor-start, capacitor-run motors. The characteristics of several single-phase motor types are shown in fig. 7.

**Servomotors.**—The motors used in control systems may be operated from two-phase or single-phase supplies. Fig. 8(A) shows the usual method of energizing a servomotor through an amplifier. The reference-phase voltage is constant, but the con-

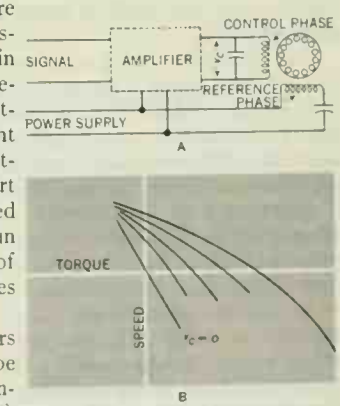



FIG. 8.—SERVOMOTOR OPERATING CHARACTERISTICS: (A) SCHEMATIC DIAGRAM OF MOTOR CIRCUIT; (B) SPEED-TORQUE CURVES AT VARIOUS VALUES OF CONTROL VOLTAGE $V_c$

trol phase has a variable voltage impressed upon it from the amplifier, which in turn receives its signal from the rest of the control system. If the rotor resistance is relatively high, the motor will exhibit variable speed characteristics. Fig. 8(B) shows a set of typical servomotor speed-torque curves.

These motors sometimes have drag-cup rotors, but they are more commonly of the squirrel-cage type. They are limited to small outputs because much of the power input appears as loss, and this loss must be dissipated as heat in the rotor.

**Speed Control.**—Induction motors basically are constant-speed devices and are used most frequently as such. However, if speed control is desired, several methods are available: frequency control, pole changing, addition of rotor or secondary resistance, stator voltage control and counter-rotor voltage control.

In discussing the revolving field it was pointed out that the speed of the field is a function solely of the power-supply frequency and the design of the winding. Thus if the frequency is varied, the synchronous speed of the field will change and, depending to some extent on the load, the shaft speed will also change. This method requires some external device to alter the ordinarily unvarying frequency of the power supply.

The pole-changing method involves connecting the individual stator coils (as in fig. 2[G]) externally. Thus, adjacent coils may be of either the same or opposite polarity, depending on how they are connected. If adjacent coils are of the same polarity, the result will be half as many magnetic poles as when the coils are of opposite polarity, and the synchronous speed will be doubled. However, this method makes it possible to change the motor speed only in discrete steps (usually 2:1); it does not provide for continuous variation.

Control of motor speed by varying the power-supply voltage is not very effective in A.C. induction motors (except in servomotors), but some speed variation is possible within narrow limits.

Secondary or rotor resistance control can be applied only to a wound-rotor motor. If external resistances are connected into the rotor circuit, the resulting speed-torque curves will be similar to those of fig. 9.

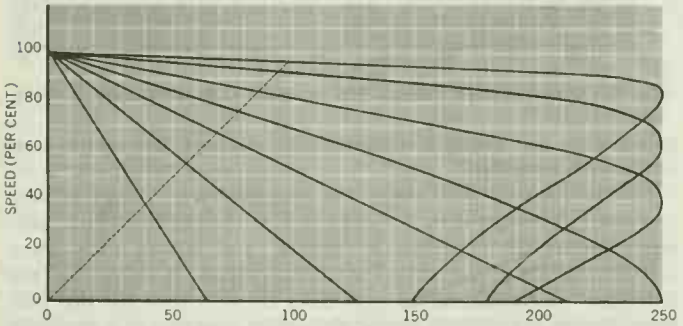



FIG. 9.—SPEED-TORQUE CURVES FOR WOUND-ROTOR INDUCTION MOTORS

One difficulty in using rotor-resistance speed control is that the losses in the external resistor may become so substantial that it is desirable to offset them by employing counter-voltage methods. These involve the use of auxiliary machines and are justifiable only when the rotor loss is sufficiently important economically to warrant the investment in additional equipment.

**Starting and Protection.**—Induction motors are extremely rugged and in the smaller sizes (under 25 h.p.) usually will withstand sudden application of full voltage at standstill without damage. However, for larger motors the electrical supply system must be protected against sudden surges arising from the large starting currents produced. All induction motors (except servomotors and those used in speed-control service) during the starting period draw from four to six times the normal running current. When the electrical system will not withstand such currents there are four techniques that may be used: reduced-voltage, resistor or reactor, Y-delta or part-winding starting.

For reduced-voltage starting an autotransformer is used to lower the applied voltage to 65%–80% of normal. Because the current is proportional to the square of the voltage, an 80% reduction in voltage will mean that only 64% of the full-voltage current will be drawn. However, because of derating, these autotransformers can be used only for very short periods of time.

The second method involves simply the provision of resistors and reactors that can be switched into the supply lines to limit the current during starting.

For motors operating on three-phase power, the windings may be connected either with both ends across the line (delta) or with one end on the line and the other connected to the remaining two windings (Y), as in fig. 10. If a motor designed with delta-connected windings is reconnected Y, the voltage across the windings is reduced to 57% of normal and the current will be only one-third that drawn at full voltage.

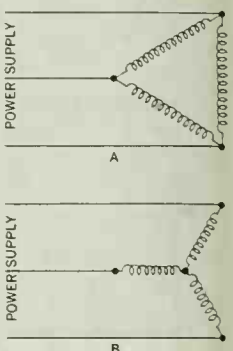



FIG. 10.—MOTOR WINDINGS FOR THREE-PHASE POWER SUPPLIES: (A) DELTA-CONNECTED (B) Y-CONNECTED

Part-winding starting is possible if connections are provided so that only part of the motor winding is in the circuit during starting, the remainder being switched in as the motor picks up speed.

Protecting induction motors is primarily a problem of preventing damage to the windings from excessive heat. On motors under 5 h.p. internal temperature-sensitive switches are provided to open the main line if the temperature rises above a certain value. Temperature detectors embedded in the windings are used on large motors.

## SYNCHRONOUS MOTORS

Synchronous motors, like induction motors, operate on the principle of the revolving magnetic field, produced usually by the stator. However, the rotor of the synchronous motor is designed so as to produce a constant field. If, for example, a two-pole rotor of this type is excited with direct current through slip rings, a north and a south magnetic pole will be produced on the rotor. If the rotor is traveling at the speed of a revolving stator field such as that shown in fig. 2([C], [D], [E], [F]), the two fields will lock together and the rotor will be pulled around at the same speed as the revolving field.

**Construction.**—In most synchronous motors the winding that produces the revolving magnetic field (known as the armature winding) is on the stator, and the design of such a stator is essentially the same as for an induction motor. (For a synchronous motor that has its armature winding on the rotor, the design is much the same as for a wound-rotor induction motor.) A unidirectional field, to interact with the revolving field produced by the stator armature winding, is produced on the rotor by exciting a direct-current winding from a 125- or 250-v. D.C. source.

Motors using D.C. fields must have some means of starting. In most motors this is accomplished by installing a squirrel-cage winding in the pole faces of the rotor. Such a motor operates on induction motor principles up to about 95–97% of synchronous speed, at which point the D.C. field is applied. The motor then locks into synchronism. Motors with this type of field winding usually are more costly to build than general-purpose induction motors in sizes up to 300–500 h.p.

In small motors it is possible to eliminate the need for a D.C. power source by building the field structure from the same metals used for permanent magnets. The field structure then is given a permanent residual magnetic field that locks in with the revolving field at synchronous speed. These so-called hysteresis motors have a lower power-to-weight ratio than the D.C.-excited types described above, but they are useful in some low-load applications where constant speed is important—as gyro-spin motors in navigational equipment, in phonographs and tape recorders and in clocks.

Another type of field construction is found in the reluctance motor, in which no rotor winding is used at all, the toothed design of the rotor producing the synchronous motor characteristics. If the rotor lags behind the revolving field, the average energy

stored in the air gap around it decreases. This produces a greater positive ratio between the stored magnetic energy and the displacement angle, and a greater torque is established, pulling the motor back into synchronism. The power-to-weight ratio here is even more unfavourable than in the hysteresis motor, but the reluctance motor can be used to power certain instruments and electric clocks.

**Polyphase Synchronous Motors.**—Like most induction motors, synchronous motors are designed to operate on three-phase power in sizes above 1 h.p. Furthermore, in such sizes they are always D.C. excited.

The source of direct current may be rectifiers, D.C. generators (exciters) driven from the motor shaft or separate motor-generator sets.

One important feature of synchronous motors is that control of the field current affords a means of power factor control. When the D.C. field of a synchronous motor is overexcited, the motor must draw a demagnetizing component of current from the power lines to compensate for the overmagnetization that takes place. The demagnetizing current drawn by the synchronous motor will balance some of the magnetizing current drawn by other induction machines on the same power line. This component of alternating current transmits no energy but does cause additional loss in all associated equipment, such as transmission lines and transformers. In most cases power company rates are adjusted to reflect the cost of supplying magnetizing current, and it is often economically feasible to correct for this condition in a manufacturing plant rather than pay the power company. Thus a synchronous motor may serve the dual purpose of driving a load at constant speed and at the same time reducing the net magnetizing current drawn from the power lines. In fact, in some cases it is economically justifiable to operate a motor solely for the purpose of power factor correction. A motor designed for this service has no output shaft and is referred to as a synchronous condenser.

**Single-phase Synchronous Motors.**—As was the case for induction motors, a revolving field is needed, and to produce it a capacitor may be inserted in the second phase of a two-phase motor or a shaded-pole structure may be used. Thus a revolving field is established, although it is inferior to that provided by a polyphase supply.

There is relatively little demand for D.C. field-excited motors in sizes under 1 h.p., so virtually all small motors are hysteresis or reluctance types. Such motors rarely develop more than 20% to 50% of the power that could be expected from a magnetic circuit of the same size in an induction motor.

Of special interest is the single-phase synchronous motor used in electric clocks. A two-pole rotating field is set up by means of shaded-pole construction. The resulting rotating field reacts with one or more thin disks of hardened steel especially chosen for their wide hysteresis loop characteristics and housed in a sealed metal container. The rotating field starts the motor by eddy-current action in the container and brings the motor up to speed, usually 3,600 r.p.m. As the motor approaches synchronous speed, the rotating field magnetizes the disks and they then are locked in with the revolving field. A sealed gear train reduces the speed to 1 r.p.m. at the motor shaft. While these motors have efficiencies of less than 1%, they are very inexpensive to build and operate.

**Speed Control.**—Synchronous motors are less amenable to speed control than are induction machines. Only two methods are suitable: frequency control and pole changing. The principles are the same as for induction motors.

**Starting and Protection.**—Small synchronous motors of the hysteresis and reluctance type are started on full voltage and are protected (if at all) by a thermal cutout in the same fashion as for induction machines.

Larger machines using D.C. fields have more troublesome starting problems than any other class of electric motors. Not only must the current inrush to the motor from the power source be controlled, as was the case for the induction motor, but the field must be protected from high voltages arising from transformer action. Then, when the rotor has been accelerated up to synchronous speed, direct current must be applied to the field at the proper instant. On the other hand, synchronous motors may be designed to have almost any type of starting torque characteristic without sacrificing good running features. Starting torques of from 40% to 600% of full load may be obtained, with corresponding starting currents 250%–600% of normal. The method of limiting current inrush to the armature winding is the same as for induction motors.

During the starting period the field winding is generally short-circuited. When the machine has accelerated to 95%–97% of synchronous speed, D.C. current is introduced to the field and the motor locks in to synchronism. Application of the D.C. field current at the proper moment can be done automatically by taking advantage of two motor characteristics: as the motor nears synchronous speed, the frequency in the rotor circuit approaches zero, and as the rotor "slips" with respect to the revolving field there are corresponding pulsations in the line current. These conditions can be detected either by a frequency-sensitive relay in the field circuit or by a special relay in the line, and the relays can then initiate the switching on of the D.C. field current.

The protection of synchronous motors, while more complicated than in the case of induction motors, centres on the same basic problem: prevention of damage to the windings from heat caused by excessive currents. Specifically, the problems encountered, and their solutions, are (1) excessive stator current, usually detected by external sensors or embedded temperature detectors; (2) excessive field current, detected by external sensors; (3) excessive field voltage, which can be controlled by short-circuiting the field winding through a resistance during starting or by the use of discharge gaps between the slip rings; (4) squirrel-cage overheating, controlled by external timers; and (5) phase failure (causing abnormally high current in the squirrel-cage winding), detected by external sensors.

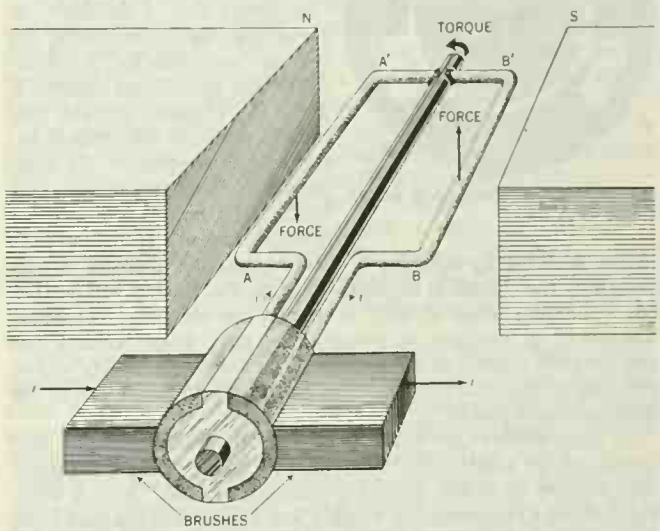



FIG. 11.—DIRECT-CURRENT MOTOR PRINCIPLES

## COMMUTATOR (D.C.) MOTORS

Commutator motors excited with direct current (called D.C. motors) were the forerunners of induction and synchronous machines, because many cities had well-established D.C. distribution systems for both lighting and power while A.C. systems were still speculative. Hence the D.C. member of the commutator motor family was well established when Nikola Tesla invented the induction motor. Modern commutator motors find their main use in speed-control applications.

**Basic Principles.**—Unlike induction and synchronous machines, commutator motors (with a few exceptions) make use of stationary rather than revolving fields—in fact, the sole purpose of the commutator is to control the position of the rotor field irrespective of the speed of rotation or the frequency of the current in the windings. For the purpose of explaining how such motors work, it is best to develop the principles for D.C. motors and then

extend those concepts to A.C. motors.

If the single conductor of fig. 1 is replaced by a coil, as in fig. 11, mounted on a shaft so that it is free to rotate in the magnetic field, and if current $i$ is caused to flow in the directions shown, a downward force will be evident on the left side of the coil and an upward force on the right side, and the coil will tend to rotate in a counterclockwise direction. However, to maintain this rotation the current $i$ must be reversed by the time the conductor AA′ comes under the south pole. This is accomplished by the commutator, which consists of an insulating member, carrying two copper segments, that rotates with the coil. Riding on the commutator but fixed to the motor frame are two brushes, usually made of graphite. These provide the connection to the external circuit. When the current $i$ is forced into the left brush, it flows through the copper commutator bar and thence into the coil side AA′. It returns through B′B to the other commutator bar segment and out the right-hand brush. When coil side AA′ has moved around to BB′ the current in the coil will have been reversed.

In an actual motor, greater field strength in the vicinity of the conductor will be achieved if the magnetic circuit cross section is like that of fig. 12. Also, in an actual motor the number of coils is multiplied so that there may be from 3 (in very small, low-voltage motors such as those used in models) to 300 or more (in very large steel mill motors). The number of commutator segments also will increase, for there must be one for every coil.

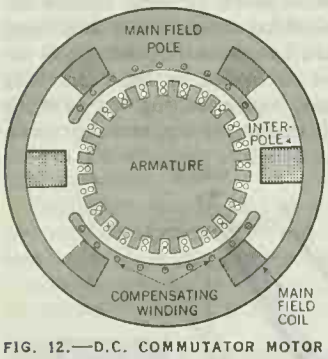



FIG. 12.—D.C. COMMUTATOR MOTOR CROSS SECTION

When the current in a rotor (armature) coil is suddenly reversed by the commutator, the coil is momentarily short-circuited and the voltage induced in it by the changed current may cause sparking at the brushes and consequent eroding of the commutator. In motors under 1 h.p. this is not a serious problem, but in larger motors it is customary to reduce sparking by inducing a voltage equal and opposite to that caused by the change in current. Shifting the brushes will do this, but a different angle of shift is needed for each load condition. The use of an interpole, or commutating pole, whose winding carries the same current as the armature, is a more satisfactory way of inducing an opposite voltage. The location and relative size of the interpoles is shown in fig. 12.

In large motors that must operate under rapidly changing load conditions, an additional winding may be used to reduce the problems created by rapidly changing armature current. Such a winding is called a compensating winding and is placed in the pole faces as shown in cross section in fig. 12. This winding is in series with the armature conductors, but it is arranged so as to oppose the field established by the rotor conductors.

The actual construction of a commutator motor is very similar to that of the induction and synchronous machines. Thin steel laminations are stacked together to form the armature and the field poles. Coils are usually preformed, although for some small motors the coils are wound on automatic winding machines that insert the wire turn by turn into the slots. The commutator is built up of segments of copper and then either cast in an insulating compound or fastened together with compression clamps.

**D.C. Motor Characteristics.**—The operating characteristics of D.C. motors are determined solely by the manner in which the main field is excited.

In the shunt motor, the main field coil is placed across the D.C. line (fig. 13[A]). This type of excitation tends to give a constant field flux, and the speed-torque characteristic would fall off only because of the resistance drop in the armature circuit. However, the armature field arising from the currents in the rotor conductors (armature reaction) tends to demagnetize the main field to some extent. The result is that the shunt motor usually has a slightly concave speed-torque characteristic, as shown in fig. 14.

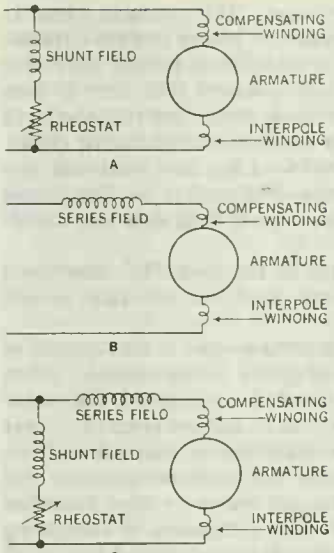



FIG. 13.—DIRECT-CURRENT MOTOR CONNECTION DIAGRAMS: (A) SHUNT MOTOR; (B) SERIES MOTOR; (C) COMPOUND MOTOR

A series motor (fig. 13[B]) has its field winding in the same circuit with the armature. This produces a speed-torque curve (fig. 14) with a high no-load speed. Because of their very great starting torque, these motors are useful for traction service.

Compound motors have both shunt and series windings (fig. 13[C]), giving them composite characteristics. Usually the series field has small effect under a normal load condition. For example, a motor whose series field aids the shunt field tends to run as a shunt motor under normal load, but it also will develop higher starting torques than a shunt motor because of the contribution of the series winding at standstill.

**A.C. Commutator Motors.**—An A.C. commutator motor presents two problems that do not arise in D.C. motors: the phase relationships between currents in different parts of the motor may not make interaction possible, and there are now voltages present due to transformer action.

In the series A.C. motor, the phase problem is not present because the currents in both the armature and field are the same. Hence the armature current reverses at the same instant the field current reverses and a unidirectional torque is produced. These motors are very common in such household appliances as vacuum cleaners, mixers and hand-held drills. These small motors for domestic use are sometimes called universal motors, since they may be used on D.C. or on any A.C. frequency to 60 c.p.s. In larger sizes, series motors are used for A.C. railway service, especially on 25- and 16⅔-c.p.s. power.

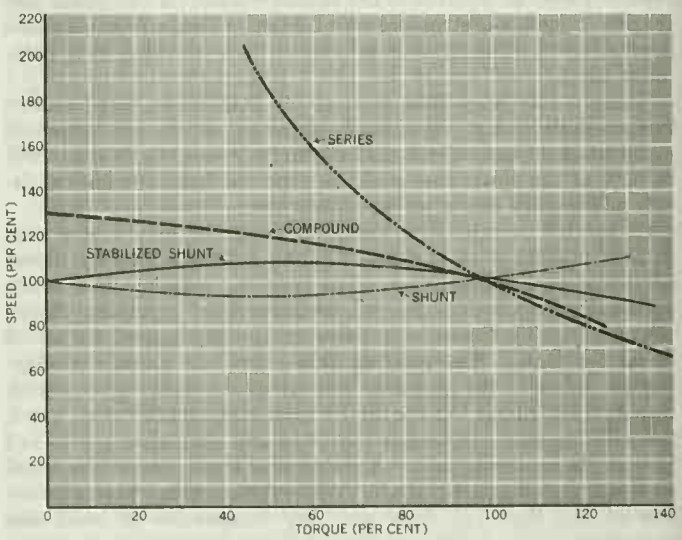



FIG. 14.—SPEED-TORQUE CURVES FOR DIRECT-CURRENT MOTORS

**Speed Control.**—Mention has been made of the use of commutator motors for A.C. speed control; however the D.C. machine is more commonly used for variable-speed applications.

The simplest way to control the speed of a shunt motor is to vary the field current or the armature voltage. Fig. 15(A) shows the circuit for a shunt motor with a variable armature resistor and a variable field resistor. If both of these are set for zero resistance, the motor will operate at its base speed. Decreasing the field current (*i.e.*, increasing the field resistance) but keeping the armature voltage unchanged will cause the motor to speed up.

The maximum speed that can be achieved in this way is about double the base speed. If the field resistor is set at zero and if the armature voltage is decreased by inserting more resistance in series with the armature, the speed will be decreased. Fig. 15(B) shows the effects of these operations.

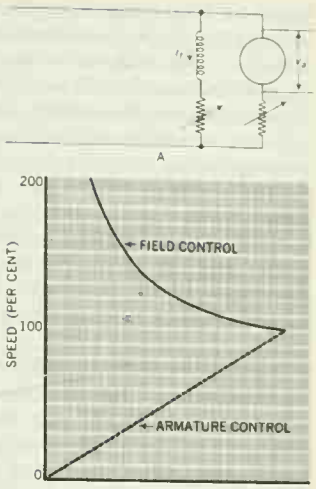


FIG. 15.—D.C. MOTOR SPEED CONTROL

**Starting and Protection.**—Except for very small sizes ($\frac{1}{8}$ h.p.), all D.C. motors must have reduced-voltage starters. Often this is a simple rheostat in the armature circuit; as the motor comes up to speed, the external resistance is gradually reduced to zero. In many cases this is done automatically by using timers or current- or voltage-sensitive relays.

Overcurrent protection, a means of keeping the windings from being overheated, is quite common. Thermal relays, which remove the motor from the line when the motor is too warm, are often used. To protect the commutator from flashover, there is sometimes provided current trip set to open the circuit at 200–300% of rated current.

Overspeed is a problem not often encountered in synchronous and induction motors but it can be serious in many commutator motors. Centrifugal switches are commonly used to detect an overspeed condition and shut off or reduce the power.

Field failure on shunt motors produces very heavy armature currents and a tendency for the motor to accelerate dangerously. A field-protection relay therefore is provided to shut off power if the field current drops to zero.

*See* also references under "Motor, Electric" in the Index.

BIBLIOGRAPHY.—*Standard Handbook for Electrical Engineers*, 9th ed. (1957); A. E. Fitzgerald and C. Kingsley, *Electric Machinery* (1961); R. A. Bruns and R. M. Saunders, *Analysis of Feedback Control Systems* (1955); B. F. Bailey and James S. Gault, *A-C Machinery* (1951); C. G. Veinott, *Fractional Horsepower Motors* (1957). For advanced treatment *see* D. C. White and H. H. Woodson, *Electromagnetic Energy Conversion* (1959). (Ro. M. S.)

**MOTORBOAT,** a small water-borne vessel, driven by internal-combustion machinery. Such a craft with a permanently installed engine is referred to as an inboard motorboat, while a boat propelled by a readily removable, comparatively portable engine clamped to the stern or in a motor well inside the hull is called an outboard motorboat. A boat with an inboard engine driving an outboard propeller unit by a shaft through the transom is known as an inboard-outboard motorboat. There is no generally accepted limit of size above which the term motorboat is replaced by motor ship; a total weight (displacement) of 200 tons represents a convenient dividing line, but most motorboats are very much smaller than that. Most motorboat engines use gasoline (petrol) as fuel, but small marine diesel engines gained in popularity following the end of World War II. In some countries marine engines burning refined kerosene were in wide use. After the 1940s many experiments were made in Great Britain, the United States and elsewhere in the application of the internal-combustion turbine to motorboat propulsion, experiments which began to see actual production usage in the middle 1950s. The engine of a motorboat usually turns a propeller acting against the water. However, some boats that commonly operate in shallow or weedy waters have airscrews, internally disposed impellers or paddle wheels. In the 1960s water-jet-propulsion units that could operate in very shallow water were introduced. (*See* BOATING: *Power Boating.*) Donald Malcolm Campbell of Great Britain became the first to qualify for official world water speed records with aircraft-type jet power in 1955.

**Types.**—Motorboats are of many types, among them the following:

The outboard runabout is an open boat usually between 8 ft. and 18 ft., generally with seats running laterally across the width of the craft and occasionally with decking over the bow area or perhaps between the several seats. This type is driven by an outboard motor, a self-contained unit arranged to clamp onto the stern. This is the most popular of all pleasure motorboats as it is the least costly, easiest way to become a boat owner.

The inboard runabout, ranging from 14 ft. to upward of 25 ft., is usually open but sometimes has a removable shelter top; there are fast, sport, cockpit models as well as open, roomy, utility craft. These boats are propelled by inboard engines, usually gasoline, either in single or twin installation; hull design is without steps, shingles or sponsons. Technically a displacement type hull, these runabouts are actually semiplaning craft.

Hydroplanes are craft built to skim over the surface of the water with only a minimum of the hull in contact with the water when the boat is traveling at speed. The bottom can have a single- or multiple-step configuration, or it may have lateral pontoonlike sponsons.

Three-point hydroplanes ride only on the after edge of each sponson and on the propeller when at speed.

The outboard cruiser, developed during the late 1940s and early 1950s, ranges from 17 ft. to 24 ft. and provides sleeping and living accommodations for two to four persons, including kitchen and toilet facilities, in a small, compact cabin. Usually it is powered with single or twin outboard motors of more than 15 h.p.

The inboard cruiser is a motorboat with sleeping, cooking and toilet facilities in a cabin, ranging upward from 18 ft. and propelled by single, twin or sometimes multiple gasoline or diesel inboard engines. An inboard cruiser longer than about 50 ft. is generally called a motor yacht. This type of boat is usually designed for operation in less protected waters, and large cruisers and motor yachts frequently navigate coastal oceanic routes.

The auxiliary sailboat, basically designed as a sailing craft, is powered with an internal-combustion engine for use in adverse weather conditions and for maneuvering in confined spaces.

The motor sailer, in contrast to the auxiliary, is designed principally to operate as a motorboat but is equipped with sail as complementary power. A rugged, sturdy craft, with the comparatively small sail area lending a steadying effect in a seaway, the motor sailer has living facilities and the roominess below of an inboard cruiser.

Work boats include ferries, fishing boats, motor barges, tugs, coasters, passenger boats, police and harbour officials' launches, canal boats, fuel and water boats, fire-fighting craft and many others. Naval craft include torpedo boats, gunboats, antisubmarine boats, rescue craft and numerous ancillary vessels.

**Early Achievements.**—There is much doubt as to who first applied internal-combustion power to the propulsion of a boat. One of the first certainly was the German Gottlieb Daimler, who demonstrated a one-horsepower launch at Cannstatt, Württemberg, in 1887. About this time a number of Daimler motorboats were produced and put into service. In Great Britain, Priestman Brothers of Hull were pioneers. G. Priestman carried out trials in 1888 with a kerosene-engined craft, but the motor was ahead of its time, having high-tension ignition. In 1890 barges powered by Priestman engines were being successfully used for canal work.

In 1904 the magazine the *Motor Boat* was brought out by the Temple press, London, and in the same year a magazine of the same name became the first United States periodical to be devoted to this young sport. It was the goal of these magazines to chronicle and encourage the development of the new type water craft, just beginning to be popular. The following year the first U.S. annual National Motor Boat show was held in New York city, becoming an international market place for motorboats that was still flourishing in the mid-20th century. In 1903 Sir Alfred Harmsworth (later Viscount Northcliffe) established the British International trophy for motorboat competition, the first international, perpetual trophy in the sport. It was won that year by S. F. Edge's "Napier I," a displacement craft, with a speed of 19.53 m.p.h., over the course at Queenstown, Ire. The 90-mi. American Gold Cup race for motorboats under 40 ft. was inaugurated the following

year and won by C. C. Riotte's "Standard" at 23.6 m.p.h.

**Recreational Usage.**—Motorboats lend themselves to many uses, including pleasure cruising, fishing, racing, water ski and aquaplane towing and family runabout activity. Inboard cruisers, motor yachts and motor sailers larger than 35 ft. are suitable for offshore angling expeditions for big game fish such as tuna, marlin and broadbill sword. They also are designed to accommodate six or more persons for considerable time afloat, and many owners and their families spend months at a time on their cruisers; a few live permanently on board. Smaller inboard cruisers and the outboard variety make excellent family living quarters for week ends or vacations, and are useful for fishing in semiprotected waters. Inboard and outboard runabouts and utilities, ranging in horsepower from 3 to well over 300, are used for fishing, water skiing, racing and family day cruising on protected and semiprotected waters.

**Inboard Engines.**—Most inboard, fixed motorboat propulsion units are four-cycle gasoline engines, designed specifically for marine use. However, there have been many successful nautical conversions of automotive power plants, and the fuel-oil burning diesel engine was recognized by boatmen as an efficient, economical source of boat power, particularly following World War II. Four- and six-cylinder models of gasoline marine engines were the most popular for cruiser and runabout power, but eight-cylinder V-8 models began to gain favour for high-speed operation. Early diesel engines for marine use were big and bulky with a low horsepower-to-weight ratio, but post-World War II engineering produced small, compact diesels designed to fit into craft as small as 25 ft. The initial cost of the diesel engine was higher than that of a comparable gasoline engine, but the fact that this type of power plant reduced fire hazards and utilized a relatively inexpensive fuel and in considerably less quantity than gasoline made it attractive to pleasure and work boat owners.

**Outboard Motors.**—A self-contained, detachable nautical propulsion unit was first introduced in 1902 in France, the Motogodille, a direct-drive engine hinged to the top of the transom and the crankshaft coupled directly to the propeller shaft, which led out at an angle over the stern of the boat. A few years later the American Cameron Waterman developed a small outboard in the United States. However, Ole Evinrude, of Milwaukee, Wis., is considered to be the man who popularized the outboard motor. He put his first Evinrude into production in 1909, a single-cylinder 1½-h.p. unit with the vertical shaft and bevel-gear drive to the propeller which was used in outboard motors for many years. The early motors were heavy for the power developed and did not always prove to be a dependable motive source. To correct these drawbacks manufacturers made use of lighter metals such as aluminum, and through progressive engineering developed a dependable engine that would start at the touch of an electric starter button or a single pull of the starter cord. A later development was noise reduction by means of rubber powerhead mountings.

An overwhelming majority of outboard motors are two-cycle units with the lubricating oil mixed directly into the gasoline fuel. Earlier motors had integral tanks for fuel, but as the units became bigger and more powerful, manufacturers provided separate fuel tanks permitting greater cruising range.

**Speeds.**—From the early competitive speeds of 20 m.p.h. common in 1904, racing motorboats were developed to the point where the unlimited propeller-driven hydroplanes were turning in heats well over 100 m.p.h. by 1955. These huge craft would do 150 m.p.h. on the straightaways in competition, but had to slow down for the turns at each end of the course. Sir Malcolm Campbell held the world one-mile water speed record of 141.74 m.p.h. from 1939 until 1950, when the revolutionary three-point hydroplane "Slo-Mo-Shun IV," owned and driven by Stanley S. Sayres, captured the record with an average of 160.323 m.p.h. on Lake Washington at Seattle, Wash., in June 1950. Two years later Sayres, again driving the same boat, increased his mark to 178.497 m.p.h. Donald Malcolm Campbell, son of Sir Malcolm, on July 23, 1955, became the first man successfully to pilot a jet-propelled boat over an official time trial course. His mark was 202.32 m.p.h. At least two men, John Cobb of England and Mario Verga of Italy, were killed in the 1950s trying to reach 200 m.p.h. The younger Campbell later boosted his record to 239.07 m.p.h. on Lake Coniston in England on Nov. 7, 1957, and on the same water on May 14, 1959, he was officially timed at 260.35 m.p.h.

While inboard speeds were approaching 200 m.p.h., the world's outboard pilots were making a concerted assault on 100 m.p.h. for their mile straightaway runs. Finally Massimo Leto di Priolo of Italy hit 100.36 statute miles an hour in a Molinari class X hydroplane with a special Lesco engine in Dec. 1954. Roy Duby in the Arena-designed, Merlin-powered "Miss U.S. I" at Guntersville, Ala., on April 17, 1962, was clocked at 200.419 m.p.h. for the mile, the first to surpass 200 m.p.h. in other than a jet-propelled craft.

**Boatbuilding Materials.**—Wooden planked construction has been the perennial favourite for small motorboats, but in the years following World War II other materials began to take hold, namely sheet and molded plywood, aluminum and polyester resins reinforced with glass fibres. Steel came to be favoured for larger inboard cruisers, motor yachts and big motor sailers. Among the woods used for planking are cedar, mahogany, teak, pitch pine, English oak and silver spruce. White oak and American elm are popular for framing. A great many small utilities, cruisers and hydroplanes are built of marine mahogany or fir sheet plywood, while mahogany plywood is favoured for pressure molding of runabout and dinghy hulls.

The development of the lighter metals, particularly aluminum, as materials for boat hull construction greatly lightened the craft, making them more easily transportable atop automobiles or on boat trailers attached to automobiles. The reinforced plastic resin and glass materials that were introduced in the later 1940s and further developed in the 1950s gave an added toughness to hull construction, eliminating much of the annual maintenance work needed on wooden hulls.

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**MOTORCAR:** *see* AUTOMOBILE.

**MOTORCYCLE,** a vehicle in which the principles of the bicycle and of the internal-combustion engine are combined. The term covers a range of machines from 50 c.c. piston displacement or below (mopeds or motor bicycles) to 1,000-c.c. multiple-cylinder models, of which the U.S. Harley-Davidson and Indian V-twins, the British 1,000-c.c. square-four Ariel and the four-cylinder Italian MV Agusta are representative examples. The term motorcycle also covers motor scooters, which have power units of from 70 to 250 c.c.

An Englishman, Edward Butler, built the first motor tricycle in 1884; the first motorcycle to appear publicly was one built by Gottlieb Daimler of Cannstatt, Württemberg, Ger., in 1885. Motorcycles did not attain even slight public popularity until toward the end of the 19th century. French and Belgian designers were among the makers of the first practical motorcycle engines and motorcycles. They were followed by British, German, Italian and U.S. makers.

Manufacture and use of motorcycles increased steadily throughout the first 30 years of the 20th century. All the European combatants in World War I employed motorcycles extensively, particularly for dispatch riders. In the early 1920s there were 200 firms in Britain alone manufacturing motorcycles. By the 1930s, however, a decline in popularity had set in. In Britain, for instance, there were then only 40 significant producers and in the United States 3. The decline was attributed to the growing number of small cars available and also to the overspecialization that had led to the manufacture of fast racing and sports machines (*see* MOTORCYCLING) rather than to concentration on large-scale production of utility models.

In World War II motorcycles were again widely used for military purposes, though for many the jeep displaced them. Civilian sales were severely restricted, but many prewar models rendered

sterling service in combatant countries as an economical means of transport between home and business, and also for many official purposes. It was this general recognition of the value of the two-wheeler that laid the foundation for the remarkable post-war revival of public interest in motorcycles, mopeds and scooters.

The British motorcycle and cycle industry was the one that gained most in export earnings from the world-wide expansion in motorcycle sales. Between 1945 and 1960 it earned a total of £250,000,000 ($700,000,000) abroad. Other large exporters were the Italian, German, French and Belgian industries. Many of the British export sales were to the United States and Canada, and also to the armed and police forces of Europe, Australia, Africa and Asia. Total British production of motorcycles ran at levels of between 150,000 and 200,000 a year.

By the mid 1960s output of Japanese two-wheelers had reached about 1,600,000 annually, making its powered two-wheeler industry the largest in the world. Of this output, about 65% was produced by Honda. There were nine large-scale Japanese producers of motorcycles and mopeds, other leading firms being Yamaha, Suzuki and Tohatsu. The Japanese home market took most two-wheelers. Best export sales of Japanese motorcycles were to the United States and Britain. Scooter manufacture remained at a low level.

While production in the United States did not return to the 1913 level of 70,000, the years after World War II witnessed a revival of interest that can be compared with that in western Europe. Most of the U.S. business was in British four-stroke motorcycles, notably of Triumph, BSA, AJS, Matchless, Norton and Velocette machines, some of which had their own sales corporations in the U.S. Trade was largely in sporting models.

Although at times the continuing popularity of two-wheeled transport has been questioned, there is no doubt that it was firmly established in the second half of the 20th century. Its chief rival was the inexpensive small car. However, the motorcycle provided a means of individual powered transport, combining reliability, economy and comfort. Young people had always been quick to appreciate its advantages. Moreover, the sporting and travel appeal of the two-wheeler expanded yearly; scrambles, racing, trials, rallies and touring by means of motorcycles and scooters continued to gain popularity in the 1960s.

National shows featuring motorcycles are held in London, Frankfurt am Main, Geneva, Amsterdam, Milan, Paris and Brussels. The world's largest and most representative motorcycle museum is at Beaulieu abbey, Hampshire, Eng., where more than 200 motorcycle exhibits can be seen.

**The Development of the Machine.**—Development of motorcycles from the first machines, which were bicycles fitted with auxiliary engines, was steady. In the formative years positioning of the power unit varied, but by 1910 designers had recognized that the most practical point was low and central, to ensure a low centre of gravity and steering stability and ease. Later, motorcycle engine units (consisting of engines and gearboxes) were carried in twin-tube cradles or were attached by long bolts and plates to the frame. Frames were built up from steel tubing, jointed by either welding or brazing.

The early commercial motorcycles were single-cylinder types, a style which persisted in the second half of the 20th century. Most models of more than 250 c.c. were four-strokes, in which valves were employed with the compression firing stroke in one direction (upward or outward) only; many below 250 c.c. capacity were two-strokes, compression firing being on both strokes through a succession of passageways and ports. The European method of rating an engine is by the volumetric displacement of the pistons in cubic centimetres. The horsepower rating is used in some countries, including the United States; a rough equivalent is 1 h.p. per 100 c.c.

In the second half of the 20th century the capacities of modern machines ranged from 25 c.c. for engines used as auxiliaries on bicycles to 1,000 c.c. for models with two or four cylinders. Multiple cylinders ensure smooth running and, because lightweight models were cheap to run and easy to maintain, two of the foremost British designs, the four-stroke 192-c.c. water-cooled Velocette LE and the two-stroke 250-c.c. Ariel Arrow, had won for themselves foremost positions.

Carburetion and ignition were greatly improved over even the methods of 25 years earlier and bore little resemblance to the rudimentary forms on pioneer motorcycles. The carburetor was a compact and reliable instrument, measuring precisely the proportions of fuel and air admitted to the engine cylinder or cylinders for explosion and able to serve indefinitely without major adjustment. Elementary tube ignition had given way to advanced forms of electrical generation by means of a magneto or an induction coil. The magneto was either a separate piece of mechanism driven from the engine by means of gearing or chains, or was integral with the flywheel (the latter form becoming widespread on ultralightweight and lightweight two-strokes).

Transmission was usually by chain between engine and gearbox (two- and three-speed on smaller models; four-speed on larger ones); a few models employed shaft drive.

The earlier front-end springing of motorcycles by means of a compression spring operating inside parallelograms joined by link action had been superseded by hydraulic suspension, working telescopically, or by leading link; rear suspension, formerly rigid, was largely hydraulic as well. These improvements provided increased comfort and better control.

Braking developed consistently with the introduction of new metals for the drums and more effective antifriction linings. Braking surfaces increased, too, and hub barrels were increased in size to equal brake drums, ensuring a more stable hub and quick dispersion of heat generated by braking action. Internal-expanding brakes superseded other forms of braking. Control was improved, too, by improved clutches and by finer throttle adjustments. Modern clutches were multiplate, able to absorb the stresses brought about by constant gear changing in heavy traffic, on mountainous roads and in road racing. Throttle control and the use of lower gears assisted brakes as checks on speed.

**Motor-Assisted Bicycles, Mopeds and Scooters.**—Early in the 1950s, in western Europe and parts of the United States, auxiliary engines for use on bicycles became popular. One design, the Cyclemaster (a rear wheel embracing an engine unit of 32 c.c.), reached a total production of more than 120,000. The engines being sold represented a revival of vogues of the 1920s and earlier.

Soon afterward there was a marked public demand for the moped, which originated in Germany as a 50-c.c. machine with simple controls, with low initial and running costs, and largely free (except in England and France) of licensing and insurance complications. The moped attained popularity all over western Europe and was also introduced elsewhere, including the United States and Canada. The German Quickly and the French Mobylette continued as the leaders in European sales, but the Netherlands, Italy, Belgium, Norway and Britain also paid particular attention to mopeds. In 1958 large-scale manufacture of British mopeds began at the Raleigh and Phillips factories. There is no reliable estimate of the number of mopeds in use, but by 1964 there were in Britain alone about 800,000 machines of 50 c.c. or less, representing a minor revolution in powered travel.

Even more significant than the increase in mopeds was the rapid expansion in the use of motor scooters, which had enjoyed a transient vogue in the 1920s. The modern scooter was first developed in Italy, where factories that had been engaged for war purposes were turned over to civilian production. The pioneer was the 125-c.c. Vespa, which by 1964 was selling better than any other scooter in all western European countries except Britain, where its Italian rival the Lambretta was in the lead.

The scooter had smaller wheels than the conventional motorcycle—anything from 8 to 14 in. in diameter (*cf.* 18 or 19 in. for motorcycles); its welded-tube or pressed-steel frame was well shielded; the rider sat inside the machine (not on it, as with a motorcycle or moped); and the riding position was lower. Power units were ordinarily positioned low and close to the rear wheel, which was driven by bevel gearing or by the more conventional chains, as used on motorcycles and mopeds. Controls were similar to those of motorcycles, with the important exception that the

clutch movement and gear changes were often worked by a dual hand control. The large shieldings of scooters (covering most of the working parts and much of the wheels) lent themselves to brilliant and two-tone finishes.

The differences between motorcycles and scooters, in seating position, controls and colours especially, led them to appeal to women who might otherwise never have driven a two-wheeled vehicle. By the mid-1960s, out of a total of over 1,800,000 British motorcycle riders, approximately 600,000 were scooter enthusiasts. Perhaps the greatest factor in the advances made in moped and scooter engineering was the perfection attained in the design and machining of the small parts required for engine construction.

The enclosure of parts and wheels seen on scooters was not without its repercussions on standard motorcycle design. Unit construction of power units, noticeable in the late 1940s in the Czech CZ-Jawa and the British BSA Bantam, had brought about a starkness and simplicity of appearance that matched the mood of the riding public. To add to riding comfort, the next step was the enclosure of the frontal area (with a windshield incorporated) and part of the sides by means of fibreglass shroudings.

**Sidecars.**—Sales of sidecars for attachment to motorcycles never rose to great levels in any country, the normal British output being about 6,000 annually. Before 1939 the lowest engine capacity regarded as desirable for sidecar use was 350 c.c. However, the improvements in two-stroke techniques led to the fitting of lightweight sidecars to motorcycles and scooters of capacities as low as 125 c.c. Lower gears had to be fitted to the machines, however. Developments in chassis and body design made sidecars more attractive. One-point chassis fixing became more pronounced as lighter metals and fibreglass came to be employed widely in bodywork. Braking and better waterproofing of sidecars also helped to retain their appeal. Additionally, the direct steering and general stability of motorcycles fitted with sidecars made insurance premiums lower than those for solo machines. Also providing greater stability is the three-wheeled motorcycle, with one front and two rear wheels; it is often used by police departments. (Hd. B.)

**MOTORCYCLING.** Although most motorcycles, scooters and mopeds (motor bicycles) in Britain are employed for strictly utilitarian purposes, an important minority of owners also use these machines for competitive sport. In the U.S. and Canada, pleasure motorcycling, including competitions, accounts for most of the use. The international controlling body for motorcycle sport is the Fédération Internationale Motorcycliste, which normally meets in Europe and has its headquarters in Britain. The controlling body in Great Britain is the Auto-Cycle union, and in the U.S. it is the American Motorcycle association.

**Reliability Trials and Roughriding.**—The commonest type of competitive event is the reliability trial, which may last for any period up to a week. These contests are held on public highways, with riders starting at intervals of a minute or longer. Time checks are taken, there are observed "rough stuff" or hilly sections or both, and the rider who loses the fewest points is judged to be the winner. In their more strenuous forms, reliability trials are run over moorland or broken country, with water splashes and steep rock-strewn pathways as common hazards. Such an event is the annual Scottish Six-Days trial in May; its route includes some of the roughest and most remote mountain tracks in the northwest Highlands. For experienced teams from many countries, the international Six-Days trial is the most grueling event of its type; after World War II it generally was held either in central Europe or in Wales. Motorcycle manufacturers and traders everywhere regard reliability trials as the most searching tests possible of their standard models. Trade-supported teams are usual in the major trials, although enthusiastic amateurs compete.

Scrambling or roughriding generally takes place on rough enclosed circuits and is easier for the spectator to witness than are reliability trials. Cash prizes are an incentive to riders, who start en masse and make very many circuits of the course. The machines used are usually tuned-up lightweight two-strokes with generous ground clearance.

**Racing.**—Even more specialized is motorcycle racing, which may take place on closed and cleared roads, on private circuits or on sand. Full-scale racing requires motorcycles of proved reliability with top-grade tuning, and drivers who are both fit and also masters of roadcraft. While it is primarily a young man's pursuit, it is not unusual for men in the 40s and 50s to ride.

The Isle of Man T.T. (Tourist Trophy) race was first run in 1907, being won by C. R. Collier on a Matchless at 38.33 m.p.h. The Isle of Man Mountain course, the most famous motorcycle road-racing circuit in the world, was first used in 1911. It consists of well-surfaced highways running mostly through the pleasant Manx countryside, but also traversing parts of two towns. Hairpin corners and steep rises and falls abound, the highest point being 1,400 ft. above sea level. The two most important races, the Senior and Junior International events (in June), are each of seven laps, or 264.13 mi. The fastest lap record in the Senior event was put up by John Surtees, of England, in 1960, with 104.08 m.p.h. on an Italian MV Agusta. Other leading motorcycle races in Europe are the German Grand Prix (May), the French Grand Prix (May), the Dutch T.T. (June), the Belgian Grand Prix (July), the Ulster Grand Prix (August) and the Italian Grand Prix des Nations (September).

In the United States the first recorded fast time was established in 1902 by Albert Champion, who covered a mile on a circular track in 1 min. 10⅘ sec. The 100-mi. amateur and 200-mi. professional events are held annually on a circular course at Daytona Beach, Fla. Speed-record trials are held every year at the Bonneville, Utah, salt flats, where in 1956 W. Herz set a world kilometre solo record of 210 m.p.h. on a 499-c.c. NSU. Other important annual events include the Big Bear run; the Langhorne, Pa., 1-mi. track 100-mi. championship; the Dodge City, Kan., 200-mi. and 50-mi. championships; the Laconia, N.H., T.T. championship; and the Peoria, Ill., National T.T. championship.

**Scooter Rallies.**—After World War II a number of international, national and local motor-scooter rallies were established. The larger ones usually include a long-distance driving test, contests for "scooter queens" and the most attractive machines and timed tests over extended circuits. In the Isle of Man, 12- and 24-hour time trials were introduced in 1958. One of the most popular British scooter rallies is the *Daily Mirror* event held in the south midlands, on Whitmonday. (Hd. B.)

**MOTORING,** driving or touring by automobile for pleasure, has emerged as one of the most socially significant developments of the 20th century, an influential factor in the leisure hours of an ever-more affluent society and an integral part of the world's economy. Related subjects, such as the history and development of the automobile, the construction and improvement of roads and highways and the laws governing the operation of motor vehicles, are treated in separate articles: *see* Automobile; Roads and Highways; Traffic Regulation. The article Automobile Racing discusses the sport of competitive motoring, while there is a separate article on Camping, which is often associated with touring for pleasure.

## EARLY MOTORING

Motoring history began during the last decade of the 19th century. By 1895 automobiles were a booming industry in France and Germany; individual cars had been built in other continental countries, as well as Australia, New Zealand and the United States; the first motoring papers had been founded. By 1903 there were 53,000 automobiles in existence, 30,200 of them built in France. Early motor shows were held in Paris, London, New York city and Turin. In 1900 the first national auto show in New York city was offering three different types of motor; steam, electric and gasoline (internal combustion). Steam cars were quiet and odorless; electric cars were even smoother and quieter and quite reliable as long as the batteries held up; at that time it did not seem likely that the noisy, smoky, vibrating gasoline-powered vehicle would survive its two competitors.

**Adverse Conditions.**—It is difficult for the motorist of today to imagine the conditions under which cars were driven at the turn of the century although many of the vehicles are preserved. Drivers had to make their way cautiously in a world accustomed

to the deliberate pace of man and horse, of horse-drawn vehicles and bicycles. Farmers and estate owners, having affection for their horses, detested the noisy, fume-spreading contraptions that invaded their rural tranquility.

In France, Germany and the United States the early motorist had to brave merely the skeptical onlooker; in Great Britain he had to bear also the hostility of the law, where, under the Locomotive act, in force between 1865 and 1878, a self-propelled vehicle on the public highway had to be preceded by a man on foot carrying a red flag. The raising of the speed limit to 14 m.p.h. in 1896 was celebrated by an "emancipation run" from London to Brighton, and not until 1904 was the speed limit raised to 20 m.p.h.

Many roads were winding and narrow; sometimes high hedges and walls obstructed the view; gates and tolls were numerous. Drivers of carts and horse-drawn coaches were careless about keeping position on the road and their startled animals often added to the confusion. Roads outside of urban limits were dusty in dry weather, impassably muddy in wet weather, and so full of frozen ruts in winter that steering was a problem and tires were easily ruined. Dust necessitated the wearing of long, smocklike coats and of goggles by driver and passengers. A common method of road repair was to scatter loose, sharp stones across the width of the highway, and these cut tires. Gangs of labourers had to shovel paths through the snow to enable a Model T Ford to make the 4,000 mi. journey from New York city to Seattle in the 1909 record time of 22 days 55 min. Hills which would be laughed at by the modern car owner often presented almost insurmountable barriers and cars had to be backed up the slope in order to get fuel into the carburetor. If this failed, there remained only the humiliation of being towed up by horses.

The pioneer motorist carried his own tools and spare parts for repairs and had to seek out facilities to park or service his car, and accommodations for himself and his companions. He was often refused at the local livery stable, whose owner sensed the competition of the motorcar and abhorred the noise and smell which disturbed his horses. Some country inns and social clubs refused to accommodate the early "sports" who drove automobiles. Hardware stores and blacksmith shops became the first sources of gas and oil and repairs, oil companies frequently exhorting potential customers to write ahead and book their requirements when planning long trips. The easy availability of petroleum spirit (the early "straight run," or gasoline) in France at the turn of the 20th century was a factor in that country's initial lead in automobile production. In the United States the gas and oil companies were the first to solicit the motorists' business and the first specialized service stations began to appear around 1906. On the continent of Europe filling stations did not appear generally until after World War I. For example, it was not until 1924 that the German Shell company set up the first of 100 gasoline pumps, known as "iron maidens," to meet the demand.

A trip of any length required much preparation. There were at first no road maps and few road signs at intersections. Courageous motorists followed along railroads or telegraph poles to avoid being lost. Available maps were inadequate and for some countries virtually nonexistent. When British motorists wanted to go to the Balkans and Turkey, tracings had to be taken from maps in the British museum. In Europe generally, even where otherwise excellent maps existed, they were often overcoloured and when traveling over bumpy roads in a vibrating vehicle, it was practically impossible to distinguish one road from another. Eventually the various national automobile clubs produced maps which recommended motoring roads specially and clearly.

**Early Rallies and Tours.**—Races early became a means of publicizing the new automobile. The splendid straight thoroughfares of France and Germany were ideal for this purpose and between 1894, when *Le Petit Journal* organized the first Paris-Rouen run, and 1906 when the Gordon Bennett cup ceased to be competed for, a series of town-to-town races provided an opportunity to demonstrate the new vehicle. In this period the first Tour de France, the British Thousand Miles trial and the first race in America, organized in 1895 by the *Chicago Times Herald* with two starters, were run. The 1903 Paris-Madrid run, in which many people were killed, however, proved a setback. After 1906 (when the French Grand Prix was established) these runs became the field for competing motor manufacturers (*see* AUTOMOBILE RACING).

The American continent was crossed by both H. Nelson Jackson and Tom Fetch in 1903, a distance of 3,000 mi. taking two months' journey. The Peking to Paris run sponsored by the French newspaper *Le Matin* in 1907 was an outstanding event. A test of endurance rather than a race, the winner after two months' journeying was an Itala driven by the Italian prince Scipio Borghese. The following year the American Thomas Flyer won what was described as the first "round the world" race from New York to Paris and in 1909 the Guggenheim trophy marked the opening of the Alaska-Yukon-Pacific exposition. By that year automobiles were being imported into Russia and Japan. By 1914 every inhabited continent had been crossed: Australia by H. Dutton in 1907–08, Africa in 1907–09 by Lieut. Graetz, while Ernest Shackleton took a car to the Antarctic in 1908–09 and Johnson Martin crossed the Andes in 1914. The Sahara was finally crossed in 1923, though a desert car with caterpillar tracks was made as early as 1908.

An annual "pleasure" motoring event in the United States known as the Glidden tours attracted nationwide attention. The project of an amateur motorist, businessman and banker, Charles Jasper Glidden (*q.v.*), who wanted to prove that the automobile was a reliable method of transportation under all road and weather conditions, the first official tour began in 1905 after an unofficial trip in 1904. The number of entries averaged between 25 and 50 and the distance covered ran well over 1,000 mi. for each tour and extended as far as Australia, New Zealand, China and Japan. All competed for a trophy awarded by the American Automobile association. However the commercial rivalry of manufacturers who entered automobiles for publicity reasons soon dominated the affair and it was discontinued after the eighth and final event in 1913 (there was no tour in 1912). The Glidden tours were revived in 1946.

**Improvements in Car Comfort.**—The increasing comfort and reliability of the motorcar stimulated its use for popular touring. Built-in baggage compartments began to be a standard feature in 1906 along with weather-tight tops and suitable side-curtains. By 1909 the famous Model T Fords appeared in America, bringing the automobile within the reach of many more families, especially in rural districts. World War I interrupted automobile development but motoring had already ceased to be a hazardous novelty. Electric lights began to appear on a few models, permitting safer night driving and after 1912 the electric self-starter made it possible for more women to operate automobiles and for men to drive with more assurance. The introduction of installment buying of automobiles aided purchase.

Balloon tires for driving comfort and four-wheel brakes for driving safety became standard equipment by about 1922. Hot-water heaters were adopted around 1926. Synchromesh transmissions appeared in 1928, making gear shifting easier and quieter. About the same time shatter-proof glass and automobile radios were offered in the higher-priced models. An important contribution to the easy operation of a motor vehicle came in 1937 when the fully automatic transmission was designed for passenger cars. It was constantly improved over the years. The halting of passenger-car production during World War II and gasoline (petrol) rationing reduced motoring activities considerably, but after the war interest in motoring as a recreation increased.

## AUTOMOBILE CLUBS AND RALLIES

The world's first automobile club was formed in Paris in 1895. Belgium and Britain quickly followed suit and by 1898 reciprocal arrangements were already in force between the French and British clubs. By 1900 Germany, Bavaria, Austria and Switzerland all had national automobile clubs.

In 1900, the Automobile-Club de France first published a suggestion for an international association of automobile clubs but the initial conference was not held until Dec. 12, 1904.

**British A.A. and R.A.C.**—The Royal Automobile club, first organized in 1897 under the name Automobile Club of Great Brit-

ain and Ireland (since 1907 under its present name), has played a major role in the development of motoring in Great Britain. The man mainly responsible for its existence was Frederick R. Simms, who was also the founder of the Society of Motor Manufacturers and Traders in 1902.

In 1901 the Automobile club formed the Motor union (which merged with the A.A. in 1910) "for the protection of the individual and opposition to attempts to bring about unnecessary restrictive legislation." The Motor Car act, in force in Jan. 1904, began a period of intensive persecution that threatened to drive the motor vehicle from the roads of Great Britain. The chief crime for which motorists were prosecuted was exceeding the speed limit; but having number plates and rear lights "obscured"—almost inevitable after a few miles of travel on the poor roads of the period—was often added to the indictment. Motorists retaliated by banding together and hiring the services of a handful of cyclists to spy out and warn drivers of the speed traps on the Brighton and other roads to the coast. The scheme was a great success, and in Aug. 1905 the Automobile association was formally founded to organize it on a permanent basis. After several years of active struggle the A.A., inspired by its secretary, Stenson Cooke (who was knighted in 1933), established itself as a service as well as a protective organization.

In the second half of the 20th century the A.A. had a membership of 3,000,000 and the R.A.C. one of 1,000,000. The R.A.C. is the governing body for all motor sports in the country, without whose authorization competitive events cannot be held. It also issues national and international competition licences for drivers.

**American Automobile Association.**—The American Automobile association (A.A.A.) was the result of a consolidation in 1902 of nine early auto clubs. They met in Chicago on March 4 of that year and minutes from that first meeting record that "there was a need of a national organization which would assist the general progress of the motor-driven vehicle by safeguarding the interests of the user and at the same time aiding the maker in perfecting a better car."

The A.A.A. became the leading motoring service association in the United States and grew from 10,000 members in 1910 to over 6,500,000 members in 750 affiliated clubs in the second half of the 20th century. The services offered to members include emergency road service, touring advice, bail-bond protection, personal accident insurance, claim and adjustment service, notary public service, licence delivery, theft-reward protection and club publications. For many years the A.A.A. also supervised all of the major auto races in the United States, including the Indianapolis "500," a race first organized to provide a proving ground for mechanical innovations. However, in 1955 it severed its connections with all forms of auto racing (which passed to the specially formed U.S. Auto club), because it felt that high speed road and closed circuit (track) racing of the post-World War II period was not serving the interests of American motorists.

**Spread of National Clubs.**—By the 1960s there were 102 national automobile clubs and associations throughout the world, linked in affiliations and reciprocal agreements. The first national automobile clubs had been formed primarily as social clubs where people with a common interest in motoring could meet. From the original conception most of these developed into service organizations providing rescue and breakdown assistance, engineering inspections, touring information and bookings; for instance the Automobile club of Switzerland facilitated international travel by devising a form (the triptyque) whereby motorists crossing national frontiers were exempt from customs duties on their car. The British R.A.C. and A.A. were pioneers in providing nationwide patrols, the men being mounted first on bicycles and later on motorcycles; the first roadside telephone box was installed by the R.A.C. in 1919. Some European countries only started providing patrol and radio break-down services after World War II, though touring and general information had long been supplied by the majority of clubs and many had also sponsored and organized motor sport competitions in their respective countries.

**Veteran Car Clubs.**—An interesting development of the 1950s and 1960s has been the upsurge of societies and clubs devoted to the cult and preservation of old motor vehicles. Opinions differ in such circles as to what constitutes a car worth preserving but most countries follow the classifications laid down by the Veteran Car Club of Great Britain (founded 1930) in which all cars built prior to Dec. 31, 1916, are "veterans." Of these, cars manufactured before Dec. 31, 1904, are regarded as true veterans and are eligible for the Brighton Run which annually commemorates the 1896 "emancipation run" from the Hotel Metropole, Northumberland avenue, London, to the Hotel Metropole in Brighton on the first Sunday in November and attracts around 250 entries from all over the world. Cars built between 1905 and 1916 are termed "Edwardians"; those between 1916–30 are "vintage." There is also a very active and flourishing Vintage and Sports Car club (founded 1934) in Britain. A certain number of really good cars of the 1930s are classed as "post vintage thoroughbreds," the average enthusiast having little time for the mass-produced "boxes" typical of the automobile industry of the period.

In the United States, the position is somewhat different. The Antique Automobile club, organized in 1935, which, with a membership well in excess of 10,000, is said to be the largest automotive historical society in the world, defines an "antique" as being any car made up to and including 1929. Smaller clubs of the same type in the United States include the Veteran Motor Car club (1938), the Horseless Carriage club (1949) and the Steam Automobile Club of America and the Vintage Sports Car Club of America, both organized in 1958. In 1946 the Veteran Motor Car club revived the Glidden tours; though the distances covered are shorter than the originals, an annual outing is given for 400 cars. A more specialized group of car fanciers is the Classic Car Club of America (1952), devoted to collecting and restoring only the fine custom-built luxury cars made during what they consider to be the "golden age" of motoring, the late 1920s and the 1930s and early 1940s. In 1954 a competition between ten American and ten British cars built before 1930 took place and was repeated in 1957.

In the British Commonwealth, New Zealand and Canada have flourishing veteran car clubs, while one of the earliest to be founded was the Veteran Car Club of South Australia (1934). L'Association des Proprietaires de Vieilles Voitures Automobiles was founded in France in 1935 while Germany, Belgium, the Netherlands, Denmark, Czechoslovakia—indeed, nearly every European country—has at least one such club. There also are clubs in South Africa and Japan. A development in the train of the movement is the growth in motoring museums where much worth preserving finds a permanent home.

**Motor Rallies.**—From a heavy accent on pleasure motoring at the beginning of the century, the emphasis has switched to the competitive aspect, although the overriding aim of proving reliability has remained constant. International motor rallies are now "big business" and are supported extensively by automobile manufacturers who sponsor their own "works" teams and also give help to private entrants using their make of vehicle.

Europe remains the rallying centre of the world where most of the famous events are held but the sport enjoys popularity in the United States and Canada and even in Africa, where the unique East African Safari event offers additional hazards in jungle and wild beasts.

The best-known rally is the Monte Carlo, first held in 1911. Although no longer regarded as the best by the experts, it remains the most well-known to the lay public. Other leading rallies are the Liège-Rome-Liège, Alpine, Acropolis, the Tulip rally in the Netherlands, Tour de France, R.A.C. British International, the Swedish Midnight Sun, the Norwegian rally, the Finnish Thousand Lakes, Dolomites, German, Polish, Geneva, Trans-Canada and Canadian Winter.

For the Monte Carlo rally there are usually several starting points in or near widely separated towns. From each of these, competitors are sent off at one-minute intervals to drive over routes of approximately equal length to a common rallying point and from there a single route is taken to the finish. The total distance covered by each competitor is 2,000 mi. or more, covered either continuously day and night or in four or five daily runs with

overnight halts. The basis of this and similar events is regularity, by means of an average speed which has to be maintained, not merely over the route as a whole but on every section of the route between control points. Legal speed limits have to be observed, high speeds being achieved on unrestricted roads and on special sections (private land) and race circuits. Special tests of driving skill are held in difficult terrain en route. Consistent driving is needed as these tests and others at the finishing point are made against the stop watch, and the results are used, in combination with the penalty marking system for general timekeeping, in assessing the winners in the different classes. For rallies, as for racing, the world governing body is the Paris Fédération Internationale de l'Automobile (F.I.A.), founded at Hamburg in 1904 as the Association Internationale des Automobile Clubs Reconnus.

In U.S. rallies speed per se is not a factor. Rallyists follow a more or less complicated course, unknown to them until the start of the run, on public roads and under prevailing traffic regulations, the object being to maintain specified precise average speeds between check points. In the late 1950s a stock car in the low-price field crossed the United States, a 2,913-mi. trip, in 47 hr. 37 min. observing all speed limits. Rallies are sponsored by the Sports Car Club of America (founded 1944) and its regional groups. Many are run in less than a day and some are Saturday or Sunday afternoon events of only 100 or so miles. Championship two- and three-day rallies also are held by the S.C.C.A. All cars entered in a rally must pass careful inspection. Ordinarily each car is driven by a team consisting of a driver and a navigator who follows the directions for the route and calculates elapsed time, mileage and speed.

**Hill Climbing.**—One of the earliest methods of testing an automobile's power and performance characteristics was hill climbing. Almost every community had its special hill to which a car fancier would drive to see if his vehicle could "take it in high." In modern hill climbing events each driver is alone on the course, racing only against the clock. Winding curves and rough road surfaces are perhaps more of a challenge than the over-all steepness of the hill. Competition is well organized in all parts of the world and events attract top drivers and huge crowds. All types of motorcars—sports, antiques, classics and stock cars—participate under strict safety rules and regulations. This type of competition is especially rough on the low gears of the car's transmission and on the tires.

The most famous hill-climbing event in the United States is probably the annual Pikes Peak climb, dating from 1916 and held at the Colorado mountain on July 4. Other outstanding U.S. events include those at Giant's Despair (Pa.), Mt. Washington (N.H.), and Mt. Equinox (Vt.). Hill climbing is very popular in the British Isles, where an annual British championship is awarded to the driver who wins the most of about a dozen such events. Competition is well organized and drivers must have Royal Automobile club competition licences.

**Other Events.**—Other events of interest to the motoring enthusiast include the *concours d'élégance* and the gymkhana which have become especially popular in the U.S. In a *concours d'élégance* each car is judged on the basis of maintenance and appearance, taking into account the car's age and the number of miles on its speedometer. A *concours d'élégance* may be held preliminary to a rally or other event or as a separate event. Areas for judging include the condition of the paint and the finish of a car; chrome and glass; interior; motor area; undercarriage; and trunk and boot (where a soft top is fastened on and is stored).

The name gymkhana has been adopted from a display of athletics and equestrian events to apply also to motor concourses in America. A series of events are planned to test driving skill and demonstrate accurate car handling. Gymkhanas usually are held on parking lots on which a series of short but intricate courses are laid out. A typical event is a race over a tight, twisting course marked out by pylons or similar devices; competing drivers complete the course one at a time and are timed to $\frac{1}{100}$ sec. and penalized for errors, as brushing a pylon or going off course. Other events may include driving in reverse, 180° and 360° turns, parking tests, braking tests, etc.

## MODERN MOTORING

**Numbers of Vehicles.**—The number of private cars in the United States in the 1960s exceeded the combined total of all other nations. After World War I the U.S. took and held the lead in automobile manufacture and sales. The next largest national totals were the other pioneers of the motor industry, Britain, France and Germany.

Touring for pleasure is widespread and is considered one of the most distinguishing features of the contemporary culture pattern in the United States. In 1950 the United States had 40,334,000 cars, one to every four persons. By 1960 this figure had soared to 63,488,000, one for every three persons; three out of four families owned at least one car and several million families had more than one; the average car was driven 10,000 mi. annually. By the second half of the 20th century the provision of services and supplies, attractions and accommodations for touring motorists had become major enterprises, of growing importance to the economy of every state.

During the period 1950–60, Canada and New Zealand achieved an even higher rate of growth than that of the United States. Canada had one car for every seven inhabitants in 1950 but by 1960—with a car population of 1,907,000—the proportion was one in four. New Zealand had one car for every eight people in 1950 and had also reached the one-in-four mark ten years later.

Of the world's major countries only mainland China and India still had a comparatively low vehicle density and even in India the figure had radically altered from one car to every 2,325 inhabitants in 1950 to one to every 1,492 by 1960.

It is probably true to say the tendency to change cars for newer models at frequent intervals is not so marked in Europe as in the United States and Canada.

**Vehicle Size.**—Highway conditions vary enormously from country to country. In consequence, there is a pronounced tendency toward the large car in some countries, the small in others. In the Americas, where the road surfaces of the major highways are good and distances are great, the most popular type of car is large and roomy, has soft-riding suspension and a high-powered engine which will give speed without necessarily being driven at maximum revolutions. In most European countries, a car smaller both as to body and engine-size is generally preferred. A shorter distance, the narrow twisting nature of many roads, legacies of the past, and economic considerations are a big influence on the choice of a smaller vehicle.

By World War I motoring had caught the popular imagination, and after the war such men as William R. Morris (later Lord Nuffield) and Herbert (later Lord) Austin in Britain developed the manufacture of "motors for the million." The remarkable success of the "popular" car of small horsepower was largely responsible for the immense increase in the number of private cars in Europe. During the 1930s the difference between the cost of running a motorcycle and sidecar and the cost of running a small car was steadily reduced. Saloon (sedan) cars, moreover, almost completely replaced the open tourers of an earlier decade, except in the choice of the enthusiast chiefly interested in performance. In Germany Adolf Hitler stimulated the Volkswagen company to produce an inexpensive car "for the people." After World War II in France Citroën produced the low-priced "deux chevaux" (two horsepower) and in Italy Fiat produced the Topolino ("mousey").

Financial considerations—the higher cost of motor fuel in Europe—also tend to influence the European owner-driver more than his North American counterpart. At an earlier period taxation based upon engine size had considerable influence in developing British car manufacture along the lines of small units.

**Vehicle Density.**—Vehicle population, while considerably affecting the economic life of a country, is not necessarily the prime factor in determining motoring conditions. In this regard vehicle density, *i.e.*, the number of vehicles per road mile, is much more important. In this respect, the United States with its vast territories is, despite its enormous number of vehicles, at a considerable advantage over smaller countries.

Figures produced by the International Road federation showed that in 1960 Great Britain with over 8,000,000 vehicles, had 36.1

vehicles to the mile—and its vehicles were increasing at the rate of 1,000,000 a year. West Germany was not very much better placed, the figure of 31.8 representing 124% increase in a period of only six years.

Easily the lowest increase in density in the 1954–60 period when international surveys were carried out was in the United States (26%), where density was already high, whereas in Greece it was 200% and both Norway and Finland were over 150%. Even though the biggest increases are in countries with comparatively small vehicle populations, it is incontrovertible that the general trend throughout the world is to more and more motorcars with, pro rata, less road mileage for them to travel on.

**Touring Facilities.**—The growth of motoring for pleasure has resulted in a demand for ancillary services. In particular, the motoring tourist wants to know where he can get good meals and accommodation. This has led to two major developments: the appointment, after inspection, of hotels by motoring and travel organizations, supplemented by recommendations from individual writers and travel correspondents; and the motel.

Hotels value their listing in the handbooks of motoring organizations. Some motoring organizations, for example, the British, use a system of stars, five stars being awarded only to large hotels offering every facility. Undisputed leader of the publications recommending and appointing eating establishments is the French *Michelin* guide. *Michelin* employs full-time inspectors and their recommendations carry much weight among the discerning.

The motel, an idea established in the United States, was catching on in most countries by the 1960s. Motels are hotels designed for the motorist wishing to secure overnight accommodation en route quickly and without fuss. In the most popular types, each visitor has his own bungalow, chalet or flat with accompanying car-port or garage. In many countries, the motel represents a threat to the more conventional hotel which is often situated in the city centre, not easily accessible to motor traffic and sometimes lacking in garage or parking space.

The employment of the motor vehicle for vacationing and touring purposes has had an influence on their construction. In consequence, cars specially designed for these purposes have come onto the world's roads since World War II. These include station-wagons, which greatly simplify conveyance of luggage, dormobiles, which provide temporary beds, and trailers, or caravans, which are small-scale traveling homes. Caravaning is now less nomadic than it was. Often trailers are towed to a permanent site at the start of the summer season and left there until the end of the season or longer, their owners paying periodic visits and/or renting the accommodation to others when they do not require it themselves. France and some other European countries are much ahead of the rest of the world in providing permanent trailer and camping sites with excellent toilet accommodations, etc., at a low charge, while in the U.S.S.R. the well-appointed Intourist camping sites also provide for tourists on recognized routes.

The period since World War II has seen a remarkable increase in touring holidays in Europe. For instance, the number of British cars touring on the continent increased from 23,000 in 1938 to over 100,000 annually after 1956. The ferrying of automobiles across the sea has become established: across the English channel, from Scandinavia to the continent of Europe, across the Mediterrancan from Europe to Africa, etc. Car ferries now operate not only by sea but by air and rail. Cars carried on specially constructed two-decker railway trucks make up the rear part of the train that carries the owners in regular sleepers. Among the first to offer such a service were French railways with a car-by-train service from channel ports to the larger resorts of central and southern Europe, and Britain and other countries followed.

For those who plan long journeys to holiday destinations but cannot or do not wish to motor there, car rental has supplied the answer, and this has proved particularly useful for the long distances involved in travel in America. The travel and motoring organizations make the arrangements, the visitor arrives at his destination by airplane and a self-drive hire car awaits him.

**Government Regulation.**—There is great variety among rules regulating motorists; each state in the United States makes its own traffic regulations and driving rules, and in Europe too there is variety among the countries.

From the earliest days, however, most countries have insisted that drivers obtain a licence to drive, though Belgium only decided to follow the rest of Europe in 1963. The introduction of driving examinations before a licence is issued guarantees a certain minimum standard of driving. Third-party insurance is compulsory in many countries while the licensing of all motorists makes redress easier.

Accompanying a licence for the driver is a licence and registration for his vehicle. The registration index (licence) number usually is borne fore and after on the car and is recognized in most countries throughout the world. (*See* TRAFFIC REGULATION and MOTOR VEHICLE INSURANCE for details of U.S. and British procedure.) Many nations are parties to the Convention on Road Traffic of 1949, and the valid domestic registration plates and drivers' licences of their nationals are recognized by all other ratifying countries. Other measures found in a number of countries and of U.S. states are compulsory mechanical checks for vehicles and eyesight and medical tests for drivers. Some countries—Norway and Sweden, for example—are much more severe than others on the motorist who drinks alcohol (*see* LIQUOR LAW). Maximum or minimum speed limits or both are employed in nearly every country.

International travel has become easier. For many years the principal document used for taking a motor vehicle temporarily from one European continental country to another has been the *carnet de passages en douanes* (note of customs clearance), in effect the vehicle's passport, but from April 1958 this was no longer required for entry into Austria, Belgium, Denmark, France, the Federal Republic of Germany, Luxembourg, the Netherlands, Sweden or Switzerland. Passport regulations were being eased by the 1960s and fewer countries demand the production of an international driving permit from visitors. Where an international certificate for motor vehicles, driving permit or international insurance certificate ("green card") are required they can be obtained through national motoring organizations.

**Cost to the Community.**—Road accidents have become a matter of concern in all automobile-using countries. However in, for example, Great Britain the total number of people killed in road accidents each year has remained fairly constant over a 30-year period, while the vehicle population has increased six-fold.

Road construction and repair work is becoming more complex and expensive and the position is aggravated where large vehicle populations coincide with great density, as in the Federal Republic of Germany or Great Britain. In all western countries the parking and garaging of automobiles in cities is already a serious problem which is hardly alleviated by a low overall density, such as the United States enjoys. (*See* CITY PLANNING.) On the other hand, vehicles pay an increasingly heavy tax. In the United States motor vehicle users, excluding trucks, paid over $9,000,000,000 in 1961 in various taxes connected with motoring activities. In Britain the figure was £649,000,000, while road expenditure in the same year was £196,000,000.

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**MOTOR RACING:** *see* AUTOMOBILE RACING.

**MOTOR TRANSPORTATION.** This article deals with the vehicles used in commercial applications of motor transportation. The kinds of vehicles can be divided into three distinct classes: buses, taxicabs and trucks. For a discussion of the automobile, *see* AUTOMOBILE.

To gain an understanding of the numbers involved, some statistics are considered here. World motor vehicle registrations in the early 1960s numbered approximately 104,750,000 automobiles, 29,000,000 trucks and 1,200,000 buses. Of these the United States accounted for approximately 63,275,000 automobiles, 12,320,000 trucks and 280,000 buses.

Taxicab registrations are not separated from those of automobiles, but in 1961 in the United States there were 73,000 taxicabs in regularly organized operation. Estimates indicated that if a complete count were available, this number would be approximately 120,000. Worldwide, buses represented 0.9% of the registration, and trucks 22%. In the United States, buses represented 0.4%, taxicabs 0.2% and trucks 16%, the remainder being passenger cars.

## TECHNOLOGICAL DEVELOPMENT

### Buses

Functionally, motor buses may be divided into three classes: city, intercity and school. Of the 280,000 buses in operation in the United States in 1961, 204,000 were school buses and 76,000 were city and intercity.

Until 1922 the history of the bus was that of the motor truck; the early buses consisted of bus bodies mounted on a truck chassis of the buyer's choice. The majority of the present-day school buses retain this design. In 1922 the first vehicle with a chassis specifically designed for bus service was made by Fageol Safety Coach company of Oakland, Calif. Its frame was about one foot lower than a truck frame, and it also had an extra-long wheel base and a wide tread. The engine remained in the front. In 1926 the Fageol organization, which had moved to Kent, O., developed the first integral-frame bus, with twin engines mounted amidships under the floor. The integral frame utilized the roof, floor and sides of the bus as structural members.

Other early bus manufacturers were Mack and Yellow Coach, both of which built gas-electric models. In these buses a gasoline engine drove a direct-current generator. The electric output of the generator provided electrical power for the driving motors on the rear wheels. Thus, this electric system performed the functions of the transmission; *i.e.*, multiplying driving torque and providing a means of connecting and disconnecting the engine from the drive wheels. In 1928 the first transcontinental bus service was initiated in the U.S.

The truck and coach division of General Motors corporation (formerly Yellow Coach and Truck Co.) in 1931 introduced the first rear engine in the integral-frame bus. In 1938 two-stroke-cycle diesel engines were first used in buses; a large majority of the city and intercity models continued to use this engine in the 1960s.

In 1953 air suspension (a suspension in the spring and axle system to provide suitable ride characteristics) was first used in buses; in the mid 1960s most of the integral-frame models continued to employ this type of suspension. The others used leaf springs. Air suspension, although tried on automobiles and trucks, found most general acceptance in buses. In automobiles it required another engine-driven accessory, an air compressor. Manufacturers and consumers soon concluded that the improvement in riding comfort did not justify the expense of the additional equipment.

Air suspension consists of two or four air springs (heavy rubber bellows) per axle. These air springs are supplied with air from an air reservoir in which the pressure is maintained at about 100 per square inch (p.s.i.). An advantage gained from this type of suspension is that as the load increases or decreases the level and height of the vehicle remain constant. This is accomplished by valves that are actuated by the vehicle height between the body and the axle. Thus, as the load is increased the air pressure is increased in the air spring. The increased unit pressure multiplied by a nearly constant area gives a greater load capacity. As the load is removed, the air is released from the air spring, reducing the pressure and load capacity.

Unlike the leaf spring and like the coil spring, the air spring is capable of withstanding only vertical forces. Consequently, braking and cornering forces must be absorbed by links or arms with one end attached to the axle and the other to the body by pin or ball joints.

Another interesting development in motor bus transportation was the Scenicruiser, introduced by GM Truck and Coach Co. in 1954. This vehicle was a unit designed for transcontinental use. It utilized air suspension and employed six wheels, two in the front for the steering axle and four in the rear in a tandem arrangement (one axle directly behind the other with an interconnection to permit load equalization). Thus the weight of this vehicle, about 30,000 lb. not loaded, was supported by ten tires, two on the front axle and four on each of the rear axles. The frame was of the integral type and provided two levels. The first level carried the driver, ten passengers and sanitary facilities. The upper level carried 33 passengers and had a windshield so that passengers could see forward. The Scenicruiser was powered by two four-cylinder two-stroke-cycle diesel engines of 133 h.p. each. Only a limited number of these vehicles were built because of cost and weight. Many are being repowered with V-8 two-stroke-cycle diesel engines.

An average intercity bus in the mid 1960s carried 38 passengers, had sanitary facilities, and was powered by a 200 h.p. diesel engine mounted in the rear; the bus was mounted on two axles, had a wheel base of 261 in., was 420 in. long, weighed 22,000 lb. unladen, had four forward speeds, used one gallon of diesel fuel about every seven miles and cost approximately $45,000.

The bus operating within a city differs from an intercity bus in that the floor level is lower to permit standing, no luggage space beneath the floor is required, there are two doors instead of one and the transmission is automatic instead of manual-mechanical. Seating capacity varies from about 30 to more than 50, and the average cost is $32,000. Both types of buses are equipped with power steering and air brakes.

Technological developments in other parts of the world are similar to those in the U.S. City buses with two passenger levels are common in Europe.

### Taxicabs

The development of taxicabs closely parallels that of automobiles. Many of the cabs in operation are four-door passenger cars especially fitted for taxicab service. One manufacturer, the Ford Motor company, provided several modifications of its automobile design for the more severe service of taxi operation. The engine contained solid instead of hydraulic lifters, copper-lead alloy instead of Babbitt's metal main bearings, an oil bath air cleaner instead of a dry type, a specially hardened camshaft and heavy-duty timing gears instead of chain drive. Interior upholstery was vinyl for longer wear, and the doors had special check links and hinge reinforcements to aid in holding them open and closing them. To provide better low-speed charging, the manufacturer replaced the standard 30-amp. automobile generator with a choice of a 40-, 42- or 60-amp. unit. Heavier coil springs and shock absorbers were used in the front suspension system, and the rear suspension was equipped with heavy-duty leaf springs and shock absorbers. Brake lining area and clutch face area were in the order of 25% greater for taxicab service.

The Checker Motors Co. of Kalamazoo, Mich., began building vehicles especially for taxicab service in the 1920s. Features which contributed to the reliability of these vehicles included the extra-heavy double-channel X-brace frame, shock absorbers fastened to a frame cross member, reinforced seat mountings, the engine supported by two frame cross members, transmission supported by a frame cross member, battery supported directly on the frame, oil bath filter on engine breather and carburetor, each of the four fenders easily replaced in event of damage, an extra-heavy A-frame on the front suspension and a heavy-duty 10-in.-diameter clutch. Other features included a flat floor in both the front and rear for easy entrance and exit, universal fitting on sun visors to allow maximum protection from glare and an underseat heater for rear passengers. The Checker vehicle is available in four-, six- and eight-door models and can accommodate from 8 to 12 passengers.

## Trucks

Near the beginning of the 20th century several firms began the serious manufacture of vehicles to transport items of commerce. Among the notable makes in the United States with the first year of their production are: Winton (1898); Autocar (1899); Mack and White (1900); Rapid (later GMC in 1911) and Studebaker (1902); Reo (R. E. Olds) (1904); Ford, Dart, Packard and Oldsmobile (1905); IHC, Euclid and Sternberg (Sterling) (1907); Diamond T (1911); Brockway, F.W.D. and Stewart (1912); Jeffrey (1913); Kenworth (1915); Ford Model T and Dodge (1917); Chevrolet and Oshkosh (1918); Walter (1920); Divco (1927); Ford Model A (1928); and Willys Jeep (1941). Many of the same manufacturers still produce trucks.

**Types and Definitions.**—Trucks are divided into two main classes, straight and articulated. A straight truck is one in which all axles are attached to a single frame. An articulated vehicle is one which consists of two or more separate frames connected by suitable couplings. Following is a list of definitions of terms often used in the trucking industry.

*Truck Tractors.*—A truck tractor is a motor vehicle designed primarily for drawing truck trailers and constructed to carry part of the weight and load of a semitrailer.

*Semitrailer.*—A semitrailer is a truck trailer equipped with one or more axles, and so constructed that the front end and a substantial part of its own weight and that of its load rests upon a truck tractor.

*Full Trailer.*—A full trailer is a truck trailer constructed so that all its own weight and that of its load rests upon its own wheels.

*Fifth Wheel.*—A fifth wheel is a device used to connect a truck tractor to a semitrailer and to permit articulation between the units. It generally includes a lower half, consisting of a trunnion, plate and latching mechanism, mounted on the truck tractor for connection with a kingpin mounted on the semitrailer.

*Trailer Converter Dolly.*—A trailer converter dolly consists of an auxiliary axle assembly equipped with the lower half of a fifth wheel, a drawbar and other parts necessary to convert a semitrailer to a full trailer.

*Tandem Axle.*—A tandem axle is an integral assembly of two or more axles, any one of which may be powered and spaced so that the distance between axle centres is not more than one-and-one-half times the overall diameter of the wheel and tire.

*Spread Tandem.*—A spread tandem is an axle assembly in which the axles are separated by a distance in excess of one-and-one-half times the overall diameter of the tire and wheel.

*Sliding Fifth Wheel.*—A sliding fifth wheel is a fifth wheel assembly capable of being readily moved either forward or backward on the truck tractor to obtain desired load distribution from the semitrailer onto the truck tractor axles.

*Sliding Tandem.*—A sliding tandem is a trailer tandem assembly which is capable of being readily moved, either forward or backward with respect to the trailer body, to obtain desired load distribution to the axles.

*Powered Axle.*—A powered axle is an axle designed to support a portion of the vehicle weight and to transmit a driving force to the wheels.

*Non-powered Axle.*—A non-powered axle is an axle that is designed to support a portion of the vehicle weight but that does not transmit a driving force to the wheels.

*Steering Axle.*—A steering axle is an axle through which directional control of the vehicle is applied. It may be powered or non-powered.

*Landing Gear.*—A landing gear is a retractable support located near the front end of a semitrailer.

*Cab-Behind-Engine.*—A cab-behind-engine (CBE) motor truck or truck tractor is one in which the driver's compartment and controls are located at the rear of a hood-enclosed power plant.

*Cab-Over-Engine.*—A cab-over-engine (COE) motor truck or truck tractor is one in which either all or a substantial part of the engine is located under the cab.

*Tilt Cab.*—A tilt cab is a cab for a truck or truck tractor, designed to be tilted or raised to provide ready access to the engine.

*GVW.*—Gross vehicle weight; *i.e.,* empty vehicle weight plus payload.

*GCW.*—Gross combination weight; *i.e.,* empty vehicle weight plus payload.

*Single Wheel.*—A single wheel is a wheel which carries a single tire.

*Dual Wheel.*—A dual wheel consists of two wheels, each carrying a tire on the same axle and spaced less than a tire width apart.

*4 x 2.*—A truck or truck tractor with four wheels, only two of which are powered.

*4 x 4.*—A truck or truck tractor with four wheels, all of which are powered.

*6 x 4.*—A truck or truck tractor with six wheels, four of which are powered.

*6 x 6.*—A truck or truck tractor with six wheels, all of which are powered.

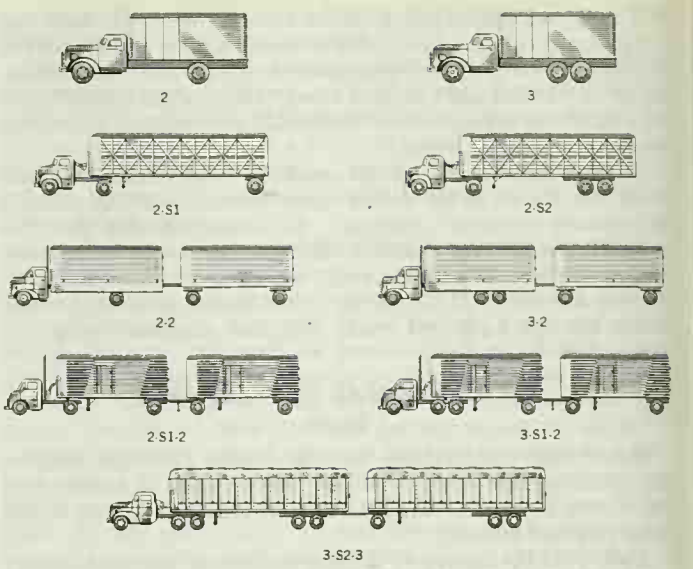


FIG. 1.—TRUCK TYPES AS DESIGNATED BY CODE BASED ON AXLE ARRANGEMENT

Shown in fig. 1 are several types of trucks and truck tractors in use, and a digit code to aid in identification of the vehicles. The first digit refers to the power unit and a second single digit refers to a full trailer, while a digit with an S prefix refers to a semitrailer. For example:

2–S1 = 2-axle tractor and 1-axle semitrailer
3–2 = 3-axle truck with 2-axle full trailer
2–S1–2 = 2-axle tractor, 1-axle semitrailer and 2-axle full trailer.

**Sizes and Weights.**—Vehicle sizes and weights have been the subject of much legislative action in the United States. The American Association of State Highway Officials (AASHO) recently established a policy for the guidance of legislators. The values adopted by the association are as follows:

*Sizes.*—Maximum width, 102 in.; maximum height, 13 ft. 6 in.; maximum length (straight truck) 40 ft., (truck tractor semitrailer) 55 ft., (other combinations) 65 ft. The AASHO permits only one semitrailer and one full trailer. All vehicles shown in fig. 1 are permitted under this policy, but, for example, a 3–S2–2–2 would not be. The COE models introduced by Ford and Chevrolet in 1938 exemplified the efforts to make more cargo space available in a given vehicle length as well as to obtain a weight advantage by placing more weight on the steering axle of the truck tractor.

*Weights.*—Maximum weight limits, 20,000 lb. for a single axle; 32,000 lb. for a tandem axle; and a gross combination weight of 88,000 lb. for any vehicle.

**Frames.**—Truck and truck tractor frames, except for the very small sizes, have remained separate from the cab and body. The frame is generally two channel sections of alloy steel with a standardized width of 34 in. overall. Semitrailers and tank trailers in many instances now employ the integral or unitized type of construction.

**Front Suspensions.**—The most common form of front suspension is a drop-forged I-section front axle attached to the frame through leaf springs and shock absorbers. In 1960 Chevrolet introduced individual front suspension for its trucks. (*See* AUTOMOBILE: *Suspension Systems.*)

**Rear Suspensions.**—The variations of rear suspensions for trucks and truck tractors are almost limitless. In the case of a truck with a single powered axle, the axle is generally attached to the frame by leaf springs. The axle is always a full floating axle; *i.e.,* all the weight is carried by the axle housing and none by the live or driving axle which is inside the housing. Thus, if a driving axle breaks, the load is still supported by the axle housing. The axle may be a single reduction type, meaning that it has one gear reduction, the ring gear and pinion. The double reduction axle, introduced in 1930, has a gear reduction ahead of the ring gear and

pinion. A two-speed axle is one in which there is a gear change built into the axle. This makes it possible to have two speeds for each transmission speed. The tandem-drive axle has two powered axles. There may be two drive shafts, one to each axle, or just one drive shaft to the forward axle and then a short drive shaft to the rear axle. There is always a system of levers between the two axles to accomplish an equalization of load on them. A powered axle may be either the Hotchkiss type, in which all of the driving and braking thrust is taken by the leaf springs, or the torque arm type, in which the thrusts are taken by the rods, one end of which is connected to the frame and the other to the axle by ball or pin joints. Because the vertical movement of the body is only one-half that of the wheels in a tandem axle, this axle is used successfully with solid rubber springs, reducing maintenance to a minimum.

**Steering.**—Steering of trucks with their relatively heavy loads was a problem until power steering came into use in the early 1950s. Steering is always by the Akerman system of a kingpin for each front wheel. Maximum cramp angle of the front wheels is about 35°. The minimum turning radius is dependent on the wheelbase. A few vehicles have been built with two steering axles in the front. (*See* AUTOMOBILE: *Steering.*)

**Engines and Fuels.**—Until 1932 when the Indiana became the first truck to have a factory-installed diesel engine, the gasoline engine had been used exclusively. By 1946 the U.S. Bureau of Public Roads estimated that there were almost 13,000 diesel-powered trucks in the U.S., and since that time the diesel engine has become increasingly favoured for long-distance hauls. In 1950 the Boeing Co. installed the first gas turbine in a truck; in the 1960s there was renewed interest in this type of engine. In 1952 Reo and IHC began to use liquid propane gas. While the diesel engine has the disadvantage of high initial cost, the propane-burning engine has the disadvantage of lower power output for a given engine displacement.

**Tires.**—Although pneumatic tires appeared on automobiles as early as 1904 it was not until 1916 that there was interest in pneumatic tires for large trucks. Prior to this, large trucks had been equipped with hard rubber tires. Until 1936 cotton was used in the carcass of truck tires. In 1936 rayon was first used. Eleven years later both wire and nylon became available for tires. Present developments in tires include the use of a single wide tire to carry the same load as a dual wheel. Increased traction was of interest as early as 1904 when tire chains first became available. Knobby snow tires were available as early as 1936, and the type of snow tire now most commonly used was introduced in 1950. About that time tires with embedded wire coils were introduced. One of the latest and most effective versions of this tire has curved tread ribs. To reduce the cost of operating, many operators use the recapping process, thus extending the life of the carcass about 2½ times. In 1955 tubeless tires became available in the large sizes.

**Transmissions.**—Although automatic transmissions for trucks have been available since the mid 1950s, they have not received popular acceptance for large units. For some diesel engines it is necessary to operate within a relatively narrow speed range, 1500 to 2200 r.p.m. This requires a large number of forward gears. Small gasoline-powered units have a minimum of four forward speeds, while one of the most recent diesel-powered units has 16 forward speeds. This is provided by combining two transmissions that each have four forward speeds. The single-plate dry-disk clutch is commonly used to connect and disconnect the engine from the transmission.

**Brakes.**—The first truck brakes were brake shoes operating directly on the wheels. From this simple beginning, the braking system evolved into one of the most complex found on any type of vehicle. After the simple hand brake the next step was the foot-operated external contracting brakes on the rear wheels only. The first air brakes were introduced in 1918. Seven years later GMC introduced four-wheel brakes on trucks. By 1930 most manufacturers were featuring the internally expanding type of brake. In the late 1930s the vacuum booster on hydraulic brakes was introduced. (This is the power brake now available on automobiles.)

Another means of brake application is electrical. In this brake, a floating armature contacts a rotating disk on the wheel when electric current is applied. The armature, which tends to rotate with the wheel, through a cam arrangement applies the shoes to the drums. Vacuum brakes working off the vacuum in the intake manifold of the spark ignition gasoline engine have been used to apply the brakes on car carriers. Air-over-hydraulic brakes are also used in some vehicles.

Air, air-over-hydraulic, vacuum and electric brakes are all adaptable to articulated vehicles. Of these methods of application, air or full air, as it is sometimes called, is the most widely used. A diagram of an air brake system is shown in fig. 2. The engine-driven compressor supplies air at a nominal pressure of 100 p.s.i.g. (pounds per square inch gauge). The pressure is regulated by the air governor. The driver is advised of the air pressure by a pressure gauge and low pressure warning device (audible or visual). Air is stored in the reservoirs. Air from the air reservoir is supplied to the brake valves; the valve in the lower left of fig. 2 is the foot valve which supplies air to all brake chambers on the vehicle, including those being towed. The other brake valve is the hand control, which applies the brakes on the towed vehicle only. Both the foot pedal and hand valve supply air to the same service line, which extends back to the towed vehicles. The second line, labeled emergency line, carries full air pressure when the vehicle is in operation. If this line should be broken, the emergency brakes are applied on all towed vehicles from air reservoirs located on the towed vehicles. After reaching the brake chambers from the brake valves, the air acts on a diaphragm connected to a push rod, which in turn actuates a cam that moves the shoes against the brake drum. In the latest design the cam is being replaced by a wedge.

In recent years much attention has been given by the Bureau of Public Roads, the Interstate Commerce commission, manufacturers, the National Safety council and truck operators to the problem of brake failures that have resulted from loss of air pressure. In the previous paragraph the action of the emergency system was mentioned in the event of the breaking of the emergency line. This system can also be utilized in case of a failure in the service line by the use of the tractor protection valve and control valve. The driver can flip the lever of the control valve and apply all brakes on the towed vehicles.

Also shown in fig. 2 is another form of safety system which in normal use is a parking brake but in event of loss of air can be used as an emergency system. It is known as a DD3 actuator. The driver has the option of using the axle on which the DD3 actuators are mounted as a parking or as an emergency braking

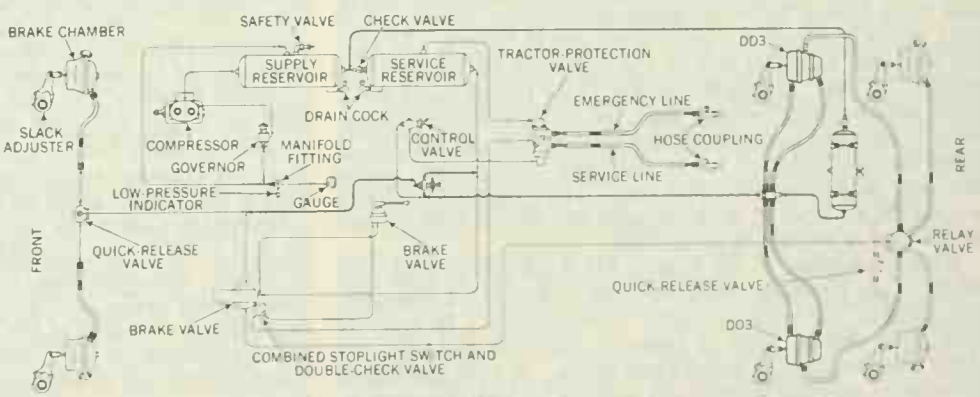


FIG. 2.—PIPING DIAGRAM FOR AN AIR BRAKE SYSTEM ON A 6-WHEEL TRUCK TRACTOR

system by operating a push-pull button. Once this system is actuated, a mechanical lock holds the brake on, even if all air pressure is lost.

Another emergency system is the spring brake system, in which springs are used to apply the brakes if the air has been lost. As long as normal air pressure is available the spring brake actuator is inactive and the normal brake chambers apply the brakes. The driver can place the system in action at his option by means of a push-pull valve.

Although air-cooled disk-type hand brakes on the drive shaft of heavy-duty trucks have been available for some time, it was not until recent years that experimental models for the wheels were seen.

**Braking Techniques.**—Studies of a four-wheel vehicle showed that:

1. Locking only the rear wheels produced an unstable condition, resulting in partial or complete loss of vehicle control.

2. Locking only the front wheels produced a condition in which the vehicle traveled on a straight path, which coincided with the centre line of the vehicle frame. Under this condition there was an almost complete loss of steering control.

3. Locking all four wheels produced a condition of near equilibrium. The vehicle traveled a path which coincided with the direction of motion of the centre of gravity at the time the brakes were applied until the velocity of the vehicle approached zero.

Locking of the wheels can occur easily on slippery pavement and result in loss of vehicle control. This has resulted in braking techniques called fanning and feathering. Fanning is rapid application and release of the brakes to allow intermittent rolling of the wheels; it permits steering control and reduces the possibility of the loss of vehicle control. Feathering utilizes the same principle of keeping the wheels rolling but does so by limiting the brake-pedal pressure to the point where the wheels are just about to lock. This technique requires considerable skill.

With the truck tractor semitrailer if (1) occurs, the unit is apt to jackknife. If on the other hand (2) occurs, then the vehicle cannot be steered. This leads then to a compromise between maximum braking with stability and steering control. Although the decision is not clear-cut, practice is to install brakes on the front wheels of four-axle vehicles but not on those of five-axle vehicles.

In other parts of the world, especially in Europe, improvements in the design and engineering of trucks have paralleled those in the U.S. (A. H. En.)

## COMMERCIAL ASPECTS

### United States

The system of commercial motor transport in the United States comprises (1) intrastate vehicle operation, regulated by the states, and (2) interstate vehicle operation, regulated under the national transportation policy of the federal government. The system is operated by private enterprise. Length, width, height and weight of trucks and trailers are regulated by state statutes that set maximum limits.

**Early Years.**—Since its beginnings in 1900, truck transportation in the United States has grown remarkably. From 1904 to 1915 trucks increased in number from 700 to 158,000. In 1935 the total was 3,675,000 and by the mid-1960s the number was about 12,000,000. During World War II the United States motor truck manufacturing industry produced military vehicles (essentially trucks) and parts valued at $2,500,000,000 per year, or 2½ times the total value of trucks and parts manufactured during the most productive peacetime year. More than 200 different and specialized types of truck transport and combat vehicles were at one time or another in production.

With the passage of the Federal-Aid Road act of 1916, new emphasis was placed on well-constructed hard-surfaced pavements and intercity highways for motor transportation. In order to qualify for federal funds to construct interstate highways, the states were required to match those funds. In 1930 the federal government provided larger grants to states for highway construction. At the same time, appropriations by state legislatures for highways increased and construction of interstate highways expanded greatly. Under the federal acts of 1921 and 1944 a new pattern was developed for a greatly expanded national highway system.

The federal highway bill passed by congress in July 1956 provided for an interstate and defense highway system, which was expected to be completed in 1972 at a total cost of about $37,000,000,000, 90% of which is contributed by the federal government. Under all federal aid highway programs, including the interstate and defense system, the total federal expenditure is expected to be about $51,500,000,000 for the entire life of the program. In order to help finance the interstate system, the federal government established additional excise taxes, which will be paid by the users, and an increased additional tax on vehicles of more than 26,000 lb. gross weight. Size limits were also placed on vehicles and combinations thereof.

As compensation for the use that commercial vehicles make of streets and highways, each state has also established a schedule of registration fees graduated according to the size and type of vehicle. The state fees plus a state fuel tax per gallon are paid by the owners of each vehicle operated. In some states trucks are also required to pay a ton-mile tax, a vehicle-mile tax, an axle-mile tax, a utility tax (for administrative costs) or other fees.

**Development and Regulation.**—With the coming of hard-surfaced highways and improved vehicles, commercial trucking developed rapidly, especially from 1918 to 1934. Shippers were attracted by the advantages of fast door-to-door transport of general freight, merchandise and supplies, and motor freight lines began to flourish, carrying intercity freight on a scheduled basis. During this period control of interstate trucking was regulated by the states under regulatory statutes administered by state agencies such as public service commissions and commerce commissions. However, there was no uniformity of pattern in state regulation, nor did there exist any set standards for administering the regulatory provisions. By 1928, 33 states had statutes regulating motor carriers of property and 43 states had laws governing passenger traffic by bus lines.

In the absence of federal regulation, many states attempted to control interstate traffic within their own boundaries; however, two rulings by the United States supreme court decreed that state regulatory bodies did not have the constitutional right to restrict or restrain interstate motor carriers. Uncontrolled rate wars thereafter began to develop among interstate operators. There followed neglect of necessary safety measures, and shippers were often the victims of irresponsible carriers. As a result, state regulatory bodies sought to promote the passage of a federal act to regulate interstate motor carriers nationally. In this objective, they were joined by trucking associations and many individual truck operators.

In 1933, as an economic measure during a period of business depression, congress passed the Emergency Railroad Transportation act and Joseph B. Eastman was appointed federal co-ordinator of transportation. Eastman, in a report issued in 1934 on the crisis in public transportation, recommended the enactment of federal control measures to regulate interstate trucking and bus operations. His recommendations included the major portion of those adopted by the organized trucking industry under the NRA (National Recovery act) code of fair practices. Eastman's program was largely supported by leaders of the trucking industry, an industry which had been organized nationally in 1933 as the American Trucking Associations, Inc. His proposals formed the basis of the Motor Carrier act of 1935.

**Interstate Commerce Commission.**—Administration of this act was given to the Interstate Commerce commission (ICC), an agency with experience in regulating competitive transport systems since 1887. In 1940 the Motor Carrier act of 1935 was incorporated as a part of the Interstate Commerce act. It included provisions for safety and economic regulation of interstate motor carriers and is administered by the ICC bureau of motor carriers.

Under this regulatory act, all interstate common and contract carriers were required to qualify for certificates of public convenience and necessity and for permits, respectively. Motor carriers of property are divided into three groups: class I, with annual gross operating revenues of $1,000,000 or more; class II, with annual gross operating revenues of $200,000 to $1,000,000; and class III, with annual gross operating revenues of less than $200,000.

Class I and class II motor carriers of property and class I motor carriers of passengers must submit quarterly and annual reports to the bureau of transport economics and statistics of the ICC, using a uniform accounting system designed to provide financial and operating statistics. Class III carriers of property, and class II and class III carriers of passengers must submit a simple annual report on their operations, which provides the commission with information on revenues, expenses, mileage, tonnage and equipment. In 1960 class I motor carriers of property comprised 7% and class II 15% of the total number of interstate regulated for-hire motor carriers.

**Motor Carrier Act Provisions.**—Interstate motor carriers of property, operating under the Motor Carrier act, are divided into three groups: common carriers, contract carriers and private carriers. For-hire carriers are classified into spheres of services as follows: regular route scheduled service; regular route non-scheduled service; irregular route non-radial service; and local cartage service. Brokers of transportation are also regulated.

The Motor Carrier act exempted from regulation specific types of operation, principally in agriculture, newspaper distribution and other specialized services. Exempted were farm trucks engaged in farm chores and in the transportation of crops, cattle, poultry, dairy products and other unprocessed agricultural products from farm to market. As the list of exempt commodities gradually increased, the regulated common carriers issued protests, declaring that the trend toward liberalization favoured the exempt and private carriers at the expense of for-hire carriers. The Transportation act of 1958 removed exemptions from certain commodities, notably frozen fruits, berries and vegetables.

Common carriers of property, operating over regular routes, comprise by far the largest segment of the for-hire motor carrier industry. They operate scheduled services between fixed terminals, and by interchange with other common carriers form a network of motor common carrier service which blankets the U.S. This group of carriers is often referred to as the "backbone" of highway freight transportation, and it is the competitive highway counterpart of the nation's railway system.

Household goods motor carriers form one of the largest and best-known groups of specialized carriers governed by the Transportation act. These carriers transport household goods by truck and trailer van from the household to the patron's new location. This service requires little crating and packing, eliminates rehandling and saves time in delivery for the customer over other methods of transportation. Another specialized type of motor carrier commonly observed is the tank truck carrier, which also comes under ICC supervision. Approximately one-fourth of all the tonnage handled by class I intercity carriers is hauled by tank trucks. There is a great variety of other specialized carriers providing service designed for special commodities.

Local cartage carriers are generally exempt from ICC control. However, when they cross state lines while carrying shipments regularly in recognized commercial zones of metropolitan areas, they are regulated as to hours of service of drivers, safety of operations and standards of equipment.

All for-hire and private carriers engaged in interstate commerce must conform to safety regulations, operating rules and maximum hours of service for employees, as established by the ICC. Daily logs must be filed reporting the hours that drivers are on the road. For-hire carriers must report all accidents in which vehicles are involved in which a fatality or an injury occurs, or in which property damage exceeds $250. Reports must be filed within 15 days after the accident to the ICC district field director in one of the 13 ICC regions. Under a complete revision of the motor carrier safety regulations, effective Feb. 1, 1952, drivers are required to be reexamined every 36 months. New standards were also set for equipment and accessories to improve safety of operation. A revision of the hours of service regulation is now in progress.

Although trucks comprise about 16.5% of the total number of registered motor vehicles in the nation, in most years they represent only about 11% of all vehicles involved in highway accidents. In recent years the trucking industry has been successful in reducing its accident involvement rate. This has been accomplished in spite of increased accident exposure due to 24-hour operation under all types of weather and terrain conditions plus the presence of ever-increasing numbers of vehicles on the road.

**Commercial Importance of the Trucking Industry.**—By the mid 1960s approximately three out of every four tons of goods moving in commerce in the United States were transported at least part of the way by trucks. Virtually all goods moving in local service were carried by trucks, and about 38% of the nation's intercity freight tonnage was carried by motor truck. Railroads transported about 28% of the intercity freight tonnage; the balance was carried by other means of transportation, or jointly by several means. Trucks hauled more than 29 billion intercity ton-miles, about 22% of the total. (A ton-mile is a load of one ton carried a distance of one mile.) Railroads carried 45% of the total ton-miles, due to the large volume of heavy, bulk items that they transport over long distances.

The trucking industry gives direct employment to about 7,500,000 persons. The average yearly wage of employees of for-hire truck carriers is about 25% higher than the national average for all private industry. Total expenditures of the trucking industry (including wages) are generally more than $42,000,000,000 a year. Trucks, although only numbering about 16.5% of all registered motor vehicles, pay about $3,000,000,000 a year in federal, state and local taxes, or more than one-third of the total of such taxes collected annually by these three levels of government.

The dominant position in the surface movement of freight now occupied by the trucking industry is due to the nation's extensive highway network, the outward expansion of population and industry, newer marketing methods and inherent advantages of trucks and trailers. These advantages include speed of delivery, flexibility in the use of routes, and versatility, as shown in the great variety of trucks and trailers designed for the transport of special types of commodities or operations. The ability to carry a load consisting of a mixed shipment of small lots (packaged goods especially) is another important advantage.

**Labour, Rates and Organization.**—Drivers and workers in interstate motor carrier operations are, for the most part, members of the International Brotherhood of Teamsters, Chauffeurs, Warehousemen and Helpers of America, commonly called the Teamsters' union. The national spokesman for the organized motor carrier operators is their trade association, American Trucking Associations, Inc., established in 1933 with headquarters in Washington, D.C. It comprises 51 state and affiliated association groups, representing all branches of the industry.

Motor common carriers of property, under the Motor Carrier act, are required to publish rate tariffs and file them with the ICC. Contract for-hire carriers also must file their rates with the ICC but need not publish them, as they are included in the terms of their contracts with shippers. Rate-making agencies, comprised of operator members, were created to secure uniformity in rates for various sectional areas. The national motor freight classifications were patterned principally after the consolidated freight classification used by the railroads. Because of the door-to-door delivery permitted by trucks, shippers often prefer truck service, even though at higher rates than competitive services.

Commodity rates are specified by motor carriers, as well as class rates, truckload, less-than-truckload and volume rates. Volume rates, which basically are lower in cents per 100 lb., for larger than for small shipments, have enabled motor carriers to compete with railroads on carload traffic. Under the Motor Carrier act of 1935, the ICC was empowered to prescribe the "lawful rate" or the maximum and minimum rates. Where minimum rates have been so prescribed, they have frequently become,

in practice, maximum rates because they are the rates actually charged.

**Co-operation with Railroads.**—A trend that promises to permit closer co-operation between the trucking industry and the railroads is the "piggy-back" type of operation. Loaded highway truck trailers, under this system, are placed aboard special flatbed railway cars and delivery is then made to the city of the consignee by rail. On arrival there, a truck tractor, owned either by the railroad or a motor carrier, makes final delivery of the loaded trailer. More than 100 U.S. railroads utilize the "piggy-back" system. These railroads not only own highway equipment, but also control motor carrier firms that are operated as normal common carriers. Railroads are required to obtain permission from the ICC to operate truck equipment; they must justify the necessity of such operations and demonstrate benefit in the public interest. (Au. S.)

### Europe

The large-scale development of commercial motor transport began in the decade following World War I. Road transport had always been important for local traffic but in the 1920s it began to compete with the railways for long-distance traffic. Under the stimulus of the war, experience had been gained in the operation of motor transport, and after the war trained drivers and army surplus trucks became available. In Britain railway strikes gave the road operators a chance to demonstrate their capabilities. Between World Wars I and II the establishment of new factories away from the railways demonstrated the declining importance of rail access for the lighter industries. World War II brought about catastrophic damage to communications and the railways suffered heavily. After that war, highway traffic increased more than railway; local rail routes were often abandoned to road transport. The numbers of commercial motor vehicles, given in the UN *Annual Bulletin of Transport Statistics*, indicates the rate of growth. However, the figures are differently compiled in the various countries and are not strictly comparable.

France in particular benefited from U.S. aid and outpaced Britain so that it had by 1960 the largest fleet of commercial vehicles in Europe. Its 1948 total of about 625,000 had reached 1,597,000 by 1960. But the 1948–60 increase of 156% (an average of 13% per annum) must be compared with the 1959–60 increase of 7.5%. In 1960 Britain had the second largest fleet with a total of about 1,406,000 vehicles. In 1948 the total had stood at 837,000 and the increase of only 68% reflected the extent to which Britain led other European countries in the late 1940s. The Federal Republic of Germany in 1960 had 687,000 vehicles, an increase of 72% over the 399,000 of 1948. The 1959–60 rate of growth was 7%. Italy had the fourth largest fleet with about 612,000 vehicles, which was 212% above the 1948 total of 196,000.

Commercial motor transport continued to specialize in the conveyance of lighter loads over shorter distances, but the greatest traffic increases occurred in the heavier loadings and longer hauls by high-capacity trucks while, especially in Germany, the use of trailers was increased. Improvements in design permitted higher speeds and the figures quoted above did not give a full measure of the increased capacity of the various fleets. There were more specialized vehicles, including bulk carriers for such goods as cement and sugar. The growth of international traffic was reflected in the work of the International Labour office on regulations for drivers and in the arrangements with customs authorities for the issue of *carnets* (customs passes) for through traffic. Specially constructed motor ferries linked the Scandinavian countries and Britain to the continent. The development of the European Common Market indicated the possibility of further increases in international motor traffic.

Governmental control varied between different countries but all gave state-owned railway systems some protection. Licensing arrangements were universal for purposes of revenue and safety, but the number of small operators made some evasion of controls possible. In most countries the railways had some financial interest in road transport, but the only approaches to integrated rail and road monopolies in western Europe were to be found in Ireland. Britain experienced a reversion from the concept of an integrated system, and the share of the nationalized undertaking in road haulage diminished following the 1953 Transport act. Finally, lower tariff barriers and expanding economies in Europe encourage the further development of road transport.

*See* also references under "Motor Transportation" in the Index. (E. A. Co.)

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## MOTOR VEHICLE INSURANCE.

Ever since an initial brief period during which motor vehicles were regarded as dangerous playthings in the hands of wealthy hoodlums, automobile accidents have been treated as giving rise only to the general liability for negligence. But increasing concern for the victims of automobile accidents has prompted extension of this liability by various legal devices. The result has been a regime of what has been described as a liability for "negligence without fault." Liability insurance, after having at first been invalidated as unlawfully protecting blameworthy action, has become the complement of this liability, designed to make increased liability bearable for the motorist.

### INTRODUCTION

Liability insurance is a contract by which the insurer assumes the risk of any liability the owner or operator of a motor vehicle may incur to third parties. The insured's principal duties are to notify the insurer promptly of any accident and to co-operate with him during the process of settlement or litigation. The insurer is obligated to defend the insured in any lawsuit and to hold him harmless within the limits of the policy. Though in some states the victim has a direct action against the insurer, most states permit the insurer to exclude such suits in their policies.

The fundamental conflict that appears in the history and present practice of liability insurance, between the law's concern for the injurer and its concern for the injured, has culminated in a crisis of automobile law. On the one hand, the compassion of courts and juries for the accident victim has induced them to increase the amounts of compensation; this, in turn, has caused a sharp rise in insurance premiums, which most motorists have felt to be disproportionate. On the other hand, limitation of recovery to cases of proved negligence, the delay and expense of such recovery, and the uncertainty of collection in the absence of insurance, have proved that liability insurance is an inadequate means for distributing the losses caused by modern traffic. Moreover, protection of the truly guilty operator is said to hamper efforts to promote greater safety.

The problem is one of enormous proportions. Every year about 40,000 persons are killed in the United States, 1,500,000 are injured and property damage of unknown billions of dollars is caused by highway accidents. Only a small proportion of the victims of these accidents are able and willing to claim compensation in costly and lengthy litigation. Even among those victims who do litigate, there are many who fail to recover. On the other hand, many among those who are found liable in such litigation, for a negligence that more often than not consists in nothing but an incorrect mechanical reaction, are burdened with financial obligations that may amount to hundreds of thousands of dollars.

This dismal picture has been improved in most countries by the introduction of compulsory liability insurance, as in the German Federal Republic and the Scandinavian countries, or guaranty funds, as in France, or a combination of these devices, as in the

Canadian provinces. In addition, assigned-risks plans have in some states of the U.S. given all applicants the opportunity to insure without regard to whether, individually or as a group, they are considered desirable risks. In the United States, Massachusetts, New York and North Carolina took the lead in adopting compulsory liability insurance, while New Jersey followed South Dakota in establishing an unsatisfied-judgment fund. Other states have variations of so-called financial- or safety-responsibility laws that compel every operator who is involved in an accident, whether he was at fault or not, to establish his financial responsibility by bond or insurance. Although they are recommended by the insurance industry as the best solution to the problem, these laws are objectionable because they do not take effect until an operator has been involved in an accident. It is small comfort for the first victim of an irresponsible driver to know that the next victim will be protected.

All existing schemes leave untouched the most grievous gap in the protection of the accident victim, namely the impossibility of recovery where negligence cannot be claimed or proved. Saskatchewan has attempted to solve this problem by a government-operated compensation plan. Other countries, such as Austria, have added strict (non-fault) liability to compulsory liability insurance. It has been argued that final reform will require the abandonment of the tort basis of automobile insurance altogether and the replacement of negligence liability and liability insurance by a new scheme of loss insurance (accident and property insurance) to be carried by the driver or owner on any potential victim's behalf. Important models are available for such a scheme. In the Federal Republic of Germany air carriers and freight forwarders are relieved of their liabilities upon taking loss insurance on behalf of any third party to be injured or damaged in their operations. But, most important, the U.S. automobile liability insurance policy itself contains the prototype of what may become a full-fledged insurance scheme of the future. Under the "first-aid" or "medical payment" clause the insurer pays to anyone injured by the insured's vehicle a specified amount (up to $5,000) without proof of fault. Extension of this kind of coverage to members of the operator's family may be a step toward a scheme that will provide a general, inexpensive and speedy means of recovery for the traffic victim. Such recovery will, of course, be limited. It will enable the insurer to avoid litigation and multiple insurance and thus to provide broader insurance at cheaper premiums. It will also relieve the owner and operator of the risk of being ruined by damage claims often based on little more than a technical error. (A. A. E.)

## UNITED STATES

With more than 75,000,000 vehicles in use in the United States, the automobile insurance industry has assumed a position of vast economic and social importance. Since 1898, when the first automobile liability policy was written in the U.S., automotive insurance has grown to a point where more than $6,000,000,000 is paid for it each year. As late as 1930, fewer than 30% of the nation's car owners carried auto insurance of any kind. By the early 1960s, between 80% and 85% of the driving population carried at least liability coverage on their cars.

**Types of Coverage.**—In studying auto insurance there are two basic areas to consider—the kind of vehicle being insured and the extent to which it is insured. Each of these areas, in turn, may be subdivided into a number of more specific categories. The kind of vehicle being insured can generally be designated by one of three broad categories—private passenger cars, public vehicles, such as taxicabs, and commercial vehicles, such as cargo-carrying trucks. Each type is subject to a different degree of hazard and therefore requires a different class of insurance protection. While there are many specific forms of insurance protection that may be purchased for each category of vehicle, there are four basic kinds—liability, collision, comprehensive, and medical payment. Liability insurance pays for damage to someone else's property or for personal injury to pedestrians, to occupants of another car or, in some instances, to occupants of the insured's car if it is involved in an accident for which the insured is judged legally liable. Collision insurance will pay for damage to the insured car if it collides with another vehicle or object. Comprehensive insurance will pay for damage to the insured car resulting from fire or theft and for glass breakage and damage resulting from many other causes such as storm or wind damage and vandalism. Medical-payment insurance pays for medical treatment for the policyholder or anyone else who is hurt while in the policyholder's car. Some types of medical-payment insurance also protect the insured and his family while they are pedestrians, and protect pedestrians struck by the insured car.

Other forms of coverage, such as protection against uninsured motorists or for emergency road service, may or may not be included in individual policies, depending upon the buyer's wishes and the coverages offered by the company with which he is insuring. Each policy specifies types of coverage that it does or does not include. In some states, protection against uninsured motorists is mandatory. More than 700 companies write auto insurance in the United States and many have their own innovations, variations and additions to the four basic coverages.

**Rates.**—A common misconception about automobile insurance is that all rates are the same. Competition in rates and coverages is, in fact, keen, especially between the "independent" companies and the "bureau" companies.

Independent companies proceed independently and competitively in determining the cost of each form of coverage. Some of the larger independents base their rates on the accident experience of their own policyholders. More than 300 of these companies are members of the National Association of Independent Insurers, an organization that actively encourages competition in insurance rates.

Bureau companies pool the combined accident experience of the policyholders of a number of companies to establish a rate at which most members of the rating bureau will sell insurance. Of the many such bureaus in the United States the most widely recognized are the National Bureau of Casualty Underwriters, the National Automobile Underwriters Association and the Mutual Insurance Rating Bureau.

Establishing the cost of automobile insurance is a complex task that never ends. Accident costs (based on semiannual and annual reports) are combined with administrative costs of selling and servicing insurance to compute the rates that companies charge for the protection they sell. There are many ways of computing rates but recent trends have been toward considering the following factors: age of the car; age and sex of the driver; where, how much and for what the car is used; make and model of the car. In order to divide the cost of insurance fairly among all drivers, most companies divide car owners into a number of groups, based on the probable accident rate for each group. In general, the lowest rates are granted to drivers with good records who are over 25 and under 65 years old, who do not use their cars for business and whose cars are not driven by unmarried males under the age of 25. Statistics show that this is the safest group of drivers. Higher rates are paid by unmarried males under the age of 25 who are principal owners and operators of their own cars. These youthful drivers have made for themselves the costliest insurance rates of any group by having proportionately more accidents, and more serious accidents, than any other group.

One important fact, often overlooked, is that the driving public basically determines insurance rates through its record of accidents and accident losses. The insurance companies or the rating bureaus relate these statistics to net cost of protection against loss. To this cost is added a figure for overhead (to include profit) in determining the insured's payment premium.

Auto insurance companies in the United States are regulated by insurance departments in each of the states. These regulatory bodies review rates to make sure that rates are neither unfairly discriminatory nor excessive. Rates set should be adequate to allow sound business operation by the companies in the state. This regulation by insurance departments means that insurance companies must be highly efficient to meet competition.

**Marketing.**—In the automobile insurance industry, the marketing process is handled through agents who represent a single

company, through agents who represent a number of companies or through brokers. The exclusive agent who writes for one organization only is an independent contractor or employee of the insurer. In most instances, his company handles the book work for him—billing, collecting, processing of renewals, etc. Many of these companies use continuous policies—that is, policies are issued only once and are renewed at the end of each policy period. The company controls the renewals and pays the agent a salary or a service fee each year for providing service to policyholders.

The other type of agent is one who represents several competing companies. He controls renewal of his customer's policies and is free to shift business from one company to another at will. Since he writes for several companies, this type of agent usually handles his own billing and collection for new and renewal business.

(T. C. M.)

### GREAT BRITAIN

Motor vehicle insurance in England, in practical form, dates from 1898, but it was not until Jan. 1, 1931, that compulsory third-party motor insurance became effective in the United Kingdom. Similar subsequent legislation is operative in the Republic of Ireland and the Isle of Man. Insurance is compulsory only insofar as personal injuries to third parties is concerned and not for accidental damage to property of third parties. There is no compulsion upon insurers to accept the risk, but in practice insurers refuse to grant insurance in accordance with the act only in extreme circumstances.

Insurers must deliver to the insured a certificate of insurance written in prescribed form and issued in accordance with the provisions of part 2 of the Road Traffic acts, 1930–34, the Motor Vehicles and Road Traffic acts (Northern Ireland), 1930–34, and of the Road Traffic acts, 1933–39 (Isle of Man). At each renewal of the policy a new certificate of insurance is necessary and, since insurers are not permitted to grant policyholders days of grace for the payment of the renewal premium, each new certificate must be in the possession of the policyholder before the expiration date of the old certificate. It is general practice among insurers to incorporate on the renewal form a note providing cover in the limited terms of the Road Traffic act of 1930 and 1960 until the 15th day from the expiration date. The act also imposed upon the insurer a liability for payment for emergency and hospital treatment; this liability was revised and extended by the Road and Rail Traffic act of 1933 and by the Road Traffic act of 1934 and was restated in the Road Traffic act of 1960.

The Law Reform (miscellaneous provisions) act of 1934 and the Law Reform (contributory negligence) act of 1945 imposed heavy additional burdens upon insurers. On the death of the motorist, his liabilities continue in his personal representatives, and when the injured person dies, his rights of action survive in addition to those of the dependents, under the Fatal Accidents acts (1846, 1864 and 1908). By the act of 1945, contributory negligence does not defeat a plaintiff's claim absolutely but extends a modified right to recover damages.

**Types of Coverage.**—There are three types of insurance coverage: liability for third-party personal injury only; full third-party; and comprehensive. The full third-party contract grants indemnity for both personal injury and property damage; fire and theft risks and other benefits may be added by agreement. Applied to private cars, the comprehensive policy covers: (1) loss of, or damage to, the insured vehicle; (2) full third-party liability and liability to passengers, the indemnity being unlimited in amount and inclusive of all law costs; (3) hospital charges, for which the insured is liable to third parties; (4) medical expenses up to £20 per person to any injured occupant of the insured car; (5) personal accident benefits to the insured, comprising capital sums for death, loss of limbs, etc.; (6) loss of, or damage to, rugs, coats and luggage (limit £20). For commercial vehicles and for motorcycles a modified comprehensive policy is granted.

**Differential Rating.**—Premium rates are assessed according to the type, age and value of the vehicle, the nature of its use and the district where it is ordinarily garaged (a higher-rate schedule applying to more hazardous areas). Uses are rated according to classification. In addition to social and domestic purposes, class 1 for private cars allows business use by the insured, in person, provided that it does not involve commercial traveling or the carrying of goods or samples. The use of the car for business or trade purposes and for the transport of goods is allowed under class 2, but commercial traveling and certain other uses are excluded and placed in a further classification.

Premium reductions are allowed in particular circumstances; *e.g.*, when the insured party agrees to bear the first amount of the loss under any section of the policy or when the policy is restricted to one named driver only. An accumulative discount is usually allowed where no claim has arisen during a specified period of insurance. Premiums for commercial vehicles are based upon district, trade and carrying capacity, and the class of vehicle licence held is also considered. For motorcycles, no distinction is made between private and business use.

In spite of the statutory compulsion to insure, cases can arise where the injured person has no redress at law. Insurers have therefore voluntarily established the Motor Insurers' bureau, a central fund to protect injured third parties when ineffective insurance, or complete absence of insurance, prevents them from recovering rightful damages.

A motorist in the United Kingdom can arrange for his policy to be extended to cover him in Europe. British motorists visiting certain European countries are provided with an international motor-insurance card as evidence of insurance against third-party risks. Motorists entering the United Kingdom from Europe have similar facilities.

### OTHER COUNTRIES

Compulsory insurance laws obtain in most European countries and, in general, insurance is compulsory in varying degrees for both third-party personal injuries and damage to property. Belgian law requires the widest protection with unlimited coverage for bodily injury (including passengers) and with a limit on property damage only for fire and explosion risks. It is not unusual in European countries for the policy, proposal and endorsement wordings, and insurance rates in some instances, to be compulsorily identical under state approval.

Premium rates are generally much higher than in the United Kingdom and therefore damage cover is usually dispensed with and full comprehensive cover little sought. Policy cover is built up in separately rated sections and in some countries unlimited indemnity for third-party risks, unless compulsory, is difficult or impossible to obtain.

In Latin America, although premium rates vary from country to country, they usually conform to a tariff subject to state approval. The insurance of motor vehicles is not generally compulsory and, where effected, the limits of cover for third-party liability are low compared with U.S. and European standards. The cost of recovering damaged vehicles in undeveloped areas is high and, because of import restrictions and absence of satisfactory registration schemes, the theft of vehicles or of essential parts presents a serious problem.

(P. Ss.)

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**MOTT, JOHN RALEIGH** (1865–1955), U.S. evangelist who was awarded the Nobel prize for peace (with Emily Greene Balch) in 1946 for his work in international church and missionary movements, was born in Livingston Manor, N.Y., on May 25, 1865. He graduated from Cornell university, Ithaca, N.Y., where he was active in student affairs. In 1888 Mott became student secretary of the International committee of the Young Men's Christian association (Y.M.C.A.), and held that position until 1915. He was chairman of the Student Volunteer Movement for Foreign Missions, 1915–28, the International Missionary council, 1921–42, and president of the World's Alliance of Y.M.C.A.'s, 1926–37. Among his many published works were *Strategic Points*

*in the World's Conquest* (1897); *The Future Leadership of the Church* (1909); *Five Decades and a Forward View* (1939); and *The Larger Evangelism* (1944). Mott died in Orlando, Fla., on Jan. 31, 1955.

**MOTT, LUCRETIA** (née COFFIN) (1793–1880), U.S. reformer and proponent of women's rights, was born at Nantucket, Mass., on Jan. 3, 1793. At 13 she was sent to a Friends' boarding school at Nine Partners, near Poughkeepsie, N.Y., where James Mott (1788–1868), whom she married in 1811, was then teacher. The Motts spent their married life in or near Philadelphia, where James Mott was a commission merchant. Concerned members of the Society of Friends, they associated themselves after the Quaker "separation" of 1827 with the "Hicksite" branch, followers of Elias Hicks. As an acknowledged minister in the society, Lucretia Mott preached ultraliberal religious views that did much to carry the "Hicksite" Friends toward a quasi-Unitarian position. Both husband and wife took an active part in the campaign against slavery.

In 1840 Mrs. Mott went to London to attend the World's Anti-Slavery convention. Her exclusion from the convention because of her sex led her to take up the cause of women's rights. In 1848 with Elizabeth Cady Stanton she called a convention at Seneca Falls, N.Y., "to discuss the social, civil and religious rights of women" which issued a "Declaration of Sentiments" modeled on the Declaration of Independence. This gathering marked the formal beginning of the organized women's rights movement in the U.S. An eloquent and effective public speaker, she also enlisted in other reform movements of the day, including anti-Sabbatarianism, temperance and peace.

Mrs. Mott died on Nov. 11, 1880, at "Roadside," near Abington, Pa.

*See* Otelia Cromwell, *Lucretia Mott* (1958) and Anna Davis Hallowell, *James and Lucretia Mott* (1884). (F. B. T.)

**MOTT, NEVILL FRANCIS** (1905– ), a leading English authority on solid state physics, particularly on the theory of electrons in metals and on dislocations and other defects in the crystalline structure, was born on Sept. 30, 1905, and educated at Clifton college and at St. John's college, Cambridge. In 1929–30 he was lecturer at Manchester university, and from 1930 to 1933 he was fellow and lecturer, later (1959) to be appointed master, Gonville and Caius college, Cambridge. He was Melville Wills professor of theoretical physics at Bristol university (1933–48) and then Henry Overton Wills professor and director of the Henry Herbert Wills physical laboratories there (1948–54). In 1954 he became Cavendish professor of experimental physics at Cambridge. He was elected a fellow of the Royal society in 1936 and received the society's Royal medal in 1953, and many other honours. Mott's publications include *An Outline of Wave Mechanics* (1930); *The Theory of Atomic Collisions*, with H. S. W. Massey (1933); *The Theory of the Properties of Metals and Alloys*, with H. Jones (1936); *Electronic Processes in Ionic Crystals*, with R. W. Gurney (1940); *Wave Mechanics and Its Applications*, with I. N. Snedden (1948); *Elements of Wave Mechanics* (1952); and papers on atomic physics, metals, semiconductors and photographic emulsions. (D. McK.)

**MOTTEUX, PETER ANTHONY** (originally PIERRE ANTOINE) (1663–1718), English translator, journalist and dramatist of French origin, remembered chiefly for his versions of Rabelais and of Cervantes' *Don Quixote*, was born at Rouen, Normandy, on Feb. 25, 1663. A Huguenot, he came to London in 1685 after the revocation of the Edict of Nantes and quickly became completely anglicized. By 1692 he had settled into the career of a man of letters, and as editor (1692–94) of the monthly *Gentleman's Journal* he was a pioneer of English literary journalism. During 1693–94 he published Sir Thomas Urquhart's translation of the first three books of *The Works of F. Rabelais*, revised and completed by himself, and in 1708 appeared his own version of the fourth and fifth books. More accurate, though less vivid than Urquhart's, it displayed his mastery of supple and colloquial English prose. His spirited version of *The History of the Renown'd Don Quixote* appeared during 1700–03 (rev. ed., 1712). His dramatic works include *Love's a Jest* (1696), *Beauty in Distress* (1698) and numerous librettos for operas and masques. During his later years he owned a prosperous India warehouse in Leadenhall street. He died in a London brothel on Feb. 18, 1718. Murder was suspected, but those accused were acquitted.

*See* R. N. Cunningham, *Peter Anthony Motteux, 1663–1718* (1933). (H. G. WH.)

**MOTTEVILLE, FRANÇOISE BERTAUT,** DAME DE (*c.* 1621–1689), one of the finest French memorialists, was the daughter of Pierre Bertaut, a gentleman of the bedchamber to Louis XIII. She was taught Spanish by her mother and soon won the favour of Anne of Austria. She was married in 1639, during exile in Normandy, to the 80-year-old Nicolas Langlois, sieur de Motteville; was widowed two years later; and returned to court in 1643. As one of Anne's ladies-in-waiting, she served her devotedly through every crisis of the regency and of the Fronde (*q.v.*). She died in Paris in Dec. 1689. Her *Mémoires pour servir à l'histoire d' Anne d'Autriche* were published in 1723 (1st English translation, 1725–26) to counteract the subversive effect of the cardinal de Retz's *Mémoires*. Clear in narration and highly informative on such matters as a lady-in-waiting could know, they are characterized by candid royalism and by a pleasantly prim tone of disapproval toward all troublemakers. The best text is provided by F. Riaux, four volumes (1855; final edition 1911; new English translation, three volumes, 1902). (J. G. R.-S.)

**MOTTL, FELIX** (1856–1911), Austrian conductor and composer known for his performances of Wagner. Born at Unter-St.-Veit, near Vienna, Aug. 24, 1856, he studied at the Vienna conservatory, and in 1876 conducted Wagner's *Ring des Nibelungen* at Bayreuth. His direction of the Karlsruhe opera from 1881 to 1903 was remarkable for his performances of the works of both Wagner and Berlioz. He conducted the *Ring* in London (1898), *Parsifal* in New York (1903) and was director of the Munich opera in 1907. He wrote three operas and orchestrated Wagner's *Wesendonck Lieder* and works by Liszt and Chabrier.

Mottl died at Munich, July 2, 1911.

**MOTYA** (modern SAN PANTALEO), a small flat island in a lagoon, situated off the west coast of Sicily. Phoenician colonists from north Syria settled there shortly before 700 B.C., at the same time that the Greeks were establishing themselves in eastern Sicily. For the next three centuries Motya was an important centre of Phoenician commerce. Relations with its Hellenic neighbours were apparently peaceful until *c.* 580 B.C., when the Phoenicians helped to foil an attempt by Pentathlos of Cnidus to found a Greek colony at Lilybaeum (Marsala); the first fortifications on the island probably date from this early period of conflict. Henceforward, the Motyans gradually passed under the sway of their kinsmen in Carthage, but this did not prevent them from succumbing to the cultural influence of their Hellenic rivals: archaic Greek inscriptions found on the island suggest the presence of a Greek community living in their midst.

Soon after the abortive Carthaginian invasion of Sicily in 480 B.C., a dedication at Olympia (according to Pausanias) commemorated a victory over Motya by Acragas. In 409 and 406 B.C. the island served as the base for further Carthaginian armaments against the Greeks, but once again the tide of war recoiled upon the Motyans: in 397 B.C. their city was captured and razed by Dionysius I of Syracuse after a prolonged siege, recorded in detail by Diodorus Siculus. The Carthaginians subsequently transferred their base to Lilybaeum: Motya was never rebuilt as a city, and remained deserted until medieval times.

The island abounds in Phoenician monuments. The whole circuit of the city walls is visible: several stretches, in handsome ashlar masonry, are well preserved. At the northern and southern extremities, double gates are flanked by massive towers. Near the north gate, traces of a causeway, linking the island with the Sicilian mainland, can be seen under shallow water. The south gate stands by the artificial rectangular harbour (cōthōn), a regular feature of Phoenician ports. Diodorus speaks of richly appointed houses, several stories high: excavations have unearthed a spacious villa of the 5th century B.C., whose floors are adorned with fantastic animals in pebble mosaic, in the contemporary Greek idiom. Further excavations, under British direction, are

in progress (early 1960s), with the aim of uncovering more of the Phoenician town.

*See* J. I. S. Whitaker, *Motya: a Phoenician Colony in Sicily* (1921). (J. N. Co.)

**MOUCHEZ, AMÉDÉE ERNEST BARTHÉLÉMY** (1821–1892), French astronomer and naval officer, whose most memorable work was the inauguration of international co-operation for charting the heavens, was born at Madrid, Spain, on Aug. 24, 1821. In 1878 he was made director of the Paris observatory with the rank of rear admiral. A spectroscopic department was established, and the gigantic task of reobserving all Lalande's stars was completed.

He published 21 volumes of *Annales,* and the first two volumes of the *Catalogue de l'observatoire de Paris.* The advances in stellar photography made by Paul and Prosper Henry and others suggested to him the magnificent idea of obtaining, through the collaboration of astronomers in all parts of the world, a chart of the entire celestial sphere containing more than 50,000,000 stars. He died at Wissous, near Antony, on June 25, 1892.

**MOUFLON** (MUFLON, MOUFFLON), the wild sheep (*Ovis musimon*) of Corsica and Sardinia. The rams carry good horns and in summer show a conspicuous light saddle-shaped mark on the otherwise dark reddish-brown coat. The Armenian and Persian mouflon (*O. orientalis*) is a larger and redder sheep, with horns curving widely, so the points are near the back of the neck. A small race (*O. orientalis ophion*) inhabits Cyprus, where, however, it was so extensively hunted that it nearly became extinct; protective measures have saved it. (J. E. HL.)

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MOUFLON (OVIS MUSIMON)

**MOULDING:** *see* MOLDING.

**MOULIN, JEAN** (1899–1943), French civil servant and hero of the Resistance during World War II, was born at Béziers (Hérault) on June 20, 1899. Educated at the faculty of law in Montpellier, he entered the civil service. In 1930 he became the youngest subprefect in France, and in 1937 the youngest prefect (of the Eure-et-Loir *département*). He gained a good reputation as an administrator and was known for his devotion to the republic. When the Germans occupied his *département* in 1940 he refused their command to sign a document describing atrocities alleged to have been committed by the French army and tried to commit suicide. After being removed from his prefecture he joined the Resistance and escaped to England. He returned to France as Gen. Charles de Gaulle's delegate-general for the unoccupied zone and played a leading part in the organization of the *maquis* (French guerrillas who fought the Germans) and in the development of the National Council of the Resistance, which co-ordinated the various movements and of which he became first chairman (May 27, 1943). As "Max" he became a legendary figure. In June 1943 the Gestapo arrested him at Caluire, near Lyons. Tortured in one prison after another and eventually taken to Germany, he died in Metz on July 8, 1943. (P. W. C.)

**MOULINS, LE MAÎTRE DE** ("THE MASTER OF MOULINS") (fl. *c.* 1480–*c.* 1500), French painter, miniaturist and possibly a designer of stained-glass windows, unidentified author of the triptych of the cathedral of Moulins. He is perhaps the most significant exponent of the French spirit in late Gothic painting, cherishing as he did decorative and monumental composition, refined form, aristocratic gesture and a feeling of delicate life, particularly striking in the faces of children.

The Moulins triptych was painted about 1498–1500 for Duke Peter II of Bourbon and his wife Anne, the daughter of King Louis XI. By comparison with this triptych the following group of works has been assembled, undoubtedly by the same hand: "Nativity With the Cardinal Jean Rolin" (*c.* 1480, Autun); "Portraits of Peter II of Bourbon and His Wife Anne of France" (1488, workshop replica of a lost original, Louvre); the two wings of a diptych (*c.* 1490): "Cardinal Charles de Bourbon" (Munich) and "Madonna With Child and Angels" (private collection, unpublished); "Portrait of Margaret of Austria" (*c.* 1491, Lehman collection, New York); "Title Page of the Statutes of the Order of St. Michael" (miniature, *c.* 1494, Bibliothèque Nationale, Paris); "Madonna With Child and Angels" (*c.* 1495, Brussels); "Portrait of a Praying Child" (*c.* 1495, Louvre); "Female Donor With St. Magdalen" (*c.* 1495–1500, Louvre); "Meeting at the Golden Gate" (*c.* 1500, London); "Annunciation" (*c.* 1500, Chicago); "St. Maurice (?) and a Donor" (*c.* 1500, Glasgow); and, possibly, the painted window at the cathedral of Moulins given by the Popillon family, about 1500.

These works reveal one of the most important French painters of the late 15th century, working for King Charles VIII, for the Bourbon family and for the archduchess Margaret of Austria. The style, although strongly influenced by Hugo van der Goes, is unmistakably rooted in French artistic traditions, those of Bourges and the Bourbonnais.

GIRAUDON

"PORTRAIT OF A PRAYING CHILD" CREDITED TO LE MAÎTRE DE MOULINS. IN THE LOUVRE, PARIS

One hypothesis, based on the sitters of his portraits, identifies the master of Moulins as Jean Perréal, official painter of Charles VIII and of Margaret of Austria; another, based only on a strong similarity of style, with Jean Hay of Flemish origin, the painter of a beautiful "Ecce Homo" (1494, Brussels museum); and a third, a purely conjectural interpretation of documents, with Jean Prévost (also called "Jean le Peintre"), a stained-glass painter active in Lyons (1470–99).

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**MOULINS,** a town of the Auvergne, on the Allier river, capital of the *département* of Allier, France, 61 mi. (98 km.) S.E. of Bourges. Pop. (1962) 23,187. The cathedral, which has notable stained-glass windows, possesses a vast choir of the 15th–16th centuries. It has a beautiful triptych by the Maître de Moulins (*c.* 1494). A 14th-century square tower, a part of the ancient castle of the dukes of Bourbon, serves as a prison. The "Jacquemart," a 15th-century belfry, is famous for its four automatons, which operate every quarter-hour. In the municipal museum are preserved fine Gallo-Roman collections and paintings by old masters. The boys' *lycée* is housed in the former Convent of the Visitation, founded in 1616 by St. Jane Frances de Chantal, who died in Moulins (1641). The library, in the Hôtel de Ville (19th century), possesses the 12th-century Souvigny Bible. Moulins is the seat of a prefecture, of a bishopric and of a court of assizes; it also has a tribunal of first instance, a commercial tribunal and a chamber of commerce. The principal industrial concerns are tanneries, a shoe factory, factories producing precision machine tools, breweries and furniture factories. Cultivation of cereals and cattle breeding (Charollaise breed) are significant in the Moulins region.

Moulins did not become important until the 10th century. It received its charter in 1232, and in 1327, when the Bourbonnais was erected into a duchy, Moulins became its capital. The Burgundians besieged it in 1412. From 1488 to 1522, under Peter II and his wife Anne of France, the town reached a high state of splendour. In 1562 the Protestants besieged the town; but it was

from Moulins that the famous *ordonnance*, an act of justice and religious toleration, was issued in 1566 on the initiative of the chancellor Michel de l'Hospital.

**MOULMEIN,** the headquarters of Amherst district and Tenasserim division of the Union of Burma and an important river port on the southern bank of the Salween near its mouth. Pop. (1953) 102,777. Shipbuilding, which was formerly an important industry, was abandoned, but there is a considerable export of teak and rice, and there are several steam-powered rice- and sawmills. Rail connection exists with Rangoon from Martaban, on the opposite bank of the Salween, and from Moulmein itself a railway runs southward to Ye. River steamers ply from Moulmein up the Salween and several of its major tributaries. The town is protected from the sea by Bilugyun Island, and the approach to the port is from the south, pilots being taken aboard at Amherst (Kyaikkami). The picturesque port, however, is silting up.
(L. D. S.)

**MOULTRIE, WILLIAM** (1730–1805), American Revolutionary War general and governor of South Carolina, was born in Charleston, S.C., Dec. 4, 1730. He was elected to the provincial assembly 1752–60, then fought against the Cherokees. He espoused the American cause on the outbreak of the Revolution and served in the provincial congress of South Carolina 1775–76. In March 1776 Moultrie took command of a fort he had built of sand and palmetto logs on Sullivan's Island off Charleston, and he held it against a heavy British attack on June 28. The fort was renamed Ft. Moultrie in his honour. He received the thanks of congress and was made a brigadier general in the continental army in Sept. 1776. Moultrie campaigned in Georgia and dislodged the British from Beaufort, S.C., in Feb. 1779 but surrendered with the fall of Charleston in May 1780. He was a prisoner on parole until Feb. 1782, when he was exchanged, and then served to the end of the war. After the war he was governor of South Carolina from 1785 to 1787 and again from 1792 to 1794, being in the state senate between terms. He was also a member of the state convention that ratified the federal constitution. Moultrie died in Charleston, on Sept. 27, 1805. His *Memoirs of the American Revolution*, two volumes, appeared in 1802. (H. H. P.)

**MOUND BUILDERS,** in North America, the name applied in the 19th century to a large segment of the prehistoric inhabitants from the Great Lakes to the Gulf of Mexico. It once was thought that the builders of a wide variety of earthen mounds were a distinctive group of people more advanced in their culture than the historic Indian tribes, but this interpretation has not held. A large number of distinctive prehistoric Indian cultures associated with various types of mounds are recognized by archaeologists.

The commonest mound type is the burial mound, which is

BY COURTESY OF STATE OF OHIO DEPT. OF INDUSTRIAL AND ECONOMIC DEVELOPMENT

THE GREAT SERPENT MOUND IN ADAMS COUNTY, O.

usually subconical or elliptical in form and varies from 2 or 3 ft. to more than 70 ft. high, and from 15 ft. to 275 ft. in diameter. Many different kinds of burials were placed in these structures. In more complex mounds log tombs or stone cysts enclosed the remains of the dead. The Adena and Hopewell mounds of the Ohio valley are outstanding examples of this mode of burial. Burial mounds were first built about 1000 B.C. and continued in use but in decreasing numbers until the early historic period.

The other major mound form was a platform of earth on which the important buildings of the agricultural communities were constructed. In large prehistoric centres as many as 50 of these were built, often in groups around a plaza area in which important ceremonies were held. The pyramidal or temple mound construction began about A.D. 700 in the southeast and lasted until the early historic period. Many of the historic tribes of the southeast from the Shawnee and Illinois on the north to the Natchez and Creek on the south built such mounds in their permanent villages.

*See* also ADENA MOUND; CAHOKIA MOUND; HOPEWELL; INDIAN, NORTH AMERICAN: *Culture Provinces: Eastern North America*; SERPENT MOUND, GREAT; and references under "Mound Builders" in the Index.

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(J. B. GR.)

**MOUNT, WILLIAM SIDNEY** (1807–1868), U.S. painter, one of the first and best American anecdotal painters, was born at Setauket, L.I., N.Y., on Nov. 26, 1807. He studied at the National Academy of Design, New York. He was pre-eminent in the genial portrayal of country life.

His notable works include "Dancing on the Barn Floor" (Suffolk museum, Stony Brook, N.Y.); "Bargaining for a Horse" (New York Historical society); "The Long Story" (Corcoran Gallery of Art, Washington, D.C.); "The Power of Music" (Century association, New York); "Eel Spearing at Setauket" (New York State Historical association, Cooperstown, N.Y.); "Long Island Farmhouse" and "Raffling for the Goose" (Metropolitan Museum of Art, New York). He also painted numerous portraits.

He died at Setauket, Nov. 19, 1868.

His brother, SHEPARD ALONZO MOUNT (1804–68), was a portrait painter.

*See* Bartlett Cowdrey and Hermann W. Williams, Jr., *William Sidney Mount 1807–1868, an American Painter* (1944). (HN. W. W.)

**MOUNTAIN,** a landform distinguished by three characteristics: it rises prominently above adjacent land, has a narrow summit area and has considerable local relief—that is, the vertical distance is great from the peaks or ridgetops to the bottom of the valleys. The term has no standardized geographic meaning; consequently, the designation of rough-terrain areas is influenced by the character of the surrounding areas. Mountains generally are understood to be larger than hills; but some low, small features rising conspicuously from the flat plains of North Dakota called the Turtle mountains are considerably smaller than the Berkshire hills of Massachusetts; and the Catskill mountains of New York would be rather inconspicuous among the foothills of the Sierra Nevada range. Mountains usually attain considerable elevation, but elevation is not a guide to nomenclature; extensive areas of the western Great Plains are higher than most of the Appalachian mountains. The characteristic of narrow summit areas is necessary to distinguish mountains from plateaus; vast flat plateau sections of Tibet, Bolivia and southern Utah stand higher than whole mountain ranges elsewhere.

For a discussion of the formation of mountains *see* GEOLOGY: *Structural Geology;* isostatic adjustments that permit mountains to stand high above their surroundings are discussed in ISOSTASY. For the various kinds of rock that make up mountains *see* PETROLOGY (for igneous rocks), SEDIMENTARY ROCKS and METAMORPHISM. The special weather phenomena associated with mountainous terrain are described in MOUNTAIN METEOROLOGY, while the highest peaks are listed in GEOGRAPHY: *Problems of Measurement. See* also separate articles on the various large ranges—Andes, Himalayas, etc.

**Distribution.**—Although mountains are widely distributed, they are neither haphazardly scattered nor evenly distributed over the globe. Most of the larger and more prominent mountains are concentrated within two huge mountainous bands. One band makes an interrupted ring around the Pacific ocean. A formidable mountain cordillera extends along the entire west coast of South America from its southern tip at Cape Horn to the Isthmus of

Panama. An almost uninterrupted band of mountains extending north from Panama forms the backbone of Central America and Mexico. The western United States is a checkerboard of rugged mountains and enclosed basins, and the mountainous zone sweeps northward as the Canadian Rockies. In Alaska, the mountainous chain turns east-west to form the northern edge of the Pacific basin. In Asia the mountainous band bends southwestward, extending almost uninterruptedly along the entire eastern edge of Asia and forming prominent mountain chains off the Asian coast, including the Japanese and Philippine islands. From southeast Asia the mountain band extends east-southeastward through the East Indies, eastern Australia and New Zealand, and finally loops around the southern edge of the Pacific basin in the mountains on the Pacific side of Antarctica.

The second mountain band extends eastward across North Africa, southern Europe, Asia Minor and Asia, intersecting the circum-Pacific band in southeastern Asia. With the exception of the high mountains of eastern Africa, virtually every major, rugged and massive mountain range on the earth's land surface lies within these two comparatively narrow belts. There are other long chains of mighty mountains beneath the oceans (*see* OCEAN AND OCEANOGRAPHY: *The Ocean Basins*), some of which reach the surface. The mountainous volcanic peaks of Hawaii rise approximately 30,000 ft. above their base on the ocean's floor, and constitute, in fact, one of the greatest irregularities on the solid surface of this planet.

**Classification.**—All mountains have been elevated above adjacent areas quite recently, geologically speaking; the processes of surface weathering and erosion, if given sufficient time to work, would have reduced them to comparatively low level. An area can be elevated, however, in a variety of ways, and the basis of mountain classification is the mode of formation of the mountain bloc.

At various times and places the earth's crust is subjected to very considerable horizontal and vertical stresses, sometimes to such an extent that the rigidity of the crust fails. Strong compressive forces may cause it to bend in a series of folds, such as may be produced in miniature by pushing the edges of a rug toward the centre. If these folds are small or in very flat areas they will be called hills, but if they are large enough they are called mountains. The Appalachian mountains of the eastern United States are folded mountains, although the original fold structures have been completely modified by erosion. The Ouachita mountains of Arkansas, the Jura mountains of northeastern France and the Ural mountains in the U.S.S.R. are of similar origin. At some places, instead of flexing into numerous relatively small parallel folds, as in the Appalachians and Juras, the crust may bend into one very large fold. The Bighorn mountains of Wyoming and the Uinta mountains of northeastern Utah belong to this class of mountain structures. (*See* also FOLD.)

Subjected to great stress, however, the surface rocks are apt to break rather than bend. Crustal breaks along which movement takes place are called faults (*q.v.*). These breaks result from compression on the surface or from tension, and blocks of the earth's crust may be uplifted or dropped along these break planes. Mountains resulting from these fault breaks in the crust are numerous and widespread, and are particularly conspicuous in the western United States; the Sierra Nevada of California and the Wasatch mountains of Utah are ranges of this type.

Since both folding and faulting result from stresses in the crustal zone, they frequently occur together; it is common for rocks to fold under compression and then finally break, that is, fault. The Alps, for example, exhibit numerous areas of intense folding and are also marked by tremendous faults.

A third great class of mountains results from volcanic activity. The simplest are the individual mountains or peaks formed by a single volcano, such as Fujiyama in Japan, Mt. Vesuvius in Italy and Mt. Hood in Oregon. More commonly, several smaller volcanoes may be active simultaneously, along with outpouring of lava from cracks and breaks in the rocks. As the volcanic forms are eroded they tend to form more compact mountain masses than do faults and folds.

At various times and places enormous masses of molten rock rise beneath the earth's crust, forming a great dome on the surface. As this dome erodes, the surface is gashed into great valleys and intervening ridges, forming a mountain mass.

Volcanic activity may result from or cause stresses in the earth's crust that produce folds and faults. When this happens a highly intricate mountain mass is formed that physical geographers designate complex mountains. (*See* also VOLCANISM and VOLCANO.)

**Features of Mountainous Terrain.**—An associated group of mountain peaks is commonly called a mountain range; a range is commonly surrounded by adjacent lower lands or is fairly clearly separated from adjacent mountain ranges. A group or row of mountain ranges is sometimes referred to as a mountain chain, for example, the Rocky mountain chain; but such usage is by no means consistent. Each individual high point in a mountain range is called a mountain peak. These are the best-known mountain features and in common speech references to a mountain usually mean a mountain peak. Mt. Aconcagua in Argentina (22,831-ft. elevation), the highest peak or mountain in South America, belongs in this category, as do Mt. McKinley (20,320 ft.), the highest in North America; Mt. Kilimanjaro (19,340 ft.), Africa's highest peak; Mt. Everest (29,028 ft.), the highest point on the globe's surface; little-known peaks like Mt. Erebus, Antarctica (12,280 ft.); and such widely known lesser peaks as Pikes peak, Mt. Mitchell, Mt. Shasta, Mt. Rainier, the Matterhorn, and Mont Blanc.

Whenever a piece of the earth's crust is lifted far above surrounding areas the rivers running from the mass cut numerous sharp, deep, precipitous valleys. Mountain peaks very commonly are simply the highest parts of the original crustal uplift that have not yet been lowered by erosion. Between the peaks will lie a relatively high ridge separating the heads of the encroaching river valleys. Such a row of peaks connected by a high ridge is called a mountain crest. Running out from the crests between the encroaching valleys are other remnants of the former high surface, called spurs. In some mountains spurs may be long ridges running perpendicular to the crest. At other places they may be comparatively short projections, pitching steeply into an adjacent valley. Mountain crests are, of course, drainage divides, and if the divide happens to divide the drainage of an entire continent, they are continental divides. (*See* also WATERSHED.)

Streams running down a sharply uplifted mountain mass are quite likely to encounter rocks of unequal hardness, and they will cut their way into the soft rocks much more rapidly than into the harder ones. This results in great unevenness in the channel; consequently, falls and rapids are common characteristics of many mountain streams.

During glacial times valleys in most of the world's mountains in the middle and high latitudes contained glaciers that profoundly modified the surface characteristics. Much mountain scenery resulted from that activity; mountain lakes, high waterfalls, mountain meadows and vast amphitheatrelike shapes of the heads of glaciated mountain valleys are among the more spectacular features of glaciated mountains. (*See* also GLACIER.)

**Structure and Topography.**—Mountains exhibit extraordinary diversity of basic structure and of topographic detail. Their characteristics are influenced partly by their structure, partly by the kinds of rock that form the mountains and partly by the climate in which the mountains are found.

The Andes, for example, form an uninterrupted mountain wall extending along the entire western edge of South America, but they exhibit great differences over their tremendous length. The southern end of the Andean cordillera in Chile was severely glaciated. The valleys were deepened and broadened into a U-shape; numerous lakes were formed; and great amphitheatrelike forms and high sharp peaks were scraped and carved by the ice. Numerous active sharp volcanic peaks rise above the general mountain level. All the features combine to make the southern Chilean mountains extraordinarily scenic.

In Peru the form of the Andes is considerably different. Much of the mountain surface stands at a 10,000- to 15,000-ft. elevation over broad areas but is not particularly rough. Many shallow

basins partially filled with rock debris are separated only by low divides. Rising above this general level is a great series of high, truly mountainous peaks 18,000 to 21,000 ft. above sea level. Because of their elevation and despite the fact they are only a short distance south of the equator, the highest areas were glaciated and exhibit many features typical of glaciated mountains, as well as enormously deep, precipitous valleys that have been cut by streams.

Still farther north in Colombia the Andes are split into four separate ranges. The westernmost of these ranges is not very high, the peaks generally rising little more than a mile in elevation. The heavy rainfall of the region, however, has caused heavy stream erosion and the mountains are intricately dissected into sharp ridges, steep slopes and numerous deep valleys. Not rising to great elevations, they exhibit far less bare rock surface and much more vegetation cover than do the high Andean areas.

Although the Andes are the only rugged, sharp, high mountains in all of South America, a few low, rounded mountains are found near the east coast of the continent in southeastern Brazil. They have relatively gentle slopes because they are composed of very hard and resistant rocks. The highest peak of these Brazilian mountains, the Pico da Bandeira, exceeds 9,000 ft., but generally few peaks exceed 5,500 ft. Rainfall is heavy and the mountains are largely forest covered. Essentially similar mountains are found in extreme northern Brazil and in adjacent parts of the Guianas.

A roughly similar arrangement of mountains is found in North America. The high, rugged mountains extend north-south along the western section of the continent, but (unlike the Andes, which, except in Bolivia, are rarely more than 200 mi. wide) the western mountain belt in North America over long stretches is several hundred miles wide, with long, isolated mountain chains separated from one another by broad basins or plateaus. As in South America, eastern North America has a small chain of low, old, forest-covered mountains—the Appalachian chain. Although the various ranges have different origins and many different names—Great Smoky mountains, Cumberland mountains, Blue Ridge, Catskill mountains, Green mountains, White mountains and numerous others—they all have the characteristics mentioned above. In the extreme northeastern corner of the continent are the little-known Torngat mountains and associated highlands in northern Labrador. Although only a few places in the Torngats reach a 5,500-ft. elevation, they are nevertheless rugged, rocky mountains, almost devoid of vegetation because of their severe glaciation.

The mountains of Europe exhibit a great diversity of character, structure and orientation. Their predominant orientation is east-west, as can be seen in the Caucasus in the extreme southern U.S.S.R., the Pyrenees between Spain and France, the Atlas mountains of Algeria and, in a general way, the Austrian and Swiss Alps. Some of the mountain ranges, however, probably because of the way in which they were formed, have a bow shape; a particularly good example is the Carpathian range, and the Alps have a rough bow shape. Other European mountain masses are irregular or compact because they are of complex structure and origin. A few European ranges are perpendicular to those just described; the Pennines in England, the Kjolen mountains of Norway and Sweden, the Apennine range in Italy and the Urals in the U.S.S.R. all have a predominantly north-south orientation.

**Economic Aspects.**—Mountains are among the more difficult land types for people to occupy and utilize successfully. Agriculture is difficult. Only the bottoms of the large valleys commonly have enough flat land for cultivated crops; temperatures in middle- and high-latitude mountains are normally too low to permit crop growing even in summer and may make the mountains difficult if not impossible to inhabit during the long cold winters. In such mountains a worldwide practice is transhumance, the migration of livestock between mountain pastures in summer and lower altitudes the rest of the year.

Tropical mountains are in many cases preferred habitations because at greater elevations the tropical temperatures are more moderate, permitting greater human exertion, making possible the growth of crops that cannot stand the persistent high temperatures of the lowlands and often making the mountains more healthful places to live. There is an altitudinal zonation of climate in tropical mountains, which in turn produces zones with different vegetation, different agricultural practices, varying population densities and unlike settlement patterns.

Mountainous terrain is a major obstacle to transportation. Before the development of modern transportation, rugged difficult mountains might almost prohibit the interchange of goods and people between lowlands on opposite sides. The importance of easier passes and routes through mountain chains has been repeatedly emphasized by military campaigns to assert control of mountain passes, by the importance and wealth of cities that controlled trade of important passes and by the historical importance of trade routes using the major passes, particularly in Europe and Asia.

*See* also references under "Mountain" in the Index.

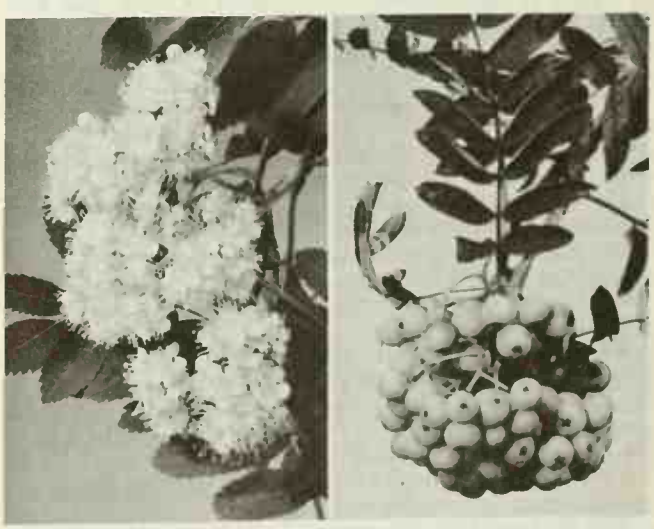
(W. C. C.)

**MOUNTAIN ASH** (ABERPENNAR), an urban district of Glamorgan, Wales, on the river Cynon, a right-bank tributary of the Taff, 18 mi. N.W. of Cardiff by road. Pop. (1961) 29,590. In the early 19th century Mountain Ash was a small village known only by its Welsh name of Aberpennar, but from 1850, with the development of its collieries, the population rapidly increased. The district comprises, besides Mountain Ash, the villages of Cwmpennar, Penrhiwceiber, Abercynon and Ynysybwl. The development of the region is associated with the coal-exporting phase in the rise of the south Wales industrial area, and with the rest of south Wales it was seriously affected by the trade depression of the 1930s.

A huge pavilion, built in 1906 for the national Eisteddfod, has played an important part in the life of south Wales; many mass meetings have been held there and it was used for the Three Valleys musical festivals (Cynon, Taff and Rhondda) from 1930 until 1937.

**MOUNTAIN ASH** (*Sorbus aucuparia*), a tree of the rose family (Rosaceae: tribe Pomeae), native to Europe and Asia, so called because of its resemblance to the true ash (*Fraxinus*) in its smooth gray bark, graceful ascending branches and form of leaf. The mountain ash attains a height of 50 ft. and is widely cultivated both in Europe and North America for its handsome foliage and bright red clustered fruit.

The American mountain ash (*S. americana*), a similar but smaller tree, grown for ornament, is native from Newfoundland to Manitoba and south to New York and Minnesota, and in the mountains to North Carolina and Tennessee. The still smaller, often shrublike, western mountain ash (*S. sambucifolia*) occurs from Labrador to New England and northwestward to Alaska and Washington and southward in the Rocky mountains to Colorado



ROCHE

BLOSSOMS AND FRUIT CLUSTER OF THE MOUNTAIN ASH (SORBUS AUCUPARIA)

and Utah. In Scotland the European variety is known as the rowan tree. (E. S. Hr.)

**MOUNTAINEERING.** Mountaineering is the sport of attaining, or attempting to attain, high points in mountainous regions, difficult of access, primarily for the pleasure of the climb. For the untrained, it is a dangerous pastime. While the term is often loosely applied to walking up low mountains which offer only moderate difficulties, it is more properly restricted to climbing in localities where the terrain and weather conditions present such hazards that, for safety, a certain amount of previous experience will be found necessary. Rock climbing, snow and ice climbing and, to a degree, skiing in high mountains are typical examples. Mountaineering differs from other outdoor sports in that its participants rely almost entirely on their own powers of physical endurance and judgment to reach their goal, and they require no artificial fields, courts, links, rinks or tracks. Nature alone provides the field of action—and just about all of the opposition—for the mountaineer.

The question, "Why do men climb mountains?" often has been asked. Some answer that it is man's desire to conquer nature, others that it is the desire to achieve what appears impossible. No doubt man's great spirit of adventure and his curiosity to explore unknown regions provide much of the real driving force behind the mountaineer. Perhaps Rudyard Kipling had the answer when he wrote:

> Something bidden—go and find it;
> Go and look behind the Ranges.
> Something lost behind the Ranges;
> Lost and waiting for you. Go!

(From: "The Explorer" from *The Five Nations,* by Rudyard Kipling. Copyright 1903 by Rudyard Kipling, reprinted by permission of Mrs. George Bambridge, Doubleday & Company, Inc., and Methuen & Co. Ltd.) Offering a combination of self-reliance, simplicity and freedom from man-made rules and regulations, the sport is peculiarly attractive to the explorer's temperament.

**History.**—Modern mountaineering started in the Alps, and may be said to date from about 1850, when English sportsmen first began to climb there for pleasure, although a few Alpine summits, including the Jungfrau (13,642 ft.), Finsteraarhorn (14,022 ft.) and Mt. Blanc (15,771 ft.), had been climbed previously. In those early days, climbing was restricted to men, and expeditions included professional guides as well as amateur sportsmen. In the late 19th century, women entered the field and soon made reputable marks. At this time, guideless climbing was also on the increase.

With surprising rapidity after 1850, groups of British climbers scaled one after another of the hitherto unclimbed high peaks of Switzerland; all the principal summits had been climbed, chiefly by English parties accompanied by Swiss, French or Italian guides, by 1870. Pioneer climbers of this period included John Ball, W. A. B. Coolidge, C. T. Dent, J. D. Forbes, E. S. Kennedy, C. E. Matthews, A. W. Moore, Leslie Stephen, John Tyndall, Alfred Wills and Edward Whymper. After 1870 climbers began to develop new and more difficult routes on Alpine peaks already ascended. As the few remaining minor virgin peaks were eliminated one by one, climbers began to turn to other mountain districts. (*See* also Alps: *Exploration of the High Alps.*)

The early prominence of British climbers in more distant regions is attested by the expeditions of D. W. Freshfield and of A. F. Mummery to the Caucasus and to the Himalayas, and by the expeditions of Edward Whymper, E. A. Fitzgerald and Sir Martin Conway to the Andes, all during the 19th century.

Climbers from the continent of Europe, while not so prominent in the early intensive exploration of the high Alps, made several important pioneer ascents elsewhere, notably the ascents of Mt. St. Elias (18,008 ft.) in Alaska-Canada, and of the Ruwenzori group (highest summit, 16,763 ft.) in east Africa, by the duke of the Abruzzi, and the (unsuccessful) attempt by Vittorio Sella on K2, Mt. Godwin Austen (28,250 ft.), in the Karakoram Himalayas, second highest peak in the world.

With the turn of the 20th century, U.S. climbers began to come into prominence: Mr. and Mrs. William Hunter Workman made five successive expeditions to the Himalayas, reaching a summit 23,300 ft. high; Howard Palmer in 1912 ascended Mt. Sir Sandford (11,590 ft.), the highest peak in the Selkirks in British Columbia; Hudson Stuck, in a remarkable tour de force in 1913, ascended Mt. McKinley (20,320 ft.) in Alaska, the highest peak in North America.

After World War I, American climbers roamed the high peaks of Alberta, British Columbia and Alaska. Among the outstanding ascents made by them were Mt. Logan (19,850 ft.), Mt. Fairweather (15,300 ft.), Mt. Robson (12,972 ft.) and a large proportion of all the remaining unclimbed high peaks of the Canadian northwest.

Among these climbers may be particularly mentioned Allen Carpé, Georgia Engelhard, A. H. MacCarthy, J. Monroe Thorington, H. Bradford Washburn, Jr., and Walter A. Wood, Jr. In 1932, also, a U.S. party ascended Minya Konka (24,901 ft.) in China, and later U.S. parties, led by Charles S. Houston and Fritz Wiessner, respectively, made two unsuccessful attempts on K2.

The British, meanwhile, were concentrating largely on the Himalayas, especially on Mt. Everest (29,028 ft.), which straddles the Nepal-China border and was named after Sir George Everest, surveyor general for India, in 1852. Several all-British expeditions had to turn back when 1,000 ft. or less short of the summit. Other British groups ascended Nanda Devi (25,645 ft.) (joint British-U.S. party), Kamet (25,447 ft.), as well as many other lesser-known peaks during the 1930s. Among prominent British climbers in those parties were T. Graham Browne, C. G. Bruce, George Leigh-Mallory, N. E. Odell, Hugh L. Ruttledge, H. W. Tilman, Eric E. Shipton and F. S. Smythe. German, French, Swiss and Polish parties also were scaling high peaks of the Himalayas about the same time. Particular note should be made of the German ascent in 1936 of Siniolchu (22,597 ft.) and of the Polish victory over the east peak of Nanda Devi (24,379 ft.) in 1939. Willi Merkl, Paul Bauer, Marcel Kurz and Mr. and Mrs. Gunther Dyhrenfurth were among the leading Himalayan climbers from continental Europe.

Between World Wars I and II, British and local parties thoroughly climbed the New Zealand Alps, and various peaks in the central and southern Andes were climbed by German, Swiss and Italian expeditions. The French, except for one trip to the Himalayas, concentrated on new and more difficult routes up the rocky aiguilles of Mt. Blanc. A Russian party climbed Mt. Stalin (now Communism Peak) (24,590 ft.) in the Tadzhik republic, U.S.S.R., in 1935.

The French ascent of Annapurna (26,391 ft.) on June 3, 1950, under trip leader Maurice Herzog, made a deep impression on mountaineers and general public alike and helped spur ascents of the next few years. When Herzog and Louis Lachenal reached the top of Annapurna, it was the highest peak man had then mastered. Caught in a blizzard on the descent, both men suffered severe frostbite that afterward cost them parts of their fingers and toes.

On May 29, 1953, two members of a British expedition attained the summit of Mt. Everest, highest mountain in the world. They were Edmund P. Hillary, a New Zealand beekeeper, and Tenzing Norgay (*qq.v.*), Sherpa guide and veteran mountaineer. News of the feat reached London June 1, on the eve of Queen Elizabeth II's coronation. Knighthood was conferred on Hillary, as well as on Col. John Hunt, who led the expedition, and the George medal was awarded to Tenzing. Colonel Hunt, who had climbed in the Himalayas in 1933, 1937 and 1940, received much credit for his organization and leadership of the expedition and for its completion without injury to any of its members. This was the eighth team in 30 years to have attempted Everest; and there had been three reconnaissance expeditions. No sign was found of George L. Mallory and Andrew Irvine who disappeared in a cloud high on Everest's northeast ridge in 1924, nor of a Russian party that disappeared on the same ridge late in 1952.

Further Everest history was made in 1956. From the South col, where the British had launched their final attack, the Swiss sent out two parties under the leadership of Albert Eggler, which reached the top on May 23 and May 25. On May 18, 1956, also from the South col, Fritz Luchsinger and Ernest Reiss made the

first ascent of neighbouring Lhotse (27,923 ft.), the world's fourth highest mountain. This triple victory constituted a major mountaineering feat and completed the conquest of nine of the world's ten highest mountains, except for the sixth, Dhaulagiri (26,790 ft.). Dhaulagiri finally was climbed in 1960 by a six-man Swiss team led by Max Eiselin. Team member Norman Dyhrenfurth, photographer for the 1952 Swiss attempt on Mt. Everest and son of the Gunther Dyhrenfurths mentioned above, was leader of the successful U.S. double assault of Everest with the first conquest of the West ridge, in 1963. (For detailed accounts of Everest expeditions from the first reconnaissance in 1921 *see* EVEREST, MOUNT.)

Nanga Parbat (26,660 ft.) was long regarded as the most treacherous mountain in the Himalayas because of its high toll of climbers. It was finally climbed on July 4, 1953, when Hermann Buhl, member of a friction-ridden German-Austrian expedition, made a solo climb from high camp to the summit. Reaching the top late in the day, he was forced to bivouac in the open all night a short distance below the summit, and next day regained high camp. Nanga Parbat had previously claimed 31 lives over a period of 60 years, 16 being lost at once when an avalanche trapped members of the 1937 German expedition.

The second highest mountain in the world, K2 (Mt. Godwin Austen) (28,250 ft.), was topped by two members of an Italian party, Achille Compagnoni and Lino Lacedelli, on July 31, 1954. Under the leadership of Ardito Desio, the party overcame early discouragements of weather and the death of one of their party, Mario Puchoz. They owed much to the attempt by a U.S. team the previous year under Charles S. Houston. This party was marooned for nine days at Camp 8, 25,500 ft. up the mountain; on the enforced descent Arthur K. Gilkey, geologist, was lost, and two other members of the expedition were seriously injured.

Cho Oyu (26,750 ft.), slightly lower than Dhaulagiri, was reached on Oct. 19, 1954, by an Austrian party including Herbert Tichy, Sepp Jöchler and the Sherpa, Pasang Dawa Lama. The Sherpa had proceeded in three days from an altitude of 13,000 ft. to the summit.

On May 15, 16 and 17, 1955, a French party succeeded in getting all of its members, plus a Sherpa, to the summit of Makalu (27,790 ft.). A neighbour of Everest, Makalu had resisted a number of previous attempts, including a U.S. party that had been turned back the previous year after reaching 23,200 ft. The first summit pair consisted of Jean Couzy and Lionel Terray.

Kangchenjunga (28,168 ft.) has often been considered the world's toughest mountaineering problem. Under the leadership of Charles Evans, who had been deputy leader of the 1953 British ascent of Everest and had reached that mountain's south peak, a British party succeeded in overcoming Kangchenjunga on May 25, 1955, George Band and Joe Brown completing the first ascent. The next day, from the same high camp, Norman Hardie and Tony Streather repeated the climb, using a slight variation of the route at its upper extremity. The actual summit remained untrodden in deference to a request of the government of Sikkim whose country forms the eastern side of the mountain, the Sikkimese regarding the summit as sacred to their gods. Because of the severe problems involved, the Kangchenjunga achievement was regarded as more noteworthy even than the ascent of Everest (*see* KANGCHENJUNGA).

On May 9 and 11, 1956, two separate Japanese parties climbed Nepal's Manaslu (26,658 ft.), the world's eighth highest mountain. This was the successful conclusion to a series of setbacks the Japanese had encountered in attempting Manaslu in previous years. Later in 1956, on July 6 and 7, British climbing teams led by John Hartog ascended the Karakoram's Muztagh Tower (23,891 ft.), an enormous spirelike peak previously regarded as unassailable. On July 12 a French party led by Guido Magnone reached the top from the south, the British having used the west ridge.

South America's many unclimbed summits had meanwhile received the attention of mountaineers, U.S. and European parties having made a number of successful forays (*see* ANDES: *Mountaineering Expeditions*). In 1955 a German expedition achieved a number of first ascents in Peru's Cordillera de Huayhuash, three with peaks of over 19,500 ft., the rest of summits in excess of 16,500 ft.

**Mountain Craft.**—Mountaineering may be divided into two sections, rock climbing and snow and ice climbing, with many devotees specializing in one or the other. However, to attack peaks which possess sheer rock walls as well as glacial ice and snow formations, the successful climber must be skilled in all phases of the sport.

*Rock climbing* is usually to be found only on the uppermost slopes of a high peak, after surmounting its lower reaches of snow and ice, as typified by the Grepon, the Zinal Rothorn and the Dru-Grepon—examples of rock climbs in the Alps; however, rock climbs in the Dolomites (eastern Alps) and the great majority of rock climbs in the U.S. are devoid of snow or ice in summer.

Rock climbing on typical climbs may involve: climbing steep slabs or ridges; climbing cracks (too small for more than a hand or foot to enter); climbing chimneys (cracks large enough for the entire body to enter); and *couloirs* or gullies (too wide for the climber's limbs to touch both walls at once). Normally, the party will be roped, usually at intervals of 30 to 40 ft. Peculiar to chimney climbing may be mentioned the back-and-knee technique, in which the climber, with his back to one wall, wedges his knees and arms against the other and works himself up, using alternately his arms and his knees. Coming down, an extra rope passed through a rope sling may be used (descending *en rappel*).

The possibilities of rock climbing were first called to general attention by A. F. Mummery on the occasion of his first ascent of the supposedly unclimbable Grepon (Alps) in 1881. Among climbers from continental Europe and in several climbing centres in the United States, there is considerable interest in specialized rock climbing, in which special techniques and unusual items of equipment are required, but because such equipment may seem to violate the fundamental simplicity of mountaineering, there are many who strongly disapprove of attempting climbs which are possible only by such aids.

*Snow and ice climbing* is construed by many to require greater skill and experience than rock climbing. On ice slopes, steps must be cut with the ice ax. The experienced leader will cut steps so that they furnish a secure footing and are not too dangerously far apart, yet require a minimum of ax work. Cutting steps is more difficult down a slope than up one, and only long experience can enable a man to maintain a safe balance while so occupied.

On the leader's judgment of the condition of a snow slope the safety of the entire party may depend, and the leader must have almost a sixth sense to detect concealed crevasses or hidden snow cornices. On steep ice slopes it is essential that the rope be constantly belayed about the shaft of the ice ax, firmly fixed or secured.

No climber can ascend any of the great peaks of Alaska, the Andes or the Himalayas, or even of the Alps, unless he is a good man on snow and ice and at least moderately proficient on rocks. Skis are used occasionally, more particularly for an approach to a peak over long, snow-covered glaciers, as in Alaska.

*Winter climbing* increased greatly in popularity after 1920, along with the growing interest in skiing. While some great peaks, either snow or rock, that have been climbed in summer can also be climbed in winter, winter climbing is generally restricted to snow climbs, where cross-country skiing finds its greatest possibilities. As crevasses of a glacier are largely filled up with snow in winter, certain ascents may be actually easier at that time. On the other hand, any rock climb will be much more difficult in winter.

**Dangers.**—In mountaineering, dangers are many and present serious risks for the inexperienced or for those climbers who work without the aid of guides well acquainted with local conditions. Objective dangers are attributable either to weather, loose or falling rocks, avalanches of snow or ice or concealed crevasses or cornices. A careful study of weather conditions is essential, especially in the higher mountainous regions where sudden changes are common. The Himalayas, with their extreme heat of the day and freezes at night and their monsoon season, present grave risks for climbing parties.

Sleet on rocks can instantly transform easy conditions into the most difficult. Rock falls are almost always localized on certain parts of the face of a peak, in gullies or *couloirs* which provide natural funnels for stones that may be loosened higher up on the face. Climbers who take a route up such gullies are thus exposed to the dangers of other falling rocks, while a route which clings to a ridge is practically immune from such risk. The character of a section's rock has much to do with the relative danger. Dolomite rock or the granite of the aiguilles of Chamonix are outstandingly secure, the sandstone and shale of the Canadian Rockies presenting the other extreme. Loose rocks are most likely to fall when the ice of the previous night, in which they have been held, begins to melt in the morning sunlight. Avalanches are similarly restricted to recognizable parts of a peak, and the experienced explorer learns to identify such places quickly and plan his ascent to avoid them. The condition of mountain snow may, in itself, greatly increase the danger of avalanches. Dry flakes, when first fallen, do not cohere, and with an angle of repose of around 25° any slope of fresh snow steeper than 25° must be considered with caution until the fresh powder snow has become packed into settled snow for more secure footing. Settled snow will not normally avalanche, but if seeping water percolates under an accumulation of snow on an ice base, on smooth rocks or on grass slopes of even moderate steepness the wet snow is liable to avalanche. Slides of wet snow are particularly dangerous to the entrapped climber for then there is the added danger that when the avalanche comes to rest the heavy, wet snow may settle into a solid frozen block of near-ice, from which the mountaineer cannot extricate himself. The dangers of being caught in a powder snow avalanche are the possibilities of suffocation or of being swept over a cliff. The competent climber never ventures forth when snow conditions are in themselves dangerous. Concealed crevasses on glaciers and unsuspected snow cornices that give way suddenly are also dangers often encountered. The more subjective dangers are related chiefly to inexperience and lack of training. An experienced leader can avoid many of the objective risks such as those named above and can also foretell bad weather. Physical condition, requiring not only muscular training but acclimatization to the rarefied air of high mountains, is most important. Failure to become acclimatized often results in mountain sickness on a climb. One climber in poor physical condition is a source of real danger to an entire party.

**Equipment.**—*Normally Indispensable.*—Clothing: woolen or thermal underwear; windproof outer garment, preferably of parka type; headgear and mittens of suitable warmth; cleated boots; heavy socks. Necessary equipment includes snow glasses, sunburn preparations, compass, map, waterproof matchbox or other lighters, scout knife, ice ax, climbing rope, crampons, rucksack and folding lantern or flashlight.

*Occasionally Required.*—Extra rope of lighter weight; *pitons*, snap rings, hammer (for difficult rock climbs); tents, sleeping bags and cooking equipment (for long expeditions); skis, willow wands (for major snow climbs); aneroid barometer; oxygen tanks (used at high altitudes such as found in the Himalayas). If a camera is carried, care must be taken that it will operate properly under mountain temperature conditions.

*Improved Equipment.*—The training of alpine troops and the improvement of equipment that resulted from research during World War II and the postwar era did much to aid the mountaineer. Lighter although warmer clothing for freezing weather, collapsible stoves and light oxygen tanks and masks were only a few of the items that appeared. Featherweight boots and other articles of clothing originally designed for the armed forces to combat subzero conditions were introduced and ensured the climber greater comfort without any restriction on mobility. The lighter portable radio, especially the walkie-talkie, enabled the bigger expeditions to keep in almost constant contact with various members as camps were established on the ascent of the once unconquerable mountains. The Mt. Everest expedition of 1953 was equipped with a mortarlike avalanche gun with which to dislodge loose and dangerous snow which might have started an avalanche in its path to "the top of the world," but it was not used.

**Personnel.**—A balanced party of climbers can be selected only by a leader from individual personal knowledge of the experience and records of the climbers under consideration. Personalities of individuals have a way of becoming more pronounced under the strain of constant close contact; at high altitudes all human responses tend to deteriorate—soundness of judgment as well as normal courtesy.

For a single day's climb, a party of three is ideal—the smaller the party, the less the delay in traversing unusually difficult terrain when only one of the party may safely move at one time. With a party of fewer than three, rescue of one member, if he falls into a crevasse, is extremely difficult at best. For an expedition into unexplored regions, however, a party should be larger, even if porters can be hired locally.

**Example of a Typical Ascent.**—The party should ordinarily consist of three experienced amateurs, if guideless, or two amateurs and a guide. Such a party would start from its bivouac or camp close to the snow line (or above) as early as possible in the morning—preferably several hours before sunrise. The air would be crisp; suitable clothing must be worn; a folding lantern is used. The party should be roped together at intervals of about 20 to 30 ft. as soon as it steps onto the névé (firn) of the glacier. The most experienced climber leads on the ascent with the weakest of the three members in the middle. Once the sun rises, snow glasses are *de rigueur* on snow or ice. If soft snow is found or much step cutting in ice is necessary, each climber spells the others as leader.

The gait should be slow, so slow that no one in the party gasps for breath. While at low altitudes, a strong party may ascend as much as 2,000 ft. vertically per hour, yet 1,000 ft. per hour, vertical ascent, is ordinarily fast climbing. The speed of ascent may drop to as little as 100 vertical feet per hour, or even less, if serious difficulties are encountered, such as step cutting or difficult rocks. There may also be quite a delay in finding a point where the bergschrund can be crossed—the bergschrund is the large crevasse just beneath the rocks at the head of the glacier. Each one takes care that his feet are securely placed at every step, whether on snow or on rock; on rock, also, care is taken not to dislodge any loose stones, lest they fall on those below. If it is necessary to use the hands in climbing rocks, they are used rather to assist balance than to pull the weight up, except in the most difficult passage. Always, too, the rope is constantly kept taut between members of the party, to check instantly any incipient slip. If unusually difficult rocks are encountered, it is necessary to use *pitons*. A *piton*, or pierced iron spike, is driven by the leader into a crack above him, as high up as he can reach; a snap ring is then slipped through the *piton;* the leader will pass his rope through that ring; then, hauled up with that rope by the others of the party to the level of that *piton*, he ties himself fast with a separate spare rope and proceeds to drive yet another *piton* still higher, and works his way up to it the same way, laboriously continuing with *piton* after *piton* until he overcomes the difficult pitch of rock. The last man on the rope retrieves the snap rings, and *pitons* if practical.

Halts during the ascent are made as rarely as possible—at low altitudes every two hours or so, but at high altitudes the human physique requires a halt more often. The leader must be constantly alive to changes in the condition of the snow, dangers of avalanches, falling rocks, concealed crevasses on glaciers, or unsuspected cornices, and possible changes in the weather. In crossing wide snow fields, willow wands may be set; stone cairns may be erected at strategic points on rocks.

On the descent, the strongest man is placed at the rear, being thus best able to hold any of the others with the rope, should they slip. In difficult spots, on the descent even more than on the ascent, the rope is belayed about a projecting piece of rock, or about an ice ax wedged into rocks or driven into snow, and only one man moves at a time under such conditions. In very difficult parts, on the descent, the party may descend *en rappel*. Care is peculiarly necessary on the descent. Fatigue or a feeling of relaxation makes for carelessness, and a surprisingly large number of serious accidents on mountains have happened on the descents.

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(J. E. Fl.; Ge. A. S.)

**MOUNTAIN GOAT** (Rocky Mountain Goat), the sole species (*Oreamnos americanus*) of a genus of North American hollow-horned ruminants of the family Bovidae, order Artiodactyla (*see* Artiodactyl). It occurs from the Yukon to the northern Rockies of the United States. It is more closely related to the antelopes than to the true goats. The body, 35–40 in. high, is stocky and slightly humped at the withers. Both sexes bear short, slightly backward-curving horns. The coarse white hair is long and shaggy over a thick woolly underfur, and a beard frames the slender muzzle. Mountain goats are white at all seasons; the blackish snout, hooves and horns stand out in contrast. These sure-footed relatives of the chamois (*q.v.*) live among the rugged, craggy mountain peaks, usually above timber line. They excel even the bighorn (*q.v.*) in climbing rocky precipices where no animal of equal size can follow. Mountain goats live in small bands. Mating takes place in November, and the males fight for possession of the females. A single kid, rarely two, is born in late spring, in a nursery group. A few minutes later the kid is walking about and nursing. The food of mountain goats consists of a variety of vegetation—moss, lichen, scrub foliage—and seemingly little is required.

H. ARMSTRONG ROBERTS

MOUNTAIN GOAT (OREAMNOS AMERICANUS)

The slow gait of these goats is a stiff-legged walk. They are agile climbers and are capable of leaping more than 12 ft.

(K. R. Kn.)

**MOUNTAIN LAUREL** (*Kalmia latifolia*), a North American shrub of the heath family (Ericaceae), called also calico bush and spoonwood. It is native to rocky soils from New Brunswick to Ontario and southward to Florida and Louisiana. Usually it is a shrub with stiff branches, forming dense thickets, 10 to 20 ft. high, but may become a tree 40 ft. high. It bears smooth, oval, pointed laurellike leaves and handsome pink or white flowers, about one inch across, in large terminal clusters. A closely related species (*K. angustifolia*), commonly known as lambkill, sheep- or dwarf-laurel, has similarly coloured but usually smaller flowers and smaller leaves. It is found from Newfoundland and Hudson bay to Georgia.

ROCHE

MOUNTAIN LAUREL (KALMIA LATIFOLIA)

**MOUNTAIN MEADOWS MASSACRE,** a tragic incident in U.S. history that occurred in 1857 when a band of emigrants bound for California were attacked and massacred in the southern part of Utah territory. In that year feelings ran high among the Mormon settlers in Utah because of the U.S. government's decision to send troops into the territory to aid in enforcing federal laws. When a company of emigrants from Arkansas, numbering 137 persons, arrived in Utah and camped 40 mi. N. of Cedar City, there was much suspicion and bad feeling on both sides. On Sept. 7 or 8 the emigrants were attacked by a party of Paiute Indians and some white settlers, of whom John Doyle Lee, a Mormon fanatic, was a leader. Under a flag of truce the attackers persuaded the emigrants to lay down their arms to avoid antagonizing the Indians and promised them safe conduct. Then, as they proceeded toward Cedar City, the emigrants were ambushed by a party of Indians and white men, and all except the young children were massacred. In spite of the efforts of those involved to keep their crime a secret, the story eventually came out. Lee was brought to trial in the town of Beaver in 1875, but the jury could not agree on a verdict. Tried again the following year, Lee was convicted of murder in the first degree and sentenced to be shot. He was taken to the scene of the massacre and executed there on March 23, 1877.

See *Utah: a Guide to the State* (1941), pp. 303–304.

**MOUNTAIN METEOROLOGY.** This article deals with the special weather phenomena associated with mountainous terrain.

**Temperature.**—On the average, the temperature of the lower atmosphere into which the mountains penetrate decreases by between about 5° and 10° C. per kilometre of height. This fall in temperature is the most significant feature of weather on mountains and it is the chief cause of the change in vegetation with altitude.

**Rainfall.**—On account of the ascent of air streams on the windward sides of mountains, the condensation and rain-forming processes are intensified. Rainfall is generally greater on mountains across which winds frequently blow than over the surrounding low ground. There is often a rain shadow in the lee, which is important if the winds are predominantly from one direction. Rainfall is also greater over mountains because cumulo-nimbus clouds are better developed there.

When stable air ascends in passing over a mountain it is cooled, so that the temperature on the mountain may be a few degrees colder than that in the air at the same altitude over the plains and valleys. This increases the fall-out of snow and rain, and also lowers the level of the cloud base and snow line.

When the cloud has its base below the mountaintop it is called hill fog. Cloud droplets are caught on grass and leaves and the rainfall may thereby be augmented. Where the ordinary rainfall is small, this may be important to the vegetation.

**Cumulus and Cumulo-nimbus Clouds.**—Cumulus clouds are formed by thermals. These are masses of warm buoyant air ascending through the surrounding air as a result of having been heated by proximity to the ground which has been warmed by the sun. On a mountain surface the heat is transferred to the air at a greater altitude than over the plains and so thermals are more buoyant and reach higher than thermals rising from lower ground. At the same time an anabatic (upslope) wind may blow up the warmed mountainsides, maintaining an almost continuous supply of air rising from the mountains into the cumulo-nimbus. There is also a compensating sinking motion of the air as a whole over the valleys, which reduces the amount of cloud there.

When small cumulus clouds appear in the morning, they appear

first over the mountains. These gradually grow into large cumulus and then, on favourable days, into cumulo-nimbus, often with heavy showers and thunderstorms in the afternoon. In the evening the supply of heat from the sun to the ground decreases, while at the same time the sunshine is cut off by the spreading anvil-shaped tops of the cumulo-nimbus.

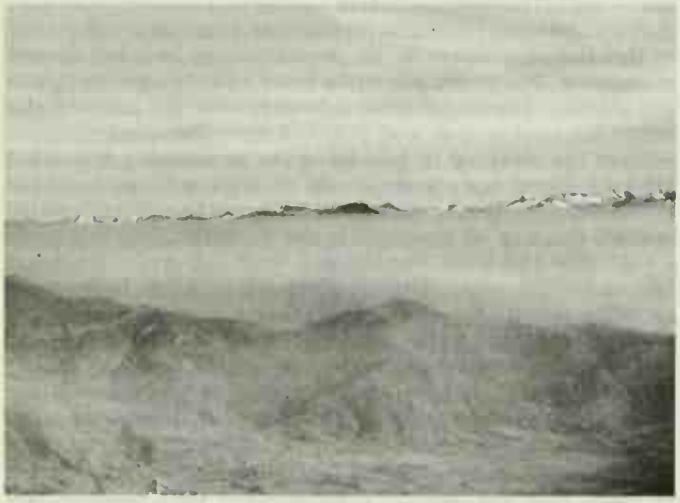
The rain partially evaporates into the air through which it falls, cooling it and causing it to flow as a torrent down the mountain slopes. Sometimes it flows far across the plains in the afternoon and evening. This cold air is a shallow layer, perhaps only from 50 to 100 m. deep, producing a sudden squall when it first arrives.

As night draws on and many of the cumulo-nimbus evaporate, the air over the mountains is cooled and caused to sink. At the same time the air over the plains ascends bodily, and if there have been any cumulus over the valleys, they may grow into cumulo-nimbus during the night. If the air is not unstable enough for cumulo-nimbus to be formed, the evaporation of the cumulus over the mountains may often induce the formation of a layer of strato-cumulus over valleys at night. This, however, soon disappears in the morning sunshine.

**Stable Air in Valleys.**—In the evening descending air currents (katabatic winds) begin to flow down the slopes as they become cool. These winds are only two to three metres deep and can be blocked by high walls which are frequently built to protect houses and gardens from them. In quiet weather, valleys may be filled with stably stratified air for several days on end. During the day there may nevertheless be anabatic winds about 50 m. deep blowing up sun-warmed slopes, even though the main mass of air in the valley is almost motionless. The air in these upslope currents spreads out horizontally at the level of the mountaintops and causes the valley air to sink and be warmed. At such times if smoke is produced in the valleys it is carried up to the level of the mountaintops but no higher and a very marked haze top is produced. When the air in the valleys is stably stratified the thermals over some mountains may be warm enough to rise into the air above and produce cumulus, or even cumulo-nimbus, above the haze top.

**Winds.**—The effect of a mountain barrier on the horizontal movement of air is most noticeable when the air on one side is colder and therefore denser than on the other. This happens when the progress of a cold front is halted by a mountain range.

When the colder air is only just deep enough to flow through narrow passes it blows with great force down the valleys on the lee side, like a flood overwhelming an embankment. On a larger scale the cold mistral blows down the valleys of the Rhône and other rivers in southern France between the Pyrenees and the Alps. The mistral is often a deep wind extending to well above the mountaintops, and may persist for several days when there is an inrush of cold air into the Mediterranean. It blows especially during the early months of the year, but may occur at all seasons. In some places the wind is strongest in the valley bottoms, so that dwellings on small hills and mountain shoulders are often more protected from it.



R. S. SCORER

FIG. 1.—AERIAL VIEW OF HORIZONTAL HAZE TOP. SMOKE POLLUTION, CARRIED UP SUN-WARMED MOUNTAINSIDES BY ANABATIC WINDS, SPREADS OVER THE VALLEYS

Within the canyons of the Rocky mountains, winds are often observed to blow along the canyon toward the low-pressure end, while the wind above more nearly follows the direction of the isobars with low pressure on the left. The same can be seen at other mountain gaps such as the Straits of Gibraltar, where the wind usually blows through the straits from the east or from the west while the wind above the mountains blows according to the larger scale weather systems. Thus when the wind aloft is from the southwest the wind below the mountaintops often blows through the straits with gale force from the east.

A similar situation exists when the Mediterranean is filled like a lake with cool damp air, especially around midsummer. A persistent east wind called the Levanter blows out through the Straits of Gibraltar, often for weeks almost continuously. There are related phenomena at other gaps in long mountain barriers, such as between the North Island and South Island of New Zealand.

When cold fronts advance to a mountain barrier, small centres of low pressure are often formed on the lee side as the progress of the cold air is held up. They occur, for example, in the western Mediterranean and in northern Italy when deep cold air spreads southward to the Alps and Pyrenees, and the mistral blows.

The air passing down the lee side of the mountains may have originated far above the ground on the windward side, the cold lower layers being blocked by the mountains. Unusually high temperatures with clear skies are then experienced on the lee side because the air is warmed and all the cloud in it evaporated by the compression it undergoes as it descends to lower altitudes.

Similar warm dry winds, but on a larger scale, known as chinook winds, are experienced on the plains east of the Rocky mountains. They are especially noticeable in the state of Colorado where the descent is steepest. When they begin to blow at Denver, the temperature may rise by as much as 40° C. In the Alps such winds are called foehn (*Föhn*) winds, but this name is also applied to many other phenomena associated with the passage of air across mountains, and it is now given to similar winds in many other parts of the world. The sudden changes in humidity and temperature, together with the oppressive appearance of the clouds and the noise and physical force of the wind, are said to produce physiological and psychological disturbances in the local inhabitants, often leading to feelings of depression, headaches, sickness, etc. Large falls in temperature usually accompany the arrival of the cold air if it has passed over the mountains.

Berg winds, which blow down from the plateau around Basutoland, appear sometimes to have originated above the mountaintops. They give very warm, dry sunny weather at Durban, and consequently the highest temperatures of the year are sometimes recorded there in midwinter.

**Waves.**—Air streams are often deep enough to flow directly over a mountain range. The air then takes an undulating path. Aircraft flying in air where the motion is not horizontal experience strong up-and-down currents whose magnitude commonly reaches five metres per second. The first wave occurs above the mountain causing it, but in most deep air streams there is a series of lee waves extending downwind. These waves are most important when they have their largest amplitude in the middle levels of the atmosphere and die away at greater heights, for then they may produce clouds and have an important effect on the weather.

The circumstance most favourable for the occurrence of lee waves is when a deep air stream with the wind stronger in the higher levels, and with a layer of stably stratified air in the lower levels, flows across a long ridge having a steep lee slope. The strongest upcurrent is then found not over the wind-facing slope of the mountain—as was thought by the early glider pilots—but at the front of the first lee wave.

There may be a series of several lee waves, and over 100 have

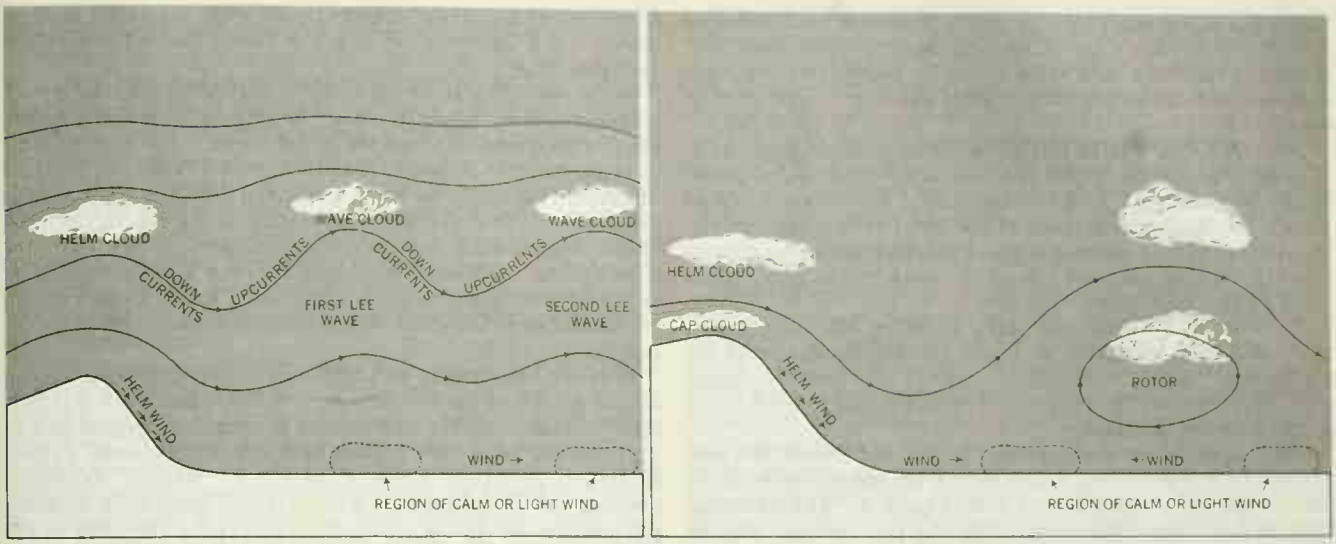



FIG. 2.—(LEFT) LEE WAVES; (RIGHT) LEE WAVES WITH ROTOR

been reported where the air stream passes out over the sea where the waves are not interfered with by other mountains.

When the lee slope is very steep and high, the waves may be of sufficient amplitude for there to be a rotor beneath, as indicated in fig. 2. In a rotor the air circulates, and the wind at the ground is reversed. At the front of the rotor the air rises vertically from the ground.

The regular spacing between the waves is usually between two and eight kilometres. If this spacing coincides nearly with the spacing of the hills, the waves become large; otherwise the lee waves of one mountain may be annulled as the air passes over a second.

In hilly country with a complicated topography intense waves may be temporarily set up in one or two places. Under the wave troughs such strong winds may occur that acres of forest are blown down. The locations of the blowdowns are difficult to predict or even explain on account of the complexity of the wave system. It is notable that on account of the stable stratification of the atmosphere, which gives rise to the waves, the flow is quite different from the flow over a similarly shaped model surface in an ordinary wind tunnel. The strongest winds are almost invariably experienced downwind of steep slopes.

H. KLIEFORTH

FIG. 3.—SIERRA WAVE WITH TURBULENT ROTOR CLOUD BELOW, SMOOTH WAVE CLOUD IN MIDDLE AND BILLOWED ICE WAVE CLOUD ABOVE. THE WIND AT GROUND UNDER THE WAVE IS OFTEN REVERSED (*see* FIG. 2, RIGHT)

By day the anabatic winds up a lee slope inhibit the formation of lee waves by inducing the flow to break away from the hilltops. At night the shallow katabatic wind induces the air flow to adhere to the slope so that waves are formed and a deep strong wind then blows down the lee slope.

**Wave Clouds.**—If the air is sufficiently lifted in passing through a wave, the water vapour in it is condensed into cloud. The cloud remains in an almost fixed position and assumes a characteristic smooth shape to which the name lenticularis is given in the international cloud classification. Wave clouds are very common in middle and high latitudes at all times of the year, even over small hills less than 200 m. high, and may occur at any height at which clouds are normally formed. Wave clouds make many waves visible, though by no means all waves have clouds in them.

Very well-developed wave clouds have long been observed in the Alps in association with foehn winds, in Bohemia, and in Silesia, where there is some folklore about them. In high latitudes seamen have called them whaleback clouds. Many wave clouds are called helm clouds, and the strong downslope winds helm winds, from the name given to them in Cumberland, Eng.

Over the Southern Alps in New Zealand a wave cloud, called the southern arch, extends the full 600 km. of the range. It may remain stationary over the mountain crest for many hours when the wind is from the northwest. Lee waves are then found over the plains to the east, and have been used by glider pilots to soar to over 7,000 m.

One of the most fully explored and spectacular of the lee waves is the Sierra wave which is found in a westerly wind over the Owens valley to the lee of the Sierra Nevada range in California. It is best developed when a jet stream, associated with a front, is blowing across the range. In it gliders have soared to over 14,000 m., the greatest height which can be safely reached without a pressurized cabin. The rotor is frequently well developed under the first lee wave.

When the air stream is very deep the wave over the mountain may extend to very great heights. "Mother-of-pearl" clouds, so called because of the iridescent colours seen in them after sunset while they are high enough to be still in the sunshine, have been seen most often in waves over Norway and have been measured to be at about 30 km. above the ground. They have also been seen in Alaska and Iceland. They are rare because air currents with constancy of direction up to that height are uncommon.

*See* also WIND. (R. S. Sc.)

**MOUNTAIN MINT,** the common name for about 15 or more species of hardy herbaceous perennial species belonging to the genus *Pycnanthemum* of the mint family (*see* LABIATAE). They are characterized by a pungent mintlike flavour, simple entire op-

posite leaves and small white or purple flowers, in many-flowered whorls with numerous bracts, forming small terminal heads. Although of relatively little value as garden plants, they are often abundant and conspicuous in old fields and open woods when in flower. (J. M. Bl.)

**MOUNTAIN PROVINCE,** in northern Luzon, Republic of the Philippines, is the largest province in the republic and almost wholly mountainous (Central Cordillera); it is drained toward the west by headwater streams of the Abra; toward the north by the Abulug; toward the east by the Chico and Magat, both tributaries of the Cagayan; and toward the south by the Agno. Area 5,458 sq.mi. Pop. (1960) 435,839.

There are many significant peaks, including Mt. Pulog (9,606 ft.), the highest mountain on Luzon and second highest in the Philippines. Southern Mountain province is a primary mining area, with the three largest gold mines and one of the two major copper mines of the country.

The Ifugao rice terraces, between Bontoc and Banaue and near Sagada, are world famous. Often narrow terraces extend from the floor of the valley to a height of almost 4,000 ft. Although some terraces have been constructed within the past century, most of them were built 2,000 to 3,000 years ago and have been under continuous cultivation since construction.

Mountain province is inhabited primarily by non-Christian tribes of Indonesian origin, and administratively it is divided into five subprovinces largely on the basis of ethnic and cultural lines. Apayao in the north (capital, Kabugao) is the most remote and the people are the most primitive, having had less contact with modern world conditions.

In the central district, from north to south, are Kalinga (capital, Lubuagan), Bontoc (capital, Bontoc) and Ifugao (capital, Kiangan). Benguet (capital, Baguio), in the southwest, whose people are commonly called Igorots, is the most accessible and the best-known area of the province. It is the mining centre and a resort area. Baguio (*q.v.;* pop. [1960] 50,436) is a modern city with considerable western influence. At an elevation of 4,500 ft., and with good highway connections with Manila, it is the foremost vacation land of the country. John Hay base, a U.S. military rest camp for far east personnel, lies on the outskirts of Baguio. (An. C.)

**MOUNTAIN SICKNESS** is a disease that may occur in an individual several hours or days after he has ascended a mountain to an altitude of about 7,000 ft. or higher. The cause of this disease is the rarefied air at high altitude and the resultant prolonged lack of an adequate supply of oxygen in the blood and body tissues. The symptoms of this disease consist of one or more of the following: headache, sleeplessness, lassitude, mental depression, irritability, rapid heart beat, shortness of breath, lack of appetite, nausea and vomiting. After several days the body usually begins to adapt itself, after which the symptoms tend to disappear. The process of adaptation consists of an increase in the number of red blood cells and the amount of hemoglobin in the blood, and possibly other bodily changes, the nature of which is unknown. This form of the disease is called acute mountain sickness.

People who reside permanently in high mountainous regions are able to live comfortably and work effectively at altitudes up to 18,000 ft. Attempts to reside permanently at higher altitudes invariably result in an attack of mountain sickness. However, especially well-acclimated individuals have been able to withstand short exposures to a height of about 28,000 ft. Occasionally, an individual who resides at less than 18,000 ft. may suddenly lose his adaptation; this condition is referred to as chronic mountain sickness.

The treatment of both the acute and chronic forms consists of either having the patient breathe oxygen or having him brought to a lower altitude.

*See* also Acclimatization; Hypoxia: *Hypoxemia.* (H. G. A.)

**MOUNTAIN VIEW,** a city of Santa Clara county, Calif., U.S., 39 mi. S.E. of San Francisco and gateway to the naval air station Moffett field, is a centre of aeronautic research, electronic components manufacture, book publishing, food processing and production of deciduous fruits and nuts, truck vegetables and cut flowers. It is served by the Southern Pacific railroad and by bus and truck lines.

Settlement began in 1852 as a stagecoach station but slow growth postponed incorporation 50 years. In 1857 the community hosted the first religious camp meeting in California. The 1859 attempt to locate the state university in the community failed but Stanford university, University of Santa Clara and San Jose State college are within a 13-mi. radius. The coming of the railroad in 1864 ended stagecoaching and decreased schooner sailings from the town's docks. Industrial development began after incorporation in 1902, a municipal land grant encouraging Pacific Press Publishing association to move its religious book publishing plant to Mountain View in 1904.

In 1929 citizens joined with neighbouring communities in buying a 1,000-ac. site for the first west coast dirigible base. After rejecting more than 100 other locations the government accepted title in 1931 and two years later Moffett field was commissioned a naval air station, permanent home of the U.S.S. "Macon," its hangar towering 198 ft. and covering 8 ac. Hangar doors, each weighing 500 tons, opened for the airship in Oct. 1933 but the crash of the dirigible off Point Sur in Feb. 1935 ended the navy's need for the facility which was then transferred to the army. Research in high-speed aerodynamics began in 1940 when the Ames laboratory of the National Advisory Committee for Aeronautics was located on the post. The station reverted to the navy in 1942, first serving as a base for coastal patrol blimps, later as a centre of naval air transport operations. The era of jet propulsion began in Dec. 1950 and 36 months later Moffett field became the first master jet airbase.

The council-manager plan of government was adopted in 1952. Summer and winter temperatures average 73° and 61° F. (23° and 16° C.) respectively and rainfall of 16–20 in. is confined to the November–May period. For comparative population figures *see* table in California: *Population.* (R. C. Rs.)

**MOUNTAIN WARFARE.** Mountain warfare is as old as war itself. In 480 B.C. the Greeks and Persians battled in the rocky passes and heights of Thermopylae. Hannibal of Carthage crossed the Alps with an entire army, transporting his supplies on elephant back to invade Italy. During World War I the same Alps became the battleground for Italian and Austrian mountain troops.

Mountain warfare tactics and techniques were largely modified following lessons learned in World War II. The greatest experience was gained in Italy, where during a 20-month campaign the U.S. 5th and British 8th armies fought through 400 mi. of rugged hills and mountains. There the German defenders made skilful use of terrain and fortifications, fighting stubbornly for control of the mountains in the path of the slowly advancing superior Allied force. The Korean War (1950–53) offered still newer and more significant lessons. Its two foremost tactical innovations, the transport helicopter and modern body armour made of lightweight plastics, had a revolutionary effect on supply, transportation and evacuation of casualties in mountain operations.

### OPERATIONS

Mountain terrain lends itself particularly well to surprise, but successful surprise action depends on mountain-trained soldiers. Decentralization of control is forced upon commanders of large units by prevailing terrain and weather conditions. Hence, the initiative, resourcefulness and judgment of small-unit commanders is taxed to the utmost as they will be operating independently or semi-independently for extended periods.

Mountain combat lacks the unity characteristic of warfare in rolling terrain, particularly in the offensive phase. The configuration of the terrain tends to give battle a piecemeal character and to divide it up into more or less isolated conflicts difficult to control by higher commanders. In the terminology of mountain warfare, the topographical crest is the highest point in altitude; the military crest is the highest point permitting a field of fire to and from the foot of the forward slope. The reverse slope is the opposite side of the hill or mountain, usually assumed in military problems to be held by the enemy.

It has been truly said that time and space factors are extremely fluid in mountain warfare, varying sharply in response to weather, altitude and lines of communication. Distance must be measured in terms of time and energy in terrain where the distance between two points is as much vertical as horizontal. Mass is not as important as velocity in campaigns where numbers are often an encumbrance along with road-bound vehicles and tanks.

**Offensive Combat.**—Offensive action is characterized in all its phases by surprise attacks and attempts at flanking maneuver, combined with frontal action on a broad front. In all offensive operations, the seizure of dominant terrain features as intermediate and final objectives becomes the core of the commander's plans. Specific effort to capture vantage points for artillery observation must be emphasized.

Flanking action sometimes is impossible, and the unit is required to attack frontally. Frontal daylight attacks in narrow sectors have little chance of success. Such attacks are bound to be canalized and observed, thus giving the enemy the opportunity to shift his reserves for counterattack. The necessity for movements under darkness in mountainous country affording the enemy dominant observation is readily apparent. Night operations were widely employed in Italy during World War II; they were especially effective against towns and villages constituting small strong points against which daylight assault proved costly in casualties. The Chinese Communists in Korea confined their offensive operations almost entirely to night attacks. In the daytime they held defensive positions on the reverse slope, where log-faced bunkers afforded protection from artillery or mortar fire. The spade was as useful as the rifle to Chinese troops. They frequently burrowed through the crest from reverse slope to forward slope, where their mortars fired from camouflaged openings on targets of opportunity. In the event of enemy counterbattery fire the mortars could be quickly withdrawn to safety.

The crossing of a lateral valley and assault of a well-defended ridge are similar to the forcing of a river crossing. The purpose is to move a force across quickly and economically and establish a bridgehead to permit the crossing of the main body.

Attack against a fortified position is extremely difficult in mountains and requires more time for planning, organization and preparation than in ordinary terrain. Careful and continuous reconnaissance, supplemented by the study of vertical and oblique aerial photographs, is essential. The gaps in fortified positions, defended only by mobile troops, are usually mined more heavily and in a more irregular pattern than in ordinary terrain.

It will be possible in many instances to bypass strong points under cover to the flanks or at night. This practice was adopted with marked success by Allied troops in Italy in World War II.

**Defensive Combat.**—Regardless of the size or composition of the units involved, defensive combat in the mountains has the following advantages: (1) dominant terrain provides the defender and denies the attacker observation and firing positions; (2) the slopes and other terrain features impose difficulties on the attacker; (3) there are zones which are either impassable or extremely difficult for the enemy to negotiate; (4) the lack or scarcity of roads places restrictions on the use of tanks or other combat vehicles and renders them extremely vulnerable.

The disadvantages of defense in mountains are: (1) the compartmentation makes it difficult or impossible to shift fires of supporting weapons readily; (2) it is usually difficult to maneuver support and reserve units to execute counterattack plans; (3) grazing fire is often impossible in rugged terrain; (4) mountains with wooded slopes and moderately difficult cliffs enable the enemy to make decisive surprise attacks at several points; (5) difficulty of digging necessitates longer time for organization of positions.

An outstanding illustration of mountain defensive combat was the German defense of the Italian peninsula in World War II. Along the whole Allied front, German engineers made skilful use of terrain and fortifications. They laid mines on the roads and trails, at the heads of gullies and in the natural cross-country approaches. All bridges and culverts were destroyed and sites for bypasses were mined. Machine-gun and mortar emplacements, dug four or five feet into solid rock, covered nearly every path. Although the Germans' main concern was to control the dominating mountains in the path of the Allied armies they also used the few small towns on the mountain slopes for organized defense and delaying tactics. The Italian houses, built of solid masonry, could be transformed into effective strong points, forcing attacking troops in many cases to reduce by artillery fire or by street fighting a town which otherwise might have been bypassed. Demolitions, mines and booby traps were used to full effect in delaying tactics afforded by the village fortresses.

## EMPLOYMENT OF ARMS AND SERVICES

**Infantry.**—Because of its self-sufficiency, mobility and versatility in the use of its many weapons, infantry must necessarily carry the chief weight of combat in mountains and must often fight for long periods without the support of other arms. As in flat country, infantry acts by means of fire, shock action and maneuver, but this method has a somewhat different application in the mountains. In general, the effect of fire is less than in ordinary terrain, since mountainous regions offer considerable natural cover such as rocks and cliffs. Maneuver is constantly hampered by the difficulties of the terrain and fire support from adjacent units cannot always be counted on. Movement will usually take the form of individual infiltration or successive rushes by small groups for very short distances.

**Artillery.**—The basic tactical principles for artillery remain valid in mountains, subject to limitations imposed by the terrain and weather encountered in mountains. All types can be used. Light and medium artillery may be brought into position with the aid of trucks, tractors, horses or mules and by the use of block and tackle or winches. Heavy motorized artillery is limited to roads and their immediate vicinity. Pack artillery, which can follow the infantry off mountain trails over comparatively rough ground, is the most dependable for close and continuous support.

Communication between artillery and the attacking echelon of the infantry and the co-ordination of its fire with that of the infantry heavy weapons require special care. Unless the attacking echelon has highly effective support up to the very point of penetration, it is likely to draw fire just before reaching its objective. An infantry attack over rising terrain is easier to support up to the moment of penetration than is one over descending terrain, although artillery fire may dislodge rocks which will endanger the advancing troops. In the final stage of the attack, machine guns and mortars must often take the place of artillery.

Because of the difficulty of supplying ammunition, the selection of targets and the allotment of ammunition are of great importance. Care must be taken to avoid wasting ammunition on unprofitable targets. Because of the decentralized nature of mountain operations, targets warranting great masses of artillery fire may be fewer than in other terrain. One type of target that is especially profitable, however, is a narrow defile being used as a route of supply advance or withdrawal by the enemy and upon which interdiction fire or heavy surprise concentrations can be placed. Another type often found in the more precipitous mountains is that presented by a large mass of snow or rocks above enemy positions. Such masses can be converted into highly destructive rockslides and avalanches by artillery fire. Avalanches accounted for more than half the casualties inflicted in the alpine fighting of World War I.

**Air Forces.**—The primary missions of the air forces in mountain operations are to gain and maintain air superiority; to observe and attack communication routes, personnel, matériel and installations; to maintain an active air defense system; to furnish visual, photographic, radar and weather reconnaissance information for use of air and ground forces; and to facilitate liaison and supply of units separated by impassable terrain obstacles. Aerial reconnaissance can penetrate ravines, slopes and defiles in a manner not easily done by ground means. Aerial photographs can disclose roads, trails, watersheds, the sky line, defiles and defiladed areas. They may also disclose many enemy installations, minor defenses and concentrations. Interpretation of photographs taken in the mountains is more difficult than those taken elsewhere and requires thorough knowledge of mountain terrain characteristics.

**Engineers.**—The conditions of mountain warfare require that a large proportion of troops be engineers. Extensive engineer work is required for the construction, maintenance, improvement and repair of routes of communication.

The construction of roads in mountainous terrain is one of the most important duties of an engineer unit. All roads built on slopes in such areas are usually the cut-and-fill types. Roads must be built as the situation changes, rather than according to a preconceived plan. Supply routes should, as far as possible, follow the contour lines. To avoid the silhouetting of men and vehicles, no roads should be built along crests of ridges.

**Supply and Transport.**—Before the Korean War, three types of transportation were used in mountain combat—wheeled vehicles where roads permitted, pack animals in more rugged country and individual soldiers or porters where there were no roads. In Korea, however, the military helicopter offered a new solution to problems of supply and transport. Even though high altitudes reduced the lifting capacity of rotary-wing aircraft, a U.S. marine corps squadron demonstrated in mountain operations that one helicopter could do the job of several trucks as a means of supply. Combat-equipped troops could be transported to the main line of resistance in much less time than it would have taken them to march, and upon arrival they were not exhausted by hours of climbing.

Both motor trucks and animal pack trains still had their uses in Korea after the advent of the helicopter, and on the main line of resistance the human back was not to be despised. But there could be no doubt that the helicopter had revolutionized methods of supply and transport in mountain warfare.

**Evacuation of Casualties.**—The evacuation of wounded in mountain warfare presents another problem that the helicopter solved to a great extent in Korea. Where it would have taken six stretcher bearers as much as half a day to evacuate a severely wounded man, the helicopter was capable of landing in roadless terrain and flying him to the aid station in 20 minutes. This difference in time often meant the difference between life and death to a patient suffering from shock.

Another tactical innovation of the Korean War, modern body armour made of lightweight plastics, also had a marked influence on mountain operations by preventing a large percentage of serious wounds, which became light, while preventing altogether many light wounds. This capability was of special importance in terrain where consideration had to be given to the conservation of manpower. (C. W. He.; Ln. Ms.)

**MOUNTBATTEN,** the name of a family of English peers. In 1917 the English members of the house of Battenberg, that is, the descendants of Princes Louis Alexander and Henry Maurice of Battenberg, renounced their German title and took the surname Mountbatten. George Louis Mountbatten (1892–1938), who succeeded his father as marquess of Milford Haven in 1921, married Countess Nadejda de Torby, by whom he had one son, David Michael (1919– ), the 3rd marquess, and one daughter. His eldest sister, Alice, married Prince Andrew of Greece (1882–1944); their only son, Prince Philip (1921– ), took the surname Mountbatten when he became a British subject in 1947 and married Princess Elizabeth, who became Queen Elizabeth II in 1952. His second sister, Louise (1889–1965), married Gustavus Adolphus, King Gustavus VI of Sweden since 1950, and his brother Louis, 1st Earl Mountbatten of Burma (1900– ), married Edwina Ashley, elder daughter of the 1st Baron Mount Temple. Prince Henry of Battenberg (1858–96) married Beatrice, youngest daughter of Queen Victoria. His eldest son, Alexander (1886–1960), was created marquess of Carisbrooke and earl of Berkhamsted; he married Lady Irene Denison. *See* also Battenberg; Edinburgh, Prince Philip, Duke of; Milford Haven, Louis Alexander.

**MOUNTBATTEN OF BURMA, LOUIS MOUNTBATTEN,** 1st Earl (1900– ), British naval officer, was born on June 25, 1900, at Windsor, Eng., the son of Prince Louis of Battenberg, first sea lord in 1914, afterward marquess of Milford Haven, and Princess Victoria of Hesse, a granddaughter of Queen Victoria. He entered the Royal Navy in 1913, and at the outbreak of World War II was in command of the destroyer "Kelly" and the 5th destroyer flotilla. He was appointed commander of H.M.S. "Illustrious" (aircraft carrier) in 1941 and, as acting admiral, served as supreme Allied commander, southeast Asia, 1943–46. He successfully conducted the campaign against Japan that led to the recapture of Burma. Viceroy and later governor general of India, 1947–48, he was successful in effecting the transfer of power to India and Pakistan at the time of partition of the subcontinent. He was later fourth sea lord, 1950–52; commander in chief of the Mediterranean fleet, 1952–54; and from 1955 first sea lord. He was created viscount in 1946 and earl in 1947. (J. B. Hn.)

**MOUNT CARMEL FOSSILS.** A series of limestone caves 15 mi. S. of Haifa, Israel, has yielded important traces of the prehistoric inhabitants of western Asia. In the valley called Wadi el-Mughara, little more than a mile from the Mediterranean coast on the western slopes of Mount Carmel, a joint expedition of the American School of Prehistoric Research and the British School of Archaeology in Jerusalem uncovered numerous stone artifacts and skeletal remains.

In 1931–32 skeletal remains of at least a dozen people were found in the cave of Mugharet et-Tabun ("cave of the oven") and in the rock shelter Mugharet es-Skhul ("cave of the kids"). The Tabun site contained a sequence of layers running from Late Acheulean through Upper Mousterian—stone tool assemblages from the early and late middle part of the Old Stone Age (Palaeolithic). Skhul was found to be a shallow Mousterian shelter.

There are noticeable anatomical differences among the inhabitants of the two sites. Tabun yielded one nearly complete skeleton of an adult woman who in many ways recalls the Neanderthal fossils of Europe (*see* Neanderthal Man). In addition, a massive adult male mandible was found which resembles the Tabun female and the European Neanderthals on the one hand and (in having a small but definite chin prominence) the Skhul skeletons and more recent forms of man on the other. Seven adults, three immature individuals and more than a dozen miscellaneous skeletal fragments were buried in Skhul. The Skhul population presents a mosaic of Neanderthal and modern characters. The Mount Carmel fossils are one of the very few instances in human paleontology in which some of the varying characteristics of a population can be observed; interpretations are on much safer ground when based on populations rather than when they are derived from individuals.

Formerly the Mount Carmel fossils were thought to be of third interglacial date, but a recently performed carbon-14 determination indicates that the Tabun layer which contains the female skeleton is only 41,000 years old. This places it near the beginning of the so-called Göttweiger interstadial and makes it contemporary with the classic Neanderthals of western Europe. The Skhul population is probably about 5,000 years more recent although the exact age remained to be determined in the 1960s.

Four interpretations for the fossils have been advanced:

1. They represent the results of hybridization between Neanderthal and populations of modern type. This has been criticized since, even if the Tabun and Skhul populations were contemporaneous, there is as yet no proof of the presence of another population of modern type.

2. They represent a population in the throes of rapid evolution in a modern direction, although they developed too late to have been the ancestors of modern races. In this theory it is claimed that they were later superseded by fully modern men who had been evolving somewhere to the east. It has also been criticized since no contemporaneous population of modern type has ever been found; nor has the concept of rapid evolution as a cause for great variability received support from genetic theory.

3. The Mount Carmel fossils are members of one of a loosely interrelated series of populations from which all later forms of man have descended. Critics of this theory have claimed that the range of variation is too large for a normal population, and that the time difference between Tabun and Skhul is too great to allow them to be considered as a single population.

4. Tabun represents the Neanderthal stage of evolution in the middle east, and Skhul represents their descendants in the course of evolving toward modern form.

The recent revision of the dating of the Mount Carmel fossils as well as changes in the whole theoretical approach toward human evolution would tend to favour this last interpretation, although it is not acceptable to all authorities. Despite disagreements, however, the mixture of Neanderthal and modern characters in the Skhul remains assures them of a position of primary importance to considerations of human evolution.

*See* also CARMEL, MOUNT.

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**MOUNT DESERT ISLAND,** an island off the eastern coast of Maine, U.S., 15 mi. long and about 8 mi. wide, offers an exceptional combination of sea, islands, mountains, lakes and fiords. Area 108 sq.mi. The island was discovered in Sept. 1604 by Samuel de Champlain in exploration of the Acadian coast from St. Croix westward and named by him from his vision of the bare rock summits of its mountains. A bridge connects the mainland and the island's network of excellent roads, bridle paths and foot paths which join the four towns on the island—Bar Harbor, Mount Desert, Southwest Harbor and Tremont.

In 1947 the island was swept by a tremendous fire that destroyed many buildings and natural attractions. Mount Desert Island's bare rock summits, including Mt. Cadillac (1,530 ft.), the highest elevation along the east coast, are the highest on the Atlantic coast north of Rio de Janeiro and, in the opinion of many, the most beautiful.

The first eastern national park in the United States, Acadia National park, was established on the island in 1919; it also includes picturesque Schoodic point on the mainland and part of Isle au Haut. (E. F. I.)

**MOUNTJOY, CHARLES BLOUNT,** 8TH BARON (*c.* 1562–1606), lord deputy of Ireland, whose victory at Kinsale in County Cork (1601) led to the complete military conquest of the country. He was born in about 1562 of a family tracing its descent from the 13th century, and succeeded his elder brother William in 1594. He made his mark at court in 1583, fought from time to time in the Low Countries against Spain and accompanied the earl of Essex on the Azores expedition of 1597. After the English forces under Sir Henry Bagnall were defeated in Ireland in Aug. 1598, it was expected that Mountjoy rather than Essex would take over command there; and after Essex' own failure and subsequent disgrace, Mountjoy was appointed lord deputy (*see* IRELAND: *History*).

In Ireland Mountjoy showed supreme competence rather than genius, and a capacity to benefit from the strategic errors of his opponent Hugh O'Neill, earl of Tyrone. After the landing of Spanish troops at Kinsale in 1601, O'Neill marched south to join them. Mountjoy waited outside Kinsale and on Dec. 24, 1601, his cavalry routed the Irish army. The Spanish evacuated Kinsale and Ulster was left open to invasion. Mountjoy received O'Neill's submission in 1603, advising James I to treat him with moderation. Mountjoy was created earl of Devonshire in 1603. A political career of some importance in Jacobean England might have followed, but he came into disfavour at court because of his marriage (1605) with Penelope, sister of the late earl of Essex and divorced wife of Robert Lord Rich (afterward earl of Warwick), who had been his mistress since 1590 and had borne him several children. He died at Savoy house, London, on April 3, 1606.

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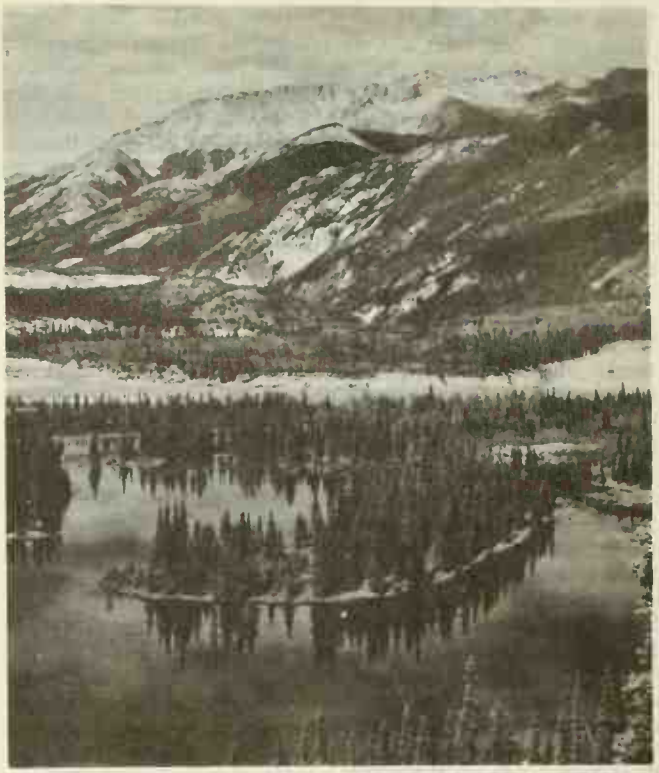
**MOUNT McKINLEY NATIONAL PARK,** a scenic U.S. nature reserve in south central Alaska, was established by congress Feb. 25, 1917, and increased in 1922 and 1932 to 3,030 sq.mi. Included are over 110 mi. of the most spectacular part of the Alaska range, with Mt. Russell (11,670 ft.), Mt. Foraker (17,395 ft.) and the highest peak in North America, Mt. McKinley (20,320 ft.). Vast snow fields and many glaciers feed cloudy, silt-laden rivers which flow swiftly north toward the Kuskokwin. In the valleys narrow strips of white spruce forest extend up to timber line (2,500 to 3,000 ft.). Between that elevation and permanent snow, the tundra is clothed by shrubs such as dwarf birch, willows, alder, blueberry, crowberry, great mats of low, shrubby dryads and many herbs.



BY COURTESY OF PAN AMERICAN WORLD AIRWAYS

HORSESHOE LAKE IN MT. MCKINLEY NATIONAL PARK, NEAR FAIRBANKS, ALASKA

Caribou, grizzly bears and ground squirrels live on the tundra, while Dall sheep, marmots and pikas stay close to rocky hills and cliffs. Alaska moose, red fox, marten, lynx and snowshoe hares range chiefly in the wooded valleys. Beaver and mink live along streams and lakes; wolverines and wolves may be encountered anywhere in the park. The most notable of the 120 recorded bird species are the short-billed gull, ptarmigan, golden eagle, jaeger, surfbird and wandering tattler. Fishermen catch mackinaw trout in the lakes and grayling in the clearer streams. No hunting is allowed, but highways, trails, trackless wilderness, mountains and wildlife offer many opportunities for those who hunt with cameras.

The park may be reached via the Alaska railroad, by automobile from Richardson highway and by private aircraft. Visitors stay at the park hotel and campgrounds or at a privately-operated camp near Kantishna. (V. H. C.)

**MOUNT RAINIER NATIONAL PARK** protects 241,782 ac. in the Cascade range of the state of Washington where the massive, symmetrical volcano which gives the park its name rises 14,410 ft. above sea level. Mt. Rainier covers about 100 sq.mi. and is surrounded by deep ice-carved canyons radiating from the peak.

Twenty-six glaciers originate in the perpetually ice-clad summit or in the glaciated cirques on the upper flanks, and are renewed each winter by the cooling of moisture-laden winds from the Pacific ocean. Emmons glacier is five miles long. The view of Mt. Rainier with its ice crown glowing in the rosy hues of dawn or sunset is an outstanding spectacle.

On the slopes of the mountain stand deep green forests of conifers, interspersed with mountain meadows; and on the high sub-

alpine tundra wildflowers grow in great profusion and variety. Black-tailed deer, bear and elk inhabit the forest and mountain goats climb the higher cliffs; many species of smaller mammals and birds are found throughout the park. Mt. Rainier presents a challenge to mountaineers and its long, snow-covered slopes offer fine skiing. Highways lead to scenic elevations and circle through the lower slopes, and there are more than 100 mi. of trails for the hiker.

Although the park receives as much as 100 in. of precipitation annually, the climate from July into September is pleasant and that season is often followed by Indian summer. (F. M. Pd.)

**MOUNT RUSHMORE NATIONAL MEMORIAL,** 25 mi. from Rapid City in the Black hills of southwestern South Dakota, U.S., is a gigantic sculptured relief of the heads of George Washington, Thomas Jefferson, Abraham Lincoln and Theodore Roosevelt, carved in granite on the northeast side of Mt. Rushmore. Each head is about 60 ft. high. The sculptor was Gutzon Borglum (*q.v.*). The original idea for the memorial is credited to Jonah Leroy "Doane" Robinson, who was superintendent of the South Dakota State Historical society for many years.

The memorial was conceived as a "shrine of democracy," with the presidents representing the founding, expansion, preservation and unification of the U.S. Work on the carving was begun in 1927 and finished in 1941, representing six and a half years of actual labour. Private donors supplied the initial funds but the United States government paid the greater part of the total cost.

The Mt. Rushmore reservation of 1,278 ac., administered by the national park service, lies near two U.S. highways. About 1,000,000 persons visit the park each year. (J. E. Cl.)

**MOUNT VERNON,** a residential and industrial city of Westchester county, N.Y., U.S., on the Bronx river, is directly north of and adjacent to the Bronx, New York city, between New Rochelle and Yonkers.

Originally a part of Eastchester township, Mount Vernon was settled in 1664 on the property where Anne Hutchinson, religious enthusiast banished from the Massachusetts Bay colony in 1638, was killed by Indians in 1643. These first settlers were ten families invited from Connecticut by Thomas Pell, who had purchased the land from the Indians. St. Paul's church, used during the American Revolution as a British military hospital, was made a national historic site in 1943.

The original church building was the scene of the election of Lewis Morris to the provincial assembly on Oct. 29, 1733. Morris, chief justice of the provincial supreme court, had been summarily removed from that position by Gov. William Cosby for declaring the governor's chancery court illegal. After the election, Morris became one of the backers of the antiadministration newspaper of John Peter Zenger (*q.v.*).

During the Revolution a stubborn delaying action there by Glover's brigade on Oct. 18, 1776, probably saved Washington's army, in retreat from New York city to White Plains, from being annihilated by Gen. William Howe. The modern history of Mount Vernon begins in 1851 when the Industrial Home Association No. One, a co-operative building group founded in New York city by merchant tailor John Stevens, purchased 367 ac. of land in the area for its 1,000 members.

Manufactures include pharmaceuticals, cosmetics, metal and wire products, electrical and electronic equipment, baby carriages and truck bodies.

Mount Vernon was incorporated as a village in 1853 and chartered as a city on March 12, 1892. It is a part of the New York-northeastern New Jersey standard consolidated area.

Pop. (1960) 76,010. For comparative population figures *see* New York: *Population.* (M. D. Hh.)

**MOUNT VERNON,** the home and burial place of George Washington, is located in Fairfax county, Va., on the Potomac river, 15 mi. below Washington, D.C. The mansion house, which stands on a bluff overlooking the river, is built of wood, but the siding is of wide, thick boards so paneled as to give the appearance of cut and dressed stonework. The rooms contain much of the furniture that was in them when they were occupied by Washington and his family; most of the pieces on the first floor and all of those in Washington's bedchamber are original. The furniture that had been lost has been in part replaced by other furniture of historic interest and of the style in use in Washington's day. Additional articles relating to Washington and his life at Mount Vernon are housed in a museum building north of the spinning house. In the main hall hangs a glass casket containing the key to the Bastille, presented to Washington in 1790 by Lafayette.

From each end of the house a curved colonnade leads to a row of outbuildings. A spacious lawn surrounds the mansion, with shaded drives, walks and beautiful gardens. A short distance southwest of the mansion house is a plain brick tomb built by Washington's direction on a site chosen by himself. It contains the remains of Washington and Mrs. Washington (removed to this tomb from the old family vault in 1831) and of a number of other members of the family.

The estate, originally called Little Hunting Creek plantation, consists of about 5,000 ac. It descended by inheritance from John Washington, the first of the family in America, to his son Lawrence, who in turn devised it to his daughter Mildred. From Mildred it was purchased in 1726 by her brother Augustine, George Washington's father. In 1735, when George was three years old, the Augustine Washington family settled on the estate and lived there for several years. It is believed that the central part of the house was built during that time. In 1740, however, Augustine conveyed the plantation to his son Lawrence, elder half-brother of George, and Lawrence settled there three years later. He renamed the plantation Mount Vernon in honour of his former commander, Adm. Edward Vernon (1684–1757), under whom he had served in the Caribbean. Augustine Washington died in 1743; young George, after his father's death, spent part of his youth at Mount Vernon with Lawrence and Lawrence's wife.

After Lawrence's death, George Washington took possession of his property by inheritance in 1754, but active military service kept him away from the plantation for another few years. In Jan. 1759 he married Martha Custis, widow of Daniel Parke Custis, and soon thereafter took up residence at Mount Vernon. In the next few years he planned and executed the enlargement of the villa into the mansion house, the addition of the smaller wings, the erection of several of the outbuildings and the extension and adornment of the gardens. After about 15 peaceful years there, he was again called into public service, and it was not until Dec. 1783, when he tendered his resignation to congress as commander in chief of the Continental army, that he could again settle at Mount Vernon. Even then his retirement was not to last. In 1789 the plantation life he so much enjoyed was broken when he became the first president of the United States and could be little at home for eight years. During his absences, his manager and distant kinsman, Lund Washington, carried on, according to George Washington's plans, the continuous improvements that invariably constitute part of the activity of a large estate.

Washington's final retirement ended with his death on Dec. 14, 1799. At his death, under the terms of his will, a life interest in Mount Vernon went to his widow, and the estate passed to his nephew, Bushrod Washington; from Bushrod it descended, by successive inheritance, to John Augustine Washington, Jr., who was, in turn, authorized by will to sell it to the U.S. government. An offer to sell the property to the government was accordingly made, but was refused.

In 1858, through the efforts of the Mount Vernon Ladies' Association of the Union, founded by Miss Ann Pamela Cunningham of South Carolina, a purchase contract was signed by which the mansion house and 200 ac. of the original estate, fast falling into decay, were to be bought. About a third of the purchase money was raised through the efforts of Edward Everett (*q.v.*). The association, under its charter (1858), bound itself to restore the estate as far as possible to the condition in which it was in the lifetime of Washington and to keep it sacred to his memory; the state of Virginia agreed to exempt it from taxation as long as these terms were fulfilled. The association became an influential pioneer in the restoration of historic places, serving as an inspiration and example for similar projects. *See* also Washington, George.

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**MOURET, JEAN JOSEPH** (1682–1738), French composer born at Avignon on April 11, 1682. Mouret spent the greater part of his life in the service of the duchesse du Maine, whose celebrated *Grandes Nuits de Sceaux* at her château near Paris were directed by him. He was appointed musical director of the *Concerts Spirituels* in 1728 and wrote for them the motets published in 1742. He composed many *divertissements* for the *Comédie italienne* and was for a time their conductor. He died at Charenton on Dec. 22, 1738. Mouret's works are of a high standard and include 47 *divertissements* and much other instrumental music as well as several cantatas, two books of motets and one Mass. His opera-ballets, notably *Les Festes de Thalie* (1714), occupy an important place in the music of the period.

*See* R. Violier, *J. J. Mouret, le musicien des graces* (1950). (B. P.)

**MOURNE MOUNTAINS,** in County Down, N.Ire., are a compact and dominating range of shapely granite peaks rising abruptly from the Irish sea and the tidal waters of Carlingford lough. Extending in length for about 9 mi., between Newcastle and Rostrevor, the range has a maximum breadth of 5 mi. Its oval outline reflects the extent of five overlapping granite intrusions into Silurian shales which occurred in Tertiary times along a Caledonian trend line (northeast-southwest). Slieve Donard, in the northeast, rises to 2,796 ft. within 2 mi. of the sea, and of the dozen other summits which exceed 2,000 ft. the most conspicuous are the tor-crowned Slieve Bearnagh and Slieve Bingian. The main economic use of the hills, apart from sheep pasturing, is for storage reservoirs of which the largest, supplying Belfast, is in the Silent valley on the Kilkeel river. Spelga dam, on the Upper Bann river, supplying Portadown and Banbridge, occupies part of a high plateau (the Deer's Meadow) through which passes the only road to cross the mountain core. The lower slopes of the hills, mainly on Silurian shales, are extensively reafforested and contrast strikingly with the bare boulder-strewn granite peaks. Between the mountains and the sea is a crescent-shaped lowland, the historic Kingdom of Mourne, now famous for its potatoes. Small coastal towns such as Newcastle, Annalong, Kilkeel and Rostrevor, once engaged in exporting dressed granite, are now busy with fishing or tourism. Ruined castles at Greencastle and Dundrum attest the efforts of the Anglo-Norman settlers to hold this difficult coast. At Hilltown and Castlewellan, on the north side, sheep fairs are held. Between Newcastle and Castlewellan is the forest park of Tollymore. (E. E. E.)

**MOUSCRON** (Flem. MOESKROEN), a town of West Flanders, Belg., lies close to the French frontier and astride the linguistic border between the French and Flemish-speaking parts of the country, 11 km. (7 mi.) S. of Kortrijk by road. Pop. (1961) 36,554. An 11th-century castle, later a farm, was converted to a folklore museum in the early 1960s. Mouscron is on the railway from Kortrijk to Tourcoing and Lille, France. It followed the development of the textile industry in northern France and has become one of Belgium's most important textile and carpet-weaving centres. First mentioned in 944, Mouscron long remained a large village, built on the site of a Roman encampment. In 1794 French revolutionary troops defeated the Allies there, and in 1848, at Risquons-Tout, an aptly named hamlet nearby, troops of the newly independent Belgium defeated rebel mercenaries. (R. M. AN.)

**MOUSE,** an imprecise term designating any small rodent but often meant to apply to the common house mouse (*Mus musculus*), the type of the genus *Mus* and the family Muridae. In North America most species of the widespread and varied family Cricetidae also are called mice. Specific kinds of mice are usually designated by a compound term such as harvest mouse (*Micromys* of Europe; *Reithrodontomys* of America), wood mouse (*Apodemus* of Eurasia), whitefooted mouse (*Peromyscus* of America) or pocket mouse (*Perognathus* of North America).

Mice are indigenous to almost every land area and in a given area are likely to be the commonest of mammals. Some species are of narrowly restricted occurrence and habitat; others are widespread and versatile. The genus *Mus*, for example, occurs naturally on all major land masses; the typical species has been distributed by man to all inhabited areas of the earth and has become naturalized. One species of *Peromyscus* occurs over most of North and Central America from the subarctic to the tropics, in swamps, deserts, forests, mountains and prairies. Mice eat a variety of foods, some consuming almost anything edible—seeds, vegetation, arthropods and flesh when available. They are in turn preyed upon by all manner of larger carnivorous mammals, rapacious birds and reptiles. Mice constitute the most important prey group of any of the mammals.

Mice mature relatively young; the house mouse typically is ready to mate two to three months after birth. Gestation periods, averaging about three weeks, is less than two in some species. From 1 to 18 young comprise a litter, the size of the litter depending upon the species, the number of litters already produced by the female (the second or third is usually the largest) and the season. Breeding may take place at any season in some species and be seasonally restricted in others; in a widespread species the climate of a given region is usually the determinant.

JOHN H. GERARD

HOUSE MOUSE (MUS MUSCULUS)

Some species are social and live in common burrows or in colonies. Others are solitary. Even in the social house mouse, however, excessive crowding produces metabolic disorders and abnormal behaviour patterns that may result in the decimation of the population, a phenomenon thought to be related to the well-known periodic "suicidal" migrations of lemmings to the sea (*see* LEMMING).

Many mice, notably the house mouse, seem to prefer dwelling in man-made structures and can become serious pests, not only for the destruction they cause but also for the disease-producing organisms they may harbour (*e.g.*, murine typhus, plague). Serious infestations may require the services of trained exterminators because of the lethality of some of the poisons that are often used. A minor infestation can be handled adequately and most safely by trapping. Mice, especially the house mouse, together with their near relatives, the brown and house rats, are responsible for enormous economic damage annually. Even those living in natural conditions may be so numerous in limited areas as to become serious, although usually temporary, agricultural pests. Except in abnormal circumstances, however, mice are on the whole beneficial to man because they form the bulk of the diet of most fur-bearing animals and of predators that otherwise prey on more valuable species, including domestic livestock. The experimental decimation of populations of native mice in North America, for example, has produced a concomitant sharp increase in fox and coyote predation on poultry and of coyote predation on sheep.

The common white laboratory mouse is a domesticated variant of the house mouse and is widely used in medical experimentation. They also are commonly kept as pets. Many other variant strains of known genetic and/or nutritional history have been developed for experimental purposes.

*See* DORMOUSE; POCKET MOUSE; RODENT; *see* also MARSUPIAL MOUSE and references under "Mouse" in the Index.

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**MOUTH,** in anatomy, is an oval cavity at the beginning of the gastrointestinal tract. The walls of the oral cavity are specialized to a high degree in order to serve the functions of mastication, salivation, swallowing, tasting and speaking.

**Anatomy.**—The mouth opening is situated between the lips and, at rest, its width reaches to the first premolar tooth on each side. The entire cavity communicates in front with the exterior

through the oval fissure and behind with the pharynx (throat). The walls are formed by the flexible lips and cheeks, the roof by the hard palate and soft palate; the movable floor is formed by the tongue, the sublingual tissue and the lower jaw (mandible).

The lips are fleshy folds surrounding the opening of the mouth; they are formed, from without inward, by skin, superficial fascia, orbicularis oris muscle and submucous tissue. They contain glands (sebaceous, mucous and serous), branches of the maxillary and mandibular divisions of the trigeminal nerve, branches of the labial arteries, corresponding tributaries of the anterior facial vein and a wealth of minute lymphatic vessels. In the midline is a reflection of the mucous membrane onto the gum, forming the fraenum labii.

The cheeks form the sides of the mouth and are continuous with the lips, with which their structure is almost identical save that the buccinator muscle replaces the orbicularis oris and the glands are buccal (cheek) rather than labial (lip). In the subcutaneous fascia is a distinct mass of fat, specially large in the infant, known as the sucking pad. On the inner surface of the cheek, opposite the second upper molar tooth, is the papilla that marks the opening of the parotid duct, leading from the parotid salivary gland in front of the ear. Just behind are four or five mucus-secreting glands, the ducts of which open opposite the last molar tooth. The mucous membrane of the cheek, like that of the rest of the mouth, is of the stratified squamous variety (*see* EPITHELIUM) and is reflected onto the gums.

The gums consist of mucous membrane connected by thick fibrous tissue to the membrane surrounding the bones of the jaws. Round the base of the crown of each tooth the gum membrane rises to a little collar. The gum tissues are rich in blood vessels, receiving branches from the alveolar arteries; these vessels also supply the teeth and the spongy bone of the upper and lower jaws, in which the teeth are lodged. The veins and lymphatics correspond essentially to the arteries.

The roof of the mouth is concave transversely and anteroposteriorly and is formed by the hard and soft palate. The hard palate consists of mucous membrane continuous with that of the gums and bound to the upper jaw and palate bones by firm fibrous tissue. In the midline is a slight ridge, the palatine raphe, which ends in front in the palatine papilla, marking the position of the anterior palatine canal, which carries an artery. From the anterior part of the raphe five or six transverse ridges or rugae of the mucous membrane run outward. (For a description of the soft palate *see* THROAT.)

The floor of the mouth can be seen only when the tongue is raised; then the reflection of the mucous membrane from the gums to it is exposed. In the midline is a prominent fold (frenulum linguae), and on each side of this a sublingual papilla, onto the summit of which the duct of the submaxillary gland opens. Running outward and backward from this is a ridge (plica sublingualis), which marks the upper edge of the sublingual salivary gland and onto which most of the ducts of that gland open.

For descriptions of the tongue, teeth and salivary glands, *see* separate articles.

**Comparative Anatomy.**—In the lancelets, the simplest vertebrates, the mouth is developed on the left side and gradually shifts to the midline; later an extra chamber, the oral hood, is formed in front of it, the external opening of which is provided with bristle-like cirri, so that in the adult the mouth is merely an aperture in the membrane that separates the oral hood from the pharynx.

In the lampreys and hagfishes the mouth is a sucking organ and resembles a funnel, the narrow end of which opens into the pharynx. It is always open and is provided with horny teeth and a tongue. At this low stage of the vertebrate scale no jaws appear, but in the larval lamprey (ammocoetes) an oral hood, resembling that of the lancelet, is present. In the fishes jaws are present and the mouth can be closed at will.

In the sharks and rays the opening is crescentic and situated well on the ventral surface of the head, but in other fishes it is at the anterior end of the body.

Until the mudfish is reached there is no communication between the mouth and the nose, but in these fishes the internal or posterior nares open into the front part of the roof of the mouth, thus adapting them to air breathing. In the Amphibia the mouth usually has an enormous gape, and the position of the posterior nares resembles that of the mudfish. At this stage of phylogeny the condition resembles that of the ontogeny of man before the palatal processes appear. The premaxillary part of the frontonasal process separates the nasal cavity from the mouth in front, but behind that the cavity is the rudiment of the mouth and nose; no palate has yet appeared to separate them. In reptiles the hard palate appears, and from this point upward in the scale the digestive and respiratory tracts form only one passage in the pharynx.

Definite lips provided with muscles first appear in mammals, though the monotremes have such specialized mouths that lips are not found in that order. In many monkeys the vestibule is enlarged so as to form cheek pouches.

**Embryology.**—The foregut (*see* GASTROINTESTINAL TRACT) at first ends blindly, ventral to the hindbrain; in front of it is the overhanging forebrain. When the heart develops, ventral to the foregut, it also projects forward toward the forebrain, so that a transverse cleft, without any lateral boundaries and lined by ectoderm, is left between these two structures. This is the stomatodeum or primitive mouth, the ectoderm of which rests against the entoderm of the foregut to form the buccopharyngeal membrane and so separates the two chambers. The position of this membrane does not correspond to the fauces or hinder limits of the adult mouth but is much more oblique, so that the front part of the roof of the pharynx is formed by stomatodeum while the greater part of the floor of the permanent mouth is foregut. During the third week the membrane disappears, and no traces of it can be seen in the adult.

Growing down from the region of the forebrain is the frontonasal process, which forms the nose and the middle piece of the upper lip, while the lateral parts of the mouth are closed in by two processes, on each side of which the lower or mandibular process rapidly meets its fellow in the midline to form the lower jaw and lip, thus separating the heart from the mouth cavity. The upper or maxillary process grows inward more slowly but at last joins with the frontonasal process, and in the adult the lines of union are seen on each side as ridges of skin that run down from the nostril to the margin of the lip and enclose the slightly depressed vertical gutter called the philtrum.

Besides forming the philtrum the frontonasal process is responsible for that part of the roof of the mouth bounded by lines drawn on each side from between the lateral incisor and canine teeth to the palatine papilla. At first the cavities of the mouth and nose are one, but later they are divided by the palatal processes, which grow in like shelves from the maxillary processes and meet in the midline.

**Diseases.**—Most of the conditions affecting the mouth and salivary glands are described under separate headings (*see* TONGUE, DISEASES OF; DENTISTRY; PERIODONTAL DISEASES; and articles on the separate dental specialties; CALCULUS [IN MEDICINE]; DIPHTHERIA; TONSILLITIS; MUMPS; ACTINOMYCOSIS). Since the mouth constitutes the beginning of the respiratory and gastrointestinal systems, it shares in some degree in the affections of these systems, as well as in general diseases (*see* SCARLET FEVER; MEASLES AND GERMAN MEASLES; SCURVY; TUBERCULOSIS). A few other aspects of the subject remain to be considered.

*Relaxed or Unduly Long Uvula.*—Either because of its inordinate length or because it shares in a general pharyngitis, the uvula may touch and irritate the back of the tongue, leading to irritable cough or repeated attempts at clearing the throat. Usually gargling with an astringent is sufficient treatment; formerly a portion of the uvula was burned with caustic or snipped off with scissors, but this procedure is undesirable since removal of too much leads to regurgitation of food or drink through the nose in swallowing, due to failure of complete coaptation of the uvula and anterior pillars of the fauces.

*Ranula.*—This is a cystic tumour in the floor of the mouth, filled with clear fluid; it results from accumulation of saliva in the duct of the salivary gland behind an impacted salivary calculus.

*Phosphonecrosis.*—This condition, also called phossy jaw, dis-

appeared after nontoxic forms or compounds of phosphorus were substituted for highly poisonous white phosphorus in the manufacture of matches. Before the substitution, the condition was common due to the fact that in match factories phosphorous fumes attacked the jaws of workers in the region of carious teeth; extensive necrosis of the bones of the jaw and falling out of teeth, followed by severe constitutional disease, often resulted, and death was not uncommon. (*See* also MATCH: *Friction Matches.*)

*Macroglossia and Macrocheilia.*—These are rare conditions in which the tongue and lips respectively are enormously enlarged from blockage of their main lymphatic channels. The condition is therefore akin to elephantiasis (*q.v.*). The tongue may be so large that it protrudes from the mouth for several inches.

*Cleft Palate and Harelip.*—Persistence of a congenital fissure in the roof of the mouth (cleft palate) is sometimes associated with a similar rift in the upper lip (harelip). Such a labial cleft may be single, or there may be one on either side of the median line. They are the result of arrest in normal development—a failure in union of the nasal and maxillary processes of the embryonic face. These deforming anomalies, in their many variations, can be dependably corrected by surgery. (*See* SPEECH DISORDERS.)

*Double Lip.*—This uncommon type of congenital deformity is rarer in the upper lip than in the lower. The malformation consists of a paramedian sulcus or pit, situated just within the vermillion border of the lip. Double lip is corrected surgically by excision of the prolapsed area of mucous membrane and joining of the edges of the incision.

For the functions of the mouth in mastication, salivation and swallowing, *see* DIGESTION. *See* also references under "Mouth" in the Index.

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**MOUTH ORGAN:** *see* HARMONICA.

**MOUTON, JEAN** (*c.* 1459?–1522), French composer known for his sacred music, was born in Haut-Wignes (Boulogne). He was a chorister in Nesle from 1477 to 1483 and worked in Amiens and Grenoble from 1500 to 1502 before joining the French chapel royal. He died in St. Quentin on Oct. 30, 1522. Mouton apparently studied with Josquin Després and taught Adriaan Willaert, and his music leads away from the older, sectional manner, which emphasized abstract structural devices, to the humanistic prosody, continuous flow and pervasive imitation of the new style.

*See* Mass in *Das Chorwerk 70*, ed. by P. Kast (1958); *Treize livres de motets . . .* i–iii, ed. by A. A. Smijers (1934–38). (B. L. TR.)

**MOVIES:** *see* MOTION PICTURES.

**MOWATT, ANNA CORA** (1819–1870), U.S. playwright, novelist and actress, whose many contributions to literature and the theatre made her one of the outstanding figures of the 19th century, was born in Bordeaux, France, on March 5, 1819, the daughter of a New York merchant, Samuel Ogden. A precocious child, she acted at the age of five and had read all of Shakespeare's plays before she was ten. Her early marriage at 15 to James Mowatt, a New York lawyer who doted on her, gave her ample opportunity to continue dabbling in the arts.

In 1841, after her husband lost his wealth, she turned to performing and writing in earnest, giving poetry readings and writing articles for the popular magazines. In 1845, at the suggestion of Epes Sargent, she wrote *Fashion*, the play with which she has since been associated. A devastating social satire, *Fashion* brilliantly expressed the growing feeling in the United States against emulation of European manners. In June 1845 Mrs. Mowatt made a successful debut as an actress and entered another phase of her many-sided career. In addition to *Fashion*, she wrote the plays *Gulzara* (1840) and *Armand* (1847) and, in 1854, her *Autobiography*. James Mowatt having died in 1851, she married William F. Ritchie in 1854 and retired from the stage. She died in London, July 28, 1870. (S. W. H.)

**MOWBRAY,** the name of an English baronial family, derived from Montbray near St. Lô in Normandy. It was founded by Geoffrey de Montbray, bishop of Coutances (1049–93), a great feudal prelate who was as much statesman as churchman. Orderic Vitalis, the chronicler, remarked that he knew more about marshaling mailed knights than edifying psalm-singing clerks, although, in fact, his early career was devoted to the reorganization of his diocese and the rebuilding of his cathedral. After 1066 his life was spent mainly in England as a principal adviser of William I the Conqueror, whom he served as soldier, administrator and judge. His reward was a great fief of about 280 manors in 12 counties, which passed after his death to his nephew (his brother Roger's son) Robert de Mowbray, earl of Northumberland. Both Geoffrey and Robert rebelled against William II in 1088, and when Robert again rebelled in 1095 he was imprisoned for life and forfeited his estates. Only a part of his Norman lands passed to the founder of the second house of Mowbray, Nigel d'Aubigny, who was also a kinsman of Bishop Geoffrey and had married Maud, Robert's widow. His loyalty to Henry I brought Nigel rich rewards: to his midland estates he added the forfeited lands of the Stutevilles in north Yorkshire and the Isle of Axholme in Lincolnshire. Nigel's son Roger (d. 1188), who took the name of Mowbray, was a leader of the rebellion of 1174–75 against Henry II, his northern castles of Thirsk and Kirkby Malzeard being destroyed when the revolt failed. But he is best remembered as a munificent patron of north-country monasticism. A founder of Newburgh priory, he was also a generous benefactor of the monks of Fountains, Byland and Rievaulx abbeys, and of the Knights Templar. His piety found further expression in the crusading movement. He went to the Holy Land with the second crusade in 1147 and returned there in 1187, when he was captured by Saladin at the battle of Hattin and died soon after his release. His son Nigel was to die there also, at the siege of Acre in 1191.

His grandson William (d. 1224) was one of the 25 barons appointed to enforce Magna Carta, but the Mowbrays played little part in 13th-century politics. Roger (d. 1297) was summoned to parliament as a baron by Edward I. John, his son, added to the family fortunes by his marriage to Aline de Braose, heiress of Gower (*q.v.*) in south Wales and Bramber in Sussex. Alarmed by the ambition of the Despensers, he joined the opposition to Edward II in 1321 and was hanged at York in 1322 after the rebels' defeat. The marriage of John, 4th Lord Mowbray, brought immense accessions of territorial power; his wife Elizabeth was heiress of the Segraves, and of her grandfather, Thomas of Brotherton, earl of Norfolk, whose half-brother Edward II had settled on him the great East Anglian estates of the Bigod family. The elevation of their son Thomas (d. 1399) to the dignities of earl of Nottingham, earl marshal and duke of Norfolk was an indication that the Mowbrays now ranked among the greatest magnates in the realm. Their influence was temporarily eclipsed by the banishment of Thomas (1398) and the loss of his ducal title; and by the treason of his young son Thomas, earl marshal, whose share in the rising of Archbishop Scrope brought about his summary execution at York in 1405 and the forfeiture of his estates. The loyalty of Thomas' brother John (d. 1432), who served Henry V well in France, enabled him to recover the family fortunes and he was restored to the dukedom in 1425.

John Mowbray, 3rd duke (d. 1461), proved a somewhat lukewarm Yorkist, but his son John, 4th duke, was one of the chief supporters of Edward IV. The male line of the Mowbrays became extinct when John died in 1476. His infant daughter Anne, who was married to Edward IV's second son Richard, duke of York, survived only until 1481. The titles and estates of the Mowbrays then passed to the Howards, who were descended from a daughter of the 1st duke (*see* NORFOLK, EARLS AND DUKES OF).

*See* J. H. Le Patourel, "Geoffrey of Monthray, Bishop of Coutances," *English Historical Review*, vol. lix (1944). (C. D. R.)

**MOWBRAY, H(ENRY) SIDDONS** (1858–1928), U.S. mural painter, was born of English parents at Alexandria, Egy., Aug. 5, 1858. Orphaned in infancy, he was raised by an uncle in Titusville, Pa., and North Adams, Mass. After a year at the U.S. Military academy, West Point, N.Y., Mowbray went to Paris

in 1878 to study painting under Léon Bonnat. Settling in New York in 1886, he turned to mural painting about 1890, and did especially notable work for the Morgan library and the University club, New York city. He was director of the American Academy in Rome in 1903–04 and later a member of the National Fine Arts commission. He died on Jan. 13, 1928. (D. H. W.)

**MOWINCKEL, JOHAN LUDWIG** (1870–1943), Norwegian statesman, shipowner and philanthropist, entered public service as mayor of his native town, Bergen. In 1906 he became member of parliament (*storting*) for the Liberal party, and president in 1916. Most of the time between World War I and 1935 he was prime minister and minister of foreign affairs. In 1911 he was instrumental in founding the Norwegian-America line, and in 1925 he became a member of the Nobel Peace Prize committee.

Mowinckel took the initiative for the Oslo convention in 1930 to encourage free trade between the Benelux and Nordic countries, thus anticipating postwar efforts toward European union.

He also took an active interest in the League of Nations, serving on the council and becoming president in 1933. He condemned the menace of Nazi philosophy, and when Germany overran Norway in 1940 he escaped with the government in exile. He died Sept. 30, 1943, in New York city, where he was representing his country. He was considered to be the outstanding statesman of his time in Norway. (J. A. Mʟ.)

**MOWINCKEL, SIGMUND OLAF PLYTT** (1884–1965), Norwegian Old Testament scholar best known for his work on the Psalms, was born at Kjerringøy on Aug. 4, 1884. After obtaining his doctorate in theology at Oslo (1916), he was a docent in Old Testament theology there (1917–22) before being professor (1922–54). Influenced by Hermann Gunkel in Giessen and Vilhelm Grönbech in Copenhagen, he found his own line in the study of cultic life in ancient Israel. His chief work, *Psalmenstudien,* in six volumes (1921–24), gives a vivid picture of the milieu in which the Psalms were composed and used, especially of their context in worship. He claims that those referring to Yahweh as king, which he calls enthronement psalms, originally had a special background in an enthronement festival of Yahweh which was later transformed into other festivals. This theory, further worked out in *Zum israelitischen Neujahr und zur Deutung der Thronbesteigungspsalmen* (1953), has proved very influential although it is not fully accepted by all scholars. Mowinckel also wrote analyses of the prophetic books and studies on the period beginning with Ezra and Nehemiah, including *Statholderen Nehemia* (1916), *Profeten Jesaja* (1925), *Jesaja-disiplene* (1929), and *Prophecy and Tradition* (1946). His important work on eschatology is *Han som kommer* (1951; Eng. trans. *He That Cometh* [1956]). He also wrote *Offersang og sangoffer* (1951; Eng. trans. *The Psalms in Israel's Worship* [1963]) and *Religion und Kultus,* and did most of the work on a new Norwegian translation of the Old Testament. He died in Oslo on June 4, 1965. (A. S. K.)

**MOXA:** *see* Acupuncture.

**MOXICO,** a district of eastern Angola, southwest Africa. Area 76,753 sq.mi. Pop. (1960) 266,709. Moxico district is divided into two *concelhos* (counties), Moxico and Dilolo; and three circumscriptions, Luchazes, Alto Zambeze and Bundas. Its capital is Luso. The two *concelhos* possess a climate suitable for European settlement and are served by the Benguela railway. The people depend upon agriculture (rice, manioc, maize [corn], broad beans, tobacco, castor beans, wax, hides) and commerce. Dilolo is rich in fish (in rivers and lakes) and game. Alto Zambeze has a good climate but is short of communications. Bundas and Luchazes (in the south) have few transport facilities; rudimentary crude rubber, wax and honey are produced. (A. A. G. P.)

**MOZAMBIQUE** (Moçambique), the name of a Portuguese overseas province in east Africa and of a district and town within that province. The province of Mozambique is discussed in the article Portuguese East Africa. This article deals only with the town and district.

Mozambique Town is situated on a small coral island, 550 mi. N.E. of Beira and 3 mi. off the coast, at the mouth of Mossuril bay. Pop. (1960) 12,493. It is an important commercial centre and has good harbour facilities. Lumbo, on the mainland (5 mi. S. of the town), is the terminal of a railway; Mossuril, 7 mi. N.W., is the European residential town. Although small in size, Mozambique is cosmopolitan in population; Europeans, Indians and Arabs mix with the Makwa natives.

J. ALLAN CASH

STATUE OF VASCO DA GAMA IN THE MAIN SQUARE NEAR MOZAMBIQUE HARBOUR

The town's existence is threatened by the neighbouring (to the north) port of Nacala, opened to navigation and exploitation in Oct. 1951, which is the best natural port of Portuguese East Africa and perhaps of all Africa. Till the completion of this harbour it was through Mozambique that all the maritime traffic relating to the fertile interior areas passed. With the development of Nacala, Mozambique began losing a good deal of its traffic.

Mozambique, like most east African towns, was originally an Arab settlement. The Portuguese settled there in 1508 and erected St. Sebastian fort, built of granite brought from Portugal. Until 1897 it was the capital of Portuguese East Africa but it declined in influence after the development of Beira and Lourenço Marques. Throughout the centuries the town has changed little; many of the solid houses with barred windows and heavily bolted doors, as well as the paved streets, were built in the 16th century.

Mozambique District, one of the nine into which the province is divided, has as administrative subdivisions two first-class *concelhos* (counties), Nampula and Mozambique; one third-class *concelho,* António Enes; and 13 circumscriptions. Area 30,815 sq.mi. Pop. (1960) 1,439,256. The district is densely populated (46.7 per square mile) and very fertile, producing maize (corn), cotton, sisal, peanuts, castor oil, manioc, coffee, mangrove bark, wax, salt, tea, tobacco, etc. In addition to Mozambique, the chief towns are Nampula, the capital (*Concelho* pop. [1960] 104,777), and António Enes (117,923). (H. A. Wf.; A. A. G. P.)

**MOZARAB,** a general term for persons not Arab by birth who have assimilated themselves to the Arabs (Spanish *Mozárabe,* a corruption of the Arabic *Musta'rib,* coll. *Musta riba*). It was applied by the Muslims in Spain to the Christian communities existing among them, in Córdoba, Seville, Toledo and other large cities. The ancient liturgy used by the Christians of Toledo is commonly known as Mozarabic. *See* Liturgy; Portugal: *Population: Racial Composition;* Spain: *Moorish Spain to 1031.*

**MOZARABIC CHANT,** the music and text of the Mozarabic or Hispanic liturgy, also known as the Visigothic liturgy, forming the eucharistic rite of Spanish Christians before the 11th century. The term Mozarabic derives from *musta'rib,* the Arabic name for the Christians who lived in Aragon, Castile, León and

other parts of Spain under the Moorish rule (711–1085). The music of the Mozarabic church dates, however, from before the Moorish invasion. A Mozarabic *Pater noster*, the oldest liturgical Latin hymn with a refrain, is believed to date from the 4th century, and the form of the Mozarabic liturgy had been defined between the 5th and the 7th centuries by the bishops of Seville, Toledo and Saragossa. Though most of the music of the Mozarabic church is preserved, the notation, even when the manuscripts were copied by a later hand, is in neumes of a type, with Eastern and Byzantine elements, that remain indecipherable. The Mozarabic *Pater noster* mentioned above is known from a copy in a Visigothic hymnal of the 9th or 10th century in diastematic notation; *i.e.*, the neumes are arranged around an imaginary horizontal line. In Aragon, Castile and León the Mozarabic chant survived until the second half of the 11th century, when the *Lex romana* was introduced in an attempt to unify the chant and liturgy of the European churches. The Mozarabic chant was, however, allowed to be retained in some monasteries and in the six old parishes of Toledo. Unfortunately, though the diastematic notation was at this time spreading rapidly, the musicians of Toledo did not transcribe their chant into the new notation, with the result that when the tradition was broken the bulk of the music of the Mozarabic liturgy became indecipherable. In the 16th century an attempt was made by Francisco Cardinal Jiménez de Cisneros to revive the Mozarabic liturgy at Toledo, but even then the key to the ancient melodies had been lost. The Mozarabic rite continues to be celebrated at Toledo, but apart from recitative sections of the sung Mass, preserved by oral tradition, only the literary text of the rite is authentic. *See* also LITURGY: *Latin Eucharistic Rites: Other Latin Eucharistic Rites.*

*See* H. Anglès, "Latin Chant Before St. Gregory" in *New Oxford History of Music*, vol. ii, ed. by Dom A. Hughes (1954); Dom Louis Brou, "L'Antiphonaire wisigothique et l'antiphonaire grégorien au début de VIII[e] siecle" in *Report of the International Congress for Sacred Music* (1950).

**MOZART, WOLFGANG AMADEUS** (1756–1791), Austrian composer who, together with Joseph Haydn, represents the climax of the late 18th-century Viennese classical style by virtue of his extraordinarily broad achievements in opera, chamber music, symphonies and piano concertos.

**Childhood and Early Travels.**—Born at Salzburg on Jan. 27, 1756, he was baptized Joannes Chrysostomus Wolfgangus Theophilus (*i.e.*, Amadeus) and was known as Wolfgang Amadeus Mozart. He was the youngest of seven children, five of whom died in infancy. His father, the composer and teacher Leopold Mozart (1719–87), was employed as a violinist in the establishment of the prince-archbishop of Salzburg; his mother, Anna Maria Pertl (1720–78), was of local origins. Their only other surviving child was Maria Anna (Nannerl) (1751–1829).

At the age of four Mozart was trying to compose, and early in 1762 his ability as a harpsichordist was so extraordinary that his father took him and his sister (scarcely less talented) to perform at the Munich court. Later in the same year they played before the Austrian emperor and empress at Vienna. Rather than allow his son's gifts to develop quietly in Salzburg, Leopold Mozart decided in 1763 to embark with Mozart and his sister on an extensive tour of western Europe, a decision with far-reaching effects on his son's personal and musical development. In June 1763 the family set out, first visiting various southern and western German cities. In October they arrived in Brussels, moving on to Paris in November. There the children appeared at Versailles, and Wolfgang, now beginning to compose in earnest, had published some sonatas for keyboard and violin (K. 6–9 in Köchel's catalogue of 626 items). These works show the influence of Johann Schobert and other German composers living in Paris.

Arriving in London in April 1764, Mozart encountered a further and much more important influence. London's leading musical figure was Johann Christian Bach (1735–82), J. S. Bach's youngest son. Enchanted by the unique combination in Bach's music of German technical solidity and Italianate sparkle and grace, Mozart copied its style in some sonatas (K. 10–15) and more particularly in two symphonies (K. 16 and 19). In style, form and orchestration the second of these (known as no. 4 in D) is very close to J. C. Bach, who represents the most important single formative influence in Mozart's development. The Mozart family stayed in London over 15 months, the children appearing at court and in public. In 1765 they spent some time in The Hague, Amsterdam and Paris, returning to Salzburg in Nov. 1766.

Mozart's compositions in the following months included a Latin intermezzo for performance at Salzburg university and part of an oratorio; he also arranged four piano concertos from sonata movements by Schobert and others. In Sept. 1767 Leopold took his children to Vienna again, where they remained (with a short break) for over a year. Mozart wrote an *opera buffa*, *La finta semplice*, but it remained unperformed. A short German comic opera, *Bastien and Bastienne*, was given privately. Mozart must have heard much up-to-date Viennese music during these months and signs of it are particularly apparent in the symphonies he wrote in the city, among which no. 8 in D (K. 48) is outstanding.

**Visits to Italy.**—After less than a year at home, Leopold obtained leave of absence to take his son to Italy, the home of opera. They left at the end of 1769, stopping to perform in Verona and Mantua on the way to Milan. Their Italian tour was extensive, embracing Bologna, Florence, Rome (where the pope invested the son with the Order of the Golden Spur) and Naples. Commissioned to write an opera for production in Milan in Dec. 1770, he composed *Mitridate*, which was highly successful. In March 1771 father and son traveled back to Salzburg.

A further visit to Milan took place in the autumn of 1771 for the performance there of his serenade (*q.v.*) *Ascanio in Alba* at royal wedding celebrations. After their return to Salzburg in December, the archbishop died and was succeeded by Count Hieronymus Colloredo, a less benevolent employer. Mozart wrote a serenade, *Il sogno di Scipione*, for Colloredo's installation the next year. In 1772 he also composed several symphonies, no. 15–21, which show a reversion to the more solid Austrian style after the markedly Italianate symphonies (such as K. 81, 95 and 97) he had written in Italy. In the autumn of 1772 Mozart went to Italy for the last time, again for the production of an opera, *Lucio Silla*, at Milan. In Milan he also wrote a set of six string quartets, K. 155–160, and a solo motet, *Exsultate, jubilate.*

**Contact With Viennese Music.**—Leopold was anxious to see his son launched on a prosperous career and already had made inquiries about openings. The small Salzburg court, with its ungenerous and unmusical head, seemed unpromising, although by now young Mozart held an official post there. In the summer of 1773 father and son spent ten weeks in Vienna, where Leopold hoped a post might be obtained. They had no success. But during these weeks Mozart underwent a crucial musical experience. His renewed contact with Viennese music, and in particular with the quartets and symphonies of Haydn, had a considerable effect on his development. Haydn's quartets, op. 9, 17 and 20, impelled Mozart to write a further set of quartets himself, and the direct influence of Haydn's works is easily discernible in Mozart's quartets, K. 168–173. The symphonies he wrote on his return home likewise show a growing intensity of style and individuality of expression, notably the highly wrought no. 29 in A (K. 201) and no. 25 in G minor (K. 183), an impassioned work owing something to symphonies in the same key by Haydn and J. C. Bach.

Many further compositions followed in late 1773 and 1774, among them his first set of piano sonatas (K. 279–284), a bassoon concerto (K. 191), his first piano concerto (K. 175), serenades (in a characteristically warm and gay Austrian style) and Masses and other sacred works for use at Salzburg. At the end of 1774 Mozart went to Munich for the production of a newly commissioned *opera buffa*, *La finta giardiniera.* The elector of Bavaria also commissioned some sacred music.

Mozart worked steadily in Salzburg for two and a half years, from March 1775. The main products of this period were an opera, *Il Rè pastore*, a considerable quantity of sacred music, several serenades and divertimentos and some important concertos. These last include all his violin concertos (notable are those in G, D and A, K. 216, 218 and 219), a three-piano concerto (K. 242) and three piano concertos (K. 238, 246 and 271). The violin concertos show a combination of an almost French elegance and

Austrian good humour. Apart from K. 271, the piano concertos, written for Salzburg amateurs, are little more than polished examples of the *galant* manner. K. 271 is on a far larger scale. The early entry of the soloist, though of no structural importance, demonstrates the greater freedom Mozart was finding as he developed more control over his material. The sombre C minor slow movement is markedly different from anything he had written before, as is the finale, in a fast-moving *moto perpetuo* style.

**Journey to Mannheim and Paris.**—By the middle of 1777, Mozart and his father decided that he must leave Salzburg and seek his fortune elsewhere. Leopold could not obtain paid leave of absence, so the 21-year-old Mozart was accompanied by his mother. They left in Sept. 1777, going first to Munich, where there was no post available for him, then to Mannheim. There Mozart made friends with the members of the court orchestra, including Christian Cannabich, the director. His hopes of a post there were high, but again he was disappointed. He stayed in Mannheim for the winter, where he fell in love with Aloysia Weber, a young singer. The first obvious conflicts between Mozart and his father arose at this time, when Leopold was irritated by his son's evident irresponsibility, especially over money matters. He reproached him for his foolishness and ordered him on to Paris, where, Leopold thought, he should be able to find a worthy appointment.

Mozart and his mother accordingly went to Paris in March 1778. The visit was ill-timed. Musical Paris was disputing the rival merits of the operas of C. W. Gluck and Niccolò Piccini, and Mozart found it hard even to obtain a hearing. Helped by F. M. Grimm, he undertook some teaching and had some works performed at the Concert Spirituel, notably the "Paris" Symphony, no. 31 in D (K. 297), written in the brilliant orchestral style favoured by the French. He was offered a post as organist at Versailles, which he declined, probably because of his inherent dislike of Paris and of French music.

During the summer, the journey to Paris turned from a failure to a tragedy. Mozart's mother was taken ill during June, and on July 3, 1778, she died. In the following weeks Mozart stayed with Grimm, but it became clear that prospects in Paris were poor. Meanwhile circumstances at Salzburg had changed and Leopold managed to obtain the promise of a better post there for his son. Mozart accepted it unwillingly. On the homeward journey he stopped at Strasbourg, Mannheim and Munich, where he was coolly received by Aloysia Weber. (The court and the Webers were now located in Munich.) He returned finally to Salzburg in Jan. 1779, heavy in heart.

**Compositions, 1778–80.**—In Mannheim and Paris, Mozart had written some relatively simple music designed for publication: the piano and violin sonatas (K. 296 and 301–306), of which K. 304, in E minor, is notable for its warmth and expressive sensibility, and some piano sonatas (including K. 309–311 and 330–333), of which K. 309 strongly reflects the Mannheim style while K. 330–333 (at Leopold's suggestion) were written in the easy, flowing manner of J. C. Bach, whom Mozart had met again in Paris. In Mannheim he also wrote some flute music (three slight quartets and two concertos, K. 313–314, of which the second was originally for oboe) and some arias for Aloysia Weber and other singers. His compositions in Paris include the elegant Flute and Harp Concerto in C (K. 299), a sinfonia concertante for wind instruments, a ballet and the "Paris" Symphony.

The effects of Mozart's contact with the Mannheim style can be perceived in the orchestral writing of some of the works composed on his return: the "Posthorn" Serenade (K. 320), the Symphony no. 32 and the forceful and brilliant Symphony no. 34 (K. 338). Symphony no. 33 (K. 319), however, is closer to the Viennese chamber music manner, though its form shows some Mannheim influence. Another work strongly influenced by the Mannheim school is the Sinfonia Concertante in E flat for violin and viola (K. 364). The sinfonia concertante was a favourite form of the Mannheim composers and Mozart's use here of the orchestral crescendo and other such devices is highly characteristic of their style. This is one of his best works of the period, with its expansive first movement and its deeply felt andantino in C minor. Other works of the time include the two-piano concerto K. 365, two Masses and two sets of vespers; the first of the Masses, the "Coronation" (K. 317), is an excellent example of the rococo, often frankly operatic style of Mozart's Salzburg church music.

In 1780 Mozart was commissioned to write an opera for production at Munich early in 1781. The librettist was the Salzburg cleric G. B. Varesco and the subject chosen was *Idomeneo*. The opera, which was a great success, is long and, despite great richness and variety in the music, is not entirely successful dramatically because of the rather stiff libretto, planned along old-fashioned lines. Musically, it owes a certain amount to Gluck and possibly more to Piccini. It is the earliest of Mozart's operas that hold the stage in modern times.

**Vienna.**—While in Munich, Mozart was summoned to Vienna by the archbishop of Salzburg to join his entourage there. After his Munich success, Mozart felt humiliated at being treated as a mere servant in Colloredo's establishment, particularly when he was prevented from developing his contacts and earning extra money in Vienna. His and the archbishop's feelings rose to a climax over a trivial matter, and Mozart angrily resigned his post. A stormy interview with a court attendant, Count Arco, ended with Mozart being literally kicked out. Possibly the archbishop was not so much to blame as posterity has assumed. Undoubtedly Mozart was a proud, even arrogant young man who probably did little to ensure the smooth running of the Salzburg musical establishment. His unfortunate inability to get on with people, due to a curious mixture of ingenuousness, suspicion and almost aggressive self-confidence, seems to have handicapped him in his professional relations throughout his life.

In Vienna, Mozart, who had resolved to make his living by teaching and performing, lodged with the Weber family, who again had moved. Aloysia was married now, but soon gossip linked Mozart's name with that of Aloysia's next younger sister, Constanze (1763–1842), the third of the four Weber daughters. He denied any interest in her during the summer of 1781, yet by December he was asking his father's permission to marry her. Mozart was partly inveigled into marriage by Constanze's guardian and her mother; but he soon convinced himself that it would be a good thing for him. They were married eventually on Aug. 4, 1782.

Mozart and his wife settled down to an easy-going, mainly happy marriage. His position in Vienna advanced steadily in the next two years; he appeared occasionally at court, his concert appearances were frequent, popular and successful, and the number of his pupils increased. Yet, apparently because of extravagance, his financial position never became secure, and he constantly had to borrow from friends.

**Compositions, 1781–83.**—In 1781 and 1782 Mozart worked on the composition of a new German comic opera, *Die Entführung aus dem Serail* (*The Seraglio*). After various delays, it was successfully produced in July 1782. The plot is simple and conventional, and the characters are more lifelike than the stiff, mythological protagonists of *Idomeneo*. The pert serving-maid Blonde and the lecherous and bloodthirsty overseer Osmin are particularly well characterized musically. Belmonte, too, is charmingly portrayed as a conventional operatic lover; Constanze, the heroine, has some splendid and dramatic music to sing, but certain of her arias are long, elaborate and out of proportion to the framework of the whole—a sacrifice Mozart made for the sake of the original singer.

Among Mozart's other compositions of 1781–82 are several serenades, including the work that survives as the "Haffner" Symphony, no. 35 in D (K. 385). This was originally designed as a serenade for a wedding in the Haffner family of Salzburg, and the symphonic version omits one or more movements from the original. It is notable for an imperious opening allegro constructed around a single thematic idea. He also wrote three serenades for wind ensemble: K. 361, a seven-movement work with some felicitous handling of the 13 instruments; K. 375, somewhat martial in mood; and K. 388, a more serious work whose impassioned style goes beyond the customary limitations of the serenade. About this time Mozart took part in concerts at the home of Baron Gottfried van Swieten, an enthusiast for the music of Handel, J. S. Bach and C. P. E. Bach. As usual, new musical contacts influenced Mozart's work, and about this time he wrote a fine two-piano

Fugue in C minor (K. 426), several keyboard works in an improvisatory style indebted to C. P. E. Bach, and a number of fugues, mostly unfinished.

Late in 1782 Mozart embarked on a series of string quartets to be dedicated to Haydn, whom he had met a short time previously. Early the next year he wrote a set of three piano concertos, K. 413–415, designed for publication and consequently in a fairly straightforward style somewhat indebted to J. C. Bach. The graceful K. 414 in A, with its nicely held balance between virtuosity and musical substance, is the most attractive of the three. The first two horn concertos and a horn quintet also date from this period. Another work from the time of his marriage is the incomplete Mass in C minor (K. 427), perhaps Mozart's supreme sacred work. Written in fulfillment (or partial fulfillment) of a vow made before his marriage, the solo soprano part was intended for Constanze. There may seem to be some incongruity in the juxtaposition of very florid solos and severe choral writing; but there is much noble music in the opening fugal Kyrie and the powerfully affirmative eight-part choruses, while the "Et incarnatus" is undeniably expressive. Mozart and his wife visited his father in Salzburg during the summer of 1783. On the return journey they stopped at Linz, where Mozart wrote the Symphony no. 36 in C (K. 425, known as the "Linz") in a ceremonious style but closer to Haydn than most of his mature works.

**The Great Piano Concertos and String Quartets.**—The year 1784 was one of Mozart's happiest. Though busy with pupils and concerts, he composed a uniquely great succession of piano concertos. The first, K. 449 in E flat, is the most intimate in mood, with an andantino of great charm and a gay finale in which simple but ingenious-sounding use is made of counterpoint. He composed K. 450 in B flat and K. 451 in D to play at his concerts. Except as a display piece, K. 451 is of less interest than K. 450, which marks the beginning of Mozart's characteristic use of woodwind in his concertos. The next two, K. 453 in G and K. 456 in B flat, are less virtuoso in style; K. 453 is notable for its warm, lyrical grace, while K. 456 has much elaborate woodwind writing and a variation slow movement of great sweetness and charm. The last concerto of 1784, K. 459 in F, is sturdy and military in mood, with a brilliant finale.

In 1785 Mozart added three more to this imposing set: K. 466 in D minor, the first of his two minor-key concertos, a sombre work with romantic and even tragic overtones (it was Beethoven's favourite among Mozart's concertos); the pompous K. 467 in C, with a highly organized first movement and a moving andante remarkable for its chromatic harmony and translucent scoring; and K. 482 in E flat, a less tautly organized work but with a happy, serenadelike use of woodwind (including clarinets).

Among the other compositions of 1783–85 are the third Horn Concerto (K. 447); a quintet for piano and wind instruments (K. 452, an awkward combination, handled with much insight); a violin sonata (K. 454); several songs; and a fantasia in C minor for piano (K. 475), which Mozart published with a sonata (K. 457) in the same key (a fine work of an intensity rare in this form).

The most important works, however, are the six string quartets dedicated to Haydn, K. 387, 421, 428, 458, 464 and 465. Of these the first is remarkable for its finale, combining fugal processes with those of sonata form. The second, in D minor, is unusually passionate and darkly coloured, especially in its first movement and minuet. K. 428 is more gentle and contemplative, with a highly chromatic slow movement. Possibly the least remarkable of the set is "The Hunt" (K. 458). K. 464 in A has a finale of particularly terse construction and a variation slow movement of much beauty; the series is aptly crowned by the "Dissonance" Quartet with its mysteriously discordant slow introduction. The elaborate textures and the sense of unified musical design in all six quartets can be partly attributed to the influence of Haydn's op. 33 quartets, published in 1781. Haydn himself was deeply impressed (and in turn influenced) by Mozart's quartets. He told Leopold, visiting his son in Vienna in 1785, "Before God and as an honest man, I tell you that your son is the greatest composer known to me either in person or by name. He has taste and, what is more, the most profound knowledge of composition."

**Da Ponte and the Marriage of Figaro.**—But opera still stood at the centre of Mozart's ambitions. In 1783 he had made two or three attempts to start on new operas but found the librettos unsatisfactory. Early in 1786 he composed a one-act comic opera, *Der Schauspieldirektor* (*The Impresario*), for performance at Schönbrunn. Late the previous year he had met Lorenzo da Ponte, a priest, adventurer and poet of Venetian Jewish origins, with whom he decided to collaborate on an Italian *opera buffa* based on Beaumarchais' political satire *Le Mariage de Figaro*. *Le Nozze di Figaro* was eventually produced at Vienna on May 1, 1786. Da Ponte had adapted the plot and written the text with highly professional skill. The musical characterizations of the lustful count, of the sad, deserted countess, of their lively servants, Figaro and Susanna, and of the page Cherubino are carried out with the highest degree of sensitivity and human understanding. An outstanding feature of the opera is its ensembles, in which Mozart maintains dramatic tension by an unerring sense of pace and situation. It is through its combination of dramatic vitality, depth of characterization and musical richness that *Figaro* stands at the head of the Italian *opera buffa* tradition, surpassing in these respects the works of such of Mozart's contemporaries as G. Paisiello and D. Cimarosa.

During and just after his work on *Figaro*, Mozart, although depressed by financial worries, produced several instrumental masterpieces. They include two piano quartets (K. 478 and 493), three piano trios (K. 496, 498 and 502, the second a ruminative work for clarinet, viola and piano, the third showing his characteristic admixture of gaiety and pathos), as well as a horn concerto (K. 495), a string quartet (K. 499), some piano music and three more piano concertos—the popular and gently poetic A major (K. 488), the C minor (K. 491), a richly scored and deeply felt work, perhaps his greatest achievement in the form, and the imperiously grand K. 503 in C. He followed these with Symphony no. 38 in D (K. 504), the first of unquestionable greatness and individuality.

**Visits to Prague: *Don Giovanni*.**—Symphony no. 38 is known as the "Prague" since Mozart took it to that city at the beginning of 1787. *Figaro* was immensely popular in the Bohemian capital, and Mozart received a commission to write a new opera for production there. He and Da Ponte chose the popular Don Juan story, and he worked on the music during 1787, producing at the same time several songs, his greatest violin sonata (K. 526), the serenade *Eine kleine Nachtmusik* (K. 525) and two outstanding chamber works, the String Quintets in C and G minor (K. 515–516). The noble and expressive Quintet in C is on the surface a happy work, though there is a wealth of deeper feeling in the moving dialogue between violin and viola in the andante, in the elaborate minuet and in the fleeting chromaticisms of the finale. The G minor quintet is more overtly a work of profound melancholy, as its poignant adagio proclaims. About the time of the composition of these quintets, Mozart's father died in Salzburg. Mozart was consoled by Freemasonry, which he had embraced in 1784.

In the autumn of 1787 Mozart and his wife went to Prague for the production of *Don Giovanni* on Oct. 29. A less perfectly constructed work than *Figaro*—the ineffective character of Don Ottavio and the temporizing episode at the beginning of act ii are particular faults—it nevertheless probes deep into the vagaries of human character. Distinctive music characterizes the peasant girl Zerlina, the pathetic, rejected noblewoman Donna Elvira and the haughty Donna Anna. Again the ensembles provide some of the greatest moments: the act i finale in which tension is built up during a ballroom scene as Don Giovanni is sought out by masked avengers; and the great concluding supper scene, where the defiant Giovanni invites his stone guest to eat with him and, unrelenting, is inexorably dragged to the flames below. But despite this climax *Don Giovanni* is an *opera buffa* rather than an *opera seria*.

Returning to Vienna at the end of 1787, Mozart was appointed chamber musician to the court in place of Gluck. His duties included providing dances for balls. The additional salary seems to have been of little help. His position as a leading figure in Viennese musical life was declining, and the next year his pitiful begging letters to Michael Puchberg, a brother Freemason, began.

**The Last Three Symphonies.**—The only major work com-

posed in the early part of 1788 was the Piano Concerto in D ("Coronation") (K. 537), a brilliant but relatively superficial work. But in the summer Mozart enjoyed one of his supremely inspired spells of composition. First came the Piano Trio in E (K. 542), one of the most personal and consistently beautiful of all his chamber works, outshining his two remaining piano trios, K. 548 and 564, which followed later in the year. The greatest products of 1788, however, are his last symphonies. No. 39 in E flat (K. 543) was completed on June 26, no. 40 in G minor (K. 550) on July 25 and the "Jupiter," no. 41 in C (K. 551), on Aug. 10. Of these, the most lyrical in mood, with the warmth of feeling Mozart generally associated with the key of E flat, is no. 39. G minor, too, is a key with special associations for Mozart, and no. 40 is another deeply personal work with an uncommon degree of nervous energy. The "Jupiter" draws together all the threads of Mozart's symphonic thought. At this period Mozart was intensifying his language by the use of counterpoint and the finale of this symphony employs fugal procedures within the framework of the sonata form, culminating in a powerful combination of the movement's five main thematic ideas.

**Mozart's Last Travels:** *Così fan tutte.*—The remainder of 1788 was uneventful. Mozart wrote his only string trio, K. 563, late in the summer. In the autumn, for performance at Baron van Swieten's home, he arranged works by Handel, introducing additional instruments. Early in 1789 he went to Berlin, giving concerts en route at Dresden and Leipzig. At Berlin he performed at court and was commissioned by Frederick William II to write six string quartets and six piano sonatas.

Back in Vienna, Mozart again found himself in financial straits. He made little progress with the Prussian commission, completing only one piano sonata, a masterly work in D (K. 576), and three of the quartets. In the quartets, however, he was musically handicapped by an obligation to provide a cello part of special interest to satisfy the king, himself an enthusiastic player, and although these three works (K. 575, 589 and 590) are on a high level, they have not quite the expressive range of the quartets dedicated to Haydn. Mozart's finest chamber work of this year is the Clarinet Quintet in A (K. 581) written for his friend Anton Stadler.

The main task of late 1789 was the composition of a new opera, *Così fan tutte.* The libretto, again the work of Da Ponte, is supremely well constructed even though its subject has been criticized as trivial and amoral. In its artificial way the opera is an unfailing delight, with great charm and sensuous beauty. Though it contains an element of burlesque only partly comprehensible in modern times, nevertheless it can give exquisite pleasure when taken at face value. Mozart's gift of characterization is seen in the distinction in strength of character and moral fibre between the two sisters, Fiordiligi and Dorabella.

The Austrian emperor died early in 1790, and Mozart vainly petitioned his successor, Leopold II, for a better post. In the autumn of 1790 he gave a concert at Frankfurt am Main during the coronation celebrations. His visit was a failure financially and he soon traveled home through Mainz, Mannheim and Munich. In the following months he composed works for mechanical organ (including the F minor Fantasia [K. 608], contrapuntally one of his most elaborate compositions), his last piano concerto and his last two chamber works. Some of these late works, the String Quintets in D and E flat (K. 593 and 614) and especially the Piano Concerto in B flat (K. 595), have a quality of cool restraint perhaps attributable to the peace of mind he had gained from his Masonic beliefs. Other works of this period include the brief but moving funeral motet, *Ave verum corpus* (K. 618), three compositions for glass harmonica, many dances, songs and a cantata.

**The Magic Flute.**—During the spring of 1791, Mozart started work on a German opera, *Die Zauberflöte* (*The Magic Flute*), to a text by Emanuel Schikaneder, a shrewd man of the theatre with whom he had been acquainted for some years. In July he undertook a commission for a Requiem and soon after he received a commission from Prague for an opera. This last had to be executed quickly and the work, *La Clemenza di Tito,* an *opera seria* to an old text (by P. Metastasio, partly modernized by C. Mazzolà), was written in less than three weeks. Mozart and his wife went to Prague for its first performance, on Sept. 6, 1791, which was not very successful. The libretto, with no real sense of drama or character, made it impossible for Mozart to give of his best. At the end of September Mozart completed his last instrumental work, the serenely beautiful Clarinet Concerto (K. 622).

Profoundly influenced by Freemasonry, *The Magic Flute* (first performed at Vienna on Sept. 30, 1791), with its blend of broad comedy and high seriousness, is an enigmatic work. Mozart wholeheartedly embraced Masonic teachings, being much attracted by the liberal ideas in Viennese Freemasonry of this period. The ritual represented in the opera is closely related to Masonic ritual, and there is much symbolism in both the libretto and score. At first the work had been planned as a kind of pantomime, modeled on a fairy-tale opera by Paul Wranitzky, but as it took shape its allegorical significance developed and deepened. Tamino and Pamina represent ideals rather than ordinary people, while Sarastro represents the forces of light and the Queen of Night those of darkness. Papageno's main function is to provide the comic element. *The Magic Flute* cannot offer the kind of brilliant, sophisticated entertainment of the Da Ponte operas, but it does offer a spiritual enrichment beyond their scope.

To Mozart *The Magic Flute* was possibly more of a personal religious document than was the *Requiem.* He was never near to disavowing Catholicism, although the church was opposed to Freemasonry, yet he was not prepared to accept its teachings without reservation. His *Requiem* lacks the sense of conviction of his earlier church music. While writing it, Mozart was in an overwrought state of mind, due to bad health and also to fears that he was writing a Requiem for himself. (A mysterious stranger—actually the emissary of a Count Walsegg, who wished to pass the work off as his own—had brought the commission.) The work was left unfinished at Mozart's death and was completed, from the Sanctus onward, by his pupil F. Süssmayr. The finest sections of Mozart's own contribution are the sombre opening, the fugal Kyrie and the powerful choruses of the Sequence section.

**Final Illness and Death.**—During 1784, Mozart had had an attack of rheumatic fever. He was ill in the summer of 1791, and in October his health began to fail seriously. During November, some of his strength returned and he even appeared once in public. At 1 A.M. on Dec. 5, 1791, he died, the cause of his death being uncertain. He was buried in a pauper's grave at St. Mark's church, Vienna, with several of his friends and relatives in attendance.

**Mozart's Achievements.**—Though he lacked the worldly intelligence needed to manage his life successfully, Mozart's greatness as a composer is unchallengeable. His instinctive grasp of musical design on a large scale ensured that virtually every piece of music he wrote was satisfying in shape; his melodic gifts, his harmonic imagination and his sense of instrumental colour likewise are outstanding features of his language. His melodic fecundity and sense of form made it unnecessary for him to explore as purposefully as did Haydn the possibilities of symphonic thematic development—a fact that led to his having less influence than did Haydn on Beethoven and the next generation of German composers. Although Mozart contributed, despite his short life span, to every contemporary form of composition, his most individual achievements lie in chamber music, in the piano concerto and above all in opera. He was no experimenter; his personal musical language was compounded from a variety of sources. By using this language he achieved a universality almost unapproached in western music. *See* also references under "Mozart, Wolfgang Amadeus" in the Index.

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*Piano Concertos* (1950); H. C. Robbins Landon and D. Mitchell (eds.), *The Mozart Companion* (1956); G. de Saint-Foix, *Mozart's Symphonies*, Eng. trans. (1957). (S. J. Sa.)

**MSAKEN,** a commune in Sousse governorate, Tunisia, is located on the Sahel (coastal strip) where the Sousse road forks to Sfax and Kairouan, 7 mi. S.S.W. of Sousse town. Pop. (1956) 26,142 (mun.). Its buildings, typical of the area, are constructed mostly of beaten earth (*tabia*). Olive growing and processing is the main occupation, with some small-scale wool weaving and market trade. Msaken is a *délégation* (second-class administrative centre) for the localities of Beni-Kaltoum, Bourdjine, Bou-Rebia and Moureddine. (J.-J. Ds.)

**MTSKHETA,** a town of the Georgian Soviet Socialist Republic of the U.S.S.R., lies on the Georgian military highway and the Transcaucasian railroad at the confluence of the Kura and Aragvi rivers, about 10 mi. N.W. of Tbilisi. Pop. (1959) 7,219. It is a small town of local importance, engaged in brickmaking, sawmilling and match manufacture. Mtskheta, however, is one of the oldest settlements of Transcaucasia (Zakavkaz'ye) and in pre-Revolutionary days it was asserted to have been founded by Mtskhetos, son of Kartlos, who lived in the fifth generation after Noah. It was the capital of Georgia (Iberia) from the 2nd to the 5th centuries and also the main ecclesiastical centre of the country. Still surviving are some fine examples of Georgian architecture, including the cathedral of Sveti-Tskhoveli (founded in the 4th century and reconstructed in the 15th and 18th centuries), the church of Dzhvari and the Samtavro convent. The cathedral was the burial place of the kings of Georgia. These architectural features, together with the picturesque site in the deep, wooded valleys, attract many tourists to the town. On a nearby hilltop are the ruins of the castle of Armaz-Tsikhe, the oldest in Georgia and seat of the Georgian kings before Mtskheta. (R. A. F.)

**MTWARA REGION, TANGANYIKA,** established in May 1963 following a reorganization of administrative units in Tanganyika, comprises Mtwara, Kilwa, Lindi, Masasi, Nachingwea and Newala districts, which previously belonged to the former Southern region. It is bounded north by Coast region, east by the Indian ocean, south by Mozambique (Portuguese East Africa), southwest by Ruvuma region and west by Morogoro region. Area 32,050 sq.mi. Pop. (1957) 747,232. The hilly topography is almost entirely below 3,000 ft. Major rivers are the Ruvuma, flowing in a deep gorge along the region's southern boundary and navigable for short distances, the Rufiji, forming with the Mbarangandu part of the western boundary, and the Matandu, Mbemkuru and Lukuledi. Metamorphic rocks of the Basement system are evident, with fossiliferous sediments of Karroo age to the west and a belt of Jurassic, Cretaceous and Tertiary sediments along the coast. Fossil dinosaurs (Jurassic) are found at Tendaguru. Mean annual rainfall is everywhere more than 30 in., though amounts are unreliable; rainfall takes place during December–April. Soils vary from red clays to black loams. A lateritic horizon is common. Brachystegia woodland (*miombo*) and savanna with baobab trees predominate inland, bush with coconuts and casuarinas at the coast and mangrove swamp south of the Rufiji delta.

Regional headquarters are at Mtwara. Small ports are Lindi and Kilwa Masoko, and inland centres include Nachingwea, Newala and Masasi. The population is most dense near the coast and in the south. Because of a complex history the distribution of African tribes is very mixed; the Ngoni of Zulu ancestry are notable. Cash crops are sesame, cotton, castor, cashew nuts, copra and sisal, with wild rubber, beeswax, roll tobacco and gums inland. In the 1960s plans were made for improving the industriously cultivated Makonde plateau (Newala district) by supplying water from the Ruvuma. Salt is produced in Lindi and Mtwara districts, but there is little mineral development. (J. M. Ke.)

**MU'ALLAQAT.** *Al-Mu'allaqat* is the name given to a collection of seven pre-Islamic Arabic poems, each considered the finest piece of its author. Since the authors themselves are among the dozen or so most famous poets of the 6th century, the collection enjoys a unique position in Arabic literature, representing the finest flower of the earliest Arabic poetic production.

The idea of grouping together these particular poems is commonly attributed to the 8th-century collector of early poetry, Hammad al-Rawiyah (*q.v.*). The critic Nahhas (d. 949) says that, "When Hammad al-Rawiyah saw how little men cared for poetry, he collected these seven pieces, urged people to study them, and said to them, 'These are the renowned poems (*al-mashhurat*)'." No evidence has been produced to controvert this statement, and it is generally accepted as factual. Indeed, Theodor Nöldeke suggests a further argument in favour of Hammad's responsibility for the collection; namely, that this would explain the inclusion of the poem by al-Harith ibn Hillizah, who is less famous than the other poets represented. The motive for this would have been to please Hammad's patrons, the Arab tribe of Bakr ibn Wa'il, to whose glory al-Harith's poem is dedicated, and this would, according to Nöldeke, have served as a counterpoise to the inclusion of the poem of 'Amr ibn Kulthum in praise of the Taghlib tribe, traditional rivals of the Bakr ibn Wa'il tribe.

**Derivation of the Title.**—Considerable obscurity surrounds the origin and implication of the name *Mu'allaqat*. According to a frequently repeated legend, which first makes its appearance in the *'Iqd* of Ibn 'Abd Rabbihi (d. 941), these poems were pieces selected for their excellence, written down in golden letters on scrolls of Egyptian linen, and hung on the walls of the Kaaba (shrine) in Mecca. This, however, can be dismissed as only a fable invented to explain the name on the basis of the everyday meaning of the word *mu'allaq* ("suspended").

Nahhas, Ibn 'Abd Rabbihi's contemporary, alludes to the legend of their being hung in the Kaaba only to reject it as a fabrication devoid of all ancient authority. And in fact, no mention of such a practice is made by any of the 8th- and 9th-century scholars who concerned themselves with the antiquities and early history of Mecca. The designation "the gilded poems" also mentioned by Ibn 'Abd Rabbihi must be taken in a purely metaphorical sense, of something splendid.

Another legend is also told by Nahhas, to the effect that the pre-Islamic kings of Arabia used to say, when they heard a specially fine poem, "Copy it down (*'alliquha*) and deposit it in my library." This too is certainly false. It is hardly possible that any pre-Islamic king can have possessed a library, and the verb *'allaq* in the sense of "copy, transcribe" is unlikely to have been in use before the age of intensive book production, which only began in the Islamic lands with the introduction of paper from the far east in the middle of the 8th century.

Several distinguished authorities (R. A. Nicholson, Nöldeke, C. J. Lyall) have held the view that Mu'allaqat in this context is a derivative of the noun *'ilq*, "a precious thing," so that its meaning would be "the poems which are esteemed precious." Another theory has been propounded in an article by J. Robson (*Journal of the Royal Asiatic Society* [1936], pp. 83–86). He suggests that the word is an allusion to Koran iv, 128, where the word *al-mu'allaqah* is employed in connection with a wife who is neglected or deserted by her husband, without being actually divorced or widowed. Robson suggests that the point of the allusion is "to indicate that the poems are still attributed to their authors, but are not given their rightful position, which would be in the authors' collected works." If we could be sure that Hammad himself used the name *Mu'allaqat*, there would be an even more cogent point in the allusion than the one mentioned by Robson, for it would fit in neatly with Hammad's remark cited above about the undeserved neglect into which the best ancient poems had fallen.

It is, however, by no means certain that Hammad himself did use the name. If he did, it is odd that none of the scholars of the generation immediately following him mention it. They normally speak simply of "the seven poems," and the first occurrence of the name *Mu'allaqat* is in the *Jamharat ash'ar al-'Arab*, a compilation dating probably from *c.* 900. It is an anthology of 49 poems, divided into seven groups of seven, and to each group a fanciful name is attached: *al-Mu'allaqat* (the first group) *al-Mujamharat* ("the amassed"), *al-Muntaqayat* ("the choice ones"), etc. And if the view that the real meaning of *al-Mu'allaqat* is "the poems esteemed precious," is correct, it is not impossible that the name was first coined by the compiler of the *Jamharah* in order to fit in with the plan of his work.

At all events, it was known in the early 10th century, since it is used by Ibn 'Abd Rabbihi. On the other hand, Nahhas (in the passage to which reference has been made above) does not employ the name *Mu'allaqat;* he speaks of the poems only as "the seven renowned ones," *al-sab' al-mashhurat,* in conformity with Hammad's reported remark. It could possibly be deduced from this that the name *Mu'allaqat* was at that time of recent origin and had not yet gained general currency.

**Poems Included.**—A further puzzle is connected with the precise poems included in the group. The list usually accepted as standard is the one recorded by Ibn 'Abd Rabbihi, namely: poems by Imru' al-Qays (*q.v.*), Tarafah (*q.v.*), Zuhayr (*q.v.*), Labid, Antarah (*q.v.*), 'Amr ibn Kulthum (*q.v.*) and al-Harith ibn Hillizah (*q.v.*). Yet the distinguished critic Ibn Qutaybah (*q.v.*) cites a poem by 'Abid ibn al-Abras with the remark that it is "one of the seven." And the *Jamharah* cites Abu 'Ubaydah (d. 825) as saying that the greatest poets of the ancient period are Imru' al-Qays, Tarafah, Zuhayr, Labid, 'Amr, al-Nabighah (*q.v.*) and al-A'sha (*q.v.*) (with these last two names instead of Antarah and al-Harith of the ordinary list); and this remark is followed up by one ascribed to "al-Mufaddal," namely, "These are the authors of the seven long poems which the Arabs call *al-Sumut* ("the Pearl-Strings"), and anyone who says that the 'Seven Poems' are by anyone else than these goes against the consensus of scholarly opinion."

The reliability of the *Jamharah* has however been questioned specially by Nöldeke; and "al-Mufaddal" cited therein seems not to be the 8th-century critic but somebody less distinguished, for he is given a genealogy which suggests that he must have lived in the late 9th century. Nahhas, although he commented on nine poems, including those of al-Nabighah and al-A'sha as well as the commonly accepted *Mu'allaqat,* does so with the express warning that "according to the opinion of the best scholars the poems of al-Nabighah and al-A'sha are not among the 'Seven Renowned Ones'."

The simplest way out of this tangle is to conclude that in 8th-9th-century scholarly circles several rival lists of "seven poems" were in circulation: (1) the selection ascribed to Hammad, which at first is normally referred to as the "renowned ones" (*al-Mashhurat*), but which by the 10th century had come to be known as *al-Mu'allaqat;* (2) Abu 'Ubaydah's list, excluding Antarah and al-Harith and including al-Nabighah and al-A'sha, which went by the name of *al-Sumut;* (3) a list including 'Abid, with what others we do not know, favoured by Ibn Qutaybah.

Following the example of Nahhas, Tibrizi (d. 1109) wrote a commentary on the same nine poems as Nahhas, to which he added "by way of completeness" a commentary on the poem of 'Abid; but again with the cautionary note that the poems of al-Nabighah, al-A'sha and 'Abid were not among the recognized "seven odes." In spite of this, one or two modern editions have published the text of all ten poems under the title *The Ten Mu'allaqat,* a phrase for which there is no ancient authority.

Ibn Khaldun (d. 1406) mentions seven poets "from among the nine *Mu'allaqat* authors and others." "Nine" here may well be a scribal error, for seven and nine are very similar in Arabic script; but in any case he evidently did not intend to give a precise list of *Mu'allaqat* authors, since he includes Alqamah, who has never been reckoned as such.

**Lives of the Authors.**—Of the authors of the *Mu'allaqat,* the earliest is Imru' al-Qays, who seems to have lived in the early part of the 6th century. The others belong to the latter half of that century; and Zuhayr and Labid are said to have survived into the time of Islam, though their poetic output belongs to the pre-Islamic period. The critics and anthologists have handed down numerous anecdotes about their lives, and a summary of these accounts will be found in A. J. Arberry's *The Seven Odes* (see *Bibliography*). But all these tales contain at best only a small kernel of historical fact. The greater part is either folklore or simply the conjecture of later critics designed to explain passages in the actual poems.

**Form and Content of the Poems.**—The *Mu'allaqat* are all in the classical *qasidah* (ode) pattern. The characteristics of this verse-form (of about 60 to 100 lines) are that a single rhyme runs through the entire piece at the ends of the lines, and the same rhyme also occurs at the end of the first half of the first line; and that it begins with a short passage constituting a romantic prelude, called the *nasib,* in which the poet calls to mind the remembrance of a former ladylove. Imru' al-Qays is said to have been the first to use this device, and nearly all subsequent composers of formal odes copied him. In the *Mu'allaqah* of 'Amr, the conventional romantic passage is preceded by eight lines of a Bacchanalian nature; many critics have concluded that this is an independent wine song and not part of the original *Mu'allaqah.*

After this conventional beginning, most of the rest of the poem is occupied with descriptive passages: similes and descriptions of the poet's horse or camel, of desert animals, scenes of desert events, bedouin life and warfare, etc. It is true, each poem has according to the critics a main theme, which is either self-glorification (of the poet or his tribe), or a panegyric on someone else. Yet the amount of space devoted in the *Mu'allaqat* to these themes in some cases is small in relation to the luxuriance of the descriptive passages. In the *Mu'allaqah* of Imru' al-Qays, only three lines in the middle of the poem of about 80 lines are devoted to self-glorification; the rest, apart from the *nasib,* is description. And it is in these descriptive passages that the chief glory of the *Mu'allaqat* rests; their vivid imagery, exact observation and deep feeling of intimacy with nature as it manifests itself in the Arabian desert, entitle the *Mu'allaqat* to be reckoned among the masterpieces of world literature. The lively description of a desert storm, with which the *Mu'allaqah* of Imru' al-Qays ends, is a splendid example.

To western taste the physiological exactitude of the descriptions of horse and camel may appear tedious and even repulsive but it was to the possession of camels (and to a lesser extent, the Arab horse) that the bedouin had owed their freedom from domination by the Byzantine and Sasanian empires; furthermore, the camel was the mainstay of their life, without which existence in the desert would have been impossible. Little wonder, therefore, that they felt a passionate, even romantic, interest in every detail connected with these animals.

Imru' al-Qays, the earliest of these poets, seems to have felt no need for closing his poem with any peroration, and it breaks off abruptly at the end of one of the descriptive passages. His successors apparently came to feel the need to round off the arbitrary succession of descriptive passages with something in the nature of an *envoi.* Thus the *Mu'allaqat* of Labid, Antarah, 'Amr and al-Harith end on the note of self-glorification, while those of Tarafah and Zuhayr conclude with lines of a gnomic and sententious character.

Little in the way of historical data can be gleaned from the actual text of the *Mu'allaqat.* The only one with a definite historical background is that of Zuhayr, which is a panegyric on two men of the Murrah clan who acted as peacemakers in a tribal war. Yet even here, it is the commentators who supply us with all the details of the affair. According to them, a quarrel over a horse-race led to bitter fighting between the nearly-related tribes of 'Abs and Dhubyan (known as the "war of Dahis," from the name of the race horse which occasioned the quarrel), until al-Harith ibn 'Awf and Harim ibn Sinan negotiated a truce by agreeing themselves to pay all the blood money involved; the truce was broken by an individual named Husayn ibn Damdam, and the two had to pay further blood money to restore peace. But the poem itself contains only the slightest and most allusive references to these events. Husayn ibn Damdam and Dhubyan are mentioned by name, but not the two peacemakers nor 'Abs; there is a description of the horrors of war, praise addressed to two individuals who "laboured for peace," and a reference to blood money "paid in parcels successive by one who sinned not in the strife," and that is all. Yet although the *Mu'allaqat* are deficient in precise historical data, they give us a picture of bedouin life, manners and modes of thought which is of immense value and interest.

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*Akademie der Wissenschaften in Wien; philosophisch-historische Classe*, vol. 140–144 (1899–1902); and B. Geiger in *Wiener Zeitschrift für die Kunde des Morgenlandes*, vol. 19 (1905). Eng. trans. by A. J. Arberry, *The Seven Odes* (1957), with survey of European translations, summary of the poets' lives and discussion of the authenticity problem. On the meaning of the name *Mu'allaqat* see also *Bulletin des études arabes* (Alger), vol. 6 (1946). (A. F. L. B.)

**MU'AWIYA I** (Mu'awiya ibn abi Sufyan) (*c.* A.D. 602–680), first Omayyad caliph (660–680) of the Arab Muslim empire. He belonged to the clan of 'Abd-Shams or Omayya of the Meccan tribe of Quraish (Quraysh), and was the son of a rich and influential merchant, Abi Sufyan, virtual leader of Mecca in its struggle against Mohammed from 624 to 627, but largely responsible for its peaceful surrender in 630. Mu'awiya and his father took part with Mohammed in the battle of Hunain and probably became Muslims soon afterward. Appointed to the governorship of Syria by Omar I in 639, he proved a careful and efficient administrator. On the death of the caliph Othman in 656, he claimed, as a close kinsman, to be the avenger of blood, and felt sufficiently strong not to acknowledge Ali (*q.v.*) as caliph. Ali eventually marched with his Iraqian army into Syria. After indecisive fighting at Siffin and an abortive attempt at arbitration, Ali's power was declining when he was assassinated in Jan. 661. Mu'awiya, proclaimed caliph at Jerusalem in July 660, then advanced into Iraq, and Ali's son, Hasan, without a struggle abandoned his claim to the caliphate.

Once Mu'awiya had tightened the central government's control of the provinces, which had been seriously relaxed since 656, further expansion became possible. In the east the Muslim armies penetrated into central Asia and northwest India; in the west, from a base in Tunisia, they proceeded through the north of modern Algeria, reaching the Atlantic in 681. An intensive military effort against the Byzantines led to several sieges of Constantinople, but to no permanent gain of territory.

Mu'awiya created the new structure which the caliphate had under the Omayyads. Their power came from the army of Syria, consisting of Arabs long settled there and more disciplined than fresh arrivals from the desert. The capital correspondingly was Damascus. In many respects Mu'awiya ruled like the chief of a nomadic tribe, but, by obtaining an oath of allegiance to his son Yazid during his own lifetime, he introduced the dynastic principle, and became the founder of the Omayyad dynasty (*q.v.*). *See* also Caliphate. (W. M. Wt.)

**MUBARRAD, AL-** (nickname of Abu-l-'Abbas Mohammed ibn Yazid al-Thumali al-Azdi) (826–898), Arab philologist, remembered for his book *al-Kamil fi 'l-Adab* ("The Perfect in Literature"). He was born in Basra on March 25, 826, but moved to Baghdad, where he spent his life teaching, and competing with the Kufan scholar Tha'lab for the caliph's favour. He died in Baghdad in Oct. 898. His book is a formless work dealing with several subjects, but valuable as a storehouse of linguistic knowledge. It is a standard textbook in Arab countries. There is also an edition by W. Wright (1884–92).

*See* also G. Flügel, *Die grammatischen Schulen der Araber* (1862); C. Brockelmann, *Geschichte der arabischen Litteratur*, vol. i, p. 108 (1898), and suppl., vol. i, p. 168 (1937). (J. A. Hd.)

**MUCH WENLOCK:** *see* Wenlock.

**MUCKRAKERS,** an unorganized group of U.S. writers, identified with pre-World War I reform and the "literature of exposure." The name was given to them pejoratively, deriving from Pres. Theodore Roosevelt's speech of April 14, 1906, which, borrowing a passage from John Bunyan's *Pilgrim's Progress*, denounced "the Man with the Muckrake . . . who could look no way but downward." But "muckraker" also took on honourable connotations of social concern and courageous exposition.

The muckrakers' work grew out of the yellow journalism of the 1890s, which whetted the public appetite for news arrestingly presented, and popular magazines, established by such entrepreneurs as John Brisben Walker, Cyrus H. K. Curtis and especially S. S. McClure, Frank A. Munsey and Peter F. Collier. The emergence of muckraking was heralded in the Jan. 1903 issue of *McClure's Magazine* by articles on municipal government, labour and trusts, written by Lincoln Steffens, Ray Stannard Baker and Ida M. Tarbell.

The intense public interest aroused by articles critical of political and financial rings, housing, labour, insurance and other problems rallied writers, editors and reformers. Leader of the reform writers was Charles Edward Russell, whose exposés ranged from *The Greatest Trust in the World* to *The Uprising of the Many*, the latter seeking to report methods being tried elsewhere in the world to extend democracy. Brand Whitlock wrote *The Turn of the Balance* (1907), a novel opposing capital punishment, and was also reform mayor of Toledo, O. Thomas W. Lawson, a Boston financier, in "Frenzied Finance" (*Everybody's*, 1904–05) provided the decade's major exposé of corporate irresponsibility. Edwin Markham's *Children in Bondage* was a major attack on child labour. Upton Sinclair's *The Jungle* and Samuel Hopkins Adams' *The Great American Fraud*, combined with the work of Harvey W. Wiley and Sen. Albert J. Beveridge, brought about passage of the Beef Inspection act and the Pure Food act. David Graham Phillips' series "The Treason of the Senate" (*Cosmopolitan*, 1906), which inspired President Roosevelt's remarks about "the Man with the Muckrake," was influential in leading to the passage of the 17th amendment to the constitution, providing for popular senatorial elections. Muckraking as a movement largely disappeared between 1910 and 1912.

*See* also biographies of various muckrakers; and Louis Filler, *Crusaders for American Liberalism* (1939). (L. Fr.)

**MUCUNA,** a genus of twining plants belonging to the pea family (Leguminosae) and a native of the tropics. *M. pruriens* is popularly known as cowage or cowitch, a corruption of the Hindu *kiwach*. It is a tall annual climber with large dark purple pealike flowers, and golden-brown velvety pods, the hairs or bristles on which often raise blisters on the skin. It is common in the tropical regions of India, Africa and America, and the hairs on the pod have long been used in medicine as a vermifuge. An allied species, *Mucuna deeringiana*, is the Florida velvet bean, a fodder plant. Some authors assign these plants to the genus *Stizolobium*.

**MUDEJAR,** in architecture, the mixed style which was developed in Spain during the middle ages by the merging of Christian and Islamic traditions, especially applied to the style developed after the Christian conquest by Muslims working under Christian supervision.

The style affected particularly brickwork, tile work and carpentry, in the detail treatment of which Moorish forms and methods persisted long into the Renaissance. Good examples of the style are the tower of S. Andres at Calatayud (probably 15th century), the dome of Saragossa cathedral (*c.* 1412, modern form 1500–20), the chapter room at Tordesillas (*c.* 1363) and many elaborate wooden ceilings, known as *artesonados*.

**MUDFISH,** a name given to several very different fishes, including the North American bowfin (*q.v.*) and the three living genera of lungfishes (*q.v.*).

**MUD PUPPY,** a popular name for the American aquatic salamander *Necturus maculosus*, which, with the European *Proteus* forms the family Proteidae. *See* Proteus; Salamander.

**MUD RAIN** occurs when a rainstorm and a dust storm combine. Falling raindrops always pick up some dust particles. But when an unusually large amount of dust is present, as with a dust storm, the drops actually become muddy and can deposit tons of dust per square mile over thousands of square miles of the earth's surface. Mud rains are far from rare and occur in many parts of the world, such as Europe, central United States, eastern China and Australia, but are probably most common in the lands surrounding the Mediterranean sea.

These rains need not occur in or even near the arid regions producing the dust storms, because large clouds of dust can be carried aloft hundreds of miles by the winds. For example, mud rains have occurred in England in association with dust storms originating in northern Africa. Mud rains have a wide variety of colours, depending upon the type of soil involved. Most common are the grays, yellows, browns and reds. The red rains at times have been brilliant enough to be called "blood rains." Other forms of precipitation also become involved with dust storms, although less frequently, resulting in coloured snow and coloured hail. (L. A. Hs.)

**MUDSKIPPER** (Mudhopper; Wriggler), any bony fish of the subfamily Periophthalminae, within the family of gobies (Gobiidae). Mudskippers, of which there are at least 13 species, are small tropical fishes of the eastern Atlantic, the Indian ocean and the western Pacific from Australia to Japan. There are two dorsal fins; the ventral fins are attached below the pectoral fins and are more or less united. The bases of the pectoral fins are long and muscular, and are used as if they were forelegs, for crawling and hopping when the fish is out of water. The eyes, which are close together and on short stalks, can be elevated, moved about independently of each other and retracted at will.

Mudskippers live in tidal pools, mud flats and mangrove swamps. They may leave the water to bask on rocks or on the roots of mangroves, often with their tails submerged. They may hop and skitter about rapidly in pursuit of insects, and often are left high and dry between tides for many hours. When out of water they breathe air, using their highly vascular opercular chamber (containing the gills) for this purpose. Mudskippers are believed also to absorb oxygen from the water through the tail. (L. A. Wd.)

**MUELLER, PAUL HERMANN** (1899– ), Swiss chemist awarded the 1948 Nobel prize in medicine and physiology "for his discovery of the high efficacy of DDT as a contact poison against several arthropods," was born at Olten, Switz., on Jan. 12, 1899. After receiving his early education at Basel he worked for two years in the electrical and chemical laboratories of industrial firms, an experience which he considered to have been of the greatest value in his later work. In 1918 he resumed his academic studies and in 1925 obtained his doctorate at the university of Basel, taking chemistry as his major subject. In the same year he entered the tanning research laboratories of the J. R. Geigy company of Basel, where he worked principally on dyes and tanning agents. Among his early achievements was the invention of synthetic tanning substances. About 1935 Mueller began work on insecticides, and after fruitlessly testing hundreds of different substances synthesized dichloro-diphenyl-trichloroethane (DDT), a compound which seemed to possess practically all the properties required of the ideal insecticide. The substance was produced in Sept. 1939 but did not become commercially available until 1942.

DDT insecticides have been applied to many spheres of insect control, often with spectacular results. It has been used with great success to control epidemics of typhus and other diseases conveyed by insects. The fact that certain insects appear to have developed resistance to DDT does not detract from the great importance of Mueller's work. His discovery yielded great practical results and stimulated further research. (W. J. Bp.)

**MUEZZIN** (Mu'addhin), in Islam, the official who proclaims the call (*azan*) to public worship on Friday and to the five daily prayers. *See* Azan.

**MUFADDALIYAT,** an anthology of ancient Arabic poems, which derives its name from al-Mufaddal ibn Mohammed ibn Ya'la, a member of the tribe of Dabbah, who compiled it some time between A.D. 762 and 784, the year of his death. Al-Mufaddal was a contemporary of Hammad al-Rawiyah and Khalaf al-Ahmar, the famous collectors of ancient Arab poetry and tradition, and was somewhat younger than Abu'Amr ibn al-'Ala, the first scholar who systematically set himself to preserve the poetic literature of the Arabs. He died about 50 years before Abu 'Ubaydah and al-Asma'i (*q.v.*), to whose labours posterity is largely indebted for the arrangement, elucidation and criticism of ancient Arabic verse; and his anthology was put together between 50 and 60 years before the compilation by Abu Tammam of the *Hamasah* (*q.v.*).

Al-Mufaddal was a careful and trustworthy collector of both texts and traditions, and is praised by all authorities on Arab history and literature as in this respect greatly the superior of Hammad and Khalaf, who are accused (especially the latter) of unscrupulous fabrication of poems in the style of the ancients. He was a native of Kufa, the more northerly of the two great military colonies founded in 638 by the caliph 'Omar. In Kufa and Basra were gathered representatives of all the Arab tribes who formed the fighting force of the Islamic empire, and from these al-Mufaddal was able to collect and record the compositions of the poets who had celebrated the fortunes and exploits of their forefathers. He, no doubt, like al-Asma'i and Abu 'Ubaydah, also himself visited the areas occupied by the tribes for their camping grounds in the neighbouring desert; and adjacent to Kufa was al-Hirah, the ancient capital of the Lakhmid kings, whose court was the most celebrated centre in pre-Islamic Arabia, where, in the century before the preaching of the Prophet, poets from the whole northern half of the peninsula were wont to assemble.

The date of al-Mufaddal's birth is unknown; but he lived for many years under the caliphs of the Omayyad line until their overthrow by the Abbasids in 750. In 762 he took part in the rising led by Ibrahim ibn 'Abdallah ibn al-Hasan, the 'Alid, called "The Pure Soul" against the caliph al-Mansur and after the defeat and death of Ibrahim was imprisoned. Al-Mansur, however, pardoned him, and appointed him the instructor in literature of his son, afterward the caliph al-Mahdi. It was for this prince that, at al-Mansur's instigation, al-Mufaddal compiled the *Mufaddaliyat.*

The collection, in its present form, contains 126 pieces of verse, long and short; that is the number included in the recension of al-Anbari, who had the text from Abu' Ikrimah of Dabbah, who read it with Ibn al-A'rabi, the stepson and inheritor of the tradition of al-Mufaddal. We know from the *Fihrist* of Mohammed al-Nadim (A.D. 988) that in his time 128 pieces were counted in the book; and this number agrees with that contained in the Vienna manuscript, which gives an additional poem, besides those annotated by al-Anbari, to al-Muraqqish the Elder, and adds at the end a poem by al-Harith ibn Hillizah. The *Fihrist* states that some scholars included more and others fewer poems, while the order of the poems in the several recensions differed; but the correct text, the author says, is that handed down through Ibn al-A'rabi. It is noticeable that this text, and the accompanying scholia, as represented by al-Anbari's recension, are wholly due to the scholars of Kufa, to which place al-Mufaddal himself belonged.

The collection is one of the highest importance as a record of the thought and poetic art of Arabia during the time immediately preceding the appearance of the Prophet. Not more than 5 or 6 of the 126 poems appear to have been composed by poets who had been born in Islam. The great majority of the authors belonged to the days of Jahiliyyah ("the Ignorance,") and though a certain number (*e.g.,* Mutammim ibn Nuwairah, Rabi'ah ibn Maqrum, 'Abdah ibn al-Tabib and Abu Dhu'aib) born in paganism accepted Islam, their work bears few marks of the new faith. The ancient virtues—hospitality to the guest and the poor, profuse expenditure of wealth, valour in battle, faithfulness to the cause of the tribe—are the themes of praise; wine and gambling, forbidden by Islam, are celebrated by poets who professed themselves converts; and if there is no mention of the old idolatry, there is also little spirituality in the outlook on life. The 126 pieces are distributed among 68 poets, and the work represents a gathering from the compositions of those who were called *al-Muqillun,* "authors of whom little has survived," in contrast to the famous poets whose works had been collected into *diwans.* At the same time many of them are extremely celebrated, and among the pieces selected by al-Mufaddal several reach a very high level of excellence. Such are the two long poems of 'Alqamah ibn 'Abadah (No. 119 and 120), the three odes by Mutammim ibn Nuwairah (No. 9, 67, 68), the splendid poem of Salamah ibn Jandal (No. 22), the beautiful *nasib* (love poem) of al-Shanfara (No. 20), and the death song of 'Abd-Yaghuth (No. 30). One of the most admirable and famous is the last of the series (No. 126), the long elegy by Abu Dhu'aib of Hudhail on the death of his sons; almost every verse of this poem is cited in illustration of some phrase or meaning of a word in the national lexicons. Only one of the poets of the *Mu'allaqat* (*q.v.*), al-Harith ibn Hillizah, is represented in the collection.

An interesting feature of the work is its treatment of the two poets of Bakr ibn Wa'il, uncle and nephew, called al-Muraqqish, who are perhaps the most ancient in the collection. The elder Muraqqish was the great-uncle of Tarafah of Bakr, the author of one of the poems in the *Mu'allaqat,* and took part in the long warfare between the sister tribes of Bakr and Taghlib, called the war of Basus, which began about the end of the 5th century A.D. Al-Mufaddal has included ten pieces (No. 45–54) by him in the

collection, which are chiefly interesting from an antiquarian point of view. It is probable that the compiler set down all he could gather of this ancient author, and that his interest in him was chiefly due to his antiquity. Of the younger Muraqqish, uncle of Tarafah, there are five pieces (No. 55–59). The only other authors of whom more than three poems are cited are Bishr ibn Abi Khazim of Asad (No. 96–99) and Rabi'ah ibn Maqrum of Dabbah (No. 38, 39, 43 and 113).

The *Mufaddaliyat* differs from the *Hamasah* in being a collection of complete odes (*qasidas*), while the latter is an anthology of brilliant passages specially selected for their interest or effectiveness, all that is prosaic or less striking being pruned away. It is of course not the case that all the poems of al-Mufaddal's collection are complete. Many are mere fragments, and even in the longest there are often *lacunae;* but the compiler evidently set down all that he could collect of a poem from the memory of the *rawi* (professional reciters) and did not, like Abu Tammam, choose only the best portions. We are thus presented with a view of the literature of the age which is much more characteristic and comprehensive than that given by the brilliant poet to whom we owe the *Hamasah,* and enables us to form a better judgment on the general level of poetic achievement. The most famous medieval recensions of the *Mufaddaliyat*, with commentaries, are those of al-Anbari (d. 916) and al-Marzuqi (d. 1030). Editions include those by H. Thorbecke (incomplete 1885); by A. M. Shakir and A. S. M. Harun (1952); and a complete edition of al-Anbari's text and commentary, with English translation, by Sir Charles Lyall, three volumes (1919–1921). (C. J. L.; X.)

**MUFFAT, GEORG** and **GOTTLIEB,** German composers and organists, father and son.

GEORG MUFFAT (*c.* 1645–1704) was of Scottish extraction. Born at Schlettstadt about 1645, he studied for six years in Paris. He was appointed organist at Strasbourg and at Salzburg and later visited Vienna and Rome. In 1682 he published his *Armonico tributo,* a set of five-part sonatas. His *Apparatus musico-organisticus* was published in Augsburg in 1690, in which year he went to Passau as organist, becoming *Kapellmeister* to the bishop in 1695. His most famous work, 12 orchestral suites, *Florilegia,* appeared in two sets (Augsburg, 1695; and Passau, 1698). These works and their prefaces contain valuable information concerning the late-17th-century French style of performance. In 1701 Muffat published a set of *concerti grossi* under the title of *Auserlesene mit Ernst und Lust gemengter Instrumental-Musik*, in which he paid an early tribute to the new Italian style. He died at Passau on Feb. 23, 1704.

Muffat's *Florilegia* was reprinted in *Denkmäler der Tonkunst in Österreich,* which also contains selections from the *Armonico tributo* and the *Instrumental-Musik.* His organ music has also been reprinted in modern editions.

GOTTLIEB MUFFAT (1690–1770), son of the above, was baptized at Passau on April 25, 1690. He was a pupil of J. J. Fux in Vienna, where he became organist to the emperor in 1717. He lived an uneventful life, retired in 1763, and died in Vienna on Dec. 10, 1770. His two most important works were the *Versetten oder Fugen* for organ (Vienna, 1726) and the more celebrated *Componimenti musicali* (*c.* 1739), from which Handel borrowed heavily. (Cs. CH.)

**MUFFLER** (SILENCER), a device through which the exhaust gases from an internal-combustion engine are passed to suppress the audible vibrations. The pressure in the engine cylinder when the exhaust valve opens causes an initial gas outflow at explosive velocity. Successive discharges from the cylinders set up pressure pulsations that produce a sharp barking sound. The muffler damps out or absorbs these pulsations so that the gases leave the outlet a relatively smooth, quiet stream.

FIG. 1.—SECTIONAL VIEW OF AN AUTOMOBILE MUFFLER

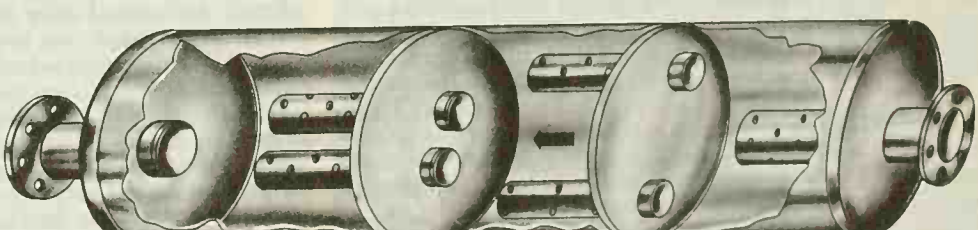
Mufflers of early design contained sets of baffles that reversed the flow of the gases or otherwise caused them to follow devious paths so that interference between the pressure waves reduced the pulsations. The mufflers most commonly used in modern motor vehicles employ resonant chambers communicating with the passages through which the gases flow. Gas vibrations are set up in each of these chambers at the fundamental frequency determined by its dimensions. These vibrations cancel or absorb those present in the exhaust stream of about the same frequency. Several such chambers, each tuned to one of the predominant frequencies present in the exhaust stream, will effectively reduce noise.

A sectional diagram of an automobile muffler of modern design is shown in fig. 1. The jacket is oval in cross section to decrease the vertical dimension and thus increase road clearance; double walls separated by asbestos insulation deaden sound and reduce heat transfer. The inlet and discharge tubes are oppositely eccentric so that the entering gases are carried into the rear compartment surrounding the discharge tube. Two flow reversals then carry the gases into the mouth of the discharge tube. Pressure waves resulting from the pulsating flow tend to cancel the major low-frequency vibrations. The annular chamber surrounding the perforated discharge tube contains glass wool acoustic material to absorb higher frequency vibrations. Dual exhaust systems for V-8 engines frequently have a small resonator connected between each muffler and tailpipe to extend the effective lower frequency range.

A heavy-duty muffler of the "snubber" type, intended for large, low-speed diesel engines and employing a different silencing principle, is shown in fig. 2. The three resonant chambers are connected by twin discharge tubes in which the gases vibrate out of phase. Elimination of flow reversals helps reduce power losses caused by back pressure.

Aluminum-coated steel is used in muffler manufacture to resist corrosive acids formed by condensed water vapour absorbing other combustion products. (O. C. C.)

**MUFTI,** an Islamic canon lawyer responsible for giving an opinion (*fatwa*) on request by a private individual or judge. Such an opinion might be an answer to some inquiry demanding competence in sacred law and jurisprudence, that is, knowledge of the Koran and the Tradition, as well as exegesis and the collections of precedents. An opinion may be a pronouncement regarding some knotty or problematic legal matter. Under the Ottoman empire the whole judicial and theological hierarchy was theoretically subject to the mufti of Istanbul, who ranked as Islam's foremost legal authority. The institution came to an end in 1924 under the Turkish republic. A celebrated mufti was Mohammed 'Abduh



BY COURTESY OF BURGESS-MANNING CO.

FIG. 2.—SECTIONAL VIEW OF A LARGE DIESEL ENGINE MUFFLER

(*q.v.*) of Egypt, a reformer who also served as rector of Al Azhar and was a formidable political figure. Development of civil codes in most Islamic countries tended to restrict the office of mufti to consideration of cases involving personal status; *e.g.*, inheritance, marriage and divorce (*see* ISLAMIC LAW). Even in this area, the prerogatives of the mufti were circumscribed by the introduction of modern legislation. Under British administration in Palestine the office was retained, and in 1921 Amin al-Husaiani was appointed mufti of Jerusalem; his activities turned out to be in the field of Arab nationalism, more expressly the Arab-Zionist conflict.

To the British regime in India the phrase "in mufti" may be traced, probably a reference to the loose robes of the mufti; it means "in civilian clothes" as opposed to "in uniform."

*See* also ISLAM: *Muslim Institutions.*

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(E. J. JU.)

**MUGGER** (MUGGAR, MUGGUR), the popular name for the marsh crocodile (*Crocodylus palustris*), the best-known Indian species of crocodile. In times of drought it undertakes long journeys overland and has even been known to invade towns. *See* CROCODILIA.

**MUGGLETON, LODOWICK** (1609–1698), leader of the Muggletonians, a small and obscure English religious sect, was born in Walnut-Tree yard, Bishopsgate, London. His father was a farrier, but he himself was apprenticed to a tailor. In 1651 he began to have revelations, and to proclaim himself and his cousin John Reeve, whose journeyman he was, as the two witnesses mentioned in Rev. xi, 3. In 1652 they put out their "commission book" under the title *A Transcendent Spiritual Treatise.* An exposition of their doctrines was published in 1656 entitled *A Divine Looking-Glass.* Among other views this work taught that the distinction of the three Persons in the Trinity is merely nominal, that God has a real human body and that he left Elijah as his vicegerent in heaven when he himself descended to die on the cross; to disbelieve the two prophets, Muggleton and Reeve, is the unforgivable sin. Muggleton's opinions gained some notable adherents, but also called forth much opposition. In 1653 he was imprisoned for blasphemy, and twice (1660 and 1670) his own followers temporarily repudiated him. His attack on the Quakers drew forth William Penn's book, *The New Witnesses proved old Hereticks* (1672). In 1677 Muggleton was tried at the Old Bailey, convicted of blasphemy and fined £500. Reeve died in 1658; Muggleton on March 14, 1698. The sect survived until the early 20th century.

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(G. HU.)

**MUGLA,** capital of an *il* (province) of the same name in southeastern Anatolia, Turkey, situated on the margin of a small plain (the main agricultural area of a barren limestone country) 100 mi. S.S.E. of Izmir. Pop. (1960) 14,035. Mugla is the historical centre of the Menteşe region, a former medieval amirate whose pirates were notorious in the Aegean. It is connected with the fertile valley of the Buyuk Menderes river and with the southern coast by excellent highways.

MUGLA IL is bordered by both the Aegean and Mediterranean. Area 5,142 sq.mi.; pop. (1960) 299,611. It is rugged country with small intermontane depressions where the settlements are concentrated. Its coast is extremely irregular with deep penetrating gulfs and bays. The climate is Mediterranean with heavy winter precipitation. Chief crops are cereals, cotton and tobacco in the hinterland, and citrus fruits are cultivated on the coastal strip.

(N. TU.; S. ER.; E. TU.)

**MUGWORT,** a name given specifically to *Artemisia vulgaris,* a perennial herb native to north temperate Eurasia and widely naturalized in the United States and Canada; it is sometimes given also to *A. absinthium,* the classical wormwood (*q.v.*) or absinthium. In North America the name is loosely applied to numerous herbaceous species of *Artemisia* native to the Great Plains region and westward, the shrubby species of the arid districts, as *A. tridentata,* being usually designated sagebrush. In Great Britain the crosswort (*Galium cruciata*) is sometimes called mugwort.

**MUGWUMP,** in U.S. political slang, a name applied to any independent voter, and especially to those independents in the Republican party who refused to support James G. Blaine when he was nominated by that party for the presidency in 1884; as since adopted in England it usually means one who stays neutral and votes for no party. Originally "mugwump" (*mogkiomp*) was a North American Indian word, in the Massachusetts dialect of the Algonkian, meaning "great man" (*mogki,* "great"; *omp,* "man"); and in New England it was used in reference to self-conceited politicians.

**MUHAMMAD:** *see* MOHAMMED.

**MUHLENBERG,** the name of a distinguished U.S. family, long associated with the state of Pennsylvania and the Lutheran Church, and numbering among its members teachers, college presidents, soldiers and members of congress.

HENRY MELCHIOR MÜHLENBERG (1711–1787), the founder of the family, was born in Einbeck, Hanover, Ger., Sept. 6, 1711. He entered the University of Göttingen in 1735 and in 1738 went to Halle, where he finished his theological studies and was a devoted worker in the orphan school established there in 1695 by A. H. Francke (*q.v.*). He was deacon at Grosshennersdorf, in Upper Lusatia in 1739–41. In 1742, in reply to a call from the Lutheran churches of Pennsylvania, he went to America. Mühlenberg occupied himself more particularly with the congregation at New Providence (now Trappe, Pa.), though he was practically overseer of all the Lutheran churches from New York to Maryland. In 1748 he organized the first Lutheran synod in America. He married in 1745 Anna Maria Weiser, by whom he became the father of six sons and five daughters. Throughout the Revolutionary War he and his sons were prominent patriots. He died at Trappe, Oct. 7, 1787.

JOHN PETER GABRIEL MUHLENBERG (1746–1807), eldest child of Henry Melchior Mühlenberg, was born at Trappe on Oct. 1, 1746. He entered the Lutheran ministry, had charge of churches at New Germantown and Bedminster, N.J., and after 1772 of a church in Woodstock, Va. There in 1775 he raised a German regiment, of which he was made colonel; in Feb. 1777 he became a brigadier general in the Continental army. Muhlenberg took part in a number of battles, and at Yorktown commanded the first brigade of light infantry. After the war he moved to Pennsylvania. He was a representative in congress for several terms and in 1803 became collector of the port of Philadelphia. He was a friend of Thomas Jefferson and of James Monroe. He died on Oct. 1, 1807.

FREDERICK AUGUSTUS CONRAD MUHLENBERG (1750–1801), brother of John Peter Gabriel, third child and second son of Henry Melchior, was born on Jan. 1, 1750, at Trappe. He was pastor of the Christ (or Swamp) German Lutheran church of New York city from 1773 to 1776. He was a member of the Continental congress and of the national house of representatives, of which he was the first speaker. He died in Reading on June 4, 1801.

GOTTHILF HENRY ERNEST MUHLENBERG (1753–1815), fifth child and third son of Henry Melchior, born at Trappe on Nov. 17, 1753, was, in addition to being a Lutheran minister, a botanist of some note, his published works in that field being numerous. He was the first president of Franklin college (1787) in Lancaster. His death occurred on May 23, 1815.

HENRY AUGUSTUS PHILIP MUHLENBERG (1782–1844), son of Gotthilf Henry Ernest, was born on May 13, 1782, at Lancaster, Pa., and was ordained in the Lutheran ministry in 1804. He served in congress (1829–38) and was first U.S. minister to Austria (1838–40). He died in Reading on Aug. 11, 1844, while campaigning for the governorship of Pennsylvania.

WILLIAM AUGUSTUS MUHLENBERG (1796–1877), a grandson of Frederick Augustus Conrad, was born in Philadelphia on Sept. 16, 1796, and graduated at the University of Pennsylvania in 1814. Though baptized a Lutheran, circumstances led to his being brought up an Episcopalian. He was ordained priest in 1820. During his rectorship at St. George's, Flushing, L.I., N.Y., he founded in 1828

the Flushing institute, which developed after a time into St. Paul's college and was probably the first Protestant Episcopal school in the United States. Muhlenberg made the Church of the Holy Communion in New York city a pioneer in the practical Christianity to which his later years were devoted. He founded there the first American order of Protestant Episcopal deaconesses, the Sisterhood of the Church of the Holy Communion (1852). As a result of the work of the sisters he established what he called his "hospital-church," St. Luke's, in 1858. St. Johnland, his "church village" begun on Long Island in 1866 as an embodiment of Evangelical brotherhood—and partly modeled on the institutions of A. H. Francke with which his great-grandfather had been associated—was designed to better the condition of the working class, particularly to provide healthful shelter for children and indigent old people. He died in New York city, April 8, 1877.

FREDERICK AUGUSTUS MUHLENBERG (1818–1901), grandson of Gotthilf Henry Ernest, was born at Lancaster, Pa., on Aug. 25, 1818. He too was a Lutheran clergyman and teacher, who contributed, as professor or president, to the life of five Pennsylvania colleges. He was first president (1867) of Muhlenberg college, Allentown. He died in Reading on March 21, 1901.

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**MÜHLHAUSEN** (MÜHLHAUSEN IN THÜRINGEN), a town of Germany in the Erfurt *Bezirk* (district), which after partition of the nation following World War II became part of the German Democratic Republic. Pop. (1961 est.) 44,830. It is situated on the Unstrut river, about 48 km. (30 mi.) N.W. of Erfurt city, and has good rail and road communications with other Thuringian towns. Originally a Germanic village and later a Frankish settlement, Mühlhausen was first documented in 775. It was granted royal privileges and it was there that Philip of Swabia was elected German king in 1198. It was created a free imperial city after 1256 and became a member of the Hanseatic league about 1420. After the Reformation, Mühlhausen became a centre of the people's reformation and during the Peasants' War (1523–25) against the feudal princes it was associated with Thomas Müntzer (*q.v.*) and Heinrich Pfeiffer who were both executed there after the battle of Frankenhausen. The city was subsequently deprived of its privileges but regained its independence under the supremacy of the German empire in 1548. From 1802 to 1945 it was in the former Prussian province of Saxony (except from 1807 to 1815 when it was attached to the kingdom of Westphalia).

Its many well-preserved medieval churches include the gothic hall church of St. Mary (with five 14th-century naves and three towers, one 12th century) and St. Blasius' (dating from 1000 and rebuilt in the 13th and 14th centuries), which has a unique organ constructed to the plans of Johann Sebastian Bach, who was precentor 1707–08. The Gothic *Rathaus* (town hall) and the ruined wall fortifications date from the 13th century. Mühlhausen has a teachers' training college, a school for agriculture and a folklore museum; among the town archives is one of the oldest laws written in German.

Industries include the manufacture of textiles, leather, metal and wood products; other economic activities are based on the agriculture of the surrounding area.

**MUIR, JOHN** (1838–1914), U.S. naturalist, was influential in establishing national forest conservation and park policies. Born at Dunbar, Scotland, April 21, 1838, he emigrated with his family in 1849 to a backwoods farm near Portage, Wis. (*Story of My Boyhood and Youth*, 1913). He attended the University of Wisconsin from 1859 to 1863, but took no degree because of his dislike of the strictures of required courses. He went on many walking trips through the midwest and into Canada, continuing work on mechanical inventions until an accident in 1867 made him fear the loss of an eye. From this time, he devoted himself to nature. He walked to the Gulf of Mexico, keeping a journal as he went (*A Thousand-Mile Walk to the Gulf*, 1916); and in 1868 went to the Yosemite valley in California, from which he took many trips into Nevada, Utah, Washington, Oregon and to Alaska, largely inspired by his predominant interests in glaciers and forests. In 1880 he married and for the next ten years so successfully devoted himself to horticulture that by 1891 he retired and resumed his travels, going so far afield as Australia, South America and Africa to study trees. To him is largely due the establishment of the Yosemite and other areas as national parks. He died at Los Angeles, Calif., Dec. 24, 1914.

His writings, 10 vol. (1916–24) were edited by W. F. Badè, who also wrote *The Life and Letters of John Muir*, 2 vol. (1923–24). His unpublished journals were edited by Linnie M. Wolfe as *John of the Mountains* (1938).

*See* Linnie M. Wolfe, *Son of the Wilderness* (1945).

**MUIR, SIR WILLIAM** (1819–1905), British administrator and scholar, best remembered as a historian of Islam, was born in Glasgow on April 27, 1819. Appointed to the East India company's civil service he had a distinguished career in India (1837–76), becoming, after long service as a settlement officer, foreign secretary to the government of India (1865) and lieutenant governor of the North-West provinces (1868). He was created knight commander of the star of India in 1867. Amid his official duties Muir found time to study Arabic and Islamic history. His works include a *Life of Mahomet and History of Islam to the Era of the Hegira*, 4 vol. (1858–61; ed. by T. H. Weir, 1923); *The Corân: Its Composition and Teaching* (1878); *Annals of the Early Caliphate* (1883); *The Caliphate: Its Rise, Decline and Fall* (1891; ed. by T. H. Weir, 1924); *The Mohammedan Controversy* (1897). Muir, who was a brother of the Sanskrit scholar John Muir, also rendered important services to education: in Allahabad he instituted the central college (Muir's college) and the university; and he was principal of Edinburgh university (1885–1903). He died in Edinburgh July 11, 1905.

**MUKACHEVO** (Czech MUKACEVO; Hungarian MUNKÁCS), a town of the Transcarpathian (Zakarpatskaya) *oblast* of the Ukrainian Soviet Socialist Republic, U.S.S.R., stands on the Latoritsa river, where it emerges from the Carpathian foothills into the Hungarian plain 23 mi. S.E. of Uzhgorod. Pop. (1959) 46,423. The town, which dates from the 12th century, controls the Hungarian approach to the Veretski pass and for long was a key fortress under the Austro-Hungarian empire. The Carpathian mountains at this point are now crossed by road and railway. Between World Wars I and II Mukachevo belonged to Czechoslovakia, was ceded to Hungary under the Munich agreement of 1938, and passed to the U.S.S.R. in 1945. The main industries are food processing and timber working, and the production of tobacco, beer and spirits, flour and furniture. (R. A. F.)

**MUKANNA', AL-** ("the veiled prophet"), the name given to HASHIM IBN HAKIM, a man of unknown parentage, originally a fuller in Merv, who posed as an incarnation of deity and headed a revolt in Khurasan against the Abbasid caliph al-Mahdi (775–785). For about three years al-Mukanna' sustained himself in the field against the troops of the caliph and for two years longer in his fortress of Sanam; then, reduced to straits in 779, he and his followers took poison and set fire to the fortress. He is a hero of Thomas Moore's *Lalla Rookh*.

**MUKDEN** (SHEN-YANG), a centre of administration and transportation of northeast China, the capital of the Liaoning province. Pop. (1957 est.) 2,411,000. It is situated on the right bank of the Hun Ho, a tributary of the Liao Ho.

Mukden controls the main north-south route which traverses the Liao corridor and the still narrower coastal sill giving access to the north China plain. Moreover the valley of the upper Hun Ho, which here debouches on to the lowland, affords one of the chief routes through the east Manchurian highlands. The strategic and focal significance of its position was realized at an early stage. In the 12th century it was the northernmost of the three capitals of the empire of the Kin Tatars (Golden Horde), originally from the steppes of northern Manchuria. About the same period Aisiu Goro, from whom ultimately descended the Manchu dynasty, had his capital in the neighbourhood of the Ch'ang-pai Shan (mountains) north of the Korean peninsula. In the early 17th century his descendant Nurhachu, for the purpose of organizing and uniting the various Manchu tribes and with a view to the conquest of

China, moved his capital down to the plain of the Liao Ho toward the Chinese frontier. Mukden was then known as Shengking and proved an admirable organizing base for the conquest of China. In 1644 when the Manchus supplanted the Mings on the Imperial throne the capital was transferred to Peking. Shengking, however, retained its prestige as the older capital of the reigning dynasty; the treasures of the royal house were deposited in its palaces and the tombs of the earlier emperors (particularly the mausoleum of Tatsung, d. 1644 at Peilung, *i.e.*, North Mausoleum, about 4 mi. from the city) are among the most famous monuments of China. In 1658 the provincial government of Feng-t'ien was established and the city became known as Feng-t'ien.

In the period of struggle between Russia and Japan for dominance in Manchuria, Mukden was inevitably one of the key positions. It was for a time a Russian stronghold and was the scene of the protracted "battle of Mukden" which lasted from Feb. 19 to March 10, 1905, when the city fell to the Japanese. After the Russo-Japanese War the Japanese concession in Mukden had been one of their chief bases for the exploitation of south Manchuria, but it had also been the seat of government of the Chinese "viceroy" of the three Manchurian provinces (Feng-t'ien, Kirin and Heilungkiang). During the civil war and warlord period Chang Tso-lin, a former bandit, governed the Manchurian provinces from Mukden under Japanese tolerance and participated with other warlords in the struggle for the control of the shadowy government in Peking. He was the last warlord to resist the advance of the Kuomintang armies against Peking in 1928, and when he, with his defeated troops, retreated, his train was blown up near Mukden at a Japanese guarded railway bridge. His son and successor Chang Hsüeh-liang adhered, against Japanese advice, to the new Nanking government.

On Sept. 18, 1931, the Mukden incident, an explosion on the railway track near Mukden, gave the signal for the Japanese occupation of Manchuria. A surprise attack on the Mukden garrison, and arsenal brought the Japanese control of the city and after protracted fighting the Chinese forces were driven out of the Manchurian provinces. On Sept. 24, 1931, in Mukden, the first puppet organization was set up with the Committee for Preservation of Local Peace and Order. But after the establishment of Manchoukuo the capital of the puppet state was moved to Ch'ang-ch'un, which the Japanese renamed Hsinking.

The Soviet Union declared war on Japan in early Aug. 1945, and Mukden was soon occupied by Russian forces. After the surrender of Japan on Aug. 14, 1945, Mukden was occupied by Nationalist Chinese troops who were flown there in U.S. transport planes. However, Chinese Communist forces controlled large rural areas of Manchuria. During the civil war that ensued from 1946 to 1948, Mukden was a stronghold of the Nationalists. Following a series of mobile offensives, the Communists captured the city on Oct. 30, 1948. It then served as a major base for the subsequent conquest of the entire Chinese mainland in the following two years by the Communist forces. (*See* also MANCHURIA: *History;* JAPAN: *History;* CHINA: *History.*)

Since 1949 Mukden has developed into a leading industrial centre of China. It is supplied with abundant raw materials in nearby iron, steel and coal centres such as An-shan, Fushun and Pen-ch'i. The city has the largest transformer plant of China, and factories for manufacturing switchgears, machine tools, pneumatic tools, wires and cables. About one fourth of China's machinery is manufactured there, amounting to nearly one half of the city's output by value. Light industries include flour, textiles, oilseeds, paper, leather, soap and chemicals. The city is supported by agricultural products from the rich surrounding plain and forested highlands to the east, which include kaoliang, soybeans, sugar beets, other grains and forest products of various kinds.

Metropolitan Mukden consists of four parts—the old walled city in the east containing the imperial palace and government offices; the new town developed by the Japanese after 1905; intermediate commercial districts; and the Teihsi ("west of the railway"), which has become the hub of heavy and metal-fabricating industries and workers' residences. The Greater Mukden municipality covers an area of 1,200 sq.mi., embodying the satellite cities of Fushun, Pen-ch'i, An-shan and Liao-yang (*q.v.*). Railways radiate from the Mukden industrial focus toward the north China plain, Korea and northern Manchuria. (KN. C.)

**MULBERRY,** the common name for deciduous trees or shrubs of the genus *Morus* (family Moraceae), comprising 12 species growing in the temperate regions of the northern hemisphere and in the mountains of the tropics. Besides those grown for ornament are species cultivated for their edible berries and one used in silkworm culture. The leaves are alternate, toothed, often three-lobed, and the flowers, both male and female, are borne in catkin-like inflorescences.

The North American red mulberry (*M. rubra*) is the largest of the genus, often reaching a height of 70 ft. It produces dark-red edible berries. The white mulberry (*M. alba*), so called from its nearly white fruit, is the one mainly employed in silkworm culture. It is a native of China and has been cultivated from the earliest times in Asia and since the 12th century in Europe, especially in the Mediterranean region. There are many varieties, among which the Philippine mulberry (var. *multicaulis*) is perhaps most highly esteemed. The weeping mulberry (var. *pendula*) is frequently used as a lawn tree. The Indian species, *M. indica* (not to be confounded with *Morinda citrifolia*, a tree of the family Rubiaceae, sometimes called Indian mulberry), is also used in silkworm culture. Both the white and the red mulberry have been grown in the eastern United States since colonial times.

JOHN H. GERARD

NORTH AMERICAN RED MULBERRY (MORUS RUBRA)

The black mulberry (*M. nigra*), a native of western Asia, spread westward in cultivation at an early period; it was cultivated by the Greeks and Romans, and in northern Europe by the 9th and 10th centuries. Up to the 15th century it was extensively grown in Italy for rearing silkworms, but has since been superseded by *M. alba*. It is now mainly cultivated for its oblong purplish-black fruit, which is much superior in flavour to that of *M. rubra*. The tree succeeds best in a rich, deep and somewhat moist loam, but grows well in any good garden soil and in a sheltered situation. It is usually propagated by either cuttings or layers. The mulberry may be grown in pots or in conservatories; under these conditions the fruit acquires a richness of flavour unknown in the fruit ripened out-of-doors, which is often sweet but insipid. Several horticultural varieties have been bred for better fruit. Most mulberry cultivation is for home consumption. Birds are especially fond of the fruit.

*Broussonetia papyrifera*, a member of a closely allied genus, is the paper mulberry, a native of Burma, China and Polynesia, and widely cultivated in Japan, where the bark is used for papermaking. The tapa cloth of the South sea islands is also made from it. The plant is a shrub or small tree with large mulberrylike, lobed or entire hairy leaves. Several forms are cultivated, differing chiefly in the shape of the leaves. The paper mulberry, often planted for ornament in the southeastern United States, has run wild in various localities.

**MULCAHY, RICHARD JAMES** (1886– ), Irish soldier, politician and leader of the Fine Gael party, was born at Waterford in Ireland on May 10, 1886. He took part as a lieutenant in the Irish rebellion of 1916, was afterward interned at Frongoch and then was returned as Sinn Fein member of parliament for the Clontarf division of Dublin in Dec. 1918. A member of the Irish Republican brotherhood, he became chief of staff of the Irish Volunteers in 1918 and assistant minister for defense (1919–21) in the *dail* ministry. He played a prominent part in the fighting before the truce of July 1921 and his assessment of the military situation caused him to give significant support to the treaty in December of that year. He was minister for defense

in the *dail* ministry formed by Arthur Griffith in Jan. 1922. After Michael Collins' death in August, Mulcahy became commander in chief of the Free State forces and carried chief responsibility for the conduct of operations against the irregulars in the civil war. He was also minister for defense in Pres. W. T. Cosgrave's administration from Sept. 1922 to March 1924 when he resigned. He returned to office as minister for local government and public health (1927–32) and represented Dublin city (north) in the *dail* (1921–37 and 1938–43). He succeeded Cosgrave as president of the Fine Gael party in 1944 when he was returned to the *dail* for County Tipperary but served under J. A. Costello, a less controversial figure, as minister for education in the interparty governments of 1948–51 and 1954–57. He resigned from the leadership of the Fine Gael party in 1960. *See* also IRELAND, REPUBLIC OF: *History*. (P. N. S. M.)

**MULCASTER, RICHARD** (1530?–1611), English schoolmaster, was educated at Eton, and at Cambridge and Oxford. In 1561 he became the first headmaster of the newly founded Merchant-Taylors' school, later acting as high master at St. Paul's. Mulcaster's fame rests mainly upon his two books *Positions* and *The First Part of the Elementarie*. He recommended special university training for teachers, parallel with that for doctors or lawyers; careful selection of and adequate pay for teachers; assignment of the best teachers to the lowest grades; and close association between teachers and parents. He emphasized the importance of individual differences in children and the adjustment of the curriculum to them, and the use of readiness rather than age in determining progress. His ideas were so far in advance of his times that his significance, as an early advocate of many of the pedagogical theories now universally accepted, was not appreciated until at least 250 years after his death, which took place on April 15, 1611. (L. Ce.)

**MULE,** the hybrid offspring of the mating of an ass and a horse; strictly speaking, it is the progeny of the cross between a male ass (jackass or jack) and a female horse (mare). The less frequent cross between a female ass (jenny ass or jennet) and a male horse (stallion) results in a hinny or hinney, which is smaller than, and in many respects inferior to, the mule. The mule is an excellent example of hybrid vigour or heterosis, combining the traits of vigour and hardiness from both parent species *(see* also HYBRIDISM). These animals were beasts of burden in Asia Minor at least 3,000 years ago and still find use today in many parts of the world because of their ability to withstand hardships and perform under conditions too severe for many other draft and pack animals. Mules are usually sterile because the chromosomes inherited from the parent species are different, thus interfering with normal production and maturation of sex cells; however, occasional cases of fertile female mules have been reported.

The mule resembles the horse in its height, the shape of the neck and croup and the uniformity of the coat. It resembles the ass in its short, thick head, long ears, thin limbs, small hoofs, short mane, lack of chestnuts (horny growths) inside the hocks, and tail scant of hair at the root. The mule rarely gallops. Its voice is a bray, not like that of the horse but something like that of the jackass. The colour of the coat is generally brown or bay-brown.

The five commonest types of mules bred in the United States are called draft, farm, sugar, cotton and mining mules. The various grades and weights fall into the following classes: choice, good, medium, common and inferior. Largest is the draft mule, which ranges from 16 to 17½ hands (64–70 in.) high and weighs from 1,200 to 1,600 lb.; the smallest is the mining mule, which weighs from 600 to 1,350 lb. and is 12 to 16 hands (48–64 in.) high.

Spain and the United States have the finest mules, followed by Portugal and Italy. As farming became more mechanized, interest in mules, as well as in horses, declined considerably. The mule population of the U.S. has declined more than 50% since 1930, the majority being distributed through the southern and southeastern states. (C. C. S.; X.)

**MÜLHEIM AN DER RUHR,** a town of Germany in the *Land* (state) of North-Rhine Westphalia, which after partition of the nation following World War II became part of the Federal Republic of Germany. Pop. (1961) 185,708. It is an important industrial centre situated on the Ruhr river, there crossed by seven bridges, at the intersection of main-line rail and road traffic, about 11 km. (7 mi.) S.W. of Essen and is a Rhine-Ruhr port.

Mülheim was first mentioned in official documents in 1093. Its early history is closely associated with the counts von Broich, whose medieval castle still stands high above the town. Mülheim was subsequently included in the duchy of Berg which passed to Prussia in 1815.

The location of heavy industry is regulated by ordinance and there are well-planned modern sections (reconstructed after World War II). Extant historic buildings include St. Peter's church (11th century, now entirely rebuilt); Styrum castle and the former Cistercian convent of Saarn (both 13th century); and the house of Gerhard Tersteegen (d. 1769), the pious braid maker and hymn writer. The Bogen quarter has half-timbered houses and old streets. There are many open-air recreational facilities including the Raffelberg racecourse and spa, Ruhr promenade and river passenger service, and the Kahlenberg, Witthausbusch and Oppspring parks.

Heavy industry is well represented by iron foundries, blast furnaces, tube and rolling mills, and machine works; there are also factories for producing electrical machinery and turbines, leather, steel wire, timber, paper, food products and beer. Mülheim is an important coal-distributing centre and at the Max-Planck Institute for Coal Research the Fischer-Tropsch process for liquefying coal and the Ziegler process for the production of polyethylene plastics were discovered. (H. R. R.)

**MULHOUSE** (Ger. MÜHLHAUSEN), a town of Alsace, France, capital of an *arrondissement* in the *département* of Haut-Rhin, on the edge of the Jura, at the junction of the Ill and Doller rivers, 21 mi. (33 km.) N.W. of Basel, Switz. Pop. (1962) 107,946. Among its treasures are the Renaissance town hall (1551); the St. John chapel, built by the Knights of Malta; the Bollwerk tower (14th century); the Devil and Nesle towers (13th century), remains of the feudal castle of the Strasbourg bishops; a fine private Renaissance building on the Place de la Réunion; and the Protestant church of St. Étienne, containing wonderful stained-glass windows of the 14th century. Mulhouse has a number of advanced technical institutions, schools of art and music and several museums. Salvator park contains an auditorium for open-air concerts and a well-known zoological and botanical garden. The town is a rail and road centre and is connected with the Rhine port of Ottmarsheim by the Rhine-Rhône canal. The international airport of Basel-Mulhouse is served by intercontinental air lines. Mulhouse spread and prospered in the 19th century, due to the invention of fine printing methods on calico which led to the creation of many spinning and weaving mills, as well as to manufactures of chemicals and machinery. After the discovery of France's largest potash deposits near Mulhouse around the turn of the century, it became the centre of the potash fertilizer industry.

Mulhouse is first mentioned in 803. It became a free imperial city in 1308 but in 1466 allied itself to the Swiss confederation for defensive purposes. In 1648 its independence was confirmed by the treaty of Westphalia, while the rest of Alsace was joined to the kingdom of France. In 1798 Mulhouse joined France. After the Franco-German War of 1870 it was under Germany for 48 years, and was returned to France in Nov. 1918. It was occupied by the Germans in June 1940 and liberated in Nov. 1944. World War II damage was severe because of the town's importance as a communications centre. Many new modern buildings and squares were erected after the war, notably the ring-shaped block near the railway station. (R. Ob.)

**MULL,** the largest island of the Inner Hebrides, Argyll, Scot. Pop. (1961) 2,149. It is bounded on the west and south by the Atlantic, on the north and northeast by the Sound of Mull, and on the east and southeast by the Firth of Lorn. Its greatest length is 27 mi., and its greatest breadth 20 mi. The coast is deeply indented, and between Salen on the east and Loch na Keal the island is only 2 mi. across. There are several freshwater lakes and the principal mountains are Ben More (3,169 ft.), Ben Buie (2,354 ft.) and Creachben (3,540 ft.). The island is terraced, as

are also those of Ulva and Gometra off the west coast, and bracken grows abundantly, with trees in the sheltered places. In the south, on the peninsula of Laggan, is a small private deer park. In the basaltic cliffs near Carsaig are numerous arches and caverns. Sheep and cattle are raised, and barley, oats and potatoes grown, though due to the damp climate the island is better suited for grazing than for cultivation. Granite is quarried and at Lochaline deposits of silica sand are worked. There are several ancient castles, the principal being those of Aros and Duart (restored in 1912 and again the seat of the Macleans). South of the latter is a lighthouse erected in memory of William Black, the novelist (1841–98), and about 1½ mi. off the lighthouse is the Lady rock, visible at low water, on which, in 1523, Lachlan Maclean of Duart marooned his wife, a daughter of the 2nd earl of Argyll, who was saved by her clansfolk.

Tobermory, which rises from a picturesque bay, is the chief town (pop. [1961] 668). Founded in 1788 as a station for fishing boats, it has a harbour and considerable local trade. It is also a summer resort, with communication by steamer with Oban. A galleon of the Spanish Armada lies sunk in Tobermory bay.

**MULLAH** (a corruption of Arabic *mawla*, "tutor" or "master") is the title given in Muslim countries to religious leaders of a conservative bent. It may be applied to teachers in religious schools, to those versed in the canon law, to leaders of prayer in the mosques (imam; *q.v.*), to reciters of the Koran, etc. There are no formal requirements for acquisition of the title, but normally persons called by it have had some training in a *madrasah* or religious school. The word is often used to designate the entire class that upholds the traditional interpretation of Islam. Among peasant populations and the lower classes of the Muslim world the mullahs enjoy considerable prestige and influence, but to the educated classes they and their conservatism often appear as symbols of an outworn past. (C. J. A.)

**MULLEIN,** the common name for several species of *Verbascum*, biennial herbs of the figwort family (Scrophulariaceae), extensively naturalized in North America, native to Europe and Asia and common in the British Isles. The common mullein or velvet plant (*V. thapsus*) grows erect, two to seven feet high, with stout unbranched stems, conspicuously winged by the close-clinging bases of the large, thick, oblong, slightly toothed, densely wooly leaves. The pale yellow flowers, about an inch broad, appearing from June to September, are closely crowded in a long, dense spike.

The moth mullein (*V. blattaria*), with yellowish flowers marked with purple, and the purple mullein (*V. phoeniceum*) are also widely naturalized, and, like the common mullein, are often troublesome pasture weeds.

RUTHERFORD PLATT

MULLEIN (VERBASCUM THAPSUS)

**MÜLLER** (MUELLER), **FERDINAND,** BARON VON (1825–1896), German botanist and explorer well known for his pioneer botanical exploration of Australia, was born at Rostock on June 30, 1825, and was educated in Schleswig. In 1847 he emigrated to South Australia, changing the spelling of his name to Mueller, and five years later was appointed government botanist for Victoria. Most of his explorations were made from late 1853 through 1856. In 1855–56 Müller joined the expedition led by A. C. Gregory into the Northern Territory and then overland to the east coast of Queensland. From 1857 to 1873 Müller was director of the botanical gardens at Melbourne. He not only introduced many plants into Victoria but made the excellent qualities of the blue-gum tree (*Eucalyptus globulus*) known and introduced it into the south of Europe, north and south Africa, California and portions of South America. He was decorated by foreign countries, and was created baron of the kingdom of Württemberg in 1871. Müller died at Melbourne on Oct. 9, 1896.

His publications include *Fragmenta phytographica Australiae*, 11 volumes (1862–81), *Plants of Victoria*, 2 volumes (1860–65), and works on the eucalyptus, acacias and other plants.

*See* Charles Daley, "Baron Sir Ferdinand von Mueller . . . Botanist, Explorer, and Geographer," *Victorian Historical Magazine*, vol. 10 (1924); A. D. Hardy, "Excerpts From the Letters of Baron Sir Ferdinand von Mueller," *Victorian Historical Magazine*, vol. 21 (1945).

**MÜLLER, FRIEDRICH** (usually known as MALER, *i.e.*, "painter," MÜLLER) (1749–1825), German poet, dramatist and painter whose prose idylls showed remarkable realism, was born at Kreuznach on Jan. 13, 1749. In 1777 he became court painter at Mannheim, but in the next year left for Italy, where he lived until his death, in Rome, April 23, 1825. Müller abandoned painting soon after his arrival in Italy. His principal works are *Fausts Leben dramatisiert* (1778), *Golo und Genoveva* (begun 1776, publ. 1811) and the idylls, *Die Schafschur* (1775) and *Das Nusskernen* (1811). His poetry ranged from the Anacreontic manner to that of the folk song, and his idylls were similar to those of Salomon Gessner. His *Werke* were edited by L. Tieck, 3 vol. (1811–25), and by M. Oeser, 2 vol. (1916–18).

*See* F. Meyer, *Maler Müller-Bibliographie* (1912); M. Oeser, *Maler Müller* (1928). (A. Gs.)

**MÜLLER, HERMANN** (1876–1931), German Social Democratic statesman, twice chancellor of the *Reich*, was born in Mannheim on May 18, 1876, the son of the managing director of a factory. He was in business in Breslau (Wroclaw) before he became editor of the Social Democratic newspaper *Görlitzer Zeitung* in 1899. In 1903 he was elected to the Görlitz town council. Having joined the executive committee of the German Social Democratic party in 1906, he represented that party at many congresses held by the Socialist International. In 1916 he was elected to the *Reichstag*. After the November revolution of 1918 Müller was a member of the executive council and of the central council of the German republic; and when Gustav Bauer formed a government on June 21, 1919, he joined it as minister for foreign affairs. Thus it was he who signed the treaty of Versailles (June 28).

On March 27, 1920, after Wolfgang Kapp's abortive *Putsch*, Müller himself took over the office of chancellor, but he resigned it on June 8, 1920, after the election of the new *Reichstag*. From 1920 he was chairman of the Social Democratic party, which was to remain eight years in opposition. In 1928, however, his party was victorious in the elections, and on June 28 Müller formed the last coalition government of the Weimar era to be constructed on a parliamentary basis. Müller's political realism led him frequently into conflict with his own party; and on March 27, 1930, he resigned when the coalition broke up. Müller died in Berlin on March 20, 1931. His memoirs, *Die November-Revolution*, were published in 1928.

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**MULLER, HERMANN JOSEPH** (1890– ), U.S. geneticist and winner of the Nobel prize for medicine in 1946 for his discovery that X-rays greatly increase the rate of mutation of genes. He was born in New York city on Dec. 21, 1890, and was educated at Columbia university (B.A., 1910; M.A., 1911; Ph.D., 1916). During his teaching years at the University of Texas, he early made outstanding contributions to an understanding of the arrangement and recombination of hereditary units or genes, linkage, crossing over and multiple-factor analysis (1916), explanations of so-called mutations in the evening primrose (1917), balanced lethal factors (1918) and the manner of occurrence of mutations (1920). These studies on the theory of the gene (*q.v.*) and its importance in mutation and evolution (*see* EVOLUTION, ORGANIC; VARIATION: *Experimental Variation*) led him to produce artificial transmutations of the gene by X-rays (1927), for which

he was awarded the American Association for the Advancement of Science prize for 1927 and much later the Nobel prize.

In 1933 Muller became the senior geneticist at the Institute of Genetics of the Academy of Sciences of the U.S.S.R. in Moscow. Disillusioned with Marxism, he left the Soviet Union in 1937. After filling various minor academic posts, he became, in 1945, professor of zoology at Indiana university.

Muller wrote *The Mechanism of Mendelian Heredity* (with T. H. Morgan and others, 1915; rev. 1922); *Out of the Night* (1935; rev. 1936–38); and *Genetics, Medicine, and Man* (with C. C. Little and L. H. Snyder, 1947). (G. F. Ss.; X.)

**MÜLLER, JOHANN** (Regiomontanus) (1436–1476), German astronomer and one of the most advanced mathematicians of his age, was born at Königsberg on June 6, 1436. Because of his birthplace, he called himself Johann de Monteregio, later modified to Regiomontanus. In 1452 he went to Vienna and studied under Georg Purbach (1423–61), later assisting him in the preparation of a work on Ptolemaic astronomy. The inadequate translations of Ptolemy's works hindered them, but a year after Purbach's death Regiomontanus visited Italy, where he studied Greek and consulted a Greek text of the *Almagest*. In 1463 he completed Purbach's *Epitome in Cl. Ptolemaei magnam compositionem*, which was published in Venice in 1496. In 1468 Regiomontanus returned to Vienna, and from there was summoned by the king of Hungary to Buda to collate Greek manuscripts. He settled in Nürnberg in 1471. Bernhard Walther became his pupil and patron and they constructed an astronomical observatory, Regiomontanus himself constructing instruments of an improved type; these are described in his *Scripta*, published posthumously in 1544. In 1472, he made extensive observations of a great comet, probably Halley's comet, and established a printing press in Walther's house. A series of popular calendars issued from the press and Purbach's *Theoricae planetarum novae* was published, while in 1474 Regiomontanus published ephemerides for 1474–1506, in which he described the method of lunar distances for determining longitude at sea.

Regiomontanus had great mechanical ability, as shown by his observatory instruments and his construction of a mechanical eagle which greeted the Emperor Maximilian I on his entry into Nürnberg; but he was primarily an advanced mathematician. His *De triangulis*, written in 1464 and published in Nürnberg in 1533, gives the earliest modern exposition of plane and spherical trigonometry, using general methods of exposition and algebra to assist in the solutions. Regiomontanus was also among the first in Europe to discuss the algebra of Diophantus and in 1475 published his *Tabulae directionum*. Pope Sixtus IV summoned him to Rome in 1472 to assist in calendar reform, and during a subsequent visit there Regiomontanus was assassinated on July 6, 1476.

(Cn. A. R.)

**MÜLLER, JOHANNES PETER** (1801–1858), German physiologist and comparative anatomist who discovered that sensation is not controlled by the stimulus but rather is dependent on the particular sense organ involved, was born in Coblenz on July 14, 1801. He studied at Bonn university, where he taught from 1824 until 1833, when he received the chair of anatomy and physiology at Berlin.

The appearance of his *Handbuch der Physiologie des Menschen* (1833–40; Eng. trans. by William Baly, 1842) marked the beginning of a new period in the study of physiology, by showing its dependence on the other sciences. The most important part of the work deals with the physiology of the nerves and the senses. Here Müller first declared that the kind of sensation following stimulation of a sensory nerve depends not on the mode of stimulation but upon the nature of the sense organ that transmits it to other nerve terminals, and expounded the mechanism of voice, speech and hearing. Müller is also noted for his early investigations of specific nerve energies, his discoveries of the fetal Müllerian duct (1825) and of the lymph hearts in the frog (1832), his work on tumours (1838) and his description of the parasitic disease, psorospermiasis (1841). In the later part of his life he devoted himself to the study of ocean fauna and comparative anatomy. He died on April 28, 1858.

**MÜLLER, JOHANNES VON** (1752–1809), the most important Swiss historian of the 18th century, was born in Neunkirchen near Schaffhausen on Jan. 3, 1752. Müller's life was marked by the tension between his work as scholar and his activity as diplomat and political journalist at the court of the archbishop of Mainz (1786–92) and in the imperial chancery at Vienna (1793–98). In the last years of his life he entered the service of Napoleon as director of education for the kingdom of Westphalia, and his posthumous reputation was long clouded by what was unjustly interpreted as a betrayal of the idea of freedom. He died at Kassel on May 29, 1809.

His most important work is *Geschichten Schweizerischer Eidgenossenschaft* (1786–1808; unfinished, up to 1489). He combined comprehensive knowledge of chronicle sources (especially Aegidius Tschudi) with a terse elegance which earned him the title of the Swiss Tacitus; Tacitus was indeed his model. The book goes beyond historical truth in its apotheosis of the freedom and moral purity of the ancient confederation, but it was through a renewed consciousness of the past that Müller hoped to save a spiritually degenerate country from impending destruction (1798). His idealistic and patriotic picture of the ancient Swiss constitution profoundly influenced the 19th-century European view of Switzerland. (Among other things, it was the source for Schiller's *Wilhelm Tell*.) Müller's attempt at universal history, the *24 Bücher allgemeiner Geschichten* (1810 *et seq.*; Eng. trans., *The History of the World*, 1840), is indebted to the historical outlook of the Enlightenment, but points forward to Leopold von Ranke in its religious conception. In *Fürstenbund* (1787) and *Reisen der Päpste* (1782), which are political journalism, Müller appears as an important theorist of the European balance of power.

As a Swiss and declared enemy of despotism, he supported the idea of the small state; as a representative of *Helvetia mediatrix* and as a cosmopolitan of the Enlightenment he tried to unite the spiritual heritage of Rome with the German origins of his civilization. The classics and Christianity coloured by pietism went to make up this remarkably gifted personality whom German classicism—Herder, Goethe and Schiller—claimed as its own historian.

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(We. R.)

**MÜLLER, KARL OTFRIED** (1797–1840), German scholar who aimed at developing classical studies as a branch of cultural history, was born at Brieg (Silesia) on Aug. 28, 1797. After studying under August Boeckh in Berlin, he lectured as classical professor at Göttingen (1819–39) with equal brilliance on ancient literature, archaeology, mythology and the history of art. He died in Athens on Aug. 1, 1840. His edition of Aeschylus' *Eumenides* (1833), which showed the play's roots in the life of 5th-century Athens, contained a spirited attack on Gottfried Hermann whose reviews of works which attempted a cultural or aesthetic interpretation of the classics criticized them solely from the viewpoint of verbal scholarship and condemned their errors in that field without reference to their positive contributions. Müller held his own in the ensuing controversy and won credit for his own broader approach. His works include numerous archaeological papers, historical surveys on the Dorians (1824) and the Etruscans (1828), an unfinished history of Greek literature (1843; Eng. trans. 1858) and valuable methodological studies in his *Prolegomena to a Scientific Mythology* (1825, Eng. trans. 1844) and his *Manual of the Archeology of Art* (1830, Eng. trans. 1847). Like Boeckh, he was a gifted man of many interests who looked on the classical past not merely as arena for the display of his own specialized skill but as a world of human experience to be brought into an organic relationship with the present.

*See* J. E. Sandys, *History of Classical Scholarship*, vol. 3, pp. 213–216 (1908); O. and E. Kern, *K. O. Müller, Lebensbild in Briefen an seine Eltern* (1908).

(R. R. Bo.)

**MÜLLER, (FRIEDRICH) MAX** (1823–1900), Anglo-German orientalist and comparative philologist, whose works stimulated widespread interest in the study of linguistics, mythology and religion, was born at Dessau on Dec. 6, 1823. He was the son of Wilhelm Müller (1794–1827), the German poet celebrated for his phil-Hellenic lyrics, who was ducal librarian at Dessau. Felix Mendelssohn, who was Müller's godfather, dissuaded him from indulging his natural bent toward the study of music; Hermann Brockhaus of the University of Leipzig, where Müller matriculated in 1841, induced him to take up Sanskrit; Franz Bopp, at Berlin (1844), transformed the Sanskrit student into a comparative philologist; Friedrich Schelling, at the same university, inspired him with a love for metaphysical speculation, though he failed to attract him to his own philosophy; Eugene Burnouf, at Paris in the following year, by teaching him Zend, started him on the study of comparative religion and impelled him to edit the Rigveda; and when, in 1846, Müller came to England upon this errand, Baron von Bunsen, in conjunction with H. H. Wilson, prevailed upon the East India company to undertake the expense of publication. Bunsen gave him introductions to Queen Victoria and the prince consort, and to Oxford university. In 1848 the printing of his Rigveda at the University press obliged him to settle in Oxford. Müller was appointed deputy Taylorian professor of modern languages in 1850, and became an honorary fellow of Christ Church and a fellow of All Souls. During this period he published the essays collected as *Chips From a German Workshop,* and his *History of Ancient Sanskrit Literature* (1859).

When at last the chair of Sanskrit fell vacant in 1860, Müller failed to secure election; it was the one great disappointment in his life and made a lasting impression upon him. Sanskrit philology received little more from him, except in connection with his later undertaking of *The Sacred Books of the East,* though he appealed to Sanskrit evidence in his *Science of Languages,* two courses of lectures delivered at the Royal institution in 1861 and 1863. Müller sought to popularize the study of Indo-European comparative philology, but he was on less sure ground in another department of the study of language—the problem of its origin. His essays on mythology are among the most alluring of his writings, but their value is impaired by too uncompromising adherence to the seductive generalization of the solar myth.

Müller's studies in mythology led him to the comparative study of religions. His *Introduction to the Science of Religion* (1873: the same year in which he lectured on the subject in Westminster abbey) was followed by the four volumes of Gifford lectures delivered between 1888 and 1892; but the most tangible result was the publication under his editorship, from 1875 onward, of *The Sacred Books of the East* in 51 volumes, including indexes, all but three of which appeared under his superintendence during his lifetime. These comprise translations by competent scholars of the important non-Christian scriptures of oriental nations. Müller also wrote on Indian philosophy in his later years, and he urged the search for oriental manuscripts and inscriptions which resulted in discoveries of early Buddhist scriptures, in their Indian form, made in Japan. He was on friendly terms with Japanese scholars, and after his death his library was purchased by the University of Tokyo.

In 1868 Müller was elected to a newly established chair of comparative philology, but he ceased to lecture in 1875 when he entered upon the editorship of *The Sacred Books of the East.* He was a curator of the Bodleian library and a delegate of the University press. His hospitality was ample, especially to visitors from India, where he was well known. His distinctions, conferred by foreign governments and learned societies, were numerous. He became a naturalized Englishman, was in high favour at court, and was sworn of the privy council. He died at Oxford on Oct. 28, 1900.

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**MÜLLER, SOPHUS OTTO** (1846–1934), Danish archaeologist and a leading European archaeologist for many years, was born in Copenhagen on May 24, 1846. He was the son of the numismatist and archaeologist Carl Ludvig Müller, director of the royal coin and medal collection (1865–91). Having taken his degree in philology in 1871, he became interested in prehistoric archaeology and was appointed assistant (1878) and inspector (1885) at the Museum of Northern Antiquities in Copenhagen.

In 1892 the various collections in the *Prinsens Palae* were formed into the National museum, and Müller was appointed a co-director, in charge of the first department (only two were then formed) which contained Danish prehistoric, antique and ethnological collections. He was also the secretary-general of the Society of Northern Antiquities from 1881–1920. After his retirement in 1921 he continued his own researches. Müller died in Copenhagen on Feb. 2, 1934.

Müller reorganized the collections in the National museum; he also developed new techniques in excavation and for the preservation of prehistoric monuments. He was a very clever, keen and productive archaeologist and his numerous publications cover the whole of Danish antiquity from the early Stone Age to the Viking period. His most important contributions to archaeology were *Vor Oldtid* (1897), *Ordning af Danmarks Oldsager,* three volumes (1888–95) and *Oldtidens Kunst i Danmark,* three volumes (1918–33). (T. MN.)

**MÜLLER, WILHELM** (1794–1827), German poet whose lyrics, including the cycles "Die schöne Müllerin" and "Die Winterreise," were given enduring fame by Schubert. He was born at Dessau on Oct. 7, 1794, studied philology at Berlin, took part in the Prussian War of Liberation and from 1819 was teacher of classics and librarian in Dessau, where he died on Sept. 30, 1827. Müller translated Italian and Greek folk songs, and his own lyrics, which were influenced by *Des Knaben Wunderhorn* (*see* BRENTANO, CLEMENS) and by Joseph von Eichendorff, are folk in character, with their attempt to convey emotion with complete simplicity. (See *Gedichte aus den hinterlassenen Papieren eines reisenden Waldhornisten,* 2 vol., 1821–24; etc.) His *Lieder der Griechen* (1821–24) put him in the forefront of German philhellenism. His interests embraced 17th-century poetry and he also translated Marlowe's *Dr. Faustus.* His other works include *Rom, Römer und Römerinnen* (letters; 2 vol., 1820).

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**MÜLLER, WILLIAM JOHN** (1812–1845), English landscape and figure painter, was born at Bristol on June 28, 1812, his father, a Danziger, being curator of the museum. He studied painting under J. B. Pyne. His early subjects deal mainly with the scenery of Gloucestershire and Wales. In 1833 he figured for the first time in the Royal Academy with "The Destruction of Old London Bridge—Morning." The next year he made a tour through France, Switzerland and Italy. Four years later he visited Athens, extending his travels to Egypt, and in the sketches made during this period and the paintings produced from them his power and individuality are apparent. After his return he settled in London, where he exhibited regularly.

In 1840 Müller again visited France, where he executed a series of sketches of Renaissance architecture, 25 of which were lithographed and published in 1841 in a folio entitled *The Age of Francis I of France.* In 1843 he accompanied Charles Fellows to Lycia, where he made a number of masterly sketches. He died at Bristol on Sept. 8, 1845.

**MULLET,** the name of two different kinds of fishes, distinguished as red mullets and gray mullets. Both are abundant in tropical waters.

Red mullets (*Mullus*) are marine fishes of the goatfish family (Mullidae), with two short dorsal fins, the first composed of feeble spines, the second of branched rays. The body is covered with large, thin scales. The anterior profile of the head slopes downward to the small mouth, which has small, feeble teeth. There are

two sensitive barbels on the lower jaw (hence the common name for the family); the barbels generally are laid back in a groove but are capable of erection when danger threatens. About 40 species are known, chiefly from the tropical and subtropical parts of the Indo-Pacific ocean. Their brilliant colours are simple and evanescent; in many, red prevails.

In the Atlantic two species occur, *Mullus surmuletus* and *M. barbatus*. The former, in addition to the general red colour, has three to five bright yellow bands along the sides from head to tail; these bands are absent in *M. barbatus*. The striped form usually is found along the coasts of England; both kinds occur in the Mediterranean.

The largest red mullets weigh only two or three pounds. They are ground feeders, using their barbels in foraging for their food, which consists of crustaceans, worms and, in the larger species, small fishes. All the species are esteemed as food but none equals the European species. During winter the fish retire into deep water; late in spring and during summer they approach the coasts and enter even brackish water, but they do not come toward the shore to breed.

The gray mullets form the family Mugilidae. They always live close to the shore, in tropical and temperate seas, and enter brackish water, some tropical forms inhabiting the fresh water without penetrating far inland. Gray mullets are plain coloured, generally greenish on the upper parts and more or less silvery on the sides. The body is streamlined and covered with scales of moderate size. The anterior of the two short dorsal fins is composed of four stiff spines. The caudal fin is strong and bilobed. The mouth is narrow, transverse in species of *Mugil;* teeth, not present in all species, are feeble. About 70 different species are known from most parts of the temperate and tropical zones; they swim in schools and are abundant wherever they occur. The commonest European species is the striped mullet, *Mugil cephalus*, found also on both coasts of North America and elsewhere; it is called black mullet in Florida. Some of the fresh-water gray mullets of the tropics have been grouped in a separate genus, *Agonostomus*.

BY COURTESY OF MIAMI SEAQUARIUM

GRAY MULLET (MUGIL CEPHALUS)

Gray mullets may grow to a weight of 10 or 12 lb. Those in which distinct teeth are developed feed on small aquatic animals, while the diet of those without teeth consists of large quantities of microscopic animals and plants mixed with mud and sand. Because they grow rapidly and are wholesome food gray mullets are cultivated in fish farms in Europe. (C. Hu.)

**MULLINGAR** (Muileann Cearr), the county town of County Westmeath, Republic of Ireland, on the river Brosna, 51 mi. W. by N. of Dublin by road. Pop. (1961) 5,894. It contains the county administration headquarters and is a large road and railway junction and the centre of a cattle-raising area. The Royal canal almost encircles the town which contains the Roman Catholic Cathedral of Christ the King (1936) for the diocese of Meath. The principal industries are the manufacture of furniture and pencils. Mullingar is the centre of excellent trout fishing on the adjoining loughs Ennell, Owel and Derravaragh and was once the site of an Augustinian convent (1227) and a Dominican convent (1239), both of which were dissolved by Elizabeth I.

**MULLION,** in architecture, a slender, vertical division between adjacent lights or subdivisions in a window, or between adjacent windows in a group. Mullions appear with the invention of tracery (*q.v.*), and are particularly characteristic of Gothic architecture throughout, and early Renaissance in north and west Europe. In traceried windows, mullions are frequently chamfered or beveled on the edges, and sometimes decorated, in addition, with a colonnette; but in late Gothic work, more elaborate moldings are common. In the rectangular window groups common in late Gothic and early Renaissance secular work, the face of the mullion is usually set back from the face of the wall so that one molding or series of moldings runs unbroken round the entire group.

A. F. KERSTING

WINDOW OF CROWCOMBE CHURCH, SOMERSET, WITH MULLIONS FROM THE ENGLISH DECORATED PERIOD, 14TH CENTURY

The mullion itself is usually molded or chamfered and this molding or chamfer is continued around the top and sides of each light. In windows whose tracery subdivides the whole into more than three lights, mullions may be of different sections, with certain mullions increased in size, or may carry an additional molding. The entire group is systematized into subdivisions of two or three lights each, the larger mullions enclosing each subdivision.

**MULLITE** (named from the Island of Mull, Inner Hebrides, Scot., where it was first recognized as a mineral) is an aluminum silicate with ideal composition $3Al_2O_3.2SiO_2$.

Rarely found in nature, mullite is formed from firing aluminosilicate raw materials, as andalusite, sillimanite, kyanite or topaz (*qq.v.*), and is the most important constituent of ceramic whiteware, porcelains and high-temperature insulating and refractory materials. For highest thermal stability, mullite is desirable to keep the alumina content of ceramic and refractory materials high since compositions having the alumina/silica ratio at least as high as 3:2 will not melt below 1,810° C.; compositions higher in silica undergo partial melting as low as 1,545° C.

Natural mullite is found as elongated orthorhombic prisms or needles, white or faintly coloured. It has so far been recognized only in buchites, or fused argillaceous enclosures in intrusive igneous rocks, suggesting very high temperatures of formation. It occurs together with cordierite, corundum, spinel and anorthite in the Island of Mull. In normal contact aureoles and regionally metamorphosed sediments the place of mullite is taken by andalusite, sillimanite or kyanite. Synthetic conditions of formation of these minerals suggest that mullite is stable under conditions of moderately low to atmospheric pressure at moderate to very high temperatures; whereas sillimanite, andalusite and kyanite require higher pressures for their formation. Synthetic mullite is manufactured by sintering or fusing mixtures of alumina and siliceous materials (as kaolin or silica).

Synthetic mullite admits $Al_2O_3$ into solid solution up to the composition $2Al_2O_3.SiO_2$ and most mullite grown from fused mixtures has this composition. It also commonly has $Fe_2O_3$ and $TiO_2$ in solid solution.

Mullite is difficult to distinguish from sillimanite, which has the composition $Al_2O_3.SiO_2$ and forms similar-appearing orthorhombic crystals. Refractive indices of pure mullite are lower than those of sillimanite, but $Fe_2O_3$ and $TiO_2$ present in solid solution in mullite increase the refractive index and make distinction difficult by this method. Unequivocal identification of the two minerals may be made by their infrared absorption spectra and detailed examination of accurate X-ray diffraction spectra. Two or three subvarieties of mullite having slightly different crystallographic properties may be distinguished by the latter method. (Ru. R.; Da. R.)

**MULOCK, SIR WILLIAM** (1844–1944), Canadian politician and jurist, was born at Bond Head, Upper Canada (Ontario), on Jan. 19, 1844. From 1882 to 1905 he was a prominent member of the Liberal party in the Canadian house of commons; and from 1896 to 1905 he was postmaster general in the government of Wilfred Laurier, serving also from 1900 to 1905 as Canada's first minister of labour. He introduced many improvements into the Canadian postal service and in 1898 he was instrumental in bringing about penny postage throughout the British empire. In 1905 he retired from politics, and was appointed chief justice of the ex-

chequer division of the supreme court of the province of Ontario; and from 1923 to 1936 he was chief justice of Ontario. He was vice-chancellor of the University of Toronto from 1881 to 1900; was largely responsible for the federation of the University of Toronto and Victoria university in 1887; and was chancellor of the University of Toronto from 1924 to his death. He was created a knight commander of St. Michael and St. George in 1902, and was appointed a privy councilor in 1925. He died in Toronto on Oct. 1, 1944.

*See* W. J. Loudon, *Sir William Mulock* (1932). (W. S. WA.)

**MULREADY, WILLIAM** (1786–1863), British painter, who excelled in the genre of the cottage door, the schoolhouse and young love, was born at Ennis, County Clare, Ire., on April 1, 1786, entering the Royal Academy schools in London in 1800. In 1804 he began a long series of successful exhibits, and in 1816 he was made an academician. Meanwhile, in 1805, David Wilkie began in London a vogue for highly wrought narrative pictures which had strong links in the field of naturalistic and sentimental literature. This vogue, backed by the prince of Wales's taste for Dutch masters, inspired a reaction against the strict academism taught by Sir Joshua Reynolds. Mulready was quick to follow this. At first, like his Dutch exemplars, he painted opaquely and directly, mainly in earth colours, but later, and especially after 1830, he turned to rich glazes. Among Mulready's best-known works are his "Interior of an English Cottage" (1828, royal collection), and those given by his friend John Sheepshanks to the Victoria and Albert museum, London.

Mulready is also noted for his academic studies, children's book illustrations and his design (1840) for the first penny postage envelope. He died in Bayswater, London, on July 7, 1863.

*See* F. G. Stephens, *Masterpieces of Mulready* (1867).

(D. C. T. T.)

**MULTAN,** a municipality and cantonment, district and division of West Pakistan. The city, headquarters of the district and division, is built on a mound about 4 mi. from the left bank of the Chenab and 190 mi. S.W. of Lahore. Pop. (1961) 358,201. It is one of the oldest cities of the subcontinent. Tradition identifies the present site with the city of Malli, stormed by Alexander in 326 B.C. Its first authentic appearance in history is in the mid-7th century A.D. when it was seized by the Chach dynasty of Sind. It was visited by renowned travelers and historians (Hsüan Tsang, Ibn Batutah, Al Beiruni, Jean Baptiste Tavernier) and is the reputed birthplace of three famous kings, Ahmad Shah Durrani, Mohammed Tughluq and Bahlol Lodhi. Formerly called Kastpur, Hanspur Bagpur, Sanb or Sanabpur and finally Mulasthan, the city derives its name from that of the idol of the temple of the Sun god, a shrine of vast wealth in the pre-Muslim period.

The city proper is enclosed on three sides by a wall and has six gates. The main bazaar, called the Chowk bazaar, is connected with the gates by sub-bazaars, which are known after the names of the gates to which they lead. The shrines of Shah Bahawal Haq and Shah Rukn-i-Alam within the premises of the old fort (now turned into a public park called Ibn-i-Qasim Bagh) are impressive examples of Muslim architecture of the Tughluq period. The shrine of Shah Rukn-i-Alam is about 115 ft. high with a circumference of 464 ft. at the base, and has one of the biggest domes in Asia. The shrine of Shams-i-Tabrez is a unique example of workmanship, built almost entirely of turquoise or sky-blue glazed bricks, exquisitely engraved. That of Sheikh Yousuf Gardez is a domeless rectangular building of glazed tiles, a masterpiece of the Multani style of architecture. The Prahlad-puri temple takes its name from Prahlad, the mythological hero of the story of the lion man, or Narsingh avatar (incarnation), of the god Vishnu. The Idgah, built by Nawab Abdusamad Khan in 1735, and the Wali Mohammed mosque (1758), a good specimen of enameled tiled work, are the other historical buildings. Large and irregular suburbs have grown outside the walls and the city now covers an area of more than 9 sq.mi. Besides small colonies, developed by the Improvement trust, two satellite towns have been set up. The modern buildings include the town hall and the Nishtar Medical college and hospital. On the site of the old fort are a stadium, a swimming pool and a small museum, known as Nigar Khana. Lange Khan garden and Aam Khas Bagh are the other main parks of the town. There are four colleges affiliated to the University of the Panjab and many schools. The Darul Ulum (centre of learning), in memory of the *qaid-i-azam* (Mohammed Ali Jinnah; *q.v.*), is to be built there.

Multan is fast growing into a great industrial centre with cotton-ginning factories, cotton and woolen textile mills, numerous power looms, flour and oil mills, a glass factory and several foundries. A natural gas fertilizer factory was set up at Piranghaib near Multan. The thermal power station, using gas piped from Sui, 200 mi. distant, has a total capacity of about 120,000 kw. The cottage industries include the manufacture of handloom cloth, pottery, camelskin work, *durris* (cotton carpets) and woolen carpets, lacquer work, tiles and shoes.

MULTAN DISTRICT occupies the southwestern angle of the Bari doab, or the tract between the Sutlej and the Ravi and Chenab, with an extension northward across the Ravi. Area 5,630 sq.mi. Pop. (1961) 2,702,354. The principal crops are wheat, millet, pulses, oilseeds and cotton. A large area is irrigated from the lower Bari doab canal. The climate is extremely hot and dry. There are factories for ginning and pressing cotton.

The early Arab geographers mention Multan as part of the kingdom of Sind, which was conquered for the caliphate by Mohammed bin Kasim in A.D. 712. In the 10th century it became a centre of the Karmatian heretics. In 1006 it was occupied by Mahmud of Ghazni. From 1526 it was subject to the Mogul emperors. On the dismemberment of the Mogul empire in the middle of the 18th century, Multan fell to the Afghans (1779), who held it with difficulty against the Sikhs. At length, in 1818 Ranjit Singh, after a long siege, carried the capital by storm. In 1821 he handed over the administration of Multan with five neighbouring districts to Sawan Mal, who raised the province to prosperity by excavating canals and inducing new inhabitants to settle. After the establishment of the council of regency of Lahore, difficulties arose between Mulraj, son and successor of Sawan Mal, and the British officials, which led to his rebellion, the second Sikh War and the annexation of the whole of the Punjab. The city of Multan, after a stubborn defense, was captured in Jan. 1849 (*see* SIKH WARS).

MULTAN DIVISION was the southwesternmost of the commissioner's divisions of the former Punjab province. Area 24,826 sq.mi. Pop. (1961) 6,602,924. On Oct. 14, 1955, on the formation of a united province of West Pakistan, it was reduced to the districts of Multan, Jhang, Lyallpur and Montgomery. In 1960 it was reconstituted to include Multan, Dera Ghazi Khan, Muzaffargarh and Montgomery. (K. S. AD.)

**MULTIPLE BIRTHS.** In most mammals the litter size is fairly constant and is roughly correlated with, among other features, body size, gestation period, life span, type of uterus and number of teats. For example, a large mammal with a normal pregnancy of more than 150 days, a life span of more than 20 years, a simple or unicornuate uterus and two breasts rarely bears more than one young (a singleton) at a birth. The great majority of primates, man included, fits into this category; multiple births among them are exceptional, and occur with decreasing frequency from twins to sextuplets.

### TWINS AND TWINNING

Twinning refers to the process that leads to the production of more than one offspring at one birth. In man the most frequent type of twinning results in the birth of two babies (twins) at once, although repetition of twinning may lead to triplets, quadruplets or other multiples of one.

The two common types of double birth are referred to by terms that indicate whether they developed from two separately fertilized eggs or from a single egg that later split into two embryos, as follows: two-egg twins (dizygotic or binovular) are commonly called fraternal; one-egg twins (monozygotic or uniovular) are called identical.

The terms monozygotic (MZ) and dizygotic (DZ) are the most desirable, since they include "zygote" (the result of the union of one egg and one sperm), which points up the contribution of both maternal and paternal factors of inheritance. In monozygotic

twins (from one zygote) both members of the set receive theoretically identical genetic endowments; these are twins in the accurate sense of the term. In dizygotic twins (from two zygotes) each member, like singletons of the same parents, receives a separate inheritance; these are actually only members of a litter.

The occurrence of twinning varies among racial groups in the United States: multiple births are commonest among negroids; less common among whites; and least common among orientals. DZ twinning is commonest in older mothers (up to about 40 years of age) and tends to recur in families having a history of multiple births, indicating that a hereditary factor may be involved. MZ twinning, on the other hand, occurs randomly in all races and follows no discernible genetic pattern; it does tend to occur more frequently in older mothers, however.

MZ twins are always of the same sex because sex is determined at the moment of fertilization, when the sperm and egg fuse and the zygote comes into existence. DZ twins may or may not be of the same sex. About 25% of the sets of DZ twins are both boys, 25% are both girls and 50% are boy and girl combinations.

In the older literature are found the terms monochorionic and dichorionic (for MZ and DZ terms), based on the mistaken idea that all MZ twins have a single placenta with a single chorion (modified placenta). This would mean that the division of a human embryo into two parts was always delayed until after the chorion was formed, which is far from true. In more than 25% of MZ sets the twinning division occurs early in embryonic development, before the chorion is formed. In such cases each co-twin forms its own placenta and chorion, which may remain separate or become joined by connective tissue into a single dichorionic one; the remaining 75% have a monochorionic placenta. All DZ twins have either two separate placentas or a single dichorionic one. Much mistaken information concerning the type of twins is based on false ideas regarding the placenta. Unless the birth membranes have been carefully examined by an expert, it is better not to base any conclusions regarding the origin of the twins on these structures.

How does one determine whether twins are identical (MZ) or fraternal (DZ)? First, identical twins invariably must be of the same sex, the same blood groups and the same haptoglobin types (haptoglobin is a blood serum protein); DZ twins may be the same in these regards but more usually there is some difference. If any one of these three characters differs between twins, the twins are dizygotic. (There are many pitfalls for the unwary in attempting to determine whether twins are monozygotic or dizygotic. Should the blood groups or haptoglobins be the same, it requires an expert to calculate the likelihood of dizygosity, based not only on the blood groups of the twins but also their parents, brothers and sisters.)

*Some Features Used in Diagnosing Twins*

| Features | Type of twins | |
|---|---|---|
| | Identical (MZ) | Fraternal (DZ) |
| Sex | same | same or opposite |
| Placenta | single monochorionic, single dichorionic or two separate placentas | single dichorionic or two separate placentas |
| Blood groups | same | same or different |
| Haptoglobins | same | same or different |
| Hand and foot prints | close similarity | close similarity or marked dissimilarity |
| Physical resemblance | very strong | ordinary familial |

MZ twins show strong physical likeness to a degree much greater than could be attributed to mere family resemblance (fraternal twins bear the resemblance of ordinary sibs). Physical likeness is not a reliable criterion for establishing the identicalness of twins, however. If the twinning of the early embryo in MZ sets has been considerably delayed, the resulting twins may differ markedly in bodily proportions, as is seen regularly in conjoined or siamese twins. Although hereditary characteristics such as eye colour and hair colour and texture should be the same in MZ twins, these traits as well as the majority of physical characteristics may be modified during embryonic development. Identical twins are therefore not "identical" in the strictest sense of that word; the correspondence between such co-twins is closer to what would be expected between the right and left sides of a single individual.

Dependable data for determining the type of twinning proceeds from the analysis of blood groups. Identical twins have *all* blood groups identical. A satisfactory examination may require expert analysis using as many as 30 antisera in determining blood groups, if parents and brothers and sisters are also examined.

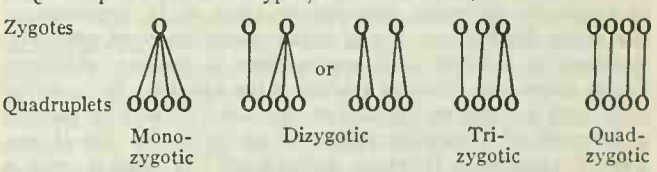
An examination of the haptoglobins of the blood, studied by starch gel electrophoresis (*q.v.*), increases further the accuracy of the determination. Using the combined criteria of the sex of the twins, blood groups and haptoglobins, 96% of fraternal twins can be recognized by differences between the members, and only the remaining 4% would be confused with identical sets. These 4% may then be studied further. Calculations based on the similarity of dermal configurations (finger, palm and sole patterns) may be of great help in the determination. Skin patterns are inherited and have the advantage of being formed five to six months before birth; they do not change thereafter. Twins cannot be separated as to type on the basis of abnormal characters, such as hare-lip, since such anomalies may appear in only one member of MZ twins because of the failure of some inherited conditions to express themselves fully (a condition termed "reduced penetrance"). No acceptable diagnosis of twins can be made subjectively, by merely looking at the twins or their photographs.

In the U.S., Canada and Great Britain about 1 out of every 83.4 births is a twin birth. Reported frequencies throughout the world vary from about 1 in 70 to 1 in 145 births; however, source records from many areas are unreliable. In North America DZ twins are more frequent than MZ twins, the relative proportions being 71.8 to 28.2; similar proportions hold among other populations of European origin.

## OTHER MULTIPLE BIRTHS

As with twins, the other types of multiple births may or may not be monozygotic. Any combination may occur; *e.g.*, triplets may be derived from a single zygote (MZ triplets); from two zygotes, one of which divided to produce MZ twins while the other developed as a singleton (the three constituting DZ triplets); or from three separate zygotes (trizygotic or TZ triplets).

Quadruplets are of five types, as shown below:




Similarly, quintuplets may originate from one up to five zygotes. After careful study the Canadian Dionne quintuplets (born in 1934) were shown to be a one-zygote set. They are the only such set, medically and genetically documented, all of whose members survived infancy.

Of the first 53 authentic recorded cases of quintuplets, only three sets have so far been definitely classified as monozygotic: the Waddingtons (girls, born 1786 in Lower Darwen, Lancashire, Eng.); the Lyons (boys, born 1896 near Mayfield, Ky.); and the Dionnes. Several sets of sextuplets have been born, but not a single member of any set has survived. A memorial to a mother of seven infants born at a single birth was erected in Europe, but the authenticity of the event is doubtful.

An approximate figure for the frequency of multiple births (and one easily remembered) is 1 in 80 births for twins, 1 in $80^2$ for triplets, 1 in $80^3$ for quadruplets and 1 in $80^4$ for quintuplets.

## CONTRIBUTIONS TO GENETICS

Twins who have been diagnosed identical objectively, by criteria based on simple clear-cut patterns of inheritance, are of great

value in genetical research. The reason is that MZ twins have (theoretically) identical genes, while DZ twins have no greater genetic identity than brothers and sisters in general. Information concerning the etiology of disease and the occurrence of anomalies may be obtained by comparing studies of MZ and DZ twins (the "twin method"). For instance, in the study of mental retardation among twins it was determined that whenever one member of a set of MZ twins was afflicted with mongolism, the other member was also a mongol; but with DZ twins, usually only one member was afflicted, while the co-twin was normal. This indicated that a genetic constitutional make-up was involved in the disease—a conclusion later verified through the study of the chromosomes of mongols.

An intensive study of the Dionne quintuplets revolved in part around the question: How alike and how different can five adults become, who began genetically as one person, since the single zygote that normally would have produced a single child, twinned and re-twinned into five individuals? The question is a reasonable one, since differences commonly occur between the right and left sides of a person's face or body. And in fact certain physical differences between the Dionne quints became obvious as they matured, indicating the kinds and degrees of variations to which a constant genetic constitution is subject.

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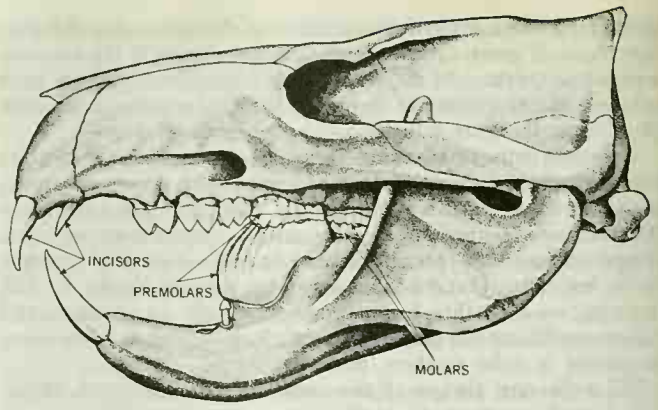
**MULTIPLE SCLEROSIS.** Multiple (disseminated) sclerosis is a disease of the brain and spinal cord caused by an unknown agent that attacks the covering (myelin) sheath of nerve fibres, causing a temporary interruption of nervous impulses, particularly in pathways concerned with vision, sensation and the use of limbs. The hard (sclerotic) patches produced by the disease eventually result in permanent paralysis. Multiple sclerosis has a worldwide distribution, mainly in the northern hemisphere. The highest incidence is in persons in the third decade of life. Diagnosis is hampered by the varying nature and duration of early symptoms, of which the following may appear alone or in combination: temporary mistiness or loss of vision, disturbances of sensation, weakness of a lower limb, unsteadiness in walking, giddiness, double vision and defective control of the bladder. Early symptoms tend to clear up (remission) but are followed by relapses at intervals of months or years with an increasing risk of permanent paralysis. However, occasionally the disease runs a benign course. Since the cause of multiple sclerosis remains uncertain, medicinal treatment is unsatisfactory. Following a relapse, a period of rest in bed and the avoidance of overfatigue and mental stress are advised. Attempts to isolate a living microorganism as a cause of the disease have failed. A form of allergy may be an important causal factor.

*See* D. McAlpine and C. E. Lumsden, *Multiple Sclerosis* (1955); W. N. P. Barbellion, *The Journal of a Disappointed Man* (1919). (D. McA.)

**MULTIPLE SHOPS:** *see* CHAIN STORE.

**MULTITUBERCULATE,** an extinct, small, superficially rodentlike mammal belonging to the order Multituberculata, which constitutes the subclass Allotheria. They existed from the Jurassic period (about 160,000,000 years ago) of the Mesozoic era through the early part of the Cenozoic era. During most of this span (about 100,000,000 years) they were by far the most abundant mammals. There are three subfamilies, but relatively little evolutionary diversification occurred throughout their long history. These small herbivores were characterized by molar teeth with 2 or 3 longitudinal rows of cusps, 5 or 6 cusps in primitive




BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

LEFT LATERAL VIEW OF COMPOSITE RESTORATION OF THE SKULL AND JAWS OF A MULTITUBERCULATE (PTILODUS MONTANUS)

forms and up to 30 in advanced genera. There was a single large lower incisor and three upper incisors, with one enlarged. In most genera the lower premolars were large, compressed, shearing teeth. The multituberculates are not closely related to any other mammals. They apparently arose from the mammallike reptiles independently of other groups of mammals and did not give rise to any other types. *See* also MAMMAL. (E. C. O.)

**MUMFORD, LEWIS** (1895– ), U.S. writer and social critic, known especially for his writings on architecture and urban planning, was born in Flushing, L.I., N.Y., on Oct. 19, 1895, and was educated in New York city. From an early age he devoted himself primarily to writing; later he taught at Stanford university (1942–44), North Carolina State college (1948–52), the University of Pennsylvania (1951–59) and Massachusetts Institute of Technology (1957–60). Beginning in 1920 he contributed to various periodicals a long series of critical essays which established him among the foremost commentators on architecture. He wrote about 20 books, all of them historical in pattern but including many excursions into art, philosophy, economics and religion. His *Sticks and Stones* (1924) and *The Brown Decades* (1931) are in form histories of architecture but their more evocative content is the social relevance that gives architecture meaning. His biographical studies, *Herman Melville* (1929) and *Green Memories* (1947), place their subjects firmly within the context of their eras. In a later work, *The City in History* (1961), the human story is enveloped in a profound understanding of social circumstance and idea. All of these works are informed by Mumford's unshaken faith in the capacity of man for the renewal of his world. (J. HUD.)

**MUMMERS,** bands of masked persons who, during European winter festivals, paraded the streets and entered houses to dance or dice in silence. The name has been connected with words such as mumble, mute, etc., with German *mumme* ("mask," "masker") and with Greek *mommo, mormo* ("a child's bugbear," "frightening mask," "ogress"). Mormo was probably an underworld goddess, resembling the ogress who gave her name to the Perchten runners, German masked mummers who paraded on Twelfth-night.

From the 13th to the 16th century the mumming or momerie was a popular (and frequently prohibited) and sophisticated amusement. John Lydgate composed the earliest extant libretti, but these were probably not intended for recital by the mummers themselves. In 1454 mummers representing 12 virtues were introduced to Philip of Burgundy by their presenter, Grace-Dieu, who handed him a letter explaining their disguises. During the 16th century the elaborate momerie was absorbed into the Italian masquerade and mumming became a purely popular amusement. In Great Britain from at least the 18th century mummers have presented a play, usually at Christmas. There are many variants, but it always contains a fight in which a champion is killed and revived by a doctor. The performers are male, with a fool and man in woman's clothes as stock characters. It is introduced by a presenter and concluded by a collection. Western European and

Balkan analogues suggest a ritual origin.

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**MUMMIUS, LUCIUS,** surnamed ACHAICUS, Roman statesman and general. As praetor in 153 B.C. he defeated the Lusitanians in Spain and celebrated a triumph in 152. Consul in 146, Mummius was appointed to take command of the war in Greece with the Achaean league. On capturing Corinth he massacred the inhabitants, removed all the works of art to Rome, destroyed the city and dissolved the Achaean league. He was the first *novus homo* of plebeian origin who received a distinctive cognomen for military services. His indifference to works of art and ignorance of their value is shown by his well-known remark to those who contracted for the shipment of the treasures of Corinth to Rome, that "if they lost or damaged them, they would have to replace them." In 142 he was censor with Scipio Aemilianus.

**MUMMY,** a dead body preserved by the ancient Egyptian or other method of embalming (Persian *mūm,* wax; later meaning pitch or asphalt).

## EGYPTIAN MUMMIFICATION

In Egypt in prehistoric times the dead were buried, sometimes loosely wrapped in mats or skins, in shallow graves, the body being placed in a flexed position. The hot dry desert sand came into direct contact with the skin and often so completely arrested the process of decay that the hair, skin and soft parts are entirely preserved. This phenomenon of natural preservation was probably made known to the Egyptians through the ravages of grave robbers whose depredations exposed the bodies to view. The discovery that the corpses of the dead did not suffer corruption undoubtedly strengthened, perhaps originated, the belief in the physical survival of the dead, which underlies the practice of mummification throughout the historic period, and prompted the ampler provision of food, utensils and other objects necessary to physical life which were buried with the dead. As the number of objects placed in the grave increased, the grave itself had to be more spacious. But the burial of the dead in roomier graves

BY COURTESY OF THE ORIENTAL INSTITUTE, THE UNIVERSITY OF CHICAGO

**PARTIALLY UNWRAPPED MUMMY OF AN EGYPTIAN WOMAN, 7TH CENTURY B.C.**

or in constructed tombs in which the corpse, no longer embedded in desiccating sand, was in a space filled with air which assisted decomposition, defeated the very object that had inspired the more lavish equipment. The body decayed, and the dead man did not survive to enjoy the objects with which he was surrounded. This probably led to the attempts at artificial preservation.

**Development and Methods.**—It is probable that attempts at mummification were being made at the time of the 1st dynasty, and what seem to be intentionally mummified bodies dating back about 6,000 years were found (1961) in Fezzan Province, Libya. In addition, quite early evidence of such attempts is afforded by a mummy of the 2nd dynasty, which was lying in a coffin in a flexed position, and was wrapped in a complex series of bandages, the innermost of which were corroded by the action of some preservative (probably crude natron) that had been applied to the skin. Similarly treated bodies belonging to the 3rd and 4th dynasties have been discovered. By the time of the 5th dynasty considerable advances had been made. The body was then laid in the extended position and the internal organs were removed through an incision in the left flank, the vacant cavity being filled with linen and resin. The outer wrappings were saturated with resin and the form of the body was then molded into shape, the details of the features being carefully modeled and emphasized by means of paint. During the Middle Kingdom, the art of embalming deteriorated somewhat; owing to the less lavish use of resin and to imperfect desiccation, the mummies of this period are usually very fragile and ill-preserved. There is definite evidence that at this period the custom of macerating the body in a salt bath had been introduced, but no attempt had as yet been made to remove the brain.

In the New Kingdom (18th–20th dynasties) numerous improvements in method were introduced. The brain was removed by forcing a passage into the skull, a better method of desiccation was used which preserved the tissues, and greater skill had been acquired in the preparation and application of the resinous preservative material with which the body was treated. Mummies of many of the kings and other members of the royal family of this period have survived, and although they were partially mutilated by tomb robbers, many of them are excellent specimens of the embalmer's art.

The order of events in the process of making a mummy was as follows: The corpse was taken to a specially erected tent or kiosk, where the operator first extracted the brain and then opened the body by an incision in the left flank. Through this incision all the viscera were removed with the exception of the heart, which was carefully left *in situ.* The body cavity having been washed out, the corpse was doubled into the smallest possible compass and placed in a large jar filled with a solution of salt or natron that reached to the level of the neck. In this jar the body remained for several weeks, during which time the fatty matter was dissolved away, and the whole of the epidermis peeled off, except from the head which was not immersed, and from the fingers and toes where the skin had been previously cut so as to form natural fingerstalls or thimbles of skin in order to retain the nails. Threads or wires were wound round the digits or metal sheaths were placed upon them in order to prevent the nails from becoming detached and lost. The body was then taken out of the jar, washed, straightened and desiccated. The final stages in the process involved the packing of the body cavity and skull with preservatives, plastering the body all over with a paste made of resin and fat, and wrapping it in a complex series of bandages. The internal organs were separately treated and placed in four vases known as canopic jars. The whole process occupied 70 days.

During the 21st and 22nd dynasties the art of mummification reached its highest pitch of perfection. In order to make the body more lifelike, an elaborate system of introducing packing material under the skin was devised. A schematic series of incisions was made in various parts of the body, and through these sand, mud or other material was forced into the space between the skin and the underlying muscular tissue. The material was distributed and molded into shape, and the shrunken contours of the body were thus plumped out into the form they had assumed during life. The use of canopic jars was discontinued, and the viscera were wrapped in linen covers and replaced in the body. The mummy was painted all over with red ochre, the lips and cheeks were rouged, artificial eyes were inserted and, in short, every care was taken not only to preserve the body but to make it complete and lifelike. This distinctive method of embalming was first described in 1906 by G. E. Smith from the examination of 44 mummies of the period. Since then numerous other specimens of the same kind have been examined.

After this period the art declined and, although well-made mummies of the later periods are occasionally found, the embalmer's craft had become superficial and slipshod, and less care was devoted to the body than to the arrangement of the superficial bandages so as to give the mummy a presentable exterior. In the Ptolemaic period, the body was usually merely treated with molten resin, which destroyed the tissues; the resulting mummy was a mere cast of the contours of the body. During the 26th dynasty and after, mummies were sometimes eviscerated *per anum* instead of by the usual flank incision. Mummification survived the advent of Christianity by several centuries. The bodies of this

period were not eviscerated or treated with resin but packed in large quantities of common salt, and are usually well preserved.

**Purposes of Mummification.**—Throughout the period of more than 30 centuries during which mummification was practised in Egypt, the embalmers had two definite objects in view: first, the preservation of the body from decay; and, second, the perpetuation of the personal identity of the deceased. During the Pyramid age the features of the mummy were painted on the outer wrappings, and in some cases a thin layer of plaster was applied to the head and the features painted upon it. In the 11th dynasty, the face and wig were modeled in cartonnage, and this headpiece was placed upon the head of the mummy. The use of cartonnage masks lasted until Ptolemaic times, but out of it was early evolved the anthropoid coffin, on which the features, dress and ornaments of the mummy were elaborately detailed. In Roman times, painted portrait panels were employed. All these measures had one object —the preservation of the dead man's personal identity. That the idea underlying mummification was physical survival is further indicated by the magical ceremonies to which the finished mummy was subjected. These ceremonies, which are usually known as "Opening the Mouth," had for their object the reanimation of the mummy by restoring to it the faculties of which death had deprived it. By means of special instruments and with recitation of formulas, the eyes, mouth and ears of the dead man were opened in belief that he might once more see, speak, eat and hear. The use of his limbs was invoked that he might move and walk, and amulets were said to stimulate the functions of the heart, the spine and the blood. Moisture and warmth were restored to the mummy by the ceremonial use of incense and libations. The funerary banquet which followed was envisaged not as spiritual food but materialistically as physical sustenance to be consumed by the mummy with its restored faculties. (*See* EGYPT: *Ancient Religion.*)

Just as many of the drugs used in ancient Egyptian medicine, even when therapeutic, were originally introduced into the pharmacopoeia for purely magical reasons, so natron, salt and resin, all of which are excellent preservatives, probably were first employed in mummification because these substances were credited with life-giving or life-preserving properties. Natron was used in the daily ceremonies for the rebirth of the sun-god, the life-giving power of salt was a tradition which survived until classical times (*cf.* Plutarch, *Symposiacs,* v, 10) and resin was believed to be the blood or some other bodily emanation of Osiris. When therefore the necessity for artificial preservation of the dead first became apparent, it was natural that the attempt to confer or prolong life should have taken the form of applying to the corpse substances which were believed to possess divine or magical potency to that end. Bitumen does not seem to have been used in embalming. The staple material in all periods was resin, and the fact that resin often has a lustrous pitchlike appearance probably gave rise to the assertion expressed by Strabo (xvi, ii, 45) and repeated by modern writers that the Egyptians used bitumen for their mummies. Modern chemical analysis has failed to discover any trace of bitumen in hundreds of samples of various periods. Neither Herodotus (ii, 85–88) nor Diodorus Siculus (i, 91), in their well-known accounts of Egyptian embalming, makes any reference to bitumen. Their accounts of mummification are on the whole correct although seriously wrong in certain details.

**Mummified Animals.**—In relatively late periods the Egyptians mummified various sacred animals. Large numbers of mummified cats and dogs have been found, but especially elaborate was the ritual employed in embalming the Apis bulls, and their tombs and gigantic sarcophagi are familiar to visitors to Egypt. Among the birds, the ibis, falcon, owl and others have been found, in addition to the preserved remains of various reptiles (especially crocodiles) and fishes. Joints of meat and trussed poultry were mummified and provided with wooden coffins shaped to fit them. The systematic study of the technique of animal mummification by the 1960s was yet to be made.

### MUMMIFICATION IN OTHER REGIONS

Mummification in various forms has had a wide geographical distribution. In some areas, the custom has long been extinct and only tradition remains to attest its former practice, but in others it survived until more recent times, or still persists in a debased form. In studying the technique of mummification in countries from which actual mummies have been obtained, it is interesting to find that many of the arbitrary details of Egyptian procedure are repeated. In the Canary Islands, for instance, the Guanches employed certain methods which are distinctive of the Egyptian technique of the 21st dynasty. They made incisions for packing material under the skin, the sites of these incisions closely corresponding with those of the 21st dynasty Egyptian mummies, and there is a similar distribution of sandy mud in the tissues. In some cases at least, the viscera, which were always removed through a flank incision, were wrapped as parcels and returned to the body. The epidermis was removed from the whole body but carefully retained on the fingers and toes, the nails being tied on in the characteristic Egyptian fashion. Again, in the islands of Torres straits, mummification was practised until modern times. The viscera were removed through a flank incision or by the perineum, the brain was extracted, the body painted with red ochre and provided with artificial eyes. The thimbles of skin on the fingers and toes were cut, but they were pulled off, and thus contradicted the object for which the Egyptians devised them. In Australia, mummification has survived in a debased form. The bodies are flexed and are often painted with red ochre, and in some cases the epidermis is carefully removed from the body even when it is destined for cremation immediately afterward.

In North, Central and South America mummies have been found in various localities, but the most numerous are those of the Inca civilization from Venezuela, Colombia, Ecuador, Bolivia and Peru. It was once believed that the preservation of these Inca mummies was due to natural properties of the soil and climate, and not to artificial measures. But, while the natural conditions in many localities certainly favour preservation, the circumstances in which many of the mummies were discovered, closely wrapped in dense coverings and tightly corded, show that they must have been artificially desiccated before burial. The wrappings prevent contact of the body with the desiccating influence of the soil, and the coverings moreover closely embrace the shrunken contours of the corpse. In many instances mummies have been found which prove to have been eviscerated *per anum* or by an incision in the trunk, and others again are thickly coated with preservative material. Inca mummies are often painted red, and specimens have been examined in which the epidermis had been removed from the whole body except the fingers and toes.

**Mummy as a Drug.**—The belief that Egyptian mummies were prepared with bitumen or asphalt led to the virtues of that substance being transferred to bodies that had been mummified. Throughout the middle ages and until the 18th century, mummies were exported to Europe for sale in the apothecaries' shops, and the material obtained by pounding them was reputed to have great medicinal virtue. In course of time it was forgotten that the supposed value of mummy was due to asphalt, and the virtue was transferred to bodies themselves. This led to the manufacture of spurious "mummy" from the bodies of felons and suicides, and the term was finally applied to medicated flesh in general. In spite of the denunciation of such eminent physicians as A. Paré in the 16th century, the traffic in mummy was continued until the 18th century, and the substance is frequently mentioned in the "dispensatories" of the period. In the orient, mummy is still sold in the drug bazaars. *See* also EMBALMING.

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**MUMPS** (EPIDEMIC PAROTITIS), an acute, contagious viral disease characterized by inflammatory swelling of the parotid and other salivary glands, frequently occurring as an epidemic and affecting mostly young persons. The incubation period is about 17–21 days after contact; danger of transfer begins one week

before the affected person feels sick and lasts about two weeks. The disease generally sets in with symptoms of a slightly febrile cold, soon followed by swelling and stiffening in the region of the parotid gland in front of the ear. The swelling speedily increases and spreads toward the neck and under the jaw, involving the numerous glands in that locality. The condition is often bilateral. Pain is seldom severe, nor is there much redness or any tendency to suppuration. There is, however, great interference with mastication and swallowing. After four or five days the parts return to their normal condition. During convalescence in patients past puberty there occasionally occur swelling and tenderness in other glands, such as the testicles in males (orchitis), and the mammae or ovaries (oöphritis) in females, and rarely involvement of the pancreas, but these are of short duration and usually of no serious significance. Mumps is in general a mild disease and requires no special treatment. The use, especially in adult patients, of gamma globulin prepared from mumps convalescent serum has tended to reduce the incidence of complications.

**MUN, ALBERT,** Comte de (1841–1914), French political leader and orator, a monarchist who expounded Catholic social principles in the first decades of the third republic, was born at Lumigny, Seine-et-Marne, on Feb. 28, 1841. After leaving the military school at St. Cyr, he saw active service in Algeria (1862). During the Franco-German War he took part in the fighting around Metz (1870), where he was taken prisoner. On his release he fought against the Commune of Paris. From the end of 1871, however, he began to devote himself to the formation of Catholic workers' clubs throughout France. He resigned his commission as an army officer in Nov. 1875. Elected to represent Pontivy in the chamber of deputies (1876–78 and 1881–85), he put himself at the head of the Catholic group, in alliance with the monarchists; and he subsequently sat as monarchist deputy for Morbihan (1885–93) and for Morlaix (1894–1910). He favoured "Christian socialism" as against "state socialism." In the name of the monarchist party, in a speech at Romans (Oct. 1888), he publicly declared himself a supporter of Gen. Georges Boulanger (*q.v.*). In obedience, however, to Pope Leo XIII's encyclical of 1892, he declared his readiness to rally to the republican regime provided that it respected religion. He was elected to the Académie Française in 1897. He died in Bordeaux on Oct. 6, 1914. His numerous books include *La Loi des suspects* (1901), *Contre la séparation* (1905) and *Ma Vocation sociale . . .* (1908). An outstanding speaker, he published seven volumes of his *Discours* in 1888–1904.

**MUN, THOMAS** (1571–1641), English writer on economics, who gave the first clear and vigorous statement of the theory of the balance of trade, was baptized on June 17, 1571; he was the son of a London mercer. As a member of the committee of the East India company, and of the standing commission on trade, appointed in 1622, he was a prominent figure in mercantile circles, and well qualified to discuss current economic problems. In *A Discourse of Trade, from England unto the East Indies* (1621), he defended the East India company from the recurring early mercantilistic notion that the export of bullion was harmful to English trade. Mun argued that so long as exports exceeded imports overall, a specific drain of specie from a country had no significance. In his most important work, *Discourse on England's Treasure by Forraigne Trade*, published posthumously in 1664, Mun further developed this idea. He was buried on July 21, 1641.

(D. F. Dd.)

**MUNA,** an island lying south of the southeastern arm of Celebes (Sulawesi), Indonesia, in the province of Sulawesi-Selatan/Tenggara (southeast Celebes). It is 63 mi. long from north to south and 35 mi. wide, separated from Celebes by Tioro strait and from Butung Island by the narrow Butung strait. The surface is hilly, with highest elevations at about 1,400 ft., almost entirely consisting of recently uplifted coral reefs, with many interesting karst forms. There are few streams. In the north and northeast are teak forests. Babirusa, cuscus and wild boars occur. The sparse Muslim population practises a simple agriculture. The main town is Raha, on the northeast coast.

(J. O. M. B.)

**MUNCH, CHARLES** (1891– ), French conductor, member of an Alsatian family of musicians, was born at Strasbourg on Sept. 26, 1891. His father, the organist Ernst Münch (1859–1928), was director of the Strasbourg conservatoire and, with Albert Schweitzer, established Strasbourg as a centre for performances of Bach's choral works. His brother Fritz Münch (1890– ) was a choral conductor, director of musicological studies at Strasbourg university and, from 1929, director of the conservatoire there. Charles Munch studied the violin in Paris with Lucien Capet and in Berlin with C. Flesch. He was professor of the violin at the Strasbourg conservatoire, leader of the Strasbourg orchestra (1919–25) and later leader of the Gewandhaus orchestra at Leipzig. He first appeared as conductor with the Straram orchestra in Paris in 1932. He was conductor of the Paris Philharmonic orchestra (1935–38), the Paris Conservatoire orchestra (1938–46), with both of which he gave many contemporary works, and the Boston Symphony orchestra (1949–62). At Boston he conducted 39 world and 17 U.S. premieres.

From 1951 to 1962 he was director of the Tanglewood Berkshire Music centre at Lenox, Mass. In his later years he became known for his performances of works by Brahms, Debussy and Ravel.

*See* C. Munch, *I Am a Conductor,* Eng. trans. by L. Burkat (1955).

**MUNCH, EDVARD** (1863–1944), Norwegian painter and an outstanding artist of extraordinary sensitiveness, was born on Dec. 12, 1863, at Löten. He was brought up in Christiania (Oslo), where he went to the school of design and was, for a short time, a pupil of the important naturalistic painter Christian Krohg. The principal works of his early period were "The Sick Child" (1886) and "Spring" (1889), both in the National gallery at Oslo, which has an excellent collection of his paintings. Already, from the end of the 1880s, Munch occupied himself with psychological and symbolical themes dealing with the problems of love and death, which were given in the 1890s an expressionistic form and colour of great strength. An important part of his work in these and later years are his woodcuts, etchings and lithographs. From about 1900, and especially after his ultimate return from abroad to Norway in 1909, the symbolic trend is less dominant in his art and the direct contact with nature, which always was of importance to him, is expressed in a very free, vigorous and broad way of painting in bright and rich colours. Nevertheless, the undercurrent of mental agitation, due to his extreme sensitivity, often breaks through. His principal works are the decorations in oil in the Oslo university festival hall (1913; inaugurated 1916). His subjects are mostly Norwegian landscape, figure compositions in interior and in landscape (sometimes alluding to Ibsen), nudes and portraits. Munch has had great influence, especially in central Europe (German Expressionism) and in Scandinavia. From 1916 he lived on his estate near Oslo, where he died on Jan. 24, 1944.

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(S. Wh.)

**MUNCHAUSEN,** Baron. This name is famous in literary history on account of the highly coloured mendacious stories known as the *Adventures of Baron Munchausen,* based on the anecdotes of a certain Karl Friedrich Hieronymus, Freiherr von Münchausen (1720–97) of Bodenwerder in Hanover. He was a passionate hunter, and served with the Russians against the Turks, retiring to his estates in 1760 to live the life of a country gentleman. He became famous around Hanover as a *raconteur* of extraordinary stories of his life as a soldier, hunter and sportsman. A collection of 17 such tales appeared in the eighth and ninth parts of *Vademecum für lustige Leute* (1781–83), all attributed to the baron, although several can be traced back to much earlier sources. But it was Rudolf Erich Raspe (*q.v.*) who gave the tales their international popularity. He had known the baron at Göttingen and when in need of money in London used the stories as material for a small volume published anonymously there by a certain Smith (*Baron Munchausen's Narrative of his Marvellous Travels and Campaigns in Russia,* 1785). A second edition appeared at Oxford in 1786 and later the same year Smith sold the rights to

another bookseller, G. Kearsley, who brought out an enlarged edition with illustrations under the title *Gulliver Reviv'd: the Singular Travels, Campaigns, Voyages and Sporting Adventures of Baron Munnikhousen, commonly pronounced Munchausen; as he relates them over a bottle when surrounded by his friends* (1786). This book went rapidly into several editions, and from the fourth edition the German poet Gottfried August Bürger (*q.v.*) made a free translation into German (*Wundersame Reisen zu Wasser und zu Lande, Feldzüge und lustige Abenteuer des Freyherrn von Münchausen,* 1786), subsequently adding 13 more tales of his own for a *Vermehrte Ausgabe* in 1788. The seventh English edition of 1793 is now the usual text. A *Sequel* appeared in 1792, and the whole collection became widely known and popular. It was translated into many languages and many artists illustrated it (*e.g.,* T. Rowlandson 1809, G. Cruikshank 1867, Gustave Doré 1862). It even formed the basis of a film.

Raspe's original compilation contained only a few authentic tales by the baron and from the start many additions were made by booksellers' hacks, based on Baron de Tott's *Memoirs* (Eng. trans. 1785), the aeronautical exploits of the brothers Montgolfier and François Blanchard and much contemporary news such as James Bruce's explorations in Africa and C. J. Phipps's voyage toward the north pole. The book is therefore a medley of material from all ages, from Lucian's *Vera Historia* and Renaissance anecdotes to 18th-century travels and adventures. Since Raspe's work had been published anonymously, for a long time Bürger was thought to be the original author. Karl Immermann (*q.v.*) based a novel on the character of Munchausen.

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**MÜNCH-BELLINGHAUSEN, ELIGIUS FRANZ JOSEPH,** FREIHERR VON (pseudonym FRIEDRICH HALM) (1806–1871), once Grillparzer's envied rival for popularity as a dramatist in Austria, now remembered for his stories. Born at Cracow on April 2, 1806, he studied at Vienna and rose to high rank in the Austrian civil service. In 1845 he was appointed custodian of the Kaiserliche Hofbibliothek and by 1869 was in charge of the two court theatres in Vienna. He died at Hütteldorf near Vienna on May 22, 1871. His dramas are now forgotten because the characters lack life and their behaviour is poorly motivated; the most celebrated in their day were *Griseldis* (1835), *Der Sohn der Wildnis* (1842; Eng. trans., *Son of the Wilderness,* 1852) and *Der Fechter von Ravenna* (1854; Eng. trans., *The Gladiator of Ravenna,* 1861). His most effective stories were *Die Marzipan-Lise* (1856) and *Das Haus an der Veronabrücke* (written 1862–64). In all his tales he shows both an understanding of psychology and a skill in handling dramatic situations.

*See* introduction and bibliography in *Die Marzipan-Lise,* ed. by L. H. C. Thomas (1957). (L. H. C. T.)

**MUNCIE,** an industrial city of eastern Indiana, U.S., on the White river, 54 mi. N.E. of Indianapolis, is the seat of Delaware county. Its name (originally Munseytown, but changed by the state legislature in 1845) commemorates the Munsee clan of Delaware Indians who had a village near the present centre of the city. After Indians sold the land to the U.S. government and moved west in 1820, white settlers began to arrive. Among them were Goldsmith C. Gilbert, of New York state, the city's founder. In 1825 Gilbert bought one square mile of land and built a cabin and store. When Delaware county was instituted in 1827 he and two other landowners donated land for county purposes and Muncie became the county seat. Muncie was founded in 1827 and was incorporated as a town in 1854 and as a city in 1865.

The first railroad (1852) and the discovery of natural gas (1886) contributed to the city's industrial growth. When gas failed in the late 1890s, the city was economically strong and continued to grow. Pop. (1960) 68,603; standard metropolitan statistical area (Delaware county) 110,938. (For comparative population figures *see* table in INDIANA: *Population.*)

Muncie has numerous and varied industries producing batteries, transmissions and castings, insulators, blocks for building, bottles, steel wire, metal card tables, chairs and lawn furniture. It is a trading centre for 22 counties in eastern Indiana and western Ohio.

In 1962 the Ball Brothers company ended glass manufacturing in Muncie but continued other manufacturing operations and maintained general offices and research laboratories there. Ball State Teachers college, founded in 1918, is named for the Ball family. The college is accredited to offer bachelor, master and doctoral degrees.

Muncie was the locale for the field work of Robert S. Lynd and Helen Merrell Lynd, on which they based their sociological studies *Middletown* (1929) and *Middletown in Transition* (1937).

(R. A. G.)

**MUNDA, BATTLE OF** (45 B.C.), the last victory of Julius Caesar over the Pompeians. Before the end of 46 Caesar left Rome for Spain to crush the revolt led by Pompey's sons Gnaeus and Sextus Pompeius, who commanded 13 legions and held Corduba (Córdoba), the principal city in farther Spain. After failing to bring Gnaeus to battle near this city, Caesar stormed Ategua and forced him to retreat southward. Gnaeus turned to fight at Munda, the site of which is uncertain; it lay probably just north of Urso (modern Osuna), as G. Veith and T. Rice Holmes argue (*see* below), rather than at Montilla south of Ucubi (Espejo), as suggested by A. Schulten. The Pompeians were stationed on high ground above a plain which was crossed by a small stream. After getting over this stream Caesar halted his men, and thus tempted the Pompeians to a battle which they did not decline, since the slope of the ground favoured them and they believed that Caesar's troops had halted through fear. A desperate struggle was fought for hours and at one point Caesar himself had to rush into the thick of it to steady his veteran 10th legion. When Caesar's cavalry were thrown in, Gnaeus Pompeius sent Labienus with a legion from his right wing to support his threatened left, but the Pompeians, misinterpreting this move as the start of a retreat, broke, and victory was Caesar's.

The campaign and battle are described in the *Bellum Hispaniense,* written by an unknown author who may have been, in Macaulay's charitable assessment, "some sturdy old centurion, who fought better than he wrote." At any rate the author was an eye witness, whose command of literary Latin and knowledge of the strategy of the campaign were equally weak.

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**MUNDA LANGUAGES** are the languages spoken by the Mundas, tribal inhabitants of north and central India. This is the smallest (about 5,000,000 speakers) of the three major linguistic families of India, the others being the Indo-Aryan languages (*q.v.*) and the Dravidian languages (*q.v.*). There are several geographical groups: a northern one, which includes Santali, Mundari, Bhumij, Ho, Birhar, Koda, Turi, Asuri, Korwa and Kharia spoken in the Chota Nagpur plateaus of Bihar, Bengal and Orissa. South of this, Juang is spoken in central Orissa and Sora (or Savara) and Gadaba along the Andhra Pradesh-Orissa border. To the west, Korku is found in the Mahadeo hills of Madhya Pradesh.

The northern group, which includes about 88% of all Munda speakers, is the most important. Except for Kharia, all member languages of the group are closely related and are referred to by the single name of Kherwari. Santali is the chief language in the group. Its speakers, the Santals, are largely settled agriculturalists. Literacy among them is high. The language is written in Roman, Devanagari, Bengali and Oriya scripts. It is used as a medium of instruction in primary schools in Bihar, and there are also several Santali language periodicals. Mundari and Ho are next to Santali in number of speakers, followed by Sora and Korku. The remaining languages are spoken by relatively small isolated groups of forest dwellers and are little known.

In the past, Munda languages were more widespread than at present. They have been receding into hills and remote forest areas under the impact of Aryan and Dravidian speech. This process of recession is being accelerated as communications im-

prove. Among the Bhumij of southern Bengal, for example, many have adopted the local Aryan dialect while others retain their language. Intermarriage among the two groups continues.

Historically, the closest relative of the Kherwari languages is Korku. The position of other languages is not certain. Sora and Gadaba seem to form a single group, although their relationship is not as close as that of Korku and Kherwari. Kharia and Juang seem closer to Kherwari than to Sora and Gadaba. The family as a whole is said to be part of the larger family of Austroasiatic languages (*q.v.*), comprising Khasi, Nicobarese, Mon-Khmer and several tribal tongues of Malaya and Burma. The relationship has, however, not been confirmed by systematic study. All Munda languages have been greatly influenced by the surrounding Indo-Aryan and Dravidian tongues. Present vocabularies show a high percentage of loan words. The influence has also extended to phonology and morphology. The retroflex *ṭ* and *ḍ* in Kherwari, for example, seem to be borrowings since they do not occur in either Sora or Korku.

The chief dialect of Santali has nine vowels: unrounded front *i, e, ẹ;* unrounded central *ï, ë, a;* rounded back *u, o, ọ*. The Santali of Orissa has six: *i, e, ë, a, u, o*. Mundari and Korku have five: *i, e, a, o, u*. Sora seems similar to Santali with nine vowels. There are no significant distinctions between long and short vowels in any of the languages.

The consonant systems distinguish between voiced and voiceless and aspirate and nonaspirate stops and affricates. Santali has the following: *p, ph, b, bh, t, th, d, dh, ṭ, ṭh, ḍ, ḍh, c, ch, j, jh, k, kh, g, gh*. Korku and Sora lack retroflex *ṭ, ḍ, ṭh, ḍh*, but they have significant glottal stop *ʔ*. At the end of a word, stops in all languages have unreleased and glottalized variants (sometimes referred to as checked consonants). *ʔ* is the word final variant of *k* in Mundari and Santali. Santali and Mundari have three nasal consonants: a labial *m*, a dental *n*, a velar *ṅ*. Korku and Sora show an additional palatal *ṅ*. In Mundari and Santali *ṅ* is a nonsignificant variant of *ṅ*. Other consonants are: spirants *v* (confined to Santali), *s* and *h;* a lateral *l;* a trill *r* and a retroflex *ṛ* with varying pronunciation. Santali, Sora and Korku have the semivowel *y;* Korku also has *w*.

Accent is predictable everywhere except in Korku, where syllables show two tonal distinctions, high tone and low tone (reflections of an old voiceless velar stop). All languages show a large number of diphthongs. Consonant sequences are rare, except in the middle of a word.

Munda grammar distinguishes two main classes of words: nouns and verbs. Both are formed from roots by addition of affixes (*i.e.*, suffixes, infixes, prefixes). The same root may function as a verb or a noun, depending on the affix, *e.g.*, *kombṛo*, "thief," *kombṛo-ket-a-e*, "he stole." Derivatives can also be formed from each root by means of affixes, *e.g.*, *dal*, "strike," *dapal*, "strike each other," *bar*, "two," *banar*, "both."

Nouns fall into two gender classes, animate and inanimate (except in Juang and Kharia). They show three numbers (Sora has two): singular, dual and plural. Number, time, possession and other relationships that are expressed by case forms in other languages, are indicated by suffixes or by particles following the noun, *e.g.*, *hoṛ*, "man," *hoṛ-ko*, "men," *hoṛ-kin*, "two men," *hoṛ-ak*, "of the man," *hoṛ sẹlẹt*, "together with the man." Personal pronouns have special forms in the dual and plural indicating whether or not the speaker is included.

The typical Santali verb construction consists of a base plus a suffix, indicating tense and voice, followed by *a*, the finite verb affix. The verbal base may consist of a single word or of two or more words, *e.g.*, *dak-et-a*, "(it) is raining," *nêl-ok-a*, "(it) will be seen," *dal oco-et-a*, "(it) is causing to see," "(it) is showing." Additional tense distinctions are expressed by means of auxiliaries: *dak-et tahekan-a*, "(it) was raining." Animate subjects and objects are shown in the verb construction. The subject indicator is inserted either after the *a* affix or after the word immediately preceding the verbal base. The object is shown by an infix following the base, *e.g.*, *ako idi-e-a-ko* or *ako-ko idi-e-a*, "they take away-him-finite verb affix-they" ("they take him away"). Verbal systems in other languages are similar. Korku does not have subject suffixes; Kharia and Juang show neither subject nor object in the verb.

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(J. J. G.)

**MUNDA PEOPLES** comprise about ten more or less distinct tribal groups inhabiting a broad belt in central and eastern India; they numbered approximately 5,000,000 in the 1960s. In the Chota Nagpur plateau in southern Bihar, adjacent parts of West Bengal and Madhya Pradesh, and the hill districts of Orissa they form a numerically important part of the population.

Dominant Munda physical characteristics are proto-Australoid; distinguishing features are dolichocephalic head form, relatively short stature, dark skin, wavy to curly hair, broad flat nose and well-marked supraorbital ridges. Since this general type is prominent among many other tribal groups in central and south India, and forms an important element in the lowest Hindu castes, no marked differences in physical type distinguish the Munda peoples as a separate group.

Munda history and origins are matters of conjecture. The territory they now occupy was until recently relatively difficult to reach, marginal to the great centres of Indian civilization, hilly, forested and relatively poor for agriculture. It is believed that they were once more widely distributed and retreated to their present homelands with the advance and spread of peoples with a more elaborate culture. Nevertheless, they have not lived in complete isolation and share (with some tribal variation) many culture traits with other Indian peoples. Most Munda peoples are agriculturists, but the Birhor, a small and dwindling group in Chota Nagpur, are hunters and food gatherers, who supplement a meagre livelihood by selling forest products; a few tribes or tribal segments in Orissa practise slash-and-burn cultivation. Along with their language all these groups have tended to preserve their own beliefs, values and a sense of separate identity.

At present the process of Munda assimilation to the larger Indian society, facilitated by improved communications and the introduction of a formal system of education under the British, is being accelerated under the independent government of India. The Munda-speaking peoples, with the other Indian tribal groups, are being encouraged to adopt new customs and to become fully participating members of Indian society. *See* also MUNDA LANGUAGES; KORKU; SANTAL; BIHAR; HO.

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(D. M. SP.)

**MUNDAY, ANTHONY** (1560–1633), English poet, dramatist, pamphleteer and translator, whose importance as a predecessor of Shakespeare was only understood in the 20th century, was born near St. Paul's cathedral, London, probably in the autumn of 1560. His father, a London stationer and draper, and his mother were both dead by Dec. 1570. Munday had some experience as an actor before he was 16, when he was apprenticed to a well-known printer. Soon afterward he commenced to write, but no copy has survived of his first publications, which included the romance of *Galien of France*, probably a translation, in 1578. After 1579 his writings streamed from the press; they included popular ballads, some original lyrics of great charm, much tedious moralizing in verse, translations of many volumes of French and Spanish romances, prose pamphlets some of which are still of historical interest, a number of edifying or moral works, but only two of his many plays. His writings were apparently the product of his leisure, at least until about the year 1600. In 1578 he was abroad, evidently as a secret agent sent to discover the plans of English Catholic refugees in France and Italy. Under a false name he obtained admission to the English college at Rome, remaining for several months as one of "the pope's scholars" in training for the reconversion of England. On his return he renewed his connection with the stage. In 1581–82 he was prominent

in the capture and trials of the Jesuit emissaries who followed Edmund Campion to England, many of whom he had known at Rome. He also wrote several pamphlets, apparently with official approval, justifying the prosecution of the Jesuits and incidentally giving valuable autobiographical information. His *English Romayne Lyfe* (1582) is of permanent interest as a detailed and entertaining description of life and study in the English college at Rome; although his account is hostile, its authenticity is confirmed by numerous Catholic reports of the same events. By 1586 he had been appointed one of the "messengers of her majesty's chamber," a post he seems to have held for the rest of Elizabeth I's reign.

Little is known about Munday's career as actor and playwright, the chief focus of modern interest in him. After his journey to Rome he made some attempts to act extempore like the Italian players. He was writing for the theatre, and with success, before any of the "university wits" except John Lyly and George Peele. His *Fedele and Fortunio* (1584 at latest) is a clever adaptation of Luigi Pasqualigo's *Il Fedele;* it was played at court and was printed in 1585. *John a Kent and John a Cumber,* his earliest surviving original play, was written not later than 1590 and very probably before the middle of 1589. He was apparently the only early Elizabethan dramatist who continued to write successfully for the theatre after Shakespeare's rise in the mid-1590s. Francis Mere's *Palladis Tamia* mentions him as a busy and popular dramatist in 1598, and he was still receiving commissions from Philip Henslowe in 1602. It is difficult to tell whether his four extant plays show him at his best, but he was clearly a playwright with whom no contemporary need have disdained to collaborate. Thus special interest attaches to the fact that he was the scribe of the original version of *Sir Thomas More,* one of the alterations to which is widely believed to be in Shakespeare's handwriting. From the late 1590s until at least 1623, he wrote many of the pageants with which lord mayors of London celebrated their entry into office. His connection with the City became closer still after he undertook to revise his friend John Stow's *Survey of London* (1598), of which he published an expansion in 1618, and completed a further enlargement just before his death. He was buried in St. Stephen's, Coleman street, on Aug. 9, 1633.

*See* Celeste Turner, *Anthony Mundy* (1928), the fullest account, it collects much useful material, especially bibliographical, but its conjectures need correcting. *See* also I. A. Shapiro, "Mundy's Birthdate," in *Notes and Queries,* new series, 201 (1956), "The Significance of a Date," *Shakespeare Survey,* 8 (1955). (I. A. S.)

**MUNDELEIN, GEORGE WILLIAM** (1872–1939), U.S. cardinal and archbishop of Chicago, was born in New York city on July 2, 1872. He received his education at Manhattan college and St. Vincent seminary, Beatty, Pa., subsequently proceeding to Rome and studying theology at the Urban College of the Propaganda in that city. He was ordained priest on June 8, 1895, at Rome, and became secretary to the bishop of Brooklyn, N.Y., and pastor of the Lithuanian church, being made chancellor of the diocese in 1897. He was appointed auxiliary bishop of Brooklyn, with the titular see of Loryma, in 1909 and became archbishop of Chicago on Nov. 30, 1915. He was created a cardinal by Pope Pius XI on March 24, 1924. Mundelein was a prominent figure at the Eucharistic congress held in Chicago in June 1926. He died Oct. 2, 1939, at his home adjoining the Seminary of St. Mary's of the Lake, founded by him at Mundelein, Ill., a town near Chicago named in his honour.

**MUNDY, WILLIAM** and **JOHN**, English musicians, father and son.

WILLIAM MUNDY (*c.* 1529–*c.* 1591), composer of sacred music. In 1543 he was head chorister of Westminster abbey. He became a vicar-choral at St. Paul's cathedral, London, and in 1564 a gentleman of the Chapel Royal. His place at the Chapel Royal was filled in 1591, and it seems probable that he had died sometime before this date. It is not impossible that Mundy had Catholic sympathies; the greater part of his surviving music consists of works to Latin texts—about 22 motets and 2 masses. The motets are written in the broad polyphonic style of pre-madrigalian English music. His surviving English church music includes two services and six anthems, of which "O Lord, the Maker of All Thing" is today one of the best-known pieces of Elizabethan church music.

JOHN MUNDY ( ? –1630), composer and organist, born possibly between 1550 and 1554. In 1585 he was organist of Eton college and also one of the organists at St. George's chapel, Windsor. He took his bachelor of music degree at Oxford in 1586 and his doctorate in 1624. He died at Windsor in 1630.

Mundy was essentially a composer of the period preceding the English madrigal. The few Latin works by him that have survived (all apparently incomplete) are often deeply expressive. About 20 anthems also survive, many of which are incomplete. Some of his best-known works, printed in *Songs and Psalmes* (1594), approach the style of the English madrigal and are pleasantly but unambitiously fluent. Mundy's surviving instrumental works include a few *in nomines* as well as four complete keyboard works in the Fitzwilliam virginal book. Among the latter is a programmatic fantasia with sections labeled "Faire wether," "Thunder," "Lightning," etc.; these keyboard works are disappointing and reveal a lack of descriptive musical imagination and a weakness in devising climaxes in keyboard style. (DA. C. B.)

**MUNICH** (MÜNCHEN), a town of Germany which after partition of the nation following World War II was the capital of the *Land* (state) of Bavaria, Federal Republic of Germany. It lies on the gravel banks of the Isar river, which flows through the middle of the town. It is 25–37 mi. from the edge of the Alps and 1,700 ft. above sea level. The average annual temperature is about 7° C. (45° F.). Pop. (1961) 1,085,014.

**History.**—The oldest form of the name Munich is Munichen, *i.e.,* the home of the monks; the town traces its origin to the Benedictine foundation at Tegernsee. Henry the Lion granted it the right to hold a market in 1157–58 and he therefore may be held to be Munich's real founder. In 1255 Munich became the home of the Wittelsbach family, and for 700 years, until the 1918 revolution, the Wittelsbachs remained closely connected with the town's destiny. The emperor Louis IV, called the Bavarian, in the 14th century; Maximilian I, elector of Bavaria, in the 17th; and Louis I, king of Bavaria, in the 19th, played particularly important parts in the history of the town. Louis the Bavarian expanded the town to a size at which it remained up to the end of the 18th century. The economic advance and prosperity of Munich lasted until the beginning of the Thirty Years' War, which brought a short occupation by Gustavus Adolphus in 1632 and a plague epidemic in 1634–35. During this time the population was reduced by one-third. In 1791 the gradual demolition of the fortifications was begun. In 1808 Friedrich von Sckell and Karl von Fischer produced a magnificent building plan for the Max and Ludwig suburbs. In 1800 the population was 40,000, and a year later the first Protestant was admitted to citizenship in what had been until then a purely Roman Catholic town. Since 1821 Munich has been the seat of the archbishop of München-Freising.

In 1854 Munich became a "city" with a population of 100,000 and in 1900 it exceeded 500,000. The city was the scene of Hitler's political activity in the 1920s. It was there that he joined the Nationalsozialistische (Nazi) Deutsche Arbeiter Partei and became its leader, held vast mass meetings in the square, and organized his first party army. The beer cellar can still be seen where he held meetings which led to the *Putsch* against the Bavarian authorities on Nov. 8, 1923. In this cellar too, an attempt was made on Hitler's life with a bomb in 1939 on the anniversary of the *Putsch,* the explosion occurring shortly after he had left the cellar. In World War II nearly 50% of Munich's buildings were destroyed but most of the damage was subsequently repaired.

**The Town.**—The old town is clustered round the ancient crossroads formed by Tal, Kaufinger- and Neuhausstrasse, running east and west, and by Theatiner-, Wein- (or Residenz-), Diener- and Sendlingerstrasse, running north and south. The old town has become more and more of a business centre and has lost much of its ancient character. Some of the old buildings still stand, though damaged in World War II, and among them are three of the seven town gates—Karlstor, Sendlingertor and Isartor, all dating from the 14th century—and medieval buildings such as the cathedral (1468–88), the centre of the city's religious life, and the old town

WERNER GORTER—PIX FROM PUBLIX

A VIEW OF MUNICH: THE TOWER OF PETERSKIRCHE, RECONSTRUCTED AFTER WORLD WAR II, IS A NOTABLE LANDMARK

hall (1470–80), in the Marienplatz, with its beautiful wooden barrel vault. The Peterskirche, the oldest church in the town, was completely destroyed in World War II but has been rebuilt almost in its original form; the Salvatorkirche, a medieval building, is now a Greek Orthodox church; the Heiliggeistkirche, the former arsenal of the town in Jakobsplatz, is now the municipal museum and in it are the ten original Maruska (morris) dancers carved in wood by Erasmus Grasser for the town hall; and the house at Burgstrasse no. 5 is the only remaining Gothic private house. The oldest of the Wittelsbach residences, the 15th-century Alte Hof, has retained its medieval appearance to a great extent. A later residence, the Neue Veste, lies between the Hofgarten and Max-Josef-Platz. The original building dates from 1385, but the style of every period up to the 19th century was tried out on it with superb effect; it was destroyed in World War II but it was planned to rebuild it as far as possible in its original form. Of the Maxburg, built in 1590 by Duke William V, only one tower remains; a modern steel and concrete building now stands in its place. The Renaissance left behind it the Münzhof, at one time the duke's art gallery and stables (1563–67). The Michaelkirche (1583–97) is considered to be the most important Renaissance church in Germany.

The old town is predominantly baroque and rococo. Italian models inspired the Theatinerkirche, the Dreifaltigkeitskirche and the Bürgersaal (all built around the beginning of the 18th century). St. Michael in Berg am Laim, the Johann-Nepomuk-Kirche and the Residenztheater were built in the first half of the 18th century. This theatre, in the Neue Veste, was destroyed in World War II but the costly interior decorations were saved and it was rebuilt in its original form and reopened in 1958. Outside the town walls were built summer castles: Nymphenburg, with the little rococo jewel Amalienburg, and Schleissheim. The Bavarian landed gentry and court nobility built their houses round the court at the same time early in the 18th century. Of these the Peysing-Palais, the Portia-Palais and the Palais Holnstein still remain.

Munich received the first great impetus to expand beyond the old town through the magnificent building and artistic development under King Louis I. He had the monumental Ludwigstrasse built, between Siegestor and Feldherrnhalle, and in it were the state library, the Ludwigskirche and the university. Other work commissioned by Louis I were the Königsplatz with the Glyptothek, which houses a collection of ancient and modern sculpture, the Propyläen, the Staatsgalerie, the Alte Pinakothek, containing one of the great European collections of paintings, the Bonifazius-Basilika, the king's apartments and the court banqueting hall. Louis' son, Maximilian II (1848–64), built the Maximilianstrasse with the Maximilianeum, today the seat of the Bavarian *Landtag* (diet). In addition to the university, which was moved from Landshut to Munich in 1826, there are a technical college and academies of art and music.

Since the middle of the 19th century Munich has become, to an ever increasing degree, a town for exhibitions and congresses. It is also an important industrial city, manufacturing precision instruments, optical and electrical appliances, vehicles, chemicals, cigarettes and beer. Munich is a trade centre, connected by rail to all the main towns of Germany and Austria. There are three *Autobahnen*, one to France at Karlsruhe, one to Austria at Salzburg and one to Berlin. Munich is a seat of great banking houses, a wholesale market that has one of the biggest turnovers for fruit and vegetables from south and southeast Europe and a vast slaughterhouse and stockyards.

*See* also references under "Munich" in the Index. (ML. S.)

**MUNICH, CONFERENCE OF** (1938), the meeting between the British and French prime ministers Neville Chamberlain and Edouard Daladier and the German and Italian dictators Hitler and Mussolini whereby a war over Czechoslovakia was averted less than one year before the outbreak of World War II (*see* CZECHOSLOVAKIA: *History*).

Hitler had secretly announced to his military chiefs on Nov. 5, 1937, his determination to destroy Czechoslovakia. After that, he had inflamed the discontent of the Sudeten Germans against the Czechs by every device of propaganda. In May 1938, shortly after annexing Austria, he gave secret military orders for an attack upon Czechoslovakia to be prepared for Oct. 1 of that year at the latest; and he used the Nazi party congress at Nürnberg (Sept. 6–12) to denounce the policy of the Czechoslovak president, Edvard Benes, before the world.

Czechoslovakia was allied to France by the treaty signed in Paris on Jan. 25, 1924, and to the U.S.S.R. by the treaty of mutual assistance concluded in Prague on May 16, 1935. The latter treaty contained a provision that the U.S.S.R. would go to Czechoslovakia's help in the case of an aggression only if France did the same. Great Britain was not committed to defend the territorial *status quo* in central or eastern Europe but, as a guarantor of the Franco-German frontier, was disturbed by the possibility of a Franco-German war caused by a German attack on Czechoslovakia. Accordingly Chamberlain, whose emissary, Lord Runciman, had failed in his attempt to mediate between the Czechs and the Sudeten Germans (Aug. 1938), persuaded the French to join with him in proposing to the Czechoslovak government on Sept. 19 that Czech territory with more than 50% of its population speaking German should be surrendered to Germany. After at first refusing, the Czechoslovak government with infinite reluctance agreed to this proposal on Sept. 21; but when Chamberlain saw Hitler next day at Godesberg, the German ruler, whose forces were mobilizing, said that this cession would no longer satisfy him. War seemed imminent and Chamberlain on Sept. 27 appealed to Mussolini to intervene.

On Sept. 28 Mussolini proposed to Hitler by telephone to delay his attack upon the Czechs, pending an immediate conference between Italy, Germany, Great Britain and France; Hitler offered Munich or Frankfurt as a meeting place, and Mussolini chose Munich. This four-power conference about Czechoslovakia, in Germany and without the U.S.S.R., was in itself a success for Hitler.

Hitler, Mussolini, Chamberlain and Daladier met in Munich shortly after midday on Sept. 29; the first two had already been in consultation. When Chamberlain proposed that Czechoslovakia should be represented Hitler would not hear of it. Mussolini then put forward a proposal the Germans had been willing a day earlier to accept, that is to say, a plan for the cession by Czechoslovakia to Germany of all its "predominantly German" territory: plebiscites were to be organized in disputed areas by the end of November by an international commission representing the four conference powers. Hitler agreed on condition that the cession should be carried through between Oct. 1 and Oct. 10 without the destruction of any installations. The agreement was rushed through and signed at 1:30 A.M. on Sept. 30, 1938.

Great Britain and France repeated their offer of Sept. 19 to guarantee what remained of Czechoslovakia, but Germany and

Italy declared that the claims of the Poles and Hungarians must be dealt with before they could give any guarantee. In the end all talk of plebiscites was dropped; and though Hitler had repeatedly said that he wanted no Czechs, 725,500 of them came under his rule with no minority rights. He had also repeatedly said that he would have no further claim upon the Czechs.

On Oct. 1 Chamberlain asked Hitler to sign an agreement in favour of applying the "method of consultation" to all questions concerning Great Britain and Germany. Thereupon he returned to London claiming that he had brought "peace for our time." Less than six months later Hitler tore up the Munich agreement by occupying Prague; and on Sept. 1, 1939, he attacked Poland. As a result, the word Munich became a symbol for the appeasement of dictators. *See* also EUROPE: *History.*

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**MUNICIPALITY.** In the United States a municipality is an urban unit of local government. It is one of five basic types of local government; the other types are counties, townships, school districts and special districts. A municipality, according to the U.S. bureau of the census, is a political subdivision of a state within which a municipal corporation has been established to provide general local government for a specific population concentration in a defined area. A municipality may be designated as a city, borough, village or town, except in New England states, New York and Wisconsin where "town" relates to an area subdivision of the county or state.

Municipal corporations are organized under the applicable state constitution and laws, with powers of government expressly or implicitly conferred by state constitution, state laws or charter. These powers are exercised by a governing body elected by the people. Each state sets its own legal requirements for incorporation. The states have set up restrictions designed to prevent the incorporation of territory not truly urban in nature. A municipality therefore is the response of the state government to the need for certain public services in addition to what is available from the other local governments in the area.

**Europe.**—The law in many European countries provides for one type of local government unit to which the term municipality may be applied. The same legal provisions usually apply to all municipalities, but in a few cases a special charter may be given to one or two of the largest cities. The system of the uniform type of municipality exists in France (*commune*), Italy (*comune*), the Low Countries (*Gemeente*) and in most of the Scandinavian countries. Several other European countries, the most important of which are Great Britain and Germany, have a diversified system of local government in which several different categories of local government units exist.

In Great Britain the term "municipality" is in general used only for the large boroughs (municipal corporations). *See* also CITY; CITY GOVERNMENT; CITY MANAGER; COMMUNE (OF PARIS, 1871); COMMUNE (MEDIEVAL); BOROUGH; LOCAL GOVERNMENT; HOME RULE (MUNICIPAL). (O. F. N.)

**MUNICIPAL OWNERSHIP:** *see* PUBLIC ENTERPRISE.

**MUNICIPIUM,** connected with Lat. *municeps*, a compound of *munus*, "service," and the root of *capere*, "to take." The jurist Ulpian defined it as "participating" in the performance of services, but it may mean simply "undertaking" them. Both *municeps* and *municipium* were originally applied to non-Roman individuals and communities who were performing the burdens but not sharing the privileges of Roman citizens; later the terms were used of organized communities in the empire of Latin or Roman right.

The original *municipia* were probably communities which received *civitas sine suffragio* such as Caere, the first of these (*c.* 353), Capua, Fundi and Formiae, to whom it was given as an honour and a reward. The system was extended widely in and after the settlement which followed the Latin war (340–338), even to conquered rebels such as Anagnia (306), and came to be regarded as an inferior and limited franchise, given as a penalty. The distribution of these communities suggested to P. Fraccaro that in the 4th and early 3rd centuries Rome was using them to build a defensive barrier from Campania to Etruria. These communities exercised the private rights of Roman citizens, commerce, intermarriage with Romans, etc., and performed such duties as military service (probably drawn from special lists), but could not vote or hold office. They all retained some degree of local autonomy according to the circumstances in which they had been incorporated. Prefects appointed by the praetor in Rome visited these *municipia* as they did the rest of the Roman territory and satisfied judicial needs. The survival of a wide variety of local magistracies —aediles, praetors, dictators, *octoviri*—reveals how within the Roman system the principle could become established that for Roman citizens political life in their own *municipia* was not incompatible with that in Rome. The *civitates sine suffragio* were gradually advanced to full citizenship but it remains uncertain whether all had been promoted before the social war (*i.e.*, war of the *socii* or allies; 91 onward). Meanwhile, Latin communities had come to be termed *pro municipiis*, and the term began to mean an autonomous community.

Extension of citizenship throughout Italy as a result of the social war made all the former Italian and Latin communities and tribes *municipia* of Roman citizens. *Municipia et coloniae* became a term for "all of Italy." New *municipia*, distinguished largely by the appearance of *quattuorviri*, became numerous in the enlarged Roman territory. *Municipia* tended to change to a normal form of organization, and the old city territory was steadily municipalized, a process that probably began with Sulla and was largely completed under Julius Caesar with the extension of citizenship to Transpadane Gaul.

The development of *municipia* in the provinces is a chapter in the history of romanization. Native communities in Gaul, Spain and Africa, when sufficiently advanced, would first become *municipia* with Latin rights (*q.v.*), receive a Roman municipal charter and later be promoted to Roman status. The process advanced quickly under Caesar and Augustus and subsequent emperors, until Vespasian could give Latin rights to the whole of Spain, and in the 2nd century these provinces were fully urbanized. But in the northern provinces it went more slowly and never fully superseded the native tribes and cantons. The prestige of Rome and the desire to imitate Roman forms often led *municipia* to ask for fictive colonial status, thus assimilating themselves fully to Roman law and removing the vestiges of their non-Roman origin. Caracalla's grant of Roman citizenship to the empire (212) made the difference largely one of title. *Municipia*, officially entitled such, remained a form largely peculiar to the Latin-speaking provinces, found rarely and late in the Greek-speaking east.

The series of laws and charters upon which knowledge of municipal constitutions largely depends dates from the time of Caesar and Vespasian and presents rather the general pattern fostered by the central government than the original variety of organization of the Italian towns. This pattern was common to *municipia* and colonies and in general imitated Roman precedents. The *quattuorviri iure dicundo* often split into *duoviri iure dicundo* in charge of justice and *aediles* or *duoviri aedilicia potestate* in charge of building and construction. There were quaestors in charge of finance. Qualifications were free birth (except in Caesar's foundations), a minimum age and a minimum property rating. There were also municipal priests. The magistrates were elected by an assembly organized in *curiae*, consisting of the citizens but with one *curia* allotted to residents, who might be either natives living on the territory or citizens of other towns. It was most active in elections but could pass resolutions with the *ordo* (council) and vote on patrons. In most cases, however, popular action became a form. The council (*see* DECURIO) had the chief part in determining local political and financial arrangements and eventually surpassed magistrates and assembly in authority. Higher jurisdiction was reserved to the Roman authorities. Each community was bound to perform services to the imperial government, such as the contribution of men and horses for military service, maintenance of the post (until Hadrian) and entertainment of Roman officials.

To the development of municipal life in general was due the great social and economic development in the provinces of the empire. Each community according to its means supplied its

citizens with services and amenities: the maintenance of cults, both of the ancient gods and the often expensive cult of the emperors, as well as of local native deities who survived in a pure or assimilated form; provision for police protection, public education and physicians; special care for supplies of food and water which often involved much building and great expense; public games, and works such as the paving of streets and the provision of baths and aqueducts. And on provincial towns unless they were tax-exempt or had Italic right fell the burden of imperial taxes and requisitions. To meet these demands they resorted little to direct taxation but depended on the proceeds of the city territory, or lands, often quite distant, which had been assigned to the city, and mines, quarries and forests if they had such, export and import taxes, fines, rents from public buildings, sale of public monopolies; but one of the chief sources of income was the services and benefactions of the wealthier *municipes* themselves. These were of two types, those connected with the attainment of offices of dignity, termed *honores*, and those termed *munera* which were regularly demanded though no honour ensued. The generosity with which these were carried out and the multitude of private benefactions and foundations attest, at least for the upper classes, their local patriotism and the economic development of the cities in the high empire. In fact, excessive expenditures for honours and amenities led to the appointment, beginning with Trajan, of imperial officers to regulate their finances.

But in the later empire declining economic conditions weakened the position of the towns as agricultural markets and as commercial and industrial centres for their areas. The official classes (*curiales*) were gradually weakened by demands for *munera* in the towns, responsibility for the increasing taxes and requisitions of the central government, withdrawal of lands from the *municipia* to senatorial and imperial estates, and the frequent disorder and pillage. The army consisted more and more of foreigners and the townsmen became a lower caste bound to the duty of taxpaying and production for state demands.

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**MUNK, KAJ HARALD LEININGER** (1898–1944), Danish playwright, priest and patriot who was a rare exponent of religious drama with a strong sense of the theatre and a passionate quality in his writing not often found among his fellow countrymen. He was born at Maribo on Jan. 13, 1898, and studied at Copenhagen university, where he began his first produced play, *En Idealist* (1928; Eng. trans., *Herod the King*, 1955). This was originally misunderstood by the critics, although ten years later it was received with acclamation.

In 1931 he achieved success with *Cant* (on the rise and fall of Anne Boleyn), and the impression made by *Ordet* (1932; *The Word*, a miracle play set among Jutland peasants) established him as Denmark's leading dramatist. For his principal character he often chose a dictator or "strong" man whom he showed struggling, in vain, against God. This gave Munk opportunity to preach, and to show that he could do this as effectively from the stage as from the pulpit.

*En Idealist*, *Ordet* and *Han sidder ved Smeltediglen* (1938; Eng. trans., *He Sits at the Melting-Pot*, 1944; a drama of Hitler's Germany) are his three best plays, though several others, such as *Cant*, *Kaerlighed* (1926) and *I Braendingen* (1929) remain popular. Kaj Munk was a conscientious and much-loved parish priest, and during World War II his bold, outspoken sermons, many of which were printed, drew masses to the ranks of the Resistance and led to his murder near Silkeborg by the Nazis on Jan. 4, 1944.

*See* R. P. Keigwin (ed. and trans.), *Kaj Munk, Some Examples of His Work* (1944), *Five Plays by Kaj Munk*, with preface and translations (1955). (R. P. KN.)

**MUNKÁCSY, MIHÁLY VON** (originally MICHAEL LIEB) (1844–1900), Hungarian painter, was born at Munkács on Feb. 20, 1844. He was apprenticed to a carpenter in 1855, but shortly afterward made the acquaintance of the painters Fischer and Szamossy, whom he accompanied to Arad in 1858. About the end of 1867 he was working at Düsseldorf, where he painted (1868–69) "The Last Day of a Condemned Prisoner," exhibited in the Paris Salon in 1870. He had already paid a short visit to Paris in 1867, but in 1872 he settled there permanently. Munkácsy's other chief pictures are "Milton, Blind, Dictating *Paradise Lost* to His Daughters" (Paris exhibition, 1878; now in the New York Public library), "Christ Before Pilate" (1881), "Golgotha" (1883), "The Last Moments of Mozart" (1885), "Árpád, Chief of the Magyars, Taking Possession of Hungary," exhibited at the Salon in 1893. His style was semirealist, semiacademic. He died on April 30, 1900.

**MÜNNICH, BURCHARD CHRISTOPH,** COUNT VON (1683–1767), Russian army officer and statesman, of German origin, whom Frederick the Great of Prussia described as "the Prince Eugene of the North," was born on May 19 (new style; 9, old style), 1683, at Neuenhuntorf in Oldenburg. After service in the French and Polish-Saxon armies, he came to Russia in 1720 and was entrusted by Peter the Great with the construction of the Ladoga canal. In 1728 the emperor Peter II made him count and appointed him commander in chief of the Russian army; and in 1732 Münnich became field marshal and president of the war council. In 1734, during the War of the Polish Succession, he captured Gdansk. In 1736 he began the three-year Turkish campaign which made his reputation as a military leader: he invaded and devastated the Crimea and took Ochakov in 1737, won the decisive battle of Stavuchany, near Khotin (Hotin) in northern Bessarabia, on Aug. 28 (N.S.), 1739, and established himself in Moldavia.

Münnich now came forward as the political rival of Ernst Johann Biron (*q.v.*), duke of Courland, whom he arrested and sent to Siberia in Nov. 1740. However, after the *coup d'état* of Dec. 1741, which brought about the accession of the empress Elizabeth, Münnich himself was arrested, sentenced to death, reprieved and sent to Siberia. He remained there until 1762, when he was released by the emperor Peter III. Catherine II employed the old field marshal as director general of the Baltic ports. He died in St. Petersburg on Oct. 27 (N.S.; 16, O.S.), 1767.

*See* M. Vischer, *Münnich: Ingenieur, Feldherr, Hochverräter* (1938).

**MUÑOZ-RIVERA, LUIS** (1859–1916), Puerto Rican commissioner at Washington (1910–16), was born at Barranquitas, Puerto Rico, in 1859. In 1889 he founded the newspaper *La Democracia*, the purpose of which was to obtain Puerto Rican autonomy from Spain, and he soon became a leader in the autonomist parties. In 1897 Puerto Rico was given home rule, and Muñoz-Rivera was first secretary of state and later president of the first Autonomist cabinet. He resigned in 1899 and spent most of the rest of his life in the United States, urging measures to help his country. He died in 1916, just before successful completion of his campaign for passage of the Jones bill, which gave Puerto Rico a large measure of self-government.

**MUNRO, HECTOR HUGH** (pseudonym SAKI) (1870–1916), Scottish writer, whose stories depict the Edwardian social scene with a flippant wit and power of fantastic invention used both to satirize social pretension, unkindness and stupidity and to create an atmosphere of horror. He was born at Akyab, Burma, on Dec. 18, 1870, the son of an officer in the Burma police, and at the age of two was sent to aunts near Barnstaple, north Devon. He took revenge on their strictness and lack of understanding by portraying unkind aunts in many of his stories about children. Educated at Exmouth and at Bedford grammar school, in 1893 he joined the Burma police, but was invalided out. Turning to journalism, he wrote political satires for the *Westminster Gazette*, and in 1900 published *The Rise of the Russian Empire*, a serious historical work. After acting as foreign correspondent for the *Morning Post* in the Balkans, Russia and Paris, in 1908 he settled in London, writing short stories and sketches: *Reginald* (1904), *Reginald in Russia* (1910), *The Chronicles of Clovis* (1912) and

*Beasts and Super-Beasts* (1914). Written in a style studded with epigrams, with well-contrived plots often turning on practical jokes or surprise endings, they reveal a vein of cruelty in their author and a self-identification with the *enfant terrible*. His brilliant novel *The Unbearable Bassington* (1914) describes the adventures of a maladjusted, fastidious, dislikeable hero in a manner anticipating that of the early Evelyn Waugh.

Munro was killed in action in World War I near Beaumont-Hamel, France, on Nov. 14, 1916.

*See* E. M. Munro's biography in *The Square Egg* (1924); *Selected Short Stories*, with introduction by Graham Greene (1960); *The Bodley Head Saki*, selected and introduced by J. W. Lambert (1963).

**MUNSEY, FRANK ANDREW** (1854–1925), U.S. publisher and newspaper proprietor, was born in Mercer, Me., on Aug. 21, 1854. He was one of the largest accumulators of magazines and newspapers of his day and a dominant figure in the growing trend toward journalistic consolidation. Beginning business in a country store, he became manager of the Western Union office in Augusta, Me. In 1882 he established, in New York city, the *Golden Argosy*, later the *Argosy*. Among other periodicals founded by Munsey were *Munsey's Weekly* (1889), *Munsey's Magazine* (1891), the *All-Story Weekly* (1904) and the *Railroad Man's Magazine* (1906). His outstanding newspaper purchases were the *New York Star* (1891), the *Baltimore News* (1908), the *New York Press* (1912), the *New York Sun* (1916), the *New York Evening Telegram* (1920), and the *New York Herald* (1920). He died Dec. 22, 1925, leaving most of his estate, estimated at $20,000,000, to the Metropolitan Museum of Art, New York city.

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**MÜNSTER, SEBASTIAN** (1489–1552), German Hebraist, mathematician, cartographer and cosmographer, whose *Cosmographia* is the earliest German description of the world, was born in 1489 at Ingelheim in the Palatinate. He studied at Heidelberg and Tübingen. He entered the Franciscan order, but later adopted Lutheranism. In 1527 Münster was appointed professor of Hebrew at Basel and he was the first German to edit the Hebrew Bible (2 vol., 1534–35); his edition was accompanied by a new Latin translation and a number of annotations. In 1531 he contributed to *Novus Orbis*, published by J. Herwagen of Basel (1532). In 1540 he published a Latin edition of Ptolemy's *Geographia Universalis* which included 48 woodcut maps (27 after Ptolemy and 21 designed by Münster himself), but his most important work was his *Cosmographia* which appeared first in 1544. It attracted the educated world of his day and was warmly received by Catholic and Protestant alike because of Münster's impartial tone. About 40 editions were printed in Germany alone, and copies were handed down in families as a kind of secular bible. The most valued edition is the revision of 1550, which is especially prized for its portraits and its city and costume pictures. He died of the plague at Basel on May 23, 1552.

Münster's other books include *Chaldaica Grammatica* (1527); *Dictionarium trilingue* in Latin, Greek and Hebrew (1530); *Germania descriptio* (1530); *Mappa Europae* (1536); *Rhaetia* (1538); *Organum Uranicum* (1536).

*See* V. Hantzsch, "Sebastian Münster," *Publications of the Royal Society of Sciences of Saxony*, vol. xviii (1898). (E. M. J. C.)

**MUNSTER** (MUMA), the southwestern province or kingdom, one of the traditional "Fifths" of Ireland. Geographically the area is divided by the Sliabh Luachra mountain range into south Munster (Deasmhuma, Desmond) and north Munster (Tuadhmhumha, Thomond). For centuries the main strength of the kingdom lay in the south. There the ruling people were the Érainn. Their chief fortress lay high in the Ballyhoura hills, in what is now the county of Limerick. It is called in literature Temuir Érann, the Tara of the Érainn, no doubt on the analogy of the midland Tara, the official seat of the kings of Ireland.

In northern Munster the Leinstermen had secured a strong foothold. They occupied the rich lands still known as the Golden Vein and seem to have reached, in the era of their greatest power, Lough Derg and the Shannon at Limerick. The encroachment was resented. In the struggle to free north Munster a small people, whose original home was probably in south Limerick, achieved distinction. They are known in Irish history as the Eoganachta. Under their leadership the Leinstermen were driven back to their present boundary. In the process the victors had profited by the help of professional fighting men, dési, and these were given, in reward for their services, the lands that are now the county of Waterford and a strip of south Tipperary. An offshoot of these dési invaded Connaught, and deprived that kingdom of what is now the county of Clare. This movement was complete about the year A.D. 400. From that date onward the Eoganachta were rulers of Munster. They sent colonies to Cork and Kerry and made Cashel their main fortress or capital.

In the 8th century and again in the 9th and 10th the Eoganachta were strong enough to challenge, albeit unsuccessfully, the high-kings. In the course of the 10th century they failed to defend Munster against the Vikings, who settled in Waterford and Limerick. This led to the collapse of the dynasty, which was succeeded in Munster by the Clare dynasty of Dál Chais. In the 11th and 12th centuries Eoganachta power revived, especially in Cork (McCarthys, O'Callaghans, O'Keeffes), but the Dál Chais dynasty (O'Briens) retained its distinction, especially in Thomond. Cashel, by common consent, was given to the church in 1101, and became the archiepiscopal see of Munster. After the Norman invasion the feudal families of FitzGerald, earls of Desmond, and Butler, earls of Ormonde, became all-powerful in the province. In modern times it comprises the counties of Clare, Cork, Kerry, Limerick, Tipperary and Waterford. Area 9,315 sq.mi.; pop. (1961) 849,203. Cork is the political and commercial capital and Limerick and Waterford are cities of importance. (J. J. Ry.)

**MÜNSTER,** a city of Germany and capital of the *Land* (state) of North Rhine-Westphalia, which after partition of the nation following World War II became part of the Federal Republic of Germany. Pop. (1961) 182,721. It is situated on the Dortmund-Ems canal and the Münster-Aa lake, 50 km. (32 mi.) N.E. of Dortmund at the junction of main line railways and on the Hanse *autobahn* route Ruhr-Bremen.

Mimigernaford (ford over the Aa) was first mentioned when Liudiger (Ludger), a missionary who was educated in York and sent to west Saxony by Charlemagne, founded a bishopric there in 805. The merchants' settlement that followed was renamed Münster (1068) and became a town in 1137. It grew in economic importance, notably because of its position at the intersection of long distance trade routes (from Holland, central Germany, the Rhine valley and Scandinavia) and because of its wool trade with England. English traders founded a brotherhood, Ipsenbrüder, called after the port of Ipswich. During the 13th and 14th centuries it was a prominent member of the Hanseatic league. The fanatical Anabaptists (*q.v.*) founded their "kingdom of a thousand years" at Münster in 1534; the following year the town was captured and their king, John of Leiden, was executed in 1536 with two of his accomplices, Knipperdollinck and Krechting, and the iron cages in which their bodies were exhibited still hang in the Gothic tower of St. Lambert's church. A neutralized Münster was the scene of the peace congress (1645–48) that led to the conclusion of the Thirty Years' War. In 1815 the city became the capital of Prussian Westphalia.

There was widespread destruction during World War II. The old style Prinzipalmarkt with gabled houses and arcades still stands, though restored. Exact replicas have been built of the 14th century *Rathaus* (town hall) with its Friedenssaal (peace hall of 1648) and nearby Renaissance municipal wine house. The following churches, dating mainly from the 13th and 14th centuries, have been restored: the Cathedral (in transition style with notable Romanesque and Gothic sculpture), St. Ludger's, St. Lambert's, the Church of Our Lady (Überwasserkirche, with an imposing Gothic tower), St. Martin's and St. Maurice's. The work of J. C.

Schlaum, Westphalian master architect of the baroque period, is evident in the Westfalische Wilhelms-Universität (founded 1773–80, a full university from 1902, formerly the episcopal palace built 1767–75), the high bailiff's court and the churches of St. Clement (*c.* 1750) and St. Aegidius. Modern structures include the *Land* Chamber of Commerce building, municipal administrative offices, the theatre, the railway station (1956) and Münsterland hall (exhibitions and conferences). Münster with the intellectual influence of its university is the centre of Westphalian culture and has *Land*, geological and diocesan museums and archives, a teachers' training college and schools of engineering, music and art. Open-air facilities are provided by the Palace gardens with magnificent old trees and botanical and zoological gardens, the promenade on the site of the former town walls and the Aasee (lake for boating).

Of the varied industries the major are the manufacture of machinery and textiles, and building construction. (JH. P.)

**MÜNSTERBERG, HUGO** (1863–1916), German-U.S. philosopher, psychologist, pioneer in juristic and industrial psychology and psychotherapeutics, was born in Danzig, Prussia, on June 1, 1863. Münsterberg received his early education at the *Gymnasien* in Danzig and Geneva, his Ph.D. at Leipzig (1885) with Wilhelm Wundt (*q.v.*) and his M.D. at Heidelberg (1887). He habilitated (1887) as an instructor in psychology at Freiburg, established a psychological laboratory there, and was soon publishing significant researches in his *Beiträge zur experimentellen Psychologie* (1889–92). In 1892 he went to Harvard as a visiting professor on leave of absence from Freiburg, and in 1897 he returned to Harvard, where he remained the rest of his life, to direct the psychological laboratory. He died suddenly, while lecturing to a class at Radcliffe college, on Dec. 16, 1916.

Münsterberg did not long confine himself to his laboratory; he soon was extending psychology into neighbouring and allied fields—law, business, industry, teaching, medicine, sociology. By many scientific historians he is credited with being the founder of applied psychology (*see* PSYCHOLOGY, APPLIED).

His chief books are: *Psychology and Life* (1899); *Grundzüge der Psychologie* (1900); *Die Amerikaner* (1904); *Philosophie der Werte* (1908); *Psychology and the Teacher* (1909); *On the Witness Stand* (1910); *Psychology and Industrial Efficiency* (1913); *Psychology: General and Applied* (1914); and *Grundzüge der Psychotechnik* (1914).

His biography, *Hugo Münsterberg: His Life and Work* (1922), written by his daughter, Margaret Münsterberg, is personal. No evaluation of his contributions to psychology and philosophy is attempted. The book gives his complete bibliography in an appendix. (K. M. D.)

**MUNTHE, AXEL MARTIN FREDRIK** (1857–1949), Swedish doctor, psychiatrist and writer, whose book, *The Story of San Michele* (1929), an account of his experiences as a doctor in Paris, Rome and in semi-retirement at the villa of San Michele on Capri, achieved immense popularity in its original English version and in many translations. Its lasting success may be attributed to its intimate revelation of an unusually vital personality and its sympathetic, vivid description of suffering. Born at Oskarshamn, Kalmar, on Oct. 31, 1857, Munthe studied at Uppsala, Montpellier and Paris, where he worked under Jean Martin Charcot, the pioneer neurologist. After practising in Paris and Italy (where he was awarded a gold medal for his work during the Messina earthquake), he became in 1908 physician-in-ordinary to the Swedish royal family. He died on Feb. 11, 1949, in the royal palace at Stockholm, where he had been a guest for ten years. His other books of reminiscences, *Memories and Vagaries* (1897) and *Letters From a Mourning City* (1899; about a cholera outbreak in Naples) never achieved the success of *San Michele*.

*See* G. Munthe and G. Uexküll, *The Story of Axel Munthe* (1953).

**MUNTJAC** (MUNTJAR), common name for a small deer of the genus *Muntiacus*, standing 20 to 28 in. high at the shoulder. The curious tusklike upper canine teeth that project from the mouth of the male may be used in defense. Several species are known, all from India, southeastern Asia and southern China. The antlers, only in the male, have a short brow tine and a single point on the beam; they are borne on long pedicles from which bony ridges extend down onto the face.

Muntjacs are usually found singly or in pairs inhabiting thick jungle. The female produces one or two young annually. Muntjacs escaped from captivity live at large in several counties of England. They are sometimes called "barking deer" from the cry uttered when alarmed and given by the males in the rutting season. *See* also DEER. (L. H. M.)

**MÜNTZER, THOMAS** (*c.* 1490–1525), German radical reformer and leader of the Thuringian peasants in the revolt of 1525, was born at Stolberg in the Harz mountains and attended the universities of Leipzig and Frankfurt an der Oder. In 1520 on Luther's recommendation he went as preacher to Zwickau but left after a bitter quarrel with the humanist Egranus, and after anticlerical disturbances. He went to Prague where he published a manifesto in Latin, German and Czech calling the people to rally behind him and begin a new age of the church. Failing to win support, he moved in 1523 to the little Saxon town of Allstedt, which he dominated and where he introduced liturgical reforms of worth and originality including a vernacular Mass, fully choral. He also enrolled followers in a covenant, pledged to take up arms in war against the "godless." In July 1524 he was called to preach before Duke John and John Frederick of Saxony, but his vituperative *Fürstenpredigt*, in which Müntzer defended his ideas and even challenged Duke John to join his followers, led to his hasty departure. After a short stay at Mühlhausen in Thuringia, he fled to the Black Forest area where the peasant war was beginning and worked for several weeks in the areas of the Klettgau and Hegau. He then returned to Mühlhausen, whose contingent he led into war in April 1525. The rebels were defeated at Frankenhausen, where Müntzer was captured, tortured and executed. Under torture he recanted and died apparently reconciled to the Catholic faith. Though his revolutionary ideas were discredited, his theology influenced the radicals, many of whom became Anabaptists (*q.v.*). Like his friends, the "Zwickau prophets," he denounced infant baptism. Despite his emphasis on the inspiration of the Spirit, his thought is soaked in Scripture.

Originally a disciple of Luther, Müntzer became his violent enemy when Luther repudiated his teaching about social revolution, and his later writings are vitriolic and invective against Luther as *Dr. Lügner* ("Dr. Liar") and *Bruder Sanft Leben* ("Brother Soft Life").

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**MUNTZ METAL,** a variety of brass, invented by G. F. Muntz in 1832, is also known as yellow metal because the large zinc content gives it a yellow colour. The alloy is composed of 60% copper and 40% zinc. It can be forged, and is employed for machine parts exposed to corrosion. *See* ALLOYS; BRASS.

**MURAD I** (d. 1389), Ottoman sultan of Turkey from 1362(?) to 1389, ascended the throne in succession to his father, Orkhan, the exact year of whose death is uncertain. The reign of Murad was, for the Ottomans, a period of rapid conquest in the Balkans. A number of factors facilitated their advance: the fragmentation of the Byzantine empire, of Serbia and of Bulgaria into small conflicting principalities; the rivalries of Venice and Genoa in the Levant; and the dislike felt among the Balkan peoples for the proposed union of the Greek Orthodox with the Roman Catholic Church. Adrianople (Edirne) fell to the Ottomans in 1362 and Philippopolis (Plovdiv) in 1363. A "crusade" commanded by Amadeo di Savoia sailed into the Dardanelles in 1366 and there seized Gallipoli, but the town was soon again to fall into the hands of the Ottomans. The princes of southern Serbia formed a coalition against the Ottomans in 1371. Their forces, however, suffered a crushing defeat at Cirnomen on the Marica river in September of that year. The Ottomans gained a further notable success, also in 1371, in a battle fought against the Bulgarians at Samakow (Samokovo). As a result of these victories Murad was able to reduce the emperor of Byzantium and the princes of Serbia and Bulgaria to a status of dependence on himself. Almost ten years then passed before the Ottoman advance in the Balkans was resumed in

earnest. During these years the sultan sought to strengthen his position in Asia Minor; indeed, if the Ottomans were to hold and extend their conquests in Europe, it was essential for them to dispose of far greater Muslim and Turkish resources. Murad, by a policy of diplomatic and military pressure, of marriage alliance and of purchase, acquired large territories from the Turkish emirates of Germeyan (Kermiyan), Hamid and Tekke. The last years of the reign witnessed a further Ottoman advance in the Balkans. After the fall of Sofia and Nis (Nish), the princes of northern Serbia, with aid from Bosnia and Walachia, launched a counter-offensive, which, although at first successful on the field of Pločnik, came to utter defeat, in 1389, at the first battle of Kosovo. Sultan Murad, however, was killed on this battlefield.

*See* P. Wittek, *The Rise of the Ottoman Empire* (1938, reprinted 1958). (V. J. P.)

**MURAD II** (1404–1451), Ottoman sultan of Turkey from 1421 to 1451, ascended the throne on the death of his father, Mohammed I. Murad had to overcome a rival for the Ottoman throne, Dözme ("False") Mustafa, who had been active in pursuit of his claim during the last years of Mohammed I and was now allied with the beg of Izmir (Smyrna), Junayd, and with the Byzantine emperor, Manuel II Palaeologus. By 1425 Mustafa and Junayd had been removed from the scene and Byzantium had again been forced to pay tribute to the Ottomans. Murad also reasserted Ottoman control (*c.* 1425) over much of western Asia Minor, including the Turkish emirates of Tekke and Menteshe. The attention of the sultan was then directed toward the Balkans. In 1430 the Ottomans seized Thessalonica (Salonika), which a son of the Byzantine emperor had sold to the Venetians in 1423. Serbia was at this time in a state of dependence on the Ottoman sultan. Murad indeed took as his wife, in 1433, the Serbian princess Mara, who was thereafter to wield considerable influence over him in Balkan affairs. The Ottomans, in their continued advance toward the northwest, next came into conflict with the Hungarians, who, with Serbian, Polish and German assistance, launched a great offensive in 1443 down the Danube into the heart of Bulgaria, repulsing the Ottomans at Nis (Nish), seizing Sofia and again defeating the Ottomans at Jalowaz between Sofia and Philippopolis (Plovdiv). The Hungarian campaign of 1444 ended, however, in a shattering defeat for the Christians at Varna (Nov. 1444). Thereafter Murad resolved to go into retirement, leaving the throne to his young son Mohammed, who reigned as sultan from 1444 to 1446, until Murad, in view of the need for a strong hand at the head of affairs and under pressure from the great dignitaries at the Porte, reassumed control of the state. During the last years of the reign the Hungarians were to attempt yet another major campaign against the Ottomans, only to meet with disaster at the second battle of Kosovo (1448). Murad died at Adrianople (Edirne) in Feb. 1451. *See* also TURKEY: *History*.

*See* P. Wittek, "De la Défaite d'Ankara à la prise de Constantinople," *Revue des études Islamiques* (1938). (V. J. P.)

**MURAD III** (1546–1595), Ottoman sultan of Turkey from 1574 to 1595, was born at Manisa on July 4, 1546. He came to the throne on the death of his father, Selim II. The major event of his reign was a long and arduous conflict (1578–90) with Persia. During the first years of the war the Ottomans overran the Christian principalities of Georgia and occupied the chief strategic centres in the region, including Tiflis (Tbilisi). There followed a series of brilliant campaigns by Osman Pasha, which reduced to Ottoman control the lands bordering the western shore of the Caspian sea. The later years of the conflict witnessed the Ottoman conquest of Azerbaijan, including Tabriz, and of Nahavand and Hamadan in western Persia. A peace concluded in 1590 gave to the Ottomans all the territories indicated above. The war had been expensive in men and munitions; it necessitated also the construction of fortresses and the maintenance of numerous garrisons. One consequence of this new situation was a large increase in the number of janizaries, Muslims being now admitted into their ranks, a departure which, however, impaired the excellence of this famous corps. The process thus begun was to be carried still further when, after the rout and death of the beglerbeg of Bosnia at Sisak in 1593, the Ottomans entered into a long and exhausting war (1593–1606) with Austria. Social and economic pressures combined with the strain of almost unbroken warfare to bring about a growing dislocation of the fief system established in the provinces of the empire. The reign of Murad III was a time of financial crisis and of severe inflation because of the cost of the Persian and Hungarian wars and of the penetration, into the Ottoman lands, of the flood of American silver which flowed out of Spain. It was Murad III who, in 1583, gave to England a formal grant of commercial privileges in the Ottoman empire. He died at Istanbul on Jan. 16/17, 1595. *See* also TURKEY: *History*.

*See* J. von Hammer-Purgstall, *Histoire de l'empire Ottoman,* French trans. by J. J. Hellert, vol. vii (1837). (V. J. P.)

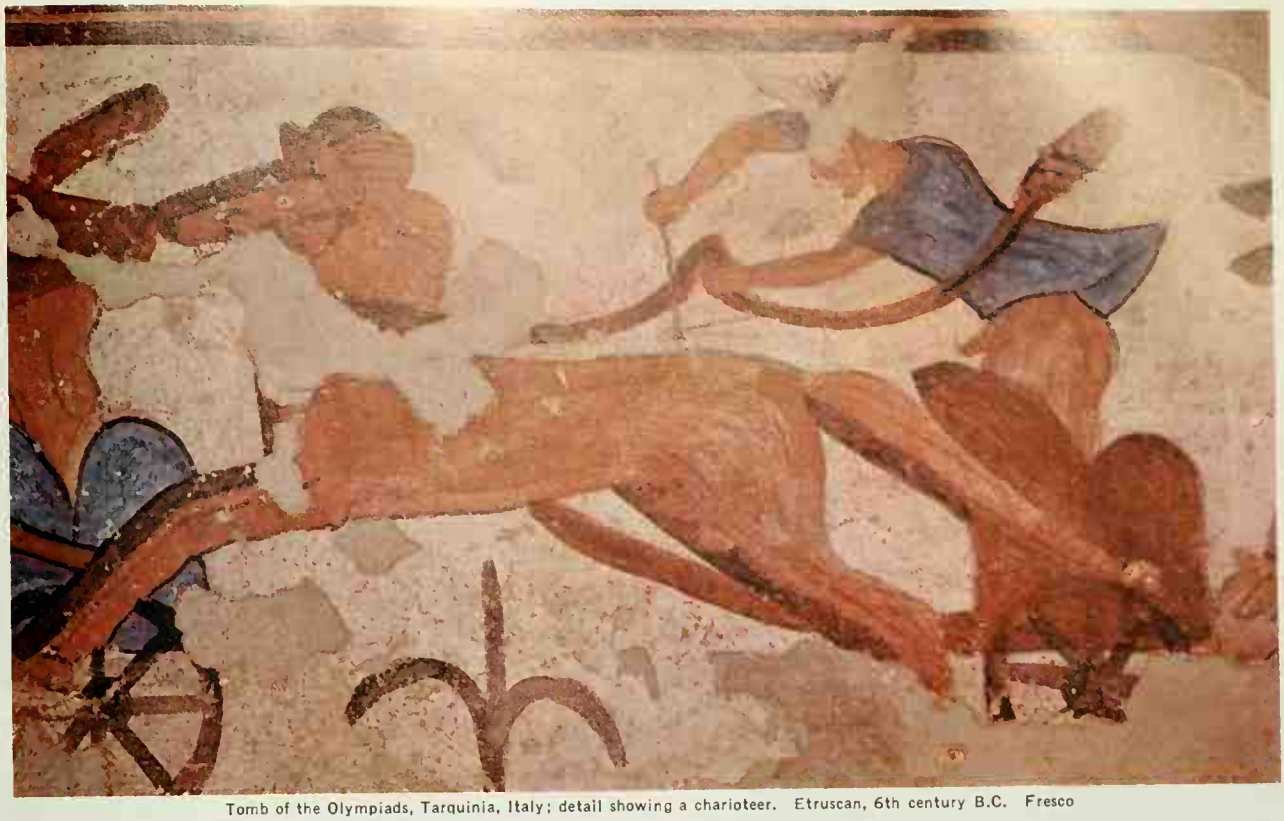
**MURAD IV** (1612–1640), Ottoman sultan of Turkey from 1623 to 1640, the son of Ahmed I, was born in Istanbul on July 27, 1612. He succeeded his uncle Mustafa I on Sept. 10, 1623, at a time when the news from all quarters of the empire was of rebellions and defeats. The first ten years of the reign saw seven grand viziers. The effective control of affairs was in the hands of the turbulent janizaries and spahis who had forced Mustafa to abdicate; and more than once they had to be placated with the blood of high officials. The last such occasion was in 1632, when the spahis invaded the palace, demanding the heads of the grand vizier Hafiz Pasha and 16 other notables. The young sultan could not save them, but soon he felt himself strong enough to put an end to the prevailing lawlessness. Rallying some loyal men, he exacted a terrible vengeance on the mutineers. Thereafter he repressed the anarchy and licentiousness of the troops with a bloody ferocity and riveted a strong yoke on every department of the state. Coffeehouses and wineshops everywhere were closed, no doubt as being breeding places for sedition; but the security of the state seems an inadequate justification for the numerous executions of people guilty or merely suspected of defying the ban on the use of tobacco. Under his heavy hand the empire enjoyed a reign of law unknown since the time of Suleiman.

Order once restored, Murad assumed personal command in the war against Persia, undertaken to win back lands lost to the shah earlier in Murad's reign. Baghdad was reconquered after a siege that ended in a pitiless massacre of garrison and citizens alike (1638). Peace was concluded the following year. On Feb. 8, 1640, the last warrior sultan of the house of Osman died in Istanbul at the age of 28, his great physique sapped by habitual intemperance. He was the first sultan who put a sheikh al-Islam to death. *See* also TURKEY: *History*. (G. L. L.; E. Z. K.)

**MURAD V** (1840–1904), Ottoman sultan of Turkey during May–Aug. 1876, the elder son of Sultan Abdul-Mejid I, was born in Istanbul on Sept. 21, 1840. He received a good education. After his father's death, he was permitted by his uncle Sultan Abdul-Aziz to live in his own villa, up to 1867, without restrictions on his liberty. A liberal by disposition he maintained relations with the Young Ottomans. He accompanied Sultan Abdul-Aziz on his visits to Egypt (1863) and Paris and London (1867). On the deposition of Abdul-Aziz (May 29, 1876) Murad was brought to the throne by Midhat Pasha and his cabinet. He had determined to introduce constitutional reforms, but after the suicide of Sultan Abdul-Aziz and the murder of some of the cabinet ministers he began to show signs of mental derangement. A doctor called from Vienna declared that his illness was incurable and Murad was deposed on Aug. 31, by the same men who had brought him to the throne. He was confined in the Chiraghan palace, Istanbul, where he died on Aug. 29, 1904. (E. Z. K.)

**MURAENA,** generic name for tropical and subtropical rock- and reef-dwelling moray eels. *See* MORAY.

**MURAL PAINTING** is that branch of painting which has to do with the decoration of the walls and ceilings of buildings. It may properly include painting on fired ceramic tiles, and is sometimes incorrectly used to include mosaic decoration (*see* MOSAIC). Mural painting is inherently different from all other forms of pictorial art in being organically connected with architecture. The use of colour, design and thematic treatment can radically alter the sensation of spatial proportions of the building. In this sense it is the only form of painting which is truly three dimensional, since it modifies and partakes of a given space. Byzantine mosaic



Tomb of the Olympiads, Tarquinia, Italy; detail showing a charioteer. Etruscan, 6th century B.C. Fresco

## ANCIENT MURALS

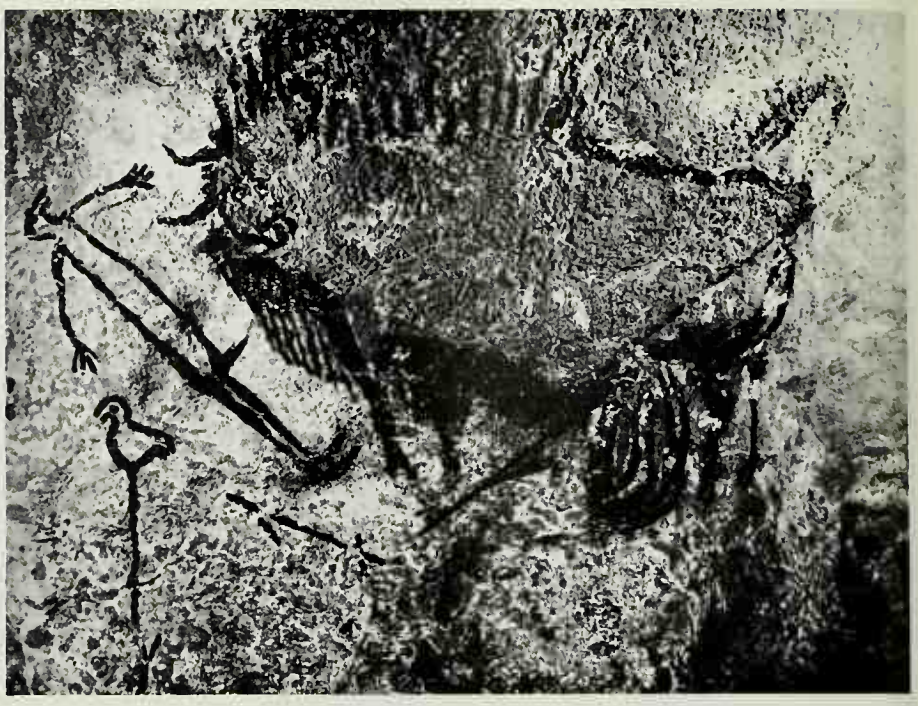
Detail from a mural in the Casa Venus Marina, Pompeii, Italy

Wall painting from the Hōryūji, Nara, Japan; about A.D. 711. Fresco

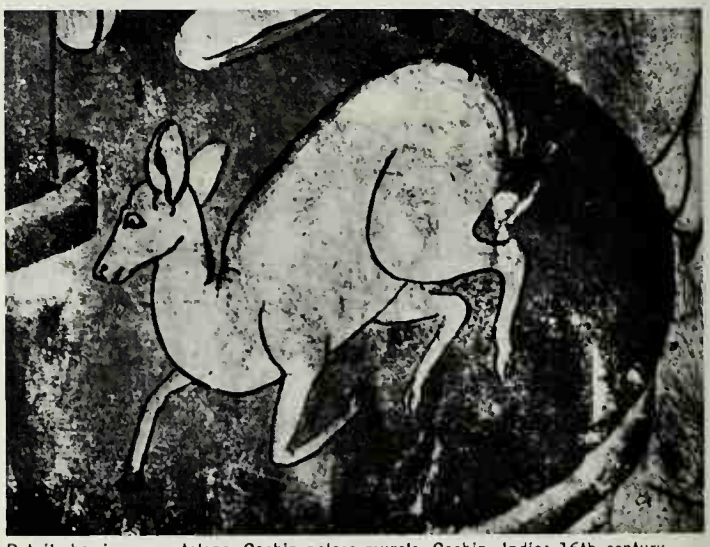
PHOTOGRAPHS, (TOP) LERICI FOUNDATION, (LEFT) EDWIN SMITH, (RIGHT) BENRIDO CO., LTD., JAPAN

# MURAL PAINTING

## EXAMPLES OF MURALS



Painting in red and black, Lascaux caves, France; Middle Magdalenian period (about 20000 B.C.)



Detail showing an antelope, Cochin palace murals, Cochin, India; 16th century

Tomb paintings from the temple at Luxor, Thebes, Egypt; 15th–14th century B.C.

"Jesse's Dream, with Two Prophets," Church of St. Michael, Hildesheim, Ger., part of a complex ceiling design on wood; about 1220

BY COURTESY OF (LEFT) EGYPTIAN STATE TOURIST ADMINISTRATION, (CENTRE RIGHT) INFORMATION SERVICE OF INDIA, LONDON; PHOTOGRAPHS, (TOP) ARCHIVES PHOTOGRAPHIQUES DES MONUMENTS HISTORIQUES, (BOTTOM RIGHT) BILDARCHIV FOTO MARBURG

20TH-CENTURY MURALS

John Steuart Curry, detail of the "John Brown" mural, state capitol building, Topeka, Kan., 1940. Oil and tempera

Joan Miró, "The Wall of the Moon," UNESCO House, Paris, 1959. Ceramic tiles on an independent wall

BY COURTESY OF (TOP) KANSAS ECONOMIC DEVELOPMENT COMMISSION, (BOTTOM) UNESCO, CLICHE FERRAND

# MURAL PAINTING

Tintoretto, "Moses Striking the Rock," Scuola di S. Rocco, Venice; 1576–1588. Oil on canvas; one of a series of panels recessed into a richly carved wooden ceiling

## RENAISSANCE AND MODERN MURALS

José Clemente Orozco, "Christ Destroying the Cross," Dartmouth college, Hanover, N.H., 1933. Fresco

Henri Matisse, "Madonna of the Rosary" and "Stations of the Cross," the Chapel of the Rosary, Vence, France, 1949–52. Painting on ceramic tiles

BY COURTESY OF (RIGHT) TRUSTEES OF DARTMOUTH COLLEGE, HANOVER, N.H.; PHOTOGRAPHS, (TOP) MANSELL-ANDERSON, (BOTTOM) FROM "ART IN EUROPEAN ARCHITECTURE" BY PAUL DANIEL, REINHOLD PUBLISHING CORPORATION, 1956, PHOTO, BERNHARD MOOSBURGER

decoration evinced the greatest respect for organic architectural form. The great artists of the Renaissance on the other hand attempted to create an illusionistic feeling for space; and the masters of the subsequent baroque period obtained such radical effects as to dissolve almost entirely the walls or ceilings.

Apart from its organic relation to architecture, a second characteristic of mural painting is its broad public significance. The mural artist must conceive pictorially a social, religious or patriotic theme on the appropriate scale in reference both to the structural exigencies of the wall and to the idea expressed.

In the history of mural painting many techniques have been used: encaustic painting (*q.v.*), tempera (*q.v.*), fresco painting (*q.v.*), ceramics, oil paint on canvas (*see* OIL PAINTING, TECHNIQUE OF) and more recently liquid silicate and fired porcelain enamel. In classical times the most common medium was encaustic, in which colours are ground in a molten beeswax binder and applied to the painting surface while hot. Tempera painting was also practised from the earliest known times; the binder was an albuminous medium such as egg yolk or egg white diluted in water. In the 16th century oil paint on canvas came into general use for murals. The fact that it could be completed in the artist's studio and later transported to its destination and attached to the wall was of practical convenience. Yet oil paint is the least satisfactory medium for murals: it lacks both brilliance of colour and surface texture, many pigments are yellowed by the binder or are affected by atmospheric conditions and the canvas itself is subject to rapid deterioration.

**Cave Painting.**—More than 100 painted or engraved caves have been discovered since the development of systematic cave exploration about the middle of the 18th century. The greatest concentration is in southwestern France and northern Spain, but isolated caves have been found in central France, central and southern Spain, Italy and Sicily, Germany and north and south Africa. No reliable method of dating cave art has yet been evolved, but a chronology has been established, largely through the work since 1901 of the abbé Henri Breuil (*q.v.*) in analyzing the debris covering paintings or blocking cave mouths and the movements and extinction of animals represented, and, later in the 20th century, by the use of the radiocarbon process. This places the earliest examples (*e.g.*, La Férrassie, Dordogne, France, and Gargas, Hautes-Pyrénées, France) at between 20000 and 30000 B.C. in the Aurignacian period of the last Ice Age.

Cave painting representing, as it usually does, animals and scenes from the hunt, seems to have been magical in purpose and ritualistic in execution; the caves were usually too inaccessible to have been much visited, and the rather fragile pictures were themselves often covered with new drawings at successive rites. Sometimes, however, they seem to have been prepared with considerable care, and in the caves at Altamira (*q.v.*) and El Castillo (Santander) in Spain, designs engraved on bone resembling sketches for the larger works, have been found. Certainly the decorative power of many paintings is undeniable, and there is good evidence of a developing artistic capacity, from the early Aurignacian linear style (*e.g.*, La Clotilde de Santa Isabel, Santander) to an increasing plasticity in the Solutrian period (*e.g.*, Le Roc, Charente, France) and the much more painterly accomplishment of the best-known Middle Magdalenian style of Altamira and Lascaux (*c.* 20000 B.C.). There are paintings of great liveliness in black, red, brown and yellow pigments, bound with a fatty medium and sometimes making use of the uneven surface wall to give relief to the figures. In some caves (*e.g.*, Cabrerets, Peche-Merle, France) the powdered colour seems to have been blown on in blotches, and there survive the "stenciled" forms of hands. In other cave art of this period, however (*e.g.*, Les Combarelles, Dordogne), an almost purely engraved, linear style continued to be used, and in the later Magdalenian periods (up to *c.* 10000 B.C.) the artists returned to a linear style, swift and rather perfunctory (*e.g.*, Les Eyzies, Dordogne). (*See* PRIMITIVE ART.) (J. S. GA.)

**Egypt.**—A few fragmentary paintings are known from western Asia but it was only in Egypt that a strongly national style of mural painting was developed. This style was maintained for nearly 3,000 years, from about 3200 B.C. until the conquest of Alexander. Egyptian painting was in the main flat, schematic and linear, like all work before the Greek invention of shading and perspective. A diagram was made of a thing as it was known to be, combining profile and front-view parts in drawing the human body and disregarding space relationship in adding together the different elements of a composition.

Abstract symbols were employed but the Egyptian's observation of nature was less reduced to formal patterns than was the practice in Mesopotamia. The painter combined a sensitivity to line and proportions with a pleasing use of a wide colour range. He could suggest differing textures by skilful brushwork. Occasionally he anticipated an effect later to be gained by more logical means.

Wall paintings have survived in domestic architecture but the Theban tombs of the 15th and 14th centuries B.C. best represent the painter's accomplishment. The development of painting, particularly its naturalistic side, had been stimulated by the desire to picture typical aspects of daily life for the dead in the hereafter. This has left a full record of a remarkable civilization.

(W. S. SH.)

**India, China and Japan.**—The surviving cycles of wall paintings from the traditional periods of Asiatic civilization are almost all on religious themes. These murals were used for the decoration of sanctuaries, tombs and cave temples in India and the far east. The technique of true fresco is unknown: oriental wall paintings are invariably executed on a dry wall, generally on a plaster ground. Among the greatest examples of Indian murals are the Buddhist paintings in the Ajanta caves in western India, dating from *c.* A.D. 100 to 700 (*see* AJANTA). In their opulent splendor of composition and rhythmic beauty of posture the styles of these paintings are the counterparts of contemporary masterpieces in Indian sculpture. In the ancient Gandhara (*q.v.*), now in northwestern Pakistan, there have been found examples of wall paintings in a provincial Roman style. Reflections of this Late Antique manner combined with Indian and Iranian elements may be noted in the wall paintings of central Asia from the 3rd to the 9th century A.D.

Painting was used for the decoration of palaces and tombs in China as early as the Shang dynasty (*c.* 1766–*c.* 1123 B.C.). There are literary descriptions of great cycles of murals ornamenting the palaces of the Han period (202 B.C.–A.D. 221). Carved replicas of these lost cycles of decoration devoted to cosmic myths, scenes of filial piety and edifying subjects from Chinese classical history may be recognized in the sepulchral tiles of Wu Liang-tze. The occasional fragments of tomb paintings from this same period already illustrate the evolution of a completely formed Chinese style with figures monumentally isolated against a plain background and defined in terms of a vivid calligraphic line drawing, in which brushstroke, rather than modeling, articulates the form.

The famous Buddhist cave temples at Tun-Huang, in Kansu province, dating from the 4th to the 10th century A.D., are decorated in a variety of styles ranging from an early imitation of central Asian models to a completely Chinese transformation of the Indian manner in some of the masterful designs of the T'ang period (A.D. 618–906). A tradition of Buddhist wall paintings persisted in China until the Ming period, but these later murals, like the sculpture of the same periods, are only a decorative and worldly repetition of the formula that produced the masterpieces of the great centuries of religious belief.

In Korea the painting of tomb chambers at Gukenri reveals an adaptation of Chinese designs of the Han period.

The earliest examples of wall painting in Japan are the symbolical and highly geometric decorations of the tombs of the pre-Buddhist period. With the introduction of Buddhism in A.D. 552 the simple indigenous styles of Japanese sculpture and painting were supplanted by an adaptation of Indian and Chinese models. The famous, but now destroyed, 8th-century cycle of Buddhist wall paintings in the Golden hall of Hōryūji at Nara were among the finest examples of the style of the T'ang period and may have been executed by Chinese painters. In later centuries, although wall paintings were occasionally used for the ornamentation of Buddhist shrines, the true mural was largely replaced by vast,

decorative screens or the painted wall partitions that formed the background for the pageantry of court life in the Muromachi (1392–1568) and Tokugawa (1615–1867) periods. It is in these latest examples of mural decoration that one finds the best illustration of the Japanese genius for moving, abstract design and decorative form both in colour and black and white. (B. R.)

**The Classical Period.**—*Greece.*—The history of ancient Greek mural painting must be pieced together from evidence in classical literature and from scanty remains. The earliest specific literary references are of the 5th century B.C., when the heroic mural, covering large walls of temples and public buildings and dealing with grand themes, was the characteristic painting form. By the end of the century the panel picture seems to have superseded it in popularity, but there are continual mentions of monumental wall painting during the rest of Greek history.

Painting the walls of private houses became customary only in the Hellenistic period, which began in 323 B.C. There are many examples in Delos and a few elsewhere. These murals created a pseudoarchitecture on the wall with stucco relief and paint, including a frieze on which were painted pictures of considerable vivacity and charm.

The Greeks did not bury their dead in chambers but the Macedonians did, and so did many of the peoples they ruled in the Hellenistic period. Such chamber tombs, with painted walls, were found in Macedonia, south Russia, Bulgaria, Alexandria, Palestine and in a few instances in Greece itself. Pseudoarchitecture was used, with pictorial elements in a variety of interesting styles—graceful, dramatic, impressionistic and heroic.

*Etruria.*—From references in Roman literature it is known that the Etruscans painted murals in their temples. None of these is extant but many Etruscan murals, with handsome figured friezes set within an architectural scheme, have been found in sepulchral chambers in Tarquinia and elsewhere, dating from the late 7th century B.C. into the Hellenistic period.

*Rome.*—The Romans used mural painting to an extraordinary extent. In Pompeii and Ostia the walls and ceilings of almost all buildings, public and private, were painted in unified, very inventive decorative schemes that encompassed a wide range of pictures, including landscape, still life and figured scenes.

Early murals in temples are known only through literature. In the second century B.C. the Hellenistic pseudoarchitectural style made its appearance in Italy, where it is called the First Pompeiian style. It was succeeded from *c.* 70 B.C. by the Second Pompeiian style, a more elaborate pseudoarchitectural treatment involving deep perspective space; from *c.* 10 B.C. by the Third Pompeiian style, delicate and linear; and from *c.* A.D. 50–79 by the Fourth Pompeiian style which was complex and sometimes extravagant. Later mural styles have not been systematically classified but they can be seen in Ostia in a continuous sequence to the 5th century A.D. and in scattered examples in Rome and elsewhere.

Innumerable sepulchral murals have been found throughout the empire. They range in quality from well-made family tombs to the summarily decorated chambers of pagan and Christian burial societies, called catacombs (*q.v.*). (B. R. Br.)

**Medieval to Modern.**—In general the medieval period in the history of European mural decoration extends from the decline of Rome and the corresponding rise of Christianity to the beginning of the 15th century. Two phases characterize the Early Christian period (3rd to 5th centuries); one is the strongly didactic, relatively crude two-dimensional fresco decorations in the catacombs (*e.g.*, SS. Peter and Marcellinus, Rome, 3rd century) with miracle scenes from the Old and New Testaments, the prayer-inspiring Orant and Christ and the Good Shepherd figures, as well as the Chi Rho, loaves and fishes, and other eucharistic symbols. The other phase is the impressive array of mosaics decorating the apses, vaults and clerestory walls of the great churches of Rome in the 4th and 5th centuries (Sta. Costanza, Sta. Pudenziana, and Sta. Maria Maggiore). Stylistic elements of the Christian near east, Hellenism, and pagan Rome appear in both phases, but while the more vital, somewhat abstract and symbolic art of the east appears stronger in the catacombs, it is the more solidly three-dimensional and monumental forms of the classic tradition that characterize the Christian decorations of the new era. (*See* also Early Christian Art.)

The significant change in concept and stylistic quality during the 7th and 8th centuries in Europe is due not only to the violent movement of peoples of that period of migrations but also to the antagonism to figure representation particularly during the iconoclastic controversy under the Byzantine emperor Leo III. As a result, much of the earlier mural decoration was destroyed and most of what was produced remained of a nonrepresentational decorative quality. The tradition of abstract mural decoration characteristic of Islamic art stems from this period, but in Italy some figure schemes survive. At Castelseprio (near Varese) a series from the infancy of Christ was painted, possibly by a refugee from Alexandria, and at Naturno (in Trentino-Alto Adige) a Celtic artist produced an ambitious cycle of external frescoes of the creation.

The rich and universally consistent style of the Romanesque period developed as an integral part of the vast monastic movement throughout Europe during the 11th and 12th centuries. Its character is a combination of Roman-Christian narrative and Byzantine stylization with expressively extended figures usually in pictographic form combined with one another through calligraphically stylized architectural forms. The extensive and harmoniously planned wall surfaces of nave, vaults, apses and transepts provided an endless variety of dogma, narrative and apocalyptic visions of the Christian teaching. The style is based in large part on the manuscript illumination and other cloister crafts that flourished in the various scriptoria and shops of the monasteries. Much of this material has been lost but the most characteristic examples are to be found in the Ottonian monastery of St. George in Oberzell; the Benedictine monastery at Reichenau; the churches of St. Michael in Hildesheim and St. Gereon, Cologne; the abbey church in St. Savin, France; and the remarkable fresco decorations in Catalonia (Barcelona museum).

The emergence of a new system of architectural design based on the pointed arch and the ribbed vault of the Gothic period produced an entirely new concept of mural decoration whereby the determining factor was the total design. The style began on the Île-de-France in the 12th century and spread all over Europe through the 15th century. Its major features were the use of colour and the decoration of the unified space so as to include both sculpture and the structural forms of the architecture. Indeed the art of stained glass (*q.v.*) is a part of this concept since the window is essentially a part of the decorated wall. Though deteriorated or poorly restored, many examples show the painting of walls, ribs and vaults so as to blend with the stained glass (Ste. Chapelle, Paris) or indeed to unify architecture and sculpture of a total facade (*e.g.*, the 13th-century drawing of Irwin von Steinbach for the Strasbourg minster).

Italian climatic conditions resulted in less of the wall space being devoted to window than was common in the north. The improved Gothic construction much increased this space which could be covered with narrative cycles of pictures with an instructional purpose, as at Asissi, where the Giottesque frescoes of the legend of St. Francis, in the lower and upper churches, were completed in the latter half of the 13th century. They represent a clarity and simplicity of style, a directness of narrative content, an emphasis on form and a largeness of scale which are a remarkable contrast to the Byzantine manner.

Two main traditions dominate the development of mural decoration in Italy through the 13th and 14th centuries. One is Florentine and is headed by Giotto, whose most important work is the decoration of the Arena chapel in Padua with scenes from the life of Mary and Christ decorating a single-aisled, barrel-vaulted chapel. The clarity of technical procedure (recorded in Cennini's handbook on painting) combined with the new emphasis on plastic form and a dramatic interpretation of content give these works a monumental character which becomes the starting point for Masaccio and the new art of the Renaissance in the next century.

The second tradition is that of Siena, headed by Duccio and Simone Martini; their soft colour, often enlivened by the use of gilded stucco relief, their easy and more graceful handling of form

and a characteristic decorative grace continue with an increasingly elaborate style in Florence through the second half of the century. Examples of this tradition are the work of Lorenzetti in the Siena town hall; of Andrea da Firenze in the Spanish chapel of Sta. Maria Novella, Florence, and the frescoes of the Campo Santo, Pisa.

At no other time before or since has mural decoration received a higher degree of creative concentration by artist and patron than in the period of the Renaissance. A continuously inventive spirit and inquiring mind, a wealth of support from patrons and an ever awakening attitude toward new creative possibilities are characteristics of this remarkable age. One speaks by and large of an Early Renaissance (15th century), a High Renaissance (1500–30) and a Late Renaissance or Mannerist style (second and third quarters of the 16th century). The centres of activity were the various cities and the rival personalities and families who dominated each area as political and cultural leaders.

In Florence, undoubtedly the most important centre, the development reveals an emphasis on specific problems of form almost to the point of obsession. It began with the concentration on the monumental figure by Masaccio whereby the solidly built forms in a three-dimensional space are closely integrated by gesture and light and shade to produce a dramatic unity. The skill seems to have been recognized and developed by succeeding artists such as Paolo Uccello, whose many-figured scenes seem awkward and wooden but reveal an interest in the movement of figures into space. Piero della Francesca's use of colour and the simplified design of flatly modeled figures, as in the church of S. Francesco, Arezzo, lend a new strength and monumentality to composition. With Melozzo da Forlì, the attempt is again to develop movement through the foreshortening of figures into space while the grandiose frescoes of Luca Signorelli (chapel of S. Brizio, Orvieto) reveal the concentration on anatomy and the well-modeled structure of many nude figures to achieve greater strength and articulation. This then becomes the point of departure for the great art of Michelangelo in the next century.

A second tradition is the more conservative and Gothic one exemplified by the pure and mystic expression of Fra Angelico (S. Marco, Florence). A third tradition is a kind of romantic realism to be found in the frescoes by Fra Filippo Lippi (the cathedral at Prato) and Benozzo Gozzoli (Medici palace chapel, Florence). Both of these reveal an awareness of the artistic problems of Masaccio but also a new interest in nature and its recognizable representation which appears not only in the careful study of realistic detail, as in landscape and the costumed figure, but also the representation of human features as recognizable portraiture. Finally, these heterogeneous elements are combined into a highly sensitive and decorative style during the last quarter of the 15th century, particularly in the frescos of Domenico Ghirlandajo and Sandro Botticelli.

Both Luca Signorelli and Benozzo Gozzoli abandoned the simple narrative sequence in a series of frames for a more unified architectural scheme, and this tendency was represented more decisively in north Italy by Andrea Mantegna, whose frescoes in the Eremetani church at Padua (largely destroyed during World War II), the canvases of the "Triumph of Caesar" (Hampton Court, London) and especially the decorations of the Camera degli Sposi in the ducal palace at Mantua introduced an architectural perspective and illusionistic detail, looking forward to the attempts of painters in the 16th century to integrate murals with their settings.

In central Italy the most important mural technique was fresco (though smaller schemes, like Paolo Uccello's Medici battle pieces and Piero di Cosimo's bacchanals, were on wood panels), but in Venice the sea air made this medium impractical, and only a single, much-weathered fragment survives (in the Venetian Academy) of Giorgione's and Titian's important work on the Fondaco dei Tedeschi. In Venice large historical compositions were generally painted on canvas and mounted on the wall; though this form of decoration was particularly vulnerable to fire, like that which destroyed Titian's "Battle of Cadore" in the doge's palace in 1577, much has survived. The earlier narrative phase is represented at its finest in Vittore Carpaccio's "Legend of St. Ursula" cycle (Academy), in the decorations of the Scuola di S. Giorgio degli Schiavoni and in the series of the "Miracle of the Holy Cross" by the Bellini circle (Academy). In the work of Tintoretto and Paolo Veronese, though there is sometimes an attempt at illusionistic perspective, the decorations (*e.g.*, Scuola di S. Rocco; doge's palace), which are often confined to panels in heavily carved and gilded ceilings, are more embellishing than architectural. Titian's "Mary Ascending the Steps of the Temple" (Academy) and some of Veronese's largest paintings (*e.g.*, "The Family of Darius Before Alexander," National gallery, London; "The Marriage at Cana," Louvre, Paris), however, show an attempt to make the picture an important spatial element in an interior design.

The development in Rome during the 15th century is more important for its impact on the next century than for its own artistic accomplishment. It reveals the gradual rise of papal power after the Great Schism, first under Pope Martin V who brought Gentile da Fabriano to Rome, then Nicholas V who brought Fra Angelico and Benozzo Gozzoli there, and finally Pope Sixtus IV who called Perugino, Signorelli, Botticelli, Ghirlandajo and others to decorate the walls of the newly built Sistine chapel (1481–83).

The High Renaissance is dominated by great individuals whose spectacular projects were often left unfinished or completed by pupils. Leonardo da Vinci was basically a craftsman in the tradition of the 15th century but was fired with a thirst for scientific knowledge and a theoretical mastery of nature which in him were identified with the continuously creative process of the artist. His rich and universal genius is best demonstrated in the dramatic movement of figures and tensely psychological interpretation of content shown in his two most important mural projects: the "Battle of Anghiari" in the Palazzo Vecchio of Florence (destroyed but known through partial copies) and the famous "Last Supper" (Sta. Maria delle Grazie in Milan).

Michelangelo, more intense and deeply religious than the scientifically minded Leonardo, sought to channel his expression through the human figure alone. Thus the dramatic movement of the figure carries the total design of his first mural (the "Battle of Cascina") for the Palazzo Vecchio of Florence (lost but known through drawings and engravings). The stupendous project for the decoration of the Sistine chapel ceiling for Pope Julius II followed the same method with increasing concentration on the figure, and the later "Last Judgment" on the end wall in the same room shows greater interest in the movement of larger figure masses in space with considerable dramatic freedom and intensity. The fresco decorations for the Cappella Paolina show the tendency to overstress the decorative combination of forms into groups, with a corresponding compositional weakness in the whole.

Raphael represents the most perfect balance and integration of all the problems of form, space and decorative unity that had been experimented with through the preceding century. Perfection of form is identified with the juxtaposition of the "Disputation on the Holy Sacrament" and the "School of Athens" in the Stanza della Segnatura (Vatican). The later historical murals of the Stanze reveal an increasing interest in movement.

Correggio is the last of the High Renaissance mural painters. His frescoes in the cathedral and the church of S. Giovanni Evangelista in Parma reflect the transition to the new concept of Mannerism, only hinted at in Mantegna. His early Camera di S. Paolo ceiling (Parma) provides a link, but in the decorative excitement, often independent of the subject matter, of large masses of figures moving through an illusionary space in these cupola decorations, the dramatic power of the new architectonic decoration is fully felt.

Two factors condition the development of mural decoration in the baroque style of the 17th century. One is the enormous building enthusiasm engendered by the Counter-Reformation, particularly through the Jesuit order. The other is the importance given to palaces and homes of the ruling aristocracy throughout Europe as the centres of society's cultural life. The roots of the style are to be found again in the work of the Renaissance masters but as interpreted and taught by the new institution of the Academy (*e.g.*, that of the Carracci at Bologna, Italy, and the French Academy founded in 1648). Its development can be followed from the allegorical decoration of the Palazzo Farnese in Rome by Annibale

Carracci to the increasingly elaborate wall and ceiling frescos of Domenichino, Pietro da Cortona and Andrea Pozzo whereby the dramatic movement of foreshortened figures and perspective blends with the architecture to achieve a total unified and endless illusion of space.

The most prolific and indeed most important single baroque artist from the decorative point of view is Peter Paul Rubens, whose designs for tapestries, historical paintings (the Marie de Medici series in the Luxembourg palace, now in the Louvre) and decorations for the Jesuit churches in Antwerp and the Banqueting hall, Whitehall, London, as well as his own home in Antwerp, reflect both the universality of his productive genius and his international acceptance.

At the court of Louis XIV it was Charles Le Brun who dominated mural style in France through the decorations of the Louvre and Versailles as well as his designs for tapestries. The same function was carried on in the 18th century by François Boucher. Outside of France, the richest development of the 18th-century mural decoration occurred in Germany particularly in the Archiepiscopal palace at Würzburg (Giovanni Battista Tiepolo) and the magnificent rococo churches of Bavaria (*e.g.*, Cosmas Damian Asam in Weltenburg) and Austria.

Political and social changes in 19th-century Europe resulted in a revival of monumental mural schemes, but there was hardly any development in style or technique. The austerer, classicist tendency, taken up from Anton Raphael Mengs in the 18th century, was developed by the German painters Johann Overbeck and Peter von Cornelius in Rome and Munich (Residenz; Ludwigskirche) and reached perhaps its finest expression in Puvis de Chavannes' cycle of St. Geneviève in the Panthéon of Paris. The second tradition, from Rubens to Tiepolo, was continued with great brilliance by Goya in his cupola for San Antonio de la Florida (Madrid) and by Eugène Delacroix (St. Sulpice, Palais Bourbon, Palais de Luxembourg, Paris), and at the end of the century, the colouristic discoveries of Impressionism were applied, rather uneasily, by Ferdinand Humbert in the Panthéon and by Claude Monet in his great series of "Water Lilies" (formerly in the Orangerie, Paris).

In England the first major attempt at the public patronage of mural painting, for the new houses of parliament, was largely thwarted by the technical inexperience of the artists (Daniel Maclise, William Dyce, John Tenniel, George Frederic Watts and others), and this was also true of the Oxford Union frescoes of Dante Gabriel Rossetti, Edward Burne-Jones and their group. One of them, William Morris, whose arts-and-crafts movement stressed competence and quality of craftsmanship, turned in his domestic interiors to small painted panels, wallpapers and tapestry. The more academic training of the Paris Beaux Arts tradition appeared in the American group of Edwin Howland Blashfield, Kenyon Cox and John La Farge who flourished after the 1893 Chicago World's fair as decorators of public buildings.

Mural decoration in the 20th century has three major phases. One is the more abstract and expressionistic form stemming from the experimental easel painting of the Cubist and Fauves groups in Paris and developing into the large projects of Pablo Picasso (UNESCO, Paris), Henri Matisse, whose chapel at Vence, France, attempts something like a complete unity of architecture and painted decoration, Fernand Leger and Joan Miró. The second is that which developed out of the revolutionary movement in Mexico with the remarkable series of frescoes by José Clemente Orozco, Diego Rivera, David Siqueiros and Rufino Tamayo. With the ensuing acceptance of 20th-century concepts of design and structure in architecture, the new large-scale use of mosaics became a distinctive feature (*e.g.*, the University of Mexico). A third phase, short-lived but extremely significant, was the U.S. mural movement of the 1930s developed under government sponsorship. The wide geographical distribution of the work in public buildings throughout the country, the freedom given both to individual and experimental modes of expression as well as to the interpretation of social and political problems, provided an artistic impetus to mural decoration not seen since the days of the Early Renaissance. Examples are murals of Ben Shahn, Boardman Robinson, George Biddle, Thomas Benton, Reginald Marsh and John Steuart Curry.

*See* also biographies of painters discussed in this article; and references under "Mural Painting" in the Index.

(L. E. S.; J. S. Ga.)

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**MURALT, BÉAT LOUIS DE** (1665–1749), Swiss moralist who interpreted England to the French and to his fellow-countrymen. He was born in Bern, Switz., and baptized on Jan. 9, 1665. He resigned his commission in the French army to travel about England (1694–95), and then returned to Bern but was banished in 1701 because of his Pietism. He settled permanently at Colombier (Neuchâtel), where he died, Nov. 19, 1749. His *Lettres sur les Anglais et les Français* and *Lettres sur les Voyages* (both 1725; Eng. trans. 2 parts, 1726) were written to friends, and he only agreed to their being published after much hesitation. *Lettres sur les Anglais* influenced Voltaire and Jean Jacques Rousseau to some extent, introducing them to English thought and English institutions. *Lettres sur les Français* shocked France, but Sainte-Beuve recognized that there was much wit in these "Swiss truths": the book strengthened English influences in Switzerland, which were very strong in the 18th century, at the expense of those (whether Catholic or materialist) from France. *Les Lettres fanatiques* demonstrate Muralt's mystical rationalism, while his *Instinct divin recommandé aux hommes* (1727; Eng. trans., 1751) is a work of visionary Illuminism mingled with Pietism.

*See* O. von Greyerz, *B. L. von Muralt* (1888); H. Perrochon, "B. de Muralt," *Revue de l'Académie des sciences morales et politiques*, vol. civ, no. 2 (1951).

(He. P.)

**MURANO,** a section of the municipality of Venice, Italy, is situated in the Venetian lagoon about 1.6 km. (1 mi.) N. of the city. Like Venice, it is composed of a number of small islands with canals and bridges. Its land area is about 459 ha. (1,134 ac.). Murano was founded sometime between the 5th and 7th centuries but its major development began in the 1290s, when glass furnaces were moved there from Venice and it became the manufacturing centre for Venetian glass, exported in large quantities to all Europe (*see* also Glass: *Venice and the Façon de Venise*). Its high point was in the 16th century, when it had more than 30,000 inhabitants; glassmaking continues, but on a considerably reduced scale. A record of this aspect of Murano's history is found in the Glass museum in the Giustinian palace.

The most important building in Murano is the basilica of SS. Maria e Donato. In its present state it dates from the 13th century, having been rebuilt several times since its foundation much earlier. Notable for the beautiful external architecture of the apse, it contains a spring-beam roof and most of the original floor. The mosaic in the apse showing the Virgin against a gold back-

ground is 13th-century Byzantine. The church of S. Pietro Martire, founded in the 14th century (rebuilt 1511), contains two paintings by Giovanni Bellini and two by Paolo Veronese.

**MURASAKI SHIKIBU** (978?–1026?), the author of *The Tale of Genji*, the greatest work of Japanese literature. Her real name is unknown, and it is conjectured that she acquired the sobriquet of Murasaki from the name of the heroine of her novel. The main source of knowledge about Lady Murasaki's life is the diary kept by her between 1007 and 1010. This work possesses considerable interest not only for its biographical information but also for the delightful glimpses it affords of life at the court of the empress Akiko, whom Lady Murasaki served.

Some critics believe that she wrote the entire *Tale of Genji* between 1001 (the year her husband Fujiwara no Nobutaka died) and 1005, when she began serving at court. More probably, however, the composition of this long and complex novel extended over a much greater number of years. The theory has been advanced, indeed, that the last 14 of the 54 chapters of the book were by another and later hand.

*The Tale of Genji* (*Genji monogatari*) is the oldest full novel written anywhere in the world and one of the finest. Much of it is concerned with the loves of Prince Genji and the different women in his life, all of whom are exquisitely delineated. If the novel is lacking in scenes of powerful action or violence, it is permeated with a sensitivity to human emotions and to the beauties of nature hardly paralleled elsewhere. The tone of the novel darkens as it progresses, indicating perhaps a deepening of Lady Murasaki's Buddhist conviction in the vanity of this world. The translation of *The Tale of Genji* (1935) by Arthur Waley is a classic of English. Lady Murasaki's *Diaries of Court Ladies of Old Japan* was translated by Omori and Doi (1935). (Do. K.)

**MURAT, JOACHIM** (1767–1815), the brilliant French cavalry leader whom the emperor Napoleon I made king of Naples in 1808, was born on March 25, 1767, at La Bastide-Fortunière, in Quercy, the son of an innkeeper. He began to study for the church at Cahors and at Toulouse, but enlisted in a regiment of light cavalry in 1787. After some vicissitudes in the early years of the French Revolution, he was promoted *chef d'escadron* in 1793. When Napoleon Bonaparte was defending the Convention against the royalist insurrection of 13 Vendémiaire, year IV (Oct. 5, 1795), he owed his victory to the cannon that Murat managed to bring up; and thenceforward Murat remained attached to him. As Bonaparte's first aide-de-camp in the Italian campaign of 1796–97 Murat began to make his name as an excellent cavalry officer; and during the expedition to Egypt (1798–99) he won distinction in command of a cavalry brigade at Alexandria, in the battle of the Pyramids, in Syria and later at Aboukir. Returning to France with the rank of general of division, he again served Bonaparte well in the *coup d'état* of 18–19 Brumaire, year VIII (Nov. 9–10, 1799), when he used force to disperse the recalcitrant deputies. Bonaparte, now first consul, rewarded Murat by making him the husband of his youngest sister, Caroline (Jan. 1800).

Murat's military career advanced rapidly. In the Italian campaign of 1800 he had a share in winning the battle of Marengo; and it was he who imposed the armistice of Foligno on Naples in Feb. 1801. Governor of Paris from Jan. 1804, he pledged himself to Bonaparte by setting up the commission which sentenced the duc d'Enghien to death. When Bonaparte had been proclaimed emperor as Napoleon I, Murat was made a marshal of the empire (May 1804) and then grand admiral and prince (Feb. 1805). Serving in every campaign between 1805 and 1808, he proved himself supreme as a cavalry general. He excelled at long-distance reconnaissance and at tactics whereby the enemy was pushed into making the move that suited the French plans: in Oct. 1805, for example, he drove the Austrian army back into Ulm, where it had to capitulate. In battle his cavalry charges were irresistible: at Austerlitz (Dec. 1805), he broke the Russian and Austrian squadrons; and at Eylau (Feb. 1807) he crushed the Russian infantry. After victory he was, as Napoleon put it, "tireless" in pursuit and could turn the enemy's retreat into a rout: on the morrow of the battle of Jena (Oct. 14, 1806), it was Murat's cavalry which completed the destruction of the Prussian army. Yet Murat was criticized for throwing himself overhastily into operations and, particularly, for acting sometimes from motives of vainglory.

On March 15, 1806, Murat was created grand duke of Berg and Cleves. Regarding himself now quite seriously as a sovereign prince, he soon grew impatient at Napoleon's authoritarian supervision. His victorious entry into Warsaw (Nov. 28, 1806, six weeks after Jena) led him to dream of becoming king of a restored Poland; and when this hope was brought to nothing by the peace of Tilsit (July 1807) he transferred his ambitions to Spain, rightly suspecting Napoleon of designs on the Spanish throne. Appointed imperial lieutenant for Spain (Feb. 20, 1808), he was soon trying to have that crown assigned to himself, but his maladroit intrigues merely exacerbated the Spanish people against the French. He harshly quelled the rising of May 2 in Madrid and left Spain on June 15 a disappointed man. It was not Murat but Napoleon's brother Joseph who was made king of Spain.

Murat, however, received generous compensation for his disappointment: on July 15, 1808, Napoleon assigned to him the throne of Naples, which Joseph had vacated. Even without Sicily, which the expedition of 1810 failed to wrest from the Bourbons and their British protectors, Naples was a considerable kingdom, and Murat accordingly entered upon his new role with enthusiasm. His affability and the splendid processions in which he displayed his horsemanship won the goodwill of his capital city, while Caroline helped him to maintain a magnificent court. The introduction of the French civil code (1809) helped to break up the vast properties of the landowners, who were also affected by the abolition of feudalism. The administrative services, reorganized by French experts, provided an opening through which the middle class could rise to influence. Cotton growing was developed in order to supply French industry. Effective measures were taken against brigandage.

Even so, Murat was not satisfied. Urged on by Caroline, he would have liked to be a real king, whereas Napoleon still scolded him as if he were a schoolboy and treated him as a vassal obliged to furnish contingents of troops and to submit to the requirements of the "continental system." Murat acquiesced but not without protest: "One is not king in order to obey." As unobtrusively as he could he proceeded to raise an army, which by 1813 numbered 60,000 men. Moreover, he entered into intrigues throughout Italy in the hope that eventually he would be able to lead a movement for Italian unification. Meanwhile he founded an "Italic" party, based on secret societies. This activity later had an important effect on the Risorgimento.

When Napoleon began to suffer defeat, Murat's intentions came to light. He had taken part in the invasion of Russia in 1812 and done marvels in the battle of Borodino; but when the terrible retreat had begun and he was left in charge of it by Napoleon he could think only of his kingdom. Abandoning the shattered remnant of the army (Jan. 1813), he hastened back to Naples. Doubtful whether he could rely any longer on Napoleon's protection and determined not to strip his kingdom of its troops in order to reinforce Napoleon's army, he now entered into clandestine negotiations with the British command in Sicily and with Austria, but could not obtain the exorbitant guarantees that he demanded. Consequently in Aug. 1813 he rejoined Napoleon in Saxony. Then the defeat of Napoleon at Leipzig (Oct. 16–18) convinced him that he must accept Austria's offer to guarantee him his kingdom if he would desert Napoleon; and by Nov. 4 he was back in Naples. He signed an alliance with Austria on Jan. 8, 1814 (modified in a treaty dated Jan. 11) and armistice with the British on Jan. 26 (likewise modified on Feb. 3); and on Jan. 30 he announced that his troops would join those of the coalition against Napoleon.

After Napoleon's fall, however, the allies showed little consideration for Murat, who in their eyes was still only the defaulting henchman of Bonaparte; and the Bourbons, especially, objected to Austria's having signed away their right to Naples. Disappointed and uneasy, Murat thought that a bold stroke might restore his fortunes. So, when Napoleon returned to France from Elba in 1815, Murat reverted to his old loyalty and staked everything on an appeal to Italian nationalism and to the idea of a

united Italy: he declared war on Austria and, in the proclamation of Rimini (March 30), called on all the people of the peninsula to fight for their independence. The Neapolitans, however, were defeated by the Austrians at Tolentino on May 2, the Bourbons were restored in Naples, and Murat fled to France. After Waterloo he made his way to Corsica, where he arrived in August; and thence, at the end of September, he sailed with only 250 men on a last attempt to recover his kingdom. Having lost four ships on the way, he landed at Pizzo in Calabria with 30 men on Oct. 8 and was taken prisoner by Bourbon troops. He was courtmartialed and shot on Oct. 13, 1815. "The bravest of men in the face of the enemy," Napoleon said of him at St. Helena, "incomparable on the battlefield, but a fool in his actions everywhere else."

Murat left two sons and two daughters. The eldest son, NAPOLÉON ACHILLE (1801–1847), went to the United States in 1821, took U.S. citizenship and died in Florida. The younger son, NAPOLÉON LUCIEN CHARLES (1803–1878), also went to the United States in 1825 but returned to France in 1848 and was recognized as a prince by Napoleon III, with the title of Prince Murat, under the second empire. From him descends the princely house of Murat surviving in the 20th century.

*See* also references under "Murat, Joachim" in the Index.

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**MURATORI, LODOVICO ANTONIO** (1672–1750), Italian scholar and pioneer of modern Italian historiography, was born at Vignola in the duchy of Modena on Oct. 21, 1672. He studied at Modena under the Benedictine Benedetto Bacchini, who introduced him to the historical-critical methods of the French Maurists (*q.v.*), and in 1694 he was ordained priest and given employment in the Ambrosian library at Milan. There he published the *Anecdota*, two volumes (1697–98; two further volumes added, 1713), a selection of texts which he had discovered among the manuscripts belonging to the library. In 1700 he went to Modena as librarian for Duke Rinaldo I. Legal disputes between the Este family and the Holy See which had arisen over the ownership of the territory of Comacchio, led Muratori to study, in the original documents, some of the juridical and ideological problems of the Italian middle ages, and he came to see in that period the origin of the modern states, although as a man of the 18th century he still considered it a "barbarous" epoch. As a result he undertook a documentary study, and, with the active collaboration of local correspondents, he collected together in his *Rerum Italicarum Scriptores*, 28 volumes (1723–51) chronicles, diaries and legal documents by which to illustrate the history of medieval Italian society.

At the same time Muratori was working on his 75 dissertations, published in the *Antiquitates Italicae Medii Aevi*, 6 vol. (1738–42), which includes the Muratorian canon, a 2nd-century list of the books of the New Testament (*see* BIBLE: *Canon and Text: The New Testament: Acknowledged Books*). These constitute his most lively and acute historical work, and are made up of detailed and penetrating studies on such subjects as the history of institutions, of economics, of religion and of social customs. They bear witness to an extraordinary familiarity with his sources, and are elaborately constructed. Particularly acute is the analysis of relationships between social events and religious traditions, relationships which he establishes with independent critical judgment. In 1744 he began the publication of the *Annali d'Italia*, 12 volumes (1744–49), a work of some significance because in it Muratori attempted to narrate the history of the Italian peninsula as a unified whole. As a work of historiography, however, the *Annali*, except for brief passages, are a failure. His analytical approach seems to be used to hide the absence of a central theme and the biographical sketches lack penetration and psychological insight. It would seem that Muratori had more understanding of the people and their needs than of individuals.

Muratori was not only an historian. As a man of letters he was sensitively aware of the connections between culture and morals and he believed that it was the duty of the critic to point them out, as can be seen from *Riflessioni sopra il buon gusto* (1708). As a priest he fought against superstition and against medieval scholasticism, as revived by the Jesuits, for reasons which were cultural as well as moral. He was even accused of Jansenism, an accusation which, although unjust in itself, was based on the apparent affinity between his own advocacy of a moral rebirth and that of the Jansenists. He was further linked to them by his definite acceptance of jurisdictional theories, due partly to his own preferences and partly to the influence of the Maurists. He died at Modena on Jan. 23, 1750.

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**MURAVIEV, MIKHAIL NIKOLAEVICH,** COUNT (1845–1900), Russian statesman, foreign minister from 1896–1900, was born at Grodno on April 19 (new style; 7, old style), 1845. He was the son of the governor there, Nikolai Mikhailovich Muraviev, and the grandson of the elder Mikhail Nikolaevich (1796–1866), who had been known as the "hangman of Wilno" because of his drastic repression of the Polish insurrection of 1863 in the Lithuanian provinces. The young Mikhail Nikolaevich entered the Russian foreign ministry in 1864, and served in various legations in Europe. Appointed Russian minister to Denmark in 1893, he was brought into close contact with the Russian imperial family, as the emperor Alexander III had married a Danish princess. Thus after the death of Prince A. B. Lobanov-Rostovski in 1896, the emperor Nicholas II appointed Muraviev minister of foreign affairs.

Mainly interested in the Russian expansion in the far east, Muraviev recommended the capture by the Russian navy of Port Arthur (Lüshun) and Dalny (Talien) in the Kwantung peninsula. This was achieved in Dec. 1897; and in the following year Muraviev concluded with China an agreement by which the entire Kwantung peninsula was leased to Russia for 25 years, with the right of linking Port Arthur via Harbin with the Trans-Siberian railway. In 1899 Muraviev exchanged notes with the British foreign office, whereby the two powers recognized their respective spheres of influence in China. It was Muraviev who, at the instance of the emperor, launched the idea of a peace conference at The Hague (*see* HAGUE CONFERENCES) on Jan. 11, 1899. He died suddenly in St. Petersburg on June 21 (N.S.; 8, O.S.), 1900.

**MURCHISON, SIR RODERICK IMPEY** (1792–1871), British geologist who first established the stratigraphic sequence of Early Paleozoic rocks, was born at Tarradale, Ross-shire, Scot., on Feb. 19, 1792. Educated at Durham and the military college, Great Marlow, he served in the army for eight years.

After his marriage in 1815, he retired from service and for some years pursued leisurely interests, particularly fox hunting. His meeting, in 1823, with Sir Humphry Davy resulted in Murchison's moving to London in the winter of 1824–25 and attending lectures at the Royal institution. In 1825 he joined the Geological Society of London; his first scientific paper was read to the society in the same year. Within three years he had explored large parts of England and Scotland and had obtained materials for three important memoirs in addition to two written in 1828 in conjunction with Adam Sedgwick (*q.v.*). He then explored with Sir Charles Lyell the volcanic region of Auvergne, parts of southern France, northern Italy, Tirol and Switzerland. Later, he and Sedgwick attacked the difficult problem of the geological structure of the Alps, and their joint paper (1830–31) giving the results of their study became a classic in the literature of Alpine geology. In 1826 Murchison was elected to the Royal society.

In 1831 he was elected president of the Geological society, having been secretary of the society for five years. In the same year, at the suggestion of William Buckland, he visited the Welsh border, to discover whether the graywacke rocks underlying the Old Red Sandstone could be grouped into a definite order of succession, as the secondary rocks of England had been made to tell their

story by William Smith. For several years he worked in that region. The result was his classification of the Silurian system (*q.v.*). These researches, together with descriptions of the coal fields and overlying formations in south Wales and the English border counties, were embodied in *The Silurian System* (1839).

The establishment of the Silurian system was followed by that of the Devonian system (*q.v.*), an investigation in which, with the paleontological assistance of W. Lonsdale, Sedgwick and Murchison worked both in the southwest of England and in the Rhineland. Murchison then projected an important geological campaign in Russia. He was accompanied by P. E. P. de Verneuil (1805–73) and Count von Keyserling (1815–91), in conjunction with whom he produced a magnificent work *The Geology of Russia in Europe and the Ural Mountains* (1845). He was knighted in 1846 and presided over the meeting of the British association at Southampton in that same year. A large part of his time was devoted to the affairs of the Royal Geographical society, of which he was one of the founders in 1830 and president in 1834 and subsequent years.

In 1855 Murchison was appointed director general of the geological survey and director of the Royal School of Mines and the Museum of Practical Geology in Jermyn street, London. He prepared successive editions of his work *Siluria* (1854; 5th ed., 1872), which presented the main features of the original *Silurian System* together with a digest of subsequent discoveries, particularly of those which showed the extension of the Silurian classification into other countries.

In 1871 Murchison founded a chair of geology and mineralogy in the University of Edinburgh. He died on Oct. 22, 1871. Under his will there was established the Murchison medal and geological fund to be awarded annually by the Geological society.

*See* Sir A. Geikie, *Life of Sir Roderick I. Murchison* (1875).

(A. GEI.; C. E. T.)

**MURCIA,** a town and province of southern Spain, in the region of the same name. The town is the seat of a bishopric, and is situated at the confluence of the Segura and Guadalentín (Sangonera) rivers, in a rich and fertile area known as the *huerta*. Pop. (1960) 249,738 (mun.). The Segura divides the city in two, the more important part lying on the left bank. The cathedral (Sta. Maria) dates from the 14th to 16th centuries but was restored in the 18th. It contains the fine chapel of the Vélez family (1507). In the Ermita de Jesús are the majority of the Passion sculptures of Francisco Salcillo; they attract many visitors during Holy Week. The university of Murcia was founded in 1915.

There was a town at Murcia before the Roman occupation of southern Spain in the 3rd century B.C., but its name then, and during the Roman rule, is unknown, although some have tried to identify it with the Roman town Vergilia. Its name is first mentioned in the histories and chronicles of the Muslims and, according to the Arab geographer Yaqut, it was founded in 825 by the Omayyad amir of Córdoba, Abd-al-Rahman II, who made it the capital of the province. After the fall of the caliphate of Córdoba in 1031, it came under the control of Almería, and then of Valencia, until in 1063 its ruler, Abd al-Rahman ben Tahir, declared himself independent (*see* MURCIA, KINGDOM OF).

Murcia is a communications centre and an agricultural trade centre for citrus fruits, almonds, cereals, olive oil and pepper cultivated in the *huerta*. The silk industry, which dates from Moorish times, is still carried on; manufactures of woolen, linen and cotton goods, of saltpetre, flour, leather, aluminum products, furniture and hats have been established.

MURCIA PROVINCE (pop. [1960] 800,463; area 4,369 sq.mi.) is part of the ancient kingdom of Murcia, made up of Albacete and Murcia and is situated mainly in the Penibetic mountain (Sistema Penibético) region. The Segura forms the basis for irrigation in the Murcian plain; its principal tributary is the Guadalentín. On the coast lies the Mar Menor, a large saltwater lagoon of 66 sq.mi. Two national highways cross the province, the roads Ocaña-Albacete-Cartagena and Motril-Almería-Murcia; also the railways Madrid-Cartagena and Alicante-Granada. The province is an important producer of lemons and oranges. Other crops include esparto, hemp, cotton, saffron and olives. There are rich deposits of minerals; zinc, lead and sulfur are important; copper and tin are also mined. There is a large oil refinery at Escombreras on the coast, belonging to the Instituto Nacional de Industria. Other industries include the manufacture of chemicals and vegetable canning. Ports include the naval base at Cartagena (*q.v.*), with the Bazan shipyards, and the fishing port at Mazarrón. There is a paratroop training base at Alcantarilla. Main towns include Lorca (pop., 58,641), Yecla (20,999), Cieza (22,438) and Caravaca (20,735).

(M. B. F.; X.)

**MURCIA, KINGDOM OF,** an independent Muslim kingdom in Spain, came into being on two occasions: in the 11th century, following the disintegration of the Spanish Omayyad caliphate; and in the 12th century, as part of the Hispanic reaction against the Almoravids. The kingdom's very complicated history is consistent in representing a nationalistic interpretation of Islam. Its ruler Abd al-Rahman ben Tahir declared himself independent in 1063, though to preserve the fiction of the religious unity of the caliphate he took the title not of king (*malik*) but of minister (*hachib*). An attempt by the ruler of the *taifa* (petty kingdom) of Seville to annex Murcia in 1079 failed because of a rebellion by the ruler's own vizier. For about ten years thereafter Murcia played an intermediary role between the Almoravids (*q.v.*) and the Castilians, but in the end religious sympathies inclined it toward the former. The Almoravid caliph Yusuf ibn Tashfin, who brought the quarreling *taifas* under his control, took possession of Murcia in 1092, incorporating it into his empire.

The Almoravids imposed a completely military regime which provoked discontent. In 1144 a former king of Saragossa, Abu Ch'afar ben Hud, known to the Christians as Zafadola, started a rising which became general. Involved internal struggles led Murcia to submit to Zafadola's authority, exercised by one of his lieutenants, Abd Allah ben Iyad, who administered the territory as a kingdom. Iyad contrived to unite Valencia and Murcia in a single kingdom after Zafadola's death. In 1147 Iyad was succeeded by Mohammed ben Mardanish. For 20 years, Mardanish, the most outstanding of the Spanish Muslim rulers of his time, aided by his father-in-law Ibn Hamushk and by alliance with Castile and Aragon, led the struggle against a new invading force from north Africa, the Almohads (*q.v.*). But a family quarrel, begun in 1168, led to the downfall of the kingdom, and on dying, Mardanish recommended his sons to submit to the Almohads. In spite of this Murcia retained an autonomous administrative system which was conserved by the Castilians when they took possession of the territory, almost without a struggle, in 1243.

(L. S. F.)

**MURDER,** the killing of another human being with malice aforethought, is the most serious crime of homicide defined by the Anglo-American law. American legislation ordinarily divides murder into degrees and reserves capital punishment for first-degree murder. The English Homicide act, 1957, also limits the death penalty to specified kinds of murder. *See* HOMICIDE.

(F. A. A.)

**MURDOCH, JAMES EDWARD** (1811–1893), U.S. actor, highly regarded during the 19th century as both tragedian and comedian, was born in Philadelphia, Pa., on Jan. 25, 1811. After performing with amateur groups in Philadelphia, Murdoch persuaded his father, a bookbinder who was opposed to his son's theatrical ambitions, to hire a theatre and an acting company for him. His debut, in Kotzebue's *Lover's Vows,* was considered a success, and after a season with the company (at no salary) Murdoch traveled about the U.S. and Canada, playing with various companies. In 1832, when he was emerging as an important actor, Murdoch mistakenly took arsenic, thinking it medicine, and was a semi-invalid thereafter. For the next 60 years he was on the stage irregularly, yet he managed to establish a reputation as one of the United States' foremost actors. His most popular successes were in *Conrad* (1832), *Velasco* (1837), *Calynos* (1851) and *De Soto* (1852). Murdoch died on May 19, 1893.

(S. W. H.)

**MURDOCK, WILLIAM** (1754–1839), British inventor, who made fundamental contributions to the development of steam power and gas lighting, was born near Auchinleck, Scot., on Aug. 21, 1754. In 1777 he entered the employment of Matthew Boulton and James Watt in the Soho works at Birmingham, and

about two years afterward he was sent to Cornwall to superintend the fitting of Watt's steam engines. At Redruth he is said to have carried a series of experiments in the distillation of coal so far that, in 1792, he was able to light his cottage and offices with gas. After his return to Birmingham about 1799, he made much progress in the discovery of practical methods for making, storing and purifying gas. In 1802 a portion of the exterior of the Soho factory was lighted with it in celebration of the peace of Amiens, and in the following year gas was brought into use for the factory interior.

Murdock was also the inventor of important improvements in the steam engine. He was the first to devise an oscillating engine, of which he made a model about 1784; in 1786 he was busy—somewhat to the annoyance of both Boulton and Watt—with a steam carriage or road locomotive; and in 1799 he invented the long D slide valve. He is also believed to have been the real deviser of the sun and planet motion patented by Watt in 1781. In addition, Murdock's ingenuity was directed to the utilization of compressed air, and in 1803 he constructed a steam gun. He retired from business in 1830, and died at Soho on Nov. 15, 1839.

**MURE, SIR WILLIAM** (1594–1657), Scottish poet, whose works combine classical learning with staunch Presbyterianism, was born at Rowallan, Ayrshire. After a quiet life, he became member for Ayrshire in the Scottish parliament in 1643, and, taking up arms for the Covenanters, was wounded at Marston moor in 1644. Little is known of his later life; he died in 1657. His best work is *Dido and Aeneas*, a verse paraphrase of book iv of Virgil's *Aeneid*. Religious zeal inspired, among other poems, *The True Crucifixe for True Catholickes* (1629) and *The Cry of Blood and of a Broken Covenant* (1650). He wrote much miscellaneous verse, including paraphrases of the psalms; his *Lute-Book*, in the Laing collection of manuscripts in Edinburgh university library, is of considerable interest. His *Works* were edited in two volumes by W. Tough for the Scottish Text society (1898).

**MUREŞ MAGYAR AUTONOMOUS REGION** (Regiunea Mureş-Autonomă Maghiară), an administrative and economic region of Rumania, is situated in eastern Transylvania (*q.v.*). Area 12,251 sq.km. (4,730 sq.mi.). Pop. (1960 est.) 801,290. The region is crossed by the volcanic range of the eastern Carpathians (the Gurghiu, Ciuc and Harghita mountains). The chief rivers are the Mureş, Tîrnava Mica, Tîrnava Mare and Olt. The administrative centre is Tîrgu Mureş (Târgu-Mureş; *q.v.*); other important towns are Reghin, Odorhei, Gheorgheni and Miercurea Ciuc. The most important mineral resource is salt; there are also lignite, iron ore and natural gas. Industries include metallurgical engineering and timber and food processing. Agriculture (particularly cereals and potatoes) and animal husbandry are also important.

**MURET, BATTLE OF** (1213), a victory of the crusaders in the war against the Albigenses or Cathari (*q.v.*) and their supporters, of crucial importance in the destiny of Languedoc and of France itself. It was fought on Sept. 12, 1213, near the small town of Muret in the Garonne valley about 13 mi. S.W. of Toulouse. The French leader Simon de Montfort (d. 1218; *see* Montfort) and his crusaders had already conquered the viscounty of Béziers-Carcassonne in 1209, but had been repelled in an assault on Toulouse, which remained loyal to its count, Raymond VI. Raymond and the bourgeois of Toulouse invoked the aid of King Peter II of Aragon; and Peter, who had not given up his predecessors' design of increasing Aragon's feudal power by acquiring vassals north of the Pyrenees, finally responded to the appeal. Though their combined forces were considerably superior to Simon's, misunderstanding between Peter and Raymond led to their defeat. Coming westward out of Muret, Simon attacked Peter's camp; and Peter's death gave the signal for a general flight, in which Raymond VI was involved. The militia of Toulouse, assailed unexpectedly in the camp, suffered heavy losses. The battle was followed by negotiations between Simon and Toulouse and by the eventual submission of the town (1214–15).

*See* P. Belperron, *La Croisade contre les Albigeois et l'union du Languedoc à la France* (1942); Z. Oldenbourg, *Le Bûcher de Montségur* (1959). (P. Wo.)

**MURETUS** (Marc-Antoine Muret) (1526–1585), French humanist and classical scholar, was born at Muret, near Limoges, on April 12, 1526. After a short career of great promise as a lecturer and man of letters, Muretus had to leave France because of charges of heresy and immorality that were perhaps never wholly substantiated. He fled to Italy. There too he quickly established himself and from 1563 to his death on June 6, 1585, he lived in Rome as a professor. Although he was hampered in the choice of subjects, he exerted much influence through his lectures and his connections with humanists in Italy and all over Europe.

He was a man of progressive scholarly ideas and must have had a great fascination as a teacher. He had considerable literary gifts: his Latin style was recognized as the very perfection of contemporary Ciceronianism, and good writing was perhaps his chief concern. And yet, unlike many a humanist, he took a genuine interest in the matter, not only the form, of the classical writings with which he concerned himself. He was a good textual critic: his *Variae lectiones* and his editions contain many fine emendations. He lectured with equal ease on Cicero, the Latin poets, Roman law, and Plato and Aristotle.

*See* C. Dejob, *Marc-Antoine Muret* (1881); Mark Pattison, "Muretus" (1882) in *Essays*, vol. i (1889). (C. O. Br.)

**MURFREE, MARY NOAILLES:** *see* Craddock, Charles Egbert.

**MURGER, (LOUIS) HENRI** (1822–1861), French novelist who first depicted Bohemian life. He was born in Paris, March 27, 1822, the son of a concierge and tailor. Leaving school at 13, he went into a lawyer's office, but later through the influence of the academician Étienne de Jouy, who lived in the house where his father was concierge, became a secretary to Count Aleksei Tolstoi, then representative in Paris of the Russian ministry of education. He was thus enabled to improve his education and publish some poems in periodicals; he also entered Bohemian society. He was often destitute; his health deteriorated and he was frequently in the hospital. These experiences give verisimilitude to his books, in which he himself figures as Rodolphe. He began to make friends, however, and to have work published. From 1847 to 1849 *Le Corsaire* published his *Scènes de la vie de Bohème* in separate episodes. Theodore Barrière dramatized it as *La Vie de Bohème* (1849) and it was highly praised. Thanks to this success, Murger was able to live more comfortably. *Le Pays latin* (1851), *Scènes de campagne* (1854) and *Les Buveurs d'eau* (1855) were first published in the *Revue des Deux Mondes;* in 1852 the Comédie Française produced *Le Bonhomme Jadis,* which remains part of the repertory.

In 1855 Murger bought a house near Melun and there wrote *Le Sabot rouge* (1860) and *Nuits d'Hiver* (1861). He died in the Maison-Dubois hospital, Paris, Jan. 28, 1861. Ruggiero Leoncavallo and Giacomo Puccini both used *La Vie de Bohème* as the basis of operas.

*See* P. Martino, *Le Roman réaliste sous le Second Empire* (1913); C. Beuchat, *Histoire du Naturalisme français,* vol. i (1949). (R. Dl.)

**MURGHAB,** a river rising in Afghanistan in a basin bounded on the north by the Band-i-Turkestan (11,472 ft.) and on the south by the Paropamisus, of similar altitude, forming the water parting between the Murghab and Hari Rud (*q.v.*). The course of the Murghab is generally westward as far as Lukh-i-Surkh, where it turns north, passing through Bala Murghab (1,538 ft.), just beyond which it forms the border between Afghanistan and the Turkmen Soviet Socialist Republic, U.S.S.R., for 10 mi. It is joined by its only important tributary, the Kushk, at Tashkepristroi. Dams control irrigation water at Tashkepristroi and Iolotan. At Mary (New Merv) it is crossed by the Transcaspian railway, from which a branch runs southward along the Murghab and Kushk to Kushka. North of Mary the river ends in the desert after a course upward of 450 mi. (B. L. C. J.)

**MURIATIC ACID:** *see* Hydrochloric Acid and Hydrogen Chloride.

**MURILLO, BARTOLOMÉ ESTEBAN** (1617–1682), the most popular Spanish religious artist of his time, was baptized in Seville on Jan. 1, 1618. After studying painting in Seville under Juan del Castillo (d. 1640), according to his first Spanish

biographer, Palomino de Castro y Velasco (*El Museo Pictórico*, iii, 1724), he made sufficient money from a consignment of pictures for the Spanish Indies to go to Madrid. There, under the protection of Velázquez, he saw the famous paintings in the royal palaces and private collections. He copied many works by Titian, Rubens and Van Dyck, much to the improvement of his colouring, drew from statues and other models and was influenced by the "grand manner" of Velázquez. Palomino places this journey to Madrid before Murillo's paintings for the monastery of San Francisco in Seville, one of which is dated 1646. However, in Feb. 1645, on the occasion of his marriage, Murillo declared that he had never been away from Seville, and, since there is no documentary evidence to confirm the story of his Madrid visit, some critics have denied that it was ever made. It is, nevertheless, probable that Palomino, who had his information from close associates of Murillo, was mistaken only in the date of the visit. This is more likely to have taken place after he made the paintings for San Francisco, possibly in 1648–49, when there is apparently no record of his presence in Seville; for the San Francisco paintings are still in the naturalistic tradition of the school of Seville, whereas Murillo's mature style after about 1650 seems to be directly dependent on those masters whom he is said to have studied in Madrid. The rest of his life appears to have been spent in Seville, where he died on April 3, 1682.

Murillo, like all Spanish painters of his time outside the court, devoted himself mainly to religious subjects. Among his chief patrons were the Franciscans and he worked for many lay confraternities. Most of his paintings were made for the cathedral and churches of Seville. His small religious compositions were doubtless usually designed for private houses.

The "Vision of Fray Lauterio" (Fitzwilliam museum, Cambridge) and the "Virgin of the Rosary" (Archbishop's palace, Seville), considered to be Murillo's earliest known works, are in the retardative style of his master Juan del Castillo, a combination of mannerism and realism. The 11 paintings for the *claustro chico* of San Francisco (now dispersed), of which the "Ecstasy of St. Diego of Alcalá," popularly called the "Angels' Kitchen" (Louvre museum, Paris), is dated 1646, are in the more "modern," naturalistic style established in Seville by Velázquez and continued by Zurbarán. In the "Charity of St. Diego" (Academia de San Fernando, Madrid), realism and tenebrism, commonplace models and emphasis on genre are directly inspired by the *bodegones* of Velázquez.

In Murillo's paintings of the 1650s, there appears the striking transformation of style which is hardly to be explained except by a visit to Madrid. The further stages of his evolution are, however, not clearly defined, and no satisfactory chronology of his work has yet been established. Throughout his life, he absorbed influences from a variety of sources, and many of his compositions are adapted from paintings and engravings of Flemish and other masters. He seldom signed or dated his paintings and only some of his official commissions are documented. But the chief characteristics of his later works are already present in those which mark the creation of his personal manner and his break with provincial naturalism.

In the large "Immaculate Conception" of 1652 (museum, Seville), Murillo's softly modeled forms, rich colours, general system of lighting and broad technique reflect the change which had taken place in Velázquez' own style after his move to Madrid, through contact with Venetian and Flemish paintings in the royal collection. Murillo's "Conception" is also strongly influenced by J. de Ribera, and may even be based on the latter's painting of this subject at Salamanca. The "St. Leandro" and "St. Isidoro," which caused Murillo to be described as the best painter in Seville when they were placed in the cathedral sacristy in 1655, are still further removed from the simple naturalism of his earlier Franciscan saints. These seated figures of holy bishops, over life size, are in the grand manner of baroque portraiture, which had become fashionable at the Spanish court through Rubens and Van Dyck. The "Vision of St. Anthony," one of Murillo's most celebrated pictures, painted for the baptistery of Seville cathedral and completed in 1656, is an early example of his so-called "vaporous" style, which derives from Venetian rather than Flemish sources. In this enormous and elaborate composition, Murillo may also have been influenced by a reflection of Roman baroque paintings which was introduced into Seville at about this time by Francisco Herrera the Younger. But, unlike Herrera and his other Sevillian contemporary Juan de Valdés Leal, Murillo never adopted the more exaggerated elements of this style: crowded space, violent movement and excited gesture. The isolated kneeling figure of St. Anthony turns with outstretched arms toward the vision of the Infant Christ, who descends in an aura of light encircled by angels and cherubs floating among clouds, and the whole glory is enveloped in a misty veil.

Nebulous apparitions of angels hovering in the sky occur in many of Murillo's later biblical compositions, as well as in representations of mystical visions, to suggest the mystery of heaven. At the same time he retained throughout his life his early interest in genre and narrative. His images of the Virgin, of Christ and the saints, though idealized and often sentimental, are based on popular local types, and the prominence which he gives to homely accessory figures, particularly of children, and to familiar details

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"THE HEAVENLY AND EARTHLY TRINITIES" BY BARTOLOMÉ ESTEBAN MURILLO. IN THE NATIONAL GALLERY, LONDON

of everyday life give an intimate character to most of his religious scenes.

The enormous success which Murillo must have enjoyed in Seville is indicated by the increasing range of his official activities. He was one of the founders and first president of the Academy of Painting established in Seville in 1660. The "Invention of Painting," a subject derived from Pliny, is the only classical legend that he is known to have represented; it is one of several works executed for the confraternity of the Guild of Painters, to which he belonged. In 1665 he completed a series of paintings for the church of Santa María la Blanca, Seville, illustrating the foundation

of Sta. Maria Maggiore, Rome (partly preserved in the Prado museum, Madrid), and began work on 22 pictures for the Capuchins (mostly preserved in the Seville museum), which he interrupted in order to decorate the chapter house of the cathedral. In 1671 he played a major role in the decoration of the cathedral for the celebration of the new cult of St. Fernando (recorded by Fernando de la Torre Farfán, *Fiestas de la S. Iglesia . . . de Sevilla* [1672], with engravings after Murillo and others). In 1665 he had been admitted to the confraternity which owned the church and hospital of San Jorge, known as La Caridad, having been recommended as a person who would be of service to God and the poor as well as for the adornment of the church. Murillo's paintings for La Caridad include the famous series of eight compositions representing works of mercy, completed in 1674 (partially dispersed in 1810)—very different from the macabre "Hieroglyphs of Our Last Days" made by Valdés Leal for the same church but themselves varied in character. "Moses Striking the Rock" and the "Feeding of the Five Thousand" (La Caridad, Seville) have romantic landscape backgrounds, like many other later works of Murillo, and numerous genre details; "Christ Healing the Paralytic" (National gallery, London) is a more monumental composition with grandiose figures and architectural setting; "St. Elizabeth of Hungary Healing the Sick" (La Caridad) and the "Return of the Prodigal Son" (National gallery, Washington, D.C.) are, in effect, dramatized genre. From 1678 onward Murillo was working on paintings for the Hospital de los Venerables Sacerdotes, which included the celebrated "Soult Conception" (one of the many paintings by Murillo taken to France by Marshal Soult; now in the Prado, Madrid). His last works for the Capuchin church at Cádiz were left unfinished at his death; but the "Heavenly and Earthly Trinities" (National gallery, London), probably painted for a private patron in Cádiz, is an example of his late style. The mystical symbolical significance of the subject is emphasized by the characteristic vaporous glow which radiates from the Holy Ghost, illuminating the figures of the "Earthly Trinity" below. But these figures, based on familiar human archetypes, with natural gestures and tender and devout expressions, create an effect of intimate rather than exalted religious sentiment, which has led to the picture being generally known as a "Holy Family."

Murillo's religious art, with its manifest appeal to popular piety, illustrates the popular teaching of the Counter-Reformation church, as opposed to its militant activities. He represented the joys rather than the sufferings of spiritual life. His paintings for the Franciscans depict the acts of faith and charity, the mystical visions of their saints, while the subjects that he painted most frequently were those relating to the Virgin, above all the "Immaculate Conception," a cult which from the early 17th century had enjoyed enormous popularity in Spain, particularly in Seville. He also painted many versions of the Infant Christ and of the infant St. John the Baptist. These idealized "portraits" of beautiful children, in landscape settings, have their secular counterpart in his numerous rustic scenes with picturesque beggar children, though the latter have the features and expressions of individual models. His few portraits give an impression of unaffected likeness. The "Self-Portrait" (National gallery, London), copied frequently in paintings and engravings, shows him in middle age, with an aspect as gentle and tranquil as is the character of his art.

Murillo had many pupils and innumerable followers, and his paintings were copied and imitated in Seville throughout the 18th century. He was the first important Spanish painter to achieve European fame, and up until the 19th century he was the only one whose works were widely known abroad. In England, his paintings were enormously popular throughout the 18th and 19th centuries; they were admired and imitated by Reynolds and Gainsborough and so highly prized by collectors that Curtis' catalogue of his works, published in 1883, shows more in England than in Spain. But many paintings attributed to Murillo are by other hands, and though authentic works are distributed all over the world, the bulk of his original work is preserved in Madrid and Seville.

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**MURIS, JEAN DE** (*c.* 1290–*c.* 1351), French philosopher and mathematician, was born in Normandy about 1290. His musical treatise *Ars novae musicae* (written in 1319) demonstrates his enthusiasm for the great changes in musical style and notation generally associated with Philippe de Vitry and the *Ars nova*. An attack on these changes known as *Speculum musicae* was mistakenly attributed to Jean de Muris, but its true author is now known to be Jacques de Liège. De Muris knew many of the great composers of his day, especially De Vitry, with whom he exchanged letters, but apparently De Muris himself composed no music. His treatise is much concerned with medieval ideas of numerical perfection based on multiples of three, and his defense of notational improvements relies to a considerable extent on mathematical reasoning. He died in Paris about 1351. The *Ars novae musicae* has been reprinted by M. Gerbert in *Scriptores ecclesiastici de musica*, iii (1784); an extract translated into English may be found in W. O. Strunk, *Source Readings in Music History* (1950).

(D. W. St.)

**MURMANSK,** a seaport and *oblast* centre of the Russian Soviet Federated Socialist Republic, U.S.S.R., stands on the eastern shore of the long, narrow Kola inlet (Kolski Zaliv) 30 mi. from the Barents sea. Pop. (1959) 221,874. The town is very young, having been founded as a supply port for Russia in 1916, during World War I. A railway was built to link the town with Petrograd (now Leningrad) about 900 mi. S. In 1918 the port was the base for the small British, French and American expeditionary forces of intervention against the Bolsheviks. In World War II Murmansk again served as a major supply base, the main port for Anglo-American convoys. The harbour is sheltered, and the southern part of the Barents sea, influenced by the tail end of the Gulf stream, is free of ice, which is rare in the inlet and can be broken by icebreakers. These factors have caused the steady growth of Murmansk, which is now the largest town in the world north of the Arctic circle. It has ship-repair yards and is the base for a large fishing fleet. Other industries include saw-milling, fish-canning and brewing. There are a teachers' institute and a research institute of marine fisheries and oceanography. Nearer the sea are the outport of Severomorsk and the naval base of Polyarny (formerly Aleksandrovsk).

MURMANSK OBLAST is more or less conterminous with the Kola peninsula (*q.v.*). Its area is 55,946 sq.mi. and its population (1959) 567,672, of whom 92% are urban (the highest proportion in the U.S.S.R.), living in 7 towns and 25 urban districts. The principal towns, aside from Murmansk, are Kandalaksha and Kirovsk. (R. A. F.)

**MURNER, THOMAS** (1475?–1537), German satirist, a vigorous critic of contemporary society and a notable early opponent of the Reformation, born on Dec. 24, 1475 (?), at Oberehnheim, Alsace, became a Franciscan in 1490, studied in Freiburg im Breisgau, Paris, Cracow, Basel and elsewhere, and later held teaching and administrative offices in his order. In 1523 he visited England. After the peasants' revolt in 1524 he fled from Alsace to Lucerne. At his death (in Aug. 1537) he was priest of Oberehnheim.

Murner translated Virgil's *Aeneid* (1515) and Justinian's *Institutiones* (1519) and wrote the *Chartiludium logicae* (1507) and numerous pamphlets; his fame, however, rests on his satirical poems, chiefly *Die Narrenbeschwörung* (1512), *Die Schelmenzunft* (1512), *Die Mühle von Schwindelsheim und Gredt Müllerin Jarzeit* (1515) and *Die Geuchmatt* (1519), in which the corruption of his age is attacked unmercifully but with broad humour and in racy, popular language. His *Von dem grossen lutherischen Narren* (1522) is one of the ablest contemporary satires on Luther.

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**MURNGIN,** a clan name in northeastern Arnhem Land, Northern Territory of Australia, also denoting a congeries of

similar clans northeast of a line from Cape Stewart to Blue Mud bay. Wulamba (mass) is an alternative name. These clans are patrilineal, exogamous and localized, the members of each one "belonging" to its country through the preexistence of their spirits there. Each clan has several totems, one of which is specially sacred (*see* TOTEMISM: *Australia*). The clans are divided between two patrilineal, exogamous moieties (Dua and Yiritja) and also exhibit slight dialectical differences. The Murngin numbered about 1,750 during the 1960s.

The social structure includes the eight subsection system (*see* AUSTRALIAN ABORIGINES). Marriage is prohibited between a man and his father's sister's daughter, but is allowed and indeed preferred with mother's brother's daughter and more distant cross-cousins classified with her. The Murngin have arranged marriage and descent of subsections so that a man's marriageable cousins are in the same subsection. Where first-cousin marriage is prohibited, such a cross-cousin is in a separate subsection.

Clans spend much time together for social, economic and religious activities, but there is no overall tribal organization and authority. The great Murngin myths and rituals form a pattern associated with initiation and with the seasons, the myths of the Wauwalik sisters (and the great python) and of the Djunkgao (Djanggawul) being the most important. The Murngin are noted for their bark paintings, woodcarving, poetry and songmen.

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**MUROM,** a town of Vladimir *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., stands on the left bank of the Oka river, where it is crossed by the main Moscow-Kazan railway. Pop. (1959) 71,567. It is one of the earliest recorded Russian towns, and was first mentioned in 862. It was the seat of a principality in the 11th century, was sacked by Bulgars and Tatars and was incorporated into Muscovite state in 1393. Surviving architectural features include the Trinity (Troitski) monastery, with its church of Our Lady of Kazan, and the monastery of the Annunciation (all 17th century); the churches of the Resurrection and the Transfiguration, of the same period; and the partly ruined church of Kosma and Demyan (16th century). Modern Murom has engineering and locomotive repair shops, textile mills and sawmills. (R. A. F.)

**MURORAN,** Japanese city, largest industrial centre and one of the chief ports of Hokkaido, located on the northeastern coast of Uchiura bay in southeastern Hokkaido. Pop. (1960) 145,679. It is noted for its iron and steel production, based on both local and imported raw materials. Muroran's port, sheltered within a large curved sandspit, handles large amounts of coal from the interior Ishikari fields, wood and wood pulp and marine products. Railways link it with principal Hokkaido cities. (J. D. EE.)

**MURPHY, FRANK** (1890–1949), associate justice of the supreme court of the United States from 1940 to 1949, one of the most militant defenders of civil rights ever to sit on that bench. He was born April 13, 1890, at Harbor Beach, Mich., and received his law degree from the University of Michigan in 1914. After service in France in World War I as an infantry officer he practised law in Detroit, taught at the University of Detroit, and from 1923 to 1930 was judge of the recorder's court. Elected mayor in 1930, he achieved national prominence by his bold efforts to blunt the impact of the depression on the city's unemployed and his demands for federal intervention in the face of economic catastrophe. In 1933 he was appointed governor-general of the Philippine Islands and promptly became an informal sponsor of the independence movement.

Returning to the United States, Murphy was elected governor of Michigan in 1936 and achieved fame in labour circles and notoriety among businessmen by refusing to employ troops to break the sit-down strikes. After being defeated for re-election in Nov. 1938 he was appointed U.S. attorney general by Pres. Franklin D. Roosevelt on Jan. 2, 1939, and, after establishing the civil rights unit (now division) of the department of justice, was named to the supreme court on Jan. 4, 1940. For almost a decade he conducted a vigilant campaign on behalf of civil rights and could inevitably be found on the side of racial and religious minorities. His greatest dissent was undoubtedly in the 1944 Korematsu case in which he denounced as "racism" the military decision to imprison the Japanese-Americans on the west coast after the bombing of Pearl Harbor. He died July 19, 1949. (J. P. Ro.)

**MURPHY, JOHN BENJAMIN** (1857–1916), U.S. surgeon, eminent as a teacher, was born in Appleton, Wis., on Dec. 21, 1857. He graduated at Rush Medical college, Chicago, Ill., in 1879, practised in Chicago for three years and then studied in Europe from 1882 to 1884. Murphy was the inventor of the anastomosis button (1892), which simplified the technique of certain intestinal operations and so reduced their danger. He taught successively at Rush Medical college, at the College of Physicians and Surgeons of Columbia university and at Northwestern university medical school. In 1911 he was president of the American Medical association. He was author of *General Surgery*, vol. ii of the "Practical Medical Series," and of numerous articles. He died Aug. 11, 1916.

**MURPHY, JOHN FRANCIS** (1853–1921), U.S. landscape painter, was born at Oswego, N.Y., on Dec. 11, 1853. He was self-taught. He first exhibited at the National Academy of Design in 1876 and was made an associate in 1885 and a full academician two years later. He died in New York city on Jan. 10, 1921.

Landscapes by Murphy are exhibited at public galleries in Pittsburgh, St. Louis, Detroit, Chicago and other cities.

**MURPHY, WILLIAM PARRY** (1892– ), U.S. physician, co-winner of the Nobel prize in medicine in 1934, was born in Stoughton, Wis., on Feb. 6, 1892. He received his A.B. degree from the University of Oregon in 1914 and his M.D. degree from Harvard university in 1920. Before entering medical school he taught physics and mathematics for two years in Oregon high schools. From 1920 to 1922 Murphy served as house officer at Rhode Island hospital, Providence, R.I. He entered the practice of medicine at Boston in 1923 and subsequently was appointed successively assistant resident, junior associate, associate and senior associate in medicine and consultant in hematology at the Peter Bent Brigham hospital, Boston, Mass. At Harvard he was successively assistant in medicine (1923), instructor (1928), associate (1935) and lecturer (1948).

In 1926 Murphy and George Richards Minot (*q.v.*) reported their successful results in the treatment of pernicious anemia with a liver diet. This discovery, and the developments which arose from it, converted a previously inevitably fatal disorder into one readily amenable to treatment. It was for this work that he and Minot (with G. H. Whipple) were awarded jointly the Nobel prize. In 1939 Murphy's textbook *Anemia in Practice* was published. (F. H. BL.)

**MURRAY, LORD GEORGE** (1694–1760), Scottish Jacobite and one of the Young Pretender's ablest generals. He was the fifth son of John, 1st duke of Atholl, and was born at Huntingtower, near Perth, on Oct. 4, 1694. He joined the army in Flanders in 1712 and in 1715 supported the Jacobite rebels under the earl of Mar. Wounded at the battle of Glenshiel in 1719, he escaped to Rotterdam several months later. He returned to Scotland in 1724 and on being granted a pardon settled at Tullibardine until 1745, when, on the eve of the Jacobite rising, the duke of Perth approached him on behalf of the Pretender; but his attitude was doubtful. He paid his respects to Sir John Cope, the commander of the government troops, and permitted his brother, the duke of Atholl, to appoint him deputy sheriff of Perthshire. He received a commission in the Jacobite army and the victory at Prestonpans, on Sept. 21, was mainly due to his able generalship. After opposing the invasion of England, he prevailed on the prince to march into Cumberland. When Carlisle was taken, he resigned his command, but the dissatisfaction of the army with his successor, the duke of Perth, compelled Charles to reinstate Murray. Obliged to retreat from Derby, his

army reached Carlisle safely and entered Stirling in Jan. 1746.

The prince laid siege to Stirling castle, while Murray defeated Gen. Henry Hawley near Falkirk; but sickness, desertion and the approach of Cumberland made retreat to the Highlands an immediate necessity. The battle of Culloden, where the Stuart cause was ruined, was fought on April 16, 1746. On the following day the duke of Cumberland intimated to his troops that "the public orders of the rebels yesterday was to give us no quarter"; and Hanoverian newssheets printed what purported to be copies of such an order. The original copies of Murray's "orders at Culloden," which are in existence, contain no injunction to refuse quarter. After the defeat Murray conducted a remnant of the Jacobite army to Ruthven, but Prince Charles had determined to abandon the enterprise, and dismissed Murray from his service. Charles's belief in the general's treachery was shared by several leading Jacobites, but there appears no ground for the suspicion. Murray escaped abroad and died in Holland on Oct. 11, 1760.

*See* W. Duke, *Lord George Murray and the Forty-five* (1927); K. Tomasson, *The Jacobite General* (1958). (W. Fe.)

**MURRAY, (GEORGE) GILBERT (AIMÉ)** (1866–1957), British classical scholar, the most widely influential of his generation, was born at Sydney, Austr., Jan. 2, 1866. He lived in Australia till the age of 11 and there acquired a physical hardihood which was unexpectedly combined with the sensibilities of a poet and experimenter in telepathy. In England, at Merchant Taylors' school, London, and at St. John's college, Oxford, he quickly made his mark; he became a fellow of New college in 1888 and professor of Greek at Glasgow university a year later, and in 1908 he was appointed to the regius professorship of Greek at Oxford which he held until 1936. He died in Oxford on May 20, 1957, and his ashes were interred in Westminster abbey.

The ancient author with whom Murray had the most immediate sympathy was Euripides, whom he interpreted as being, like himself, the prophet of liberalism and enlightenment in an age when conventions were breaking down and obscurantism seemed in retreat. His critical edition (1901–10) won immediate acceptance among scholars, while the brilliant *Euripides and His Age* (1913) had a vividness and lightness of touch unexampled in such works unless in his own earlier books. His verse translations, mainly of Euripides, undertaken with the encouragement of William Archer and George Bernard Shaw and first staged by Harley Granville-Barker, for nearly half a century brought theatregoers, readers and listeners by the million into contact with Attic drama. Their appeal faded only when the poetic manner in which they were written, that of Swinburne and William Morris, finally lost favour.

His importance in the world of scholarship was largely that, along with Jane Harrison and Francis Cornford, he applied to the study of ancient societies the insights into primitive life lately won by the new science of anthropology. These were particularly valuable for the understanding of Homer and of the older forms of religion which are often concealed in ancient literature. His works include *History of Ancient Greek Literature* (1897), *The Rise of the Greek Epic* (1907), *Five Stages of Greek Religion* (2nd ed. rev. and enlarged, 1925), *Aristophanes* (1933), *Greek Studies* (1946), *Hellenism and the Modern World* (1954) and *An Unfinished Autobiography* (1960).

Hating cruelty and suffering as he did, Murray could never have been satisfied by a life wholly retired in scholarship. His activities on behalf of exiles, especially exiled scholars, in World War I led him on to passionate engagement in the cause of the League of Nations and later the United Nations both in England and at Geneva. (D. W. Ls.)

**MURRAY, JAMES** (1721–1794), British governor of Quebec and of Minorca, was born at Ballencrief, Scot., on Jan. 21, 1721, a younger son of Alexander Murray, the fourth baron Elibank, and Elizabeth Stirling. He served with the British army in the West Indies and Europe before going to North America with rank of lieutenant-colonel in 1757. He fought under Lord Jeffery Amherst at the capture of Louisburg (1758) and under James Wolfe in the decisive battle on the Plains of Abraham (1759). When Quebec surrendered he became its military governor. He lost a pitched battle at Ste. Foy the following spring but held Quebec until reinforcements arrived by sea. He co-operated with Amherst in the advance on Montreal and when that town capitulated, and with it the colony, he became military governor of the Quebec district. He was governor-in-chief of the new province of Quebec after civil government was established in 1764.

Murray disliked the British policy of anglicizing Quebec and tried to have it modified. He won the confidence of the French seigneurs but not the English merchants, and was recalled for an investigation. He left Quebec in 1766 and, although vindicated by the privy council, did not return.

Murray was appointed governor of Minorca in 1774. He was beset with difficulties after war broke out with Spain (1779) and surrendered to a large force of French and Spanish invaders in 1782. He was court-martialed on his return to England but acquitted and promoted general. He died at Beauport House near Battle, Sussex, on June 18, 1794.

*See* A. C. Murray, *The Five Sons of Bare Betty* (1936). (Je. E. M.)

**MURRAY, SIR JAMES AUGUSTUS HENRY** (1837–1915), British lexicographer renowned as editor of the *New English Dictionary* (later known as the *Oxford English Dictionary*), was born at Denholm, near Hawick, on Feb. 7, 1837. After a local elementary education he studied at Edinburgh, the University of London, from which he graduated in 1873, and Balliol college, Oxford. Murray taught from 1855 to 1885 at Hawick Grammar school and Mill Hill school during which time his reputation as a philologist increased; in 1878 he wrote his famous article on the English language for the *Encyclopædia Britannica,* and he was president of the Philological Society from 1878 to 1880, and again from 1882 to 1884. It was in connection with this society that he undertook the chief work of his life, the editing of the *New English Dictionary on Historical Principles,* based on materials collected by the society (*see* Dictionary). These materials, which had accumulated since 1857, when the society first projected the publication of a dictionary on philological principles, amounted to an enormous quantity, of which an idea may be formed from the fact that F. J. Furnivall sent in "some ton and three-quarters of materials which had accumulated under his roof." The first section of the dictionary was printed at the Clarendon press, Oxford, in 1884. Murray himself was personally responsible only for about one-half of the dictionary, covering A–D, H–K, O, P, T. But he created the organization that made the undertaking possible, and inspired both his colleagues and his successors. Murray was an original fellow of the British Academy, and in 1908 he was knighted. He died at Oxford on July 26, 1915.

**MURRAY, SIR JOHN** (1841–1914), British naturalist and a founder of oceanography, was born at Coburg, Ont., on March 3, 1841. In 1868 he visited Jan Mayen Island and explored part of Spitsbergen. In 1872 he was appointed a naturalist to the "Challenger" expedition and on the death of Wyville Thomson in 1882 became editor of the *Reports* of the expedition. He was also part author of the *Narrative of the Cruise* and of the *Report on Deep-Sea Deposits.*

In 1880 and 1882 Murray explored the Faeroe channel and between 1882 and 1894 inspired various biological investigations in Scottish waters, establishing marine biological laboratories at Granton and Millport (later to develop into the Scottish Marine Biological association). With financial and technical assistance from Frederick and Laurence Pullar, he completed in 1906 a bathymetric survey of the fresh-water lochs of Scotland, and in 1910 he joined Johan Hjort in an oceanographical expedition to the North Atlantic ocean and was co-author, with Hjort, of *Depths of the Ocean* (1912). Murray was accidentally killed near Kirkliston, in Scotland, on March 16, 1914. (H. F. P. H.)

**MURRAY, SIR JOHN,** Bart. (Murray of Broughton) (1715–1777), secretary to Prince Charles, the Young Pretender, during the 1745 rebellion. He was educated at the universities of Edinburgh and Leiden and became involved with the Jacobites in 1738. He returned to Scotland as an official Jacobite agent in 1741 but his work there was complicated by the over-optimistic

reports that led to the abortive French invasion of Scotland in Feb. 1744. Charles nevertheless pressed on with his own plans and Murray served him efficiently during the rebellion until his health broke down in March 1746, to the detriment of the rebels' commissariat. Subsequently Murray was accused, possibly unjustly, of fomenting trouble between Charles and Lord George Murray during the campaign. He turned king's evidence but most of the evidence he gave the crown was aimed at those who, in his judgment, had failed the Jacobite cause. Lord Lovat, although incriminated by Murray, was not condemned and executed on his evidence alone. Murray was pardoned in 1748 but his later life was miserable. Shunned as a traitor, even by his wife, he became deranged. On the death of his uncle in 1770, Murray inherited the baronetcy and died at Cheshunt, in Hertfordshire, on Dec. 6, 1777. He was a sincere Jacobite and his career cannot be assessed justly from his unheroic but all too human nervous collapse in 1746.

See *Memorials of John Murray of Broughton* (1898); Robert Forbes, *The Lyon in Mourning*, ed. by H. Paton, 3 vol. (1895–96). (W. Fe.)

**MURRAY, JOHN,** the name of a great firm of London publishers, one of the oldest in Great Britain.

John MacMurray, later John Murray (1745–1793), was the founder of the firm. He was a native of Edinburgh, a lieutenant of marines who in 1768 retired from the service and bought the book business of William Sandby in Fleet street. He dropped the prefix "Mac" (which had first been adopted by his father) and set up his business under the family's original name of Murray. He was one of the original proprietors of the *Morning Chronicle* and started the monthly *English Review* (1783–96). Among his publications were J. Langhorne's *Plutarch's Lives*, the first part of Isaac D'Israeli's *Curiosities of Literature* and J. C. Lavater's *Physiognomy*. He died on Nov. 6, 1793.

His son John Murray (1778–1843), Byron's publisher and the real founder of the firm's fortunes, was 15 when his father died. During his minority the business was conducted by Samuel Highley, who was made a partner; but as soon as Murray was himself established in the business he dissolved the partnership (1803). In 1807 he shared with Archibald Constable (*q.v.*) in publishing Sir Walter Scott's *Marmion* and became part owner of the *Edinburgh Review*, although with the help of George Canning he launched in opposition the *Quarterly Review* (Feb. 1809), with William Gifford (*q.v.*) as its editor and Scott, Canning and Southey among its contributors. In 1811 the first two cantos of Byron's *Childe Harold* were brought to Murray by R. C. Dallas, to whom Byron had presented them. Murray paid Dallas £600 for the work and thus began his long association with Byron. In all Murray paid about £20,000 for Byron's poems. Byron was irritated by Murray's reluctance to publish some of his more outrageous poems and passages (he called him "the most timid of God's booksellers") and withdrew from him as publisher in 1822 after the issue of the 5th canto of *Don Juan;* but the friendship between the two lasted until Byron's death and their correspondence is one of the important literary documents of the period. After Byron's death, it was in Murray's drawing room, in 1824, that the manuscript of his memoirs (which Murray owned) was destroyed. Gifford considered the memoirs unfit for publication and Murray, in an unfortunate act of disinterested loyalty, concurred in their destruction.

In 1812 Murray had moved from Fleet street to 50 Albermarle street, and the house became one of London's literary centres. Writers with whom Murray was associated included Southey, Crabbe, Scott, Mme de Staël, Benjamin Disraeli and Washington Irving. In 1830 he gave up publishing poetry and in 1838–39 transferred his novels to other publishers. He devoted himself from this time to travels, biographies, science and general literature. He died on June 27, 1843.

John Murray (1808–1892), son of the above, began in 1836 the famous series of guidebooks known as "Murray's Handbooks" or "Murray's Red Guides." The first of their kind in assembly of practical information, they were taken as a model by K. Baedeker (*q.v.*). Murray himself wrote several volumes. Among books published by him were Darwin's *Origin of Species* and David Livingstone's *Travels* and *Last Journal*. He also published works by Gladstone, Dean Stanley, George Borrow and Samuel Smiles. He died on April 2, 1892.

His son, Sir John Murray (1851–1928), carried on the business in association with his brother A. H. Hallam Murray. Among his publications were Gibbon's *Autobiography*, Byron's correspondence and Queen Victoria's letters. He played an important part in the formation of the Publishers' association, and by acquiring Smith, Elder and Company in 1916, also gained control of the *Cornhill Magazine*. He was knighted in 1926.

His successor was his son Lieut. Col. Sir John Murray (1884– ), who was knighted in 1932.

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**MURRAY, PHILIP** (1886–1952), U.S. labour leader who organized the United Steel Workers of America (U.S.W.A.) and guided the Congress of Industrial Organizations (C.I.O.) during the early years of its existence. Born at Blantyre, Scot., on May 25, 1886, he migrated to the United States in 1902 and settled in Pittsburgh, Pa. He worked as a coal miner, became a naturalized citizen and joined the United Mine Workers of America (U.M.W.). In that union he rose from local office to the vice-presidency of the international. As the principal lieutenant of John L. Lewis, U.M.W. president, he was put in charge of the organization of the steelworkers in 1936. In 1940 he became the president of the C.I.O., a position he occupied, along with the presidency of the U.S.W.A., until his death in San Francisco, Calif., on Nov. 9, 1952. In this position Murray stanchly supported the nation's war efforts in World War II and in the Korean War and was the leader in expelling Communist-dominated unions from the C.I.O.

*See* also American Federation of Labor–Congress of Industrial Organizations; Labour (Trade) Union. (E. E. We.)

**MURRAY RIVER,** the principal river of Australia, rises in the Australian Alps (*q.v.*) and flows 1,609 mi. to enter the Indian ocean at Encounter bay, South Australia. It is the only Australian river which, by reason of its length and perennial nature, is comparable to the great rivers of other continents. Even so, it has dried across in places on at least three occasions and, although its total catchment area including its tributaries (*see* Darling River, Lachlan River, Murrumbidgee River) is 414,253 sq.mi., its annual average volume of flow is only about 12,000,000 ac.ft.

The Murray, rising close under Mt. Kosciusko in New South Wales, and in part snow-fed, flows in a general westerly and northwesterly direction as far as Morgan in South Australia, where it bends sharply southward and enters the sea through the large but shallow lagoon of Lake Alexandrina (*see* Alexandrina, Lake). For most of the South Australian portion of its course, about 250 mi., it is incised, with a narrow floodplain, between cliffs about 100 ft. high, cut in level Tertiary limestones. The uppermost 200 mi. run through mountainous country. Between this upper mountain valley and the lower gorge the river lies on a broad and very mature floodplain between the Riverina plains of New South Wales, built up by Pleistocene and Recent parallel tributaries, and the plains of northern Victoria, drained by shorter transverse streams from the Victorian highlands. The boundary between New South Wales and Victoria is largely formed by the southern bank of the Murray.

The Murray valley is of immense economic significance, lying across the great wheat-sheep belt in its climatically most reliable section. During the second half of the 19th century shipping was of great importance, but thereafter, with the competition of railways and the demands for irrigation water, navigation practically ceased. The valley has by far the most considerable irrigation, both actual and potential, of the continent. Water management is controlled broadly by the River Murray agreement between the commonwealth and the three riverain states. The largest work is the Hume reservoir (1,452,000 ac.ft. in the early 1960s, to be increased to 2,500,000 ac.ft.). The multi-purpose

Snowy Mountains scheme, a 30-year project, was begun in 1949 to greatly increase the volume of water available for irrigation. *See* AUSTRALIA, COMMONWEALTH OF: *The Economy; see* also references under "Murray River" in the Index.

*See* Department of National Development, *The Resources and Development of the Murray Valley* (1947). (O. H. K. S.)

**MURRE,** a common name for sea birds of the genus *Uria,* often considered with the guillemots (*q.v.*).

**MÜRREN,** a mountain village 5,450 ft. above sea level and situated 2,785 ft. high above the Lauterbrunnen valley in Bern canton, Switz. Pop. (1960) 450 (German-speaking and Protestant). It is a noted health resort of the Bernese Oberland, and an international winter sports centre. The Kandahar Ski club was founded there in 1924. Since 1891 it has been accessible by a mountain railway which is in two sections (Lauterbrunnen-Grütschalp and Grütschalp-Mürren); a funicular railway ascends from Mürren to Allmendhubel (6,266 ft.). Mürren is the highest settlement in the canton of Bern which is inhabited all the year round. A passenger ropeway connects Stechelberg and Mürren with the Schilthorn (9,744 ft.). Mürren is also a ballooning centre and holds an international ballooning week in the summer. (E. A. SA.)

**MURRUMBIDGEE RIVER,** the principal tributary of the Murray river (*q.v.*), rises in the southeast of New South Wales, Austr., and has a total length of 1,050 mi. It flows at first southeastward and then, after a remarkable fishhook bend, directly northward through the Australian Capital Territory, after which it trends westward for most of its course to the Murray, being joined by the Lachlan river (*q.v.*) between Maude and Balranald. It was first seen by a European in 1821, when Charles Throsby reached it near the present site of Canberra, and it was explored by Charles Sturt (*q.v.*) in his notable boat journey of 1829–30.

The Murrumbidgee irrigation area, roughly in the middle of the river's course through the plains, is the main, indeed almost the only, centre of rice growing in Australia. The area also has orchards and vineyards; hay is produced and fat lambs are raised. Water is being diverted across the divide into its headstreams as part of the complex Snowy mountains scheme of irrigation and hydroelectric development. *See* AUSTRALIA, COMMONWEALTH OF: *The Economy.* (O. H. K. S.)

**MURRY, JOHN MIDDLETON** (1889–1957), English critic, whose reputation rests on his penetrating and sympathetic literary judgment, was born in Peckham, London, on Aug. 6, 1889. He was educated at Christ's Hospital and at Brasenose college, Oxford, where he edited a journal (*Rhythm*). At first a reviewer and civil servant, he became a brilliant editor of the *Athenaeum* (1919–21) and the *Adelphi* (1923–48), with an instinct for emerging talent. His numerous critical books include *The Evolution of an Intellectual* (1919), in which he revealed his somewhat esoteric approach to the problems of life and literature, *The Problem of Style* (1922), *Studies in Keats* (1931) and *Shakespeare* (1936). He was deeply influenced by Katherine Mansfield (*q.v.*), whom he had married in 1918, and D. H. Lawrence and he wrote important studies of both. His wife's death in 1923 brought about an intensification of the mysticism which had always been discernible in his writings. Murry's later books were coloured also by his changing views on Christianity, Communism and pacifism. *The Necessity of Communism* (1932) was followed by *The Necessity of Pacifism* (1937)—in which year he contemplated becoming an Anglican priest—but *The Free Society* (1948) renounced both ideologies. As a pacifist, in 1942 he started a farm near Colchester, which he ran as a Christian community with the help of conscientious objectors. During his last phase he published *Jonathan Swift: a Critical Biography* (1954) and *Love, Freedom and Society* (1957), a study of D. H. Lawrence and Albert Schweitzer. Murry was a man of great individuality who inspired much affection and inevitable opposition. He died at Bury St. Edmunds, Suffolk, on March 31, 1957.

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**MURSA, BATTLE OF,** was fought on Sept. 28, 351, between the armies of Constantius II and Magnentius (*qq.v.*). Mursa, the modern Osijek in Yugoslavia, was a sizable city on the Drava river in the province of Pannonia Inferior. Little is known of its history, though it had already been the scene of Gallienus' defeat of the usurper Ingenuus about 258. No detailed description of the campaign that culminated in the battle of 351 exists. Magnentius had raised large forces in Gaul, including numbers of Franks and Saxons, and his army outnumbered that of Constantius. The latter, however, marched westward toward the Alps but was repulsed at Atrans (Trojane) with heavy loss and withdrew. Magnentius then made for the great city of Sirmium (Sremska Mitrovica) and rejected Constantius' offer of a compromise. But his attack on Siscia (Sisak) was repulsed and he also failed to cross the Sava river. Sirmium, too, held out against him, and he then marched to Mursa in the rear of Constantius' army, thus forcing a general engagement. After a lengthy struggle Constantius' cavalry routed Magnentius' right wing, and soon his victory was complete. Magnentius was said to have lost 24,000 men and Constantius 30,000. It has been said that Mursa, the bloodiest battle of the century, crippled the military power of the empire. This was also the first victory of heavy cavalry over the legionaries. (E. A. T.)

**MURSHIDABAD,** a town and district in the Presidency division of West Bengal, India. The town lies on the left bank of the Bhagirathi, an old and sacred channel of the Ganges, 122 mi. N. of Calcutta by rail. Pop. (1961) 16,990. It was the last Muslim capital of Bengal. In 1704 the nawab Murshid Kuli Khan transferred the seat of government from Dacca to Maksudabad, which he called Murshidabad after his own name. Even after the conquest of Bengal by the British, Murshidabad remained for some time the seat of administration. It is still the seat of the descendant of the nawab nazims of Bengal, who ranks as the first nobleman of West Bengal, with the style of nawab bahadur of Murshidabad. The palace of the nawab, dating from 1837–40, is a fine building in Italianate style. The Khusbagh, a cemetery on the right bank of the river, contains the tombs of Ali Vardi Khan, the last of the great nawabs, and Suraj ud-Daula, his grandson, vanquished at the battle of Plassey (*q.v.*). The chief industries are ivory carving, gold and silver embroidery and silk weaving.

MURSHIDABAD DISTRICT has an area of 2,056 sq.mi. and had a population of 2,290,010 in 1961. The Padma, the main channel of the Ganges, separates it from East Pakistan. The Bhagirathi divides it into two almost equal parts. The tract to the west, known as the Rarh, is high and undulating, with a hard clayey soil and a dry climate; the majority of the inhabitants are Hindus. The Bagri, or eastern half, is a low-lying alluvial plain liable to annual flooding and has a humid climate; there is a Muslim majority. The district is well wooded and has large mango orchards. The principal industry, silk, is declining. The district headquarters are at Berhampurtown. (S. GL.)

**MURUT,** a tribe living in Borneo and the southern part of North Borneo (Sabah). They numbered an estimated 250,000 in the early 1960s. The Muruts formerly built their villages on lofty escarpments in the undeveloped and heavily forested mountain country, but they are increasingly moving down into the valleys and also abandoning their communal houses in favour of private dwellings. Their life and customs are broadly similar to those of the other inland tribes of Borneo (*q.v.*). They plant hill rice, sweet potatoes, manioc and maize in jungle clearings on the shifting cultivation system. They also gather jungle fruits, fish in the rivers and hunt wild pig, deer and other animals. Many of their long houses are equipped with a remarkable springing dance floor, mounted on curved saplings, which may hold as many as 30 dancers jumping rhythmically and singing. The outer walls of the houses are of bark; and the roofs are covered with palm leaves.

*See* M. C. Clark, "The Murut Home," *Man,* vol. lii, art. 21 and 51 (1952). (W. B. FG.)

**MUS,** the name of a Roman family of the plebeian *gens Decia,* perhaps of Capuan origin.

PUBLIUS DECIUS MUS is said to have rescued a Roman army in

343 B.C. from difficulties in the Samnite War (Livy, vii, 34). He is also said to have figured in the decisive battle of the Latin War near Mt. Vesuvius (340): the consuls, in consequence of a dream, had agreed that the general whose troops first gave way should devote himself and the enemy to the gods below, and so ensure victory. When the left wing under Decius became disordered, he dashed into the ranks of the Latins, and met his death (Livy, viii, 9). His *devotio* is, however, probably an unhistorical anticipation of that of his son.

His son PUBLIUS, consul for the fourth time in 295, "devoted" himself at the battle of Sentinum against the Gauls (Livy, x, 28). A similar act of *devotio* is attributed to his son PUBLIUS at the battle of Asculum (279).

*See* J. Heurgon, *Capoue préromaine*, ch. xii (1942). (H. H. Sc.)

**MUŞ,** chief town of an *il* (province) of the same name in eastern Anatolia, Turkey, situated 85 mi. S. of Erzurum at the mouth of a gorge in the mountains on the south side of Muş plain. Pop. (1960) 11,965. The surrounding hills are covered with vineyards and oak scrub. The ruined castle Mushig (Mushel Mamikonian) is attributed to an Armenian king of Daron province, who reputedly founded the town in the 6th century. It is on the railway from Malatya and Elazig, along the Murat river valley, and good roads connect with Erzurum and Bitlis. Several miles to the west at the edge of the plain is the celebrated monastery of Surp Garabed, or St. John the Baptist.

MUŞ IL (pop. [1960] 167,638) is a mountainous area (3,164 sq.mi.) with a climate characterized by cold winters, hot summers and a fairly high precipitation (40 in. annually at Muş town).

Wheat and tobacco are grown on Muş plain, a fertile depression (35 mi. long and 12 mi. broad) between the mountains and the plateau, watered at its western end by the Murat Cayi. Wood is scarce and the usual fuel is *tezek* or dried cow dung. There are several sulfur springs, and earthquakes are frequent and sometimes severe. (N. Tu.; S. Er.; E. Tu.)

**MUSACEAE,** the banana family, monocotyledonous plants divided into 5 genera and about 150 species, all tropical and mostly treelike herbs. *Ravenala madagascariensis* is called the traveler's-tree (*q.v.*), as water accumulates in the sheathing bases of its leaf stalks and can be used for drinking. *Musa* includes the banana and plantain and also abacá (*qq.v.*). *Strelitzia reginae* is the striking bird-of-paradise flower (*q.v.*).

**MUSAEUS,** the name of three Greek poets.

1. A mythical seer and priest associated with Orpheus and also with the rites of Eleusis, was supposedly earlier than Homer. Among works attributed to him were a *Theogonia,* various epic poems, hymns to the gods, a collection of oracles known in the time of Pisistratus and a book of magical cures. Their authenticity was always doubtful in antiquity.

2. Musaeus of Ephesus (3rd century B.C.) was a court poet who wrote a *Perseid* and poems in honour of Eumenes and Attalus I of Pergamum. Nothing survives of his work.

3. Musaeus Grammaticus (? fl. beginning of the 6th century A.D.) was the author of an extant poem of singular charm on Hero and Leander (*q.v.*), in 340 hexameter lines after the style of Nonnus, telling how Leander swam the Hellespont to visit his beloved. There are many modern imitations from Christopher Marlowe onward.

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**MUSÄUS, JOHANN KARL AUGUST** (1735–1787), German writer, author of a famous collection of fairy tales, was born in Jena on March 29, 1735. After being rejected as village pastor because he had danced, he became in 1769 master at the Weimar *Gymnasium.* Musäus disliked the cult of sensibility and his first work, *Grandison der Zweite* (1760–62; rewritten as *Der deutsche Grandison,* 1781–82), was a satire on Samuel Richardson's novel. His second book, *Physiognomische Reisen* (1778–79), was directed against J. C. Lavater (*q.v.*). His best work, however, is his *Volksmärchen der Deutschen* (1782–86). He collected many of his tales from the people, and although his stories are stamped by the detachment of the Enlightenment and lack the simplicity of genuine folklore (later to be made familiar by the collection of the brothers Grimm) his book was the first to draw the attention of the educated public to tales of the kind. His book was frequently reprinted and three of the stories appear in T. Carlyle's *German Romance* (1827). Another collection of stories, *Straussfedern* (1787) was unfinished when he died in Weimar on Oct. 28, 1787.

BIBLIOGRAPHY.—*Nachgelassene Schriften,* ed. by A. von Kotzbue (1791); *Volksmärchen,* ed. by P. Zaunert (1912). *See* also M. Müller, *J. K. A. Musäus* (1867); E. Jahn, *Die Volksmärchen der Deutschen von Musäus* (1914).

**MUSCAT AND OMAN,** an independent sultanate (SALTANAT MASQAT WA 'UMAN) in southeast Arabia, closely associated with Britain. Historically Oman is a much wider region, but the sultanate extends from the borders of Trucial Oman on Ra's Musandam (on Hormuz strait) to the Aden protectorate at Ra's Durbat 'Ali, and inland to Ar Rub' al Khali ("Empty Quarter"). Its area is about 82,008 sq.mi. and the population (1962 est.) 565,000, of which about 200,000 are settled. Muscat (Masqat) on the Gulf of Oman is the capital and residence of the sultan.

The hinterland on the Gulf of Oman is mountainous, with Al Jabal al Akhdar (10,194 ft.) its highest point; immediately behind it, the Wadi Sama'il divides Al Hajar range into western and eastern parts. The districts are Ru'us al Jibal, mountainous and politically detached; populous Al Batinah plain along the gulf; Az Zahirah (Al Buraymi oasis lies on its border with Trucial Oman); Oman proper, the central area; Ash Sharqiyah, southeast of Al Jabal al Akhdar; and Ja'lan at the eastern tip. From Ja'lan to Ra's Naws a desolate coastal tract, off which lie Al Masirah and Kuria Muria (*q.v.*) islands, connects with Dhofar (Zufar), the most tropical enclave of Arabia, enclosed by the Qarah mountains.

The earliest-known inhabitants were Hamites who moved westward under pressure of Semitic Qahtanis (Joktanites) of Yemen and Adnanis of Najd. Omanis claim descent from these stocks; the Qahtanis are now called Hinawis (most belong to the Ibadhi sect of Islam) and the Adnanis are called Ghafiris (many are Sunni Muslims). The majority of Omanis are Ibadhis (or Abadites), but there are many Sunnites and a few Isma'ilis (a sect of Shi'ites). Other races, mostly on the coast, include Hindus, Khojas, Persians, Balochis and many people with a strong admixture of Negro blood. In Dhofar, the Qarah, Shaharah, Botahara and Harasis are "Veddoids" (*see* VEDDA).

**History.**—About 536 B.C. Oman fell under Persian domination. This was ended by another Joktanite Yemeni immigration of Azdites of Ya'rub stock. These Azdites ruled until the end of the 6th century when the Persians came again, until Oman accepted Islam about A.D. 630. Though a revolt was suppressed by Abu Bakr, caliphal rule was nominal until 684 when Abdul Malik subdued Oman and appointed a governor. The later appointment of local officials and adoption of the Ibadhi heresy led to the election in 751 of Julanda bin Masud as the first imam (spiritual head). Elected imams followed until 1154 when the Banu Nabhan established a dynasty of kings, largely dominant until 1428, when imams were again elected. The Abbasids twice tried to assert sovereignty at the turn of the 8th century and there were two Persian invasions in the 13th. Imams and Nabhani kings contended for mastery from 1429 to 1624 when a strong Ya'rubid line of imams began under Nasir bin Murshid. In 1508 the Portuguese sacked Muscat and secured control of the coast, as well as that of east Africa, with which the Omanis had established connections from the 9th century.

Imam Nasir's energy and perseverance soon attracted general support and having captured Julfar, where both Portuguese and Persians had forts, he kept Oman and the Portuguese in check until his death in 1649. His successor, Sultan bin Saif, captured Muscat in 1650. In 1698 Sultan's son, Saif, drove the Portuguese from their east African positions north of Mozambique.

In the 18th century Ya'rubid weakness led to civil war between Hinawis (supporting the imam) and Ghafiris. The imams en-

listed Persian help, raising the bellicose Arabism of all Omanis against themselves. In 1741, Ahmed bin Said al Busaidi expelled the Persians and was elected imam. Being of trading stock he lacked aristocratic support, and as he could not count on the tribes, he consolidated power with mercenaries. During his reign his sons obtained the title of Saiyid (lord), and the "House of the Saiyids" began to be a recognized dynasty (the Al Busaid) with first claim to the succession. On Ahmed's death in 1775, his son Said was elected imam but secular power was mostly exercised first by his son Hamed and later by the latter's brother, Sultan. Since Said was never deposed a new imam could not be elected. He died between 1811 and 1821 after his nephew Said bin Sultan had effectively established himself as Saiyid. Said built a considerable empire in Oman and east Africa and transferred his capital to Zanzibar (*q.v.*) in 1832. After his death in 1856 the rivalries of his sons led to the Canning Award of 1861 which separated Zanzibar and Oman. In 1861 they were officially styled sultans, though their Arab subjects continued to call them Saiyid. In 1862 France and Britain recognized the independence of both Zanzibar and Oman.

In the course of time support for the sultans lessened, particularly in the interior where the tribes rebelled in 1913 and elected an imam of Oman. He was murdered in 1920, and the sultan, Saiyid Taimur, signed the Treaty of Sib with the new imam, providing for mutual nonaggression and internal tribal autonomy. The imam died in 1954 and his successor, Imam Ghalib, broke the treaty by entering into relations with the Saudis. Saiyid Said bin Taimur (who had succeeded to the sultanate of Muscat and Oman in 1932 on his father's abdication), drove Ghalib from his capital at Nazwa, but the latter, aided by foreign arms, attempted to reestablish himself. The rising was suppressed with British help in 1957 and Ghalib took refuge in Al Jabal al Akhdar. Evicted in 1959 he fled to Saudi Arabia. The struggle continued.

The Wahhabis had begun hostilities in 1800 and seized Al Buraymi, a centre of strategic importance containing eight villages, two claimed by the sultan and six by Abu Dhabi (*see* TRUCIAL OMAN). The sultan received consistent British diplomatic support and in 1869 the Wahhabis were expelled. Hints of oil stimulated fresh Saudi interest in 1949 and a Saudi post was established in 1952. In 1954 arbitration was agreed on. The international tribunal broke down in 1955 and a Muscat and Abu Dhabi garrison has since prevented a Saudi coup.

The port of Gwadar (*q.v.*) and its dependent hinterland on the Baluchistan coast was purchased by Pakistan from Oman in 1958 for $8,400,000 (£3,000,000).

**Administration.**—The sultan's rule is personal. He is assisted by an Arab minister of the interior, British military and development secretaries, a Pakistani finance and foreign affairs secretary and an Egyptian director general of customs. Local administration is by *walis* (governors). Muscat and Matrah have municipal committees. Justice is mostly administered by *qadis* (Muslim judges). There is an appeal court and a court for cases concerning foreigners. The army has British officers. Oman has treaty relations with the United States (from 1833, revised 1958), France (1846), India (1953) and the Netherlands (1877). The treaty of friendship, commerce and navigation signed in 1951 was the latest governing Anglo-Omani relations.

**Economy.**—Petroleum Development (Oman) Limited and Dhofar Cities Service Petroleum corporation hold concessions for oil exploration. Trade, including entrepôt trade, mainly with India, Pakistan and the Persian gulf states, is the chief occupation of Muscat and Matrah but elsewhere it is cultivation (dates, cereals, pomegranates, limes) and fishing. Camels, bred inland, are prized in Arabia for their quality. Matrah, adjacent to Muscat on its west, is a main commercial centre and the starting point of caravans for the interior. There is a motor road on the coastal plain between Muscat and Matrah (3 mi.) which continues as a motorable track to Khawr al Fakkan (via Kalba) and Sharjah, a distance of about 260 mi. Other tracks from Matrah connect with Hajar Boshar and Ibra (via Sarur). There is an airport near Muscat and the R.A.F. maintains airfields at Salalah and Al Masirah Island in the south. The Batinah dates are well known and are mainly exported from Suhar. Other small ports are Sur and Mirbat, the port of Salalah on the Dhofar coast. Dried fish and fish meal are the principal exports. The Indian rupee, the official currency, circulates mainly on the coast but the common medium of exchange in the interior is the Maria Theresa dollar (Thaler) and in Dhofar there is also a half dollar. Omani copper coins (*baizat*) also circulate. Customs duties are the chief source of state revenue, which averages between 4;000,000 and 6,000,000 rupees a year. *See* also ARABIA.

Current history and statistics are summarized annually in *Britannica Book of the Year*. (W. H. Is.)

**MUSCATINE,** the seat of Muscatine county, Iowa, U.S., on the Mississippi river, 29 mi. W. of Davenport. Manufactured products include buttons and button machinery, woodwork, industrial alcohol, cellulose products, soybean products, livestock feeds, sand and gravel, canned foods, meats, butter, poultry, centrifugal pumps, motorized wheelbarrows, steel cabinets and other metal products. Muscatine's most distinctive industry is the making of pearl buttons from freshwater mussel shells found in the tributaries of the Mississippi river; its factories produce more than 95% of all freshwater pearl buttons manufactured in the U.S. The city was founded as a trading post in 1833 and incorporated in 1851. The name came from the Mascoutin Indian word meaning "Burning Island." For comparative population figures *see* table in IOWA: *Population*. (O. F. TA.)

**MUSCICAPIDAE,** the old world flycatchers, a large family of mostly tropical perching birds that feed on insects. They are found only in the eastern hemisphere. Some of these small songbirds catch insects on the wing; others pick their prey off leaves and twigs. *See* FLYCATCHER.

**MUSCLE AND MUSCULAR SYSTEM.** In all except the simplest organisms, specialized muscle cells perform the function of converting chemical energy into mechanical energy. The muscle cells may be combined in large, organized groups that act together as a single muscle. In like manner, individual muscles may work together as part of a muscle system. In higher animals two kinds of muscle tissue—that is, aggregations of muscle cells—are found: (1) Striated or striped muscle; this includes all the voluntary muscles used for active movements, as well as the involuntary cardiac muscle. (2) Smooth muscle; all are involuntary muscles and include those of the viscera, lungs, etc. Nerves lead from the brain and spinal cord to the muscles, and impulses sent down these nerves control the action of the muscles.

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## I. FUNCTIONS OF MUSCLES

### A. Muscular Activity

**1. Fundamental Nature.**—All muscles exercise their function by shortening or by exerting tension along some linear axis. Muscular contraction resembles a change in the elastic constants of a spring. Although muscle does not behave like an ideal spring, contraction is characterized by a reversible increase in the elastic properties or modulus of elasticity of the muscle.

To shorten a spring or a muscle and thus to lift a weight is equivalent to the accomplishment of work, and this requires energy. The energy sources of muscle contraction are derived ultimately from the oxidation of sugars and fats or from the splitting of sugars to form lactic acid. The oxidation can be compared to the industrial or domestic burning of such fuels as wood or oil, which resemble chemically the sugars and fats used by the muscle. Efficient use of fuels in industry requires high temperatures. Muscles use their fuels with efficiencies comparable with those of well-engineered industrial power plants, but they achieve these efficiencies at ordinary temperatures found naturally at the surface of the earth. (H. S. Bt.)

**2. Control.**—The method of control of muscular activity employed in the body is suited to the particular function of the muscle. Thus some slowly acting muscles such as the uterus are controlled in part at least by hormones circulating in the blood stream. Where quicker control is required it is provided by nerve endings that come into close contact with the muscle membrane. Activity in the nerve fibre may then cause merely a local depolarization and contraction of graded strength, as in certain postural muscles and muscles of crustaceans, or it may set off a self-propagating disturbance, the action potential, which passes over the whole of the muscle cell, depolarizing each part of the membrane in turn. This is the type of control employed in skeletal muscles used for ordinary voluntary movement. Fibres of these muscles exhibit all-or-nothing properties—any stimulus that is strong enough to activate them at all will activate them completely. (*See* All-or-None Law.)

Although the electrical changes associated with muscular activity are quite small, they can be easily detected by a sensitive amplifier connected to electrodes in contact with the skin over the muscle. A recording of these changes, called an electromyogram (or EMG), is useful for assessing the degree of activity of the underlying muscle. An electrocardiogram (ECG or EKG) is a recording of the electrical changes produced by the heart. Clinically an EKG is of great value, since it gives important information about the conduction of the cardiac impulse and the state of the heart muscle. It is particularly useful in diagnosing coronary thrombosis, a disease in which the blood vessels of the heart become blocked by blood clots.

**3. Muscular Contraction.**—Muscles are primarily mechanical organs that can exert forces and lift weights; so their mechanical properties are of primary physiological interest. In mammals and birds the muscles have a secondary function: they are the most important source of heat and they enable these creatures to maintain their raised, constant body temperature.

The mechanical properties of muscle are most conveniently studied on muscles that have been excised from the body. These can be kept alive for a long time if they are supplied with oxygen and are bathed in a solution containing the same inorganic ions as blood. Most of the experimental results described here were obtained on striated muscles. Smooth muscles are less well understood, but they seem to be similar in many ways.

Resting muscle is soft and extensible, like very soft rubber. If it is stimulated by applying an electric shock of a few volts, there is a sudden and radical change in its properties; it becomes hard, develops tension, resists stretching and can shorten and lift a weight, thus performing mechanical work. The change in state persists for only a short time after the stimulus—from a hundredth to a few tenths of a second in the case of most striated muscles—then the muscle returns to its original condition. This sequence of contraction and relaxation is called a twitch. If the stimulus is repeated at a high enough frequency there is not enough time for the contracted state to decline between one shock and the next. The muscle therefore remains in a state of maintained contraction called a tetanus. Most of our bodily movements are of tetanic type. Cardiac muscle cannot be tetanized because each stimulus gives rise to a long refractory period during which additional stimuli are ineffective. This type of muscle is therefore very resistant to fatigue.

When a muscle is held at a fixed length and tetanized it develops a large force of 1–3 kg. per square centimetre, depending on the type of muscle. The force varies with the length at which the muscle is held, being reduced to zero when the muscle is very short or very long and passing through a maximum in between. The graph of tension developed against length therefore looks something like a parabola. Voluntary muscles in the body are usually attached to the skeleton in such a way that they are working near their optimal length and at a considerable mechanical disadvantage, so that even in a large movement such as flexion of a limb the actual variation in muscle length is less than 10%; in consequence, tension development is about the same in all positions of the limb. Cardiac muscle, on the other hand, normally works below its optimal length. This provides the heart with a large functional reserve, since extra blood flow can cause it to dilate. This stretches its muscle fibres and increases their tension development. Dilatation of the heart is an important clinical sign that the heart is calling up its functional reserves.

The mechanical state of an active, tetanized muscle also can be examined by letting it lift various weights. It is best not to hang the weight directly on the muscle but instead to let it act through a lever system that gives the muscle a large mechanical advantage since this reduces complications due to inertia. The larger the weight applied, the shorter is the distance through which the muscle can lift it. The relation between weight and distance is the same as the tension-length graph described above. As the load is increased not only is the amount of shortening reduced but the speed of shortening also is reduced; *i.e.*, the muscle can lift a light load more quickly than a heavy one. The graph relating load and speed is part of a rectangular hyperbola. It has roughly the same shape for all muscles and even for contracting actomyosin threads; however, the speed against a given load varies widely from the slow smooth muscles to the fast striated ones.

The rate of working (= load × speed) can be calculated directly from the load-speed graph. The maximum power output is surprisingly high; for example, by bending an elbow one can produce work at the rate of a quarter of a horsepower, though only for a few seconds.

Until about 1935 theories concerning the mechanical behaviour of muscle were based on the idea that stimulation transformed the muscle into a new, stretched, elastic body, which then shortened passively toward its new equilibrium length. The relation between load and speed could then be attributed to the presence of an internal viscosity. This idea can explain many of the mechanical properties of muscle, but it later seemed more probable that the mechanical energy of contraction is generated continuously by chemical reactions all the time the muscle is active, and that the extent and speed of these reactions is linked to the tension on the muscle.

*Heat Changes in Muscle.*—These have been carefully studied because they are an index to the underlying chemical and physical processes of contraction. The total heat production has a number of separate components. Even at rest metabolic processes are going on in muscle, as they must in every living tissue. These processes produce a small amount of heat that is called the resting heat. In addition, resting muscle shows thermoelastic properties that depend not on metabolic processes but on a passive rearrangement of molecules when the muscle is stretched. Muscle behaves like rubber, giving out heat when stretched and reabsorbing the heat on release.

When a muscle becomes active its heat production increases enormously, as we all know from our experience of muscular exercise. A single muscle twitch raises the temperature by a few thousandths of a degree Celsius (centigrade) in a few tenths of a second. These changes can be measured and analyzed accurately

by modern techniques. Some of the heat, the "activation heat" or "maintenance heat," is found to accompany the state of activity; it seems that a continual flux of energy is needed to maintain the contractile machinery. "Shortening heat" is produced in addition whenever the muscle shortens and the amount of heat is proportional to the amount of shortening. Note that heat is produced only during the phase of contraction. Heat appears during relaxation only if mechanical energy is dissipated in the muscle. For example, if a weight is lifted during contraction it will fall during relaxation, and the energy of the falling weight will appear as heat in the muscle.

Following activity, production of "recovery heat" begins. This is the outward sign of chemical processes that are rebuilding the energy stores of the contractile proteins. Most of the heat comes from the oxidation of carbohydrates. The total amount of recovery heat is about equal to the total maintenance plus shortening heat.

The heat produced by muscles does not appear to play any useful part in their mechanism—almost all of it represents mere waste of energy; though, of course, mammals and birds make good use of this waste heat to maintain a constant and raised body temperature. A good deal of the waste of energy arises from the fact that maintenance heat must be produced all the time the contractile machinery is held active. This means that a muscle consumes energy even when it is doing no mechanical work—for example, when it is supporting a weight. A spring can support weight indefinitely without using up energy. Some muscles (for example, the one that holds together the two halves of the shell of the common mussel) are much more efficient than others at holding tension for long periods. They relax very slowly, so they can be tetanized by very slow rates of stimulation.

*Muscular Efficiency.*—Measurement of heat production makes it possible to estimate the efficiency of muscular contraction, for efficiency = (work done)/(energy consumed) = (work done)/(work done + total heat produced). Isolated muscles under optimal conditions have an efficiency of 20% to 25%, and in the intact body work is performed with about the same maximum efficiency. For measurements on whole animals or men it is convenient to estimate energy consumed from the oxygen used rather than from heat measurements, though large calorimeters have been constructed in which a man can exercise. It is quite easy to measure a man's oxygen consumption even during such exercise as swimming or skiing by collecting the air that he exhales in a gastight bag and analyzing it for oxygen and carbon dioxide. Each litre of oxygen used generates about 5,000 cal. of energy. Since it is difficult to estimate the mechanical work performed during many kinds of exercise, measurements of human muscular efficiency are usually made by getting the subject to pedal a stationary bicycle or climb a treadmill; then the work done can be calculated easily.

Muscle has sometimes been compared with a heat engine. It is true that both systems produce work by oxidizing combustible materials, but the parallel ends there. Muscle works at constant temperature and resembles an electric motor driven by a battery. The chemical energy of the battery is converted into mechanical work without prior conversion into heat. The consumption of zinc in the battery is analogous to the consumption of foodstuffs in the muscle. This is potentially a far more efficient system, though efficiency in muscle is limited by the extreme complexity of the chemical reactions that take place; for at each step some free energy is degraded into heat and wasted.

### B. Chemical Changes

Muscular energy is derived from the combination of carbohydrate food stores with atmospheric oxygen to form carbon dioxide and water. Carbohydrate is stored in the muscle as glycogen, which the body can form from fat and protein in the diet as well as from other carbohydrates; and oxygen is brought to the muscle by the circulating blood. This oxidation is a very complex process involving many different enzyme systems. It can take place only slowly, and the energy liberated is not in a form that can be directly used by the contractile proteins. The energy derived from these oxygen-using (or aerobic) processes is therefore used to drive forward a complex system of anaerobic chemical reactions that lead eventually to the synthesis of creatine phosphate (CP) and of adenosine triphosphate, or ATP. ATP is readily hydrolyzed in the presence of the appropriate enzyme: ATP → adenosine diphosphate (ADP) + energy, and the energy is handed on to the contractile proteins. The store of ATP is quickly regenerated by driving the above reaction backward, the energy required being derived from the hydrolysis of CP. ATP and CP are present in quite appreciable quantities, and since the hydrolysis of either of them yields about 7,000 cal. per mole, they constitute an important local store of energy. It is this that permits muscles to work at such a high rate for a few seconds until the local store is used up.

All muscles can outstrip their oxidative processes during severe exercise and the local blood supply may not be able to transport enough oxygen for current needs. Under these conditions energy can be obtained from glycogen not only by oxidizing it but also by splitting it anaerobically into lactic acid. Surplus lactic acid is carried by the blood stream to the liver and to other inactive muscles where about 20% of it is oxidized to carbon dioxide and water. The energy thus obtained is used to rebuild the remaining 80% into glycogen. In this fashion the metabolic load is spread over the whole body instead of being confined to the active muscles.

Many animals rely almost exclusively on anaerobic processes to get them out of danger. They are the animals with large amounts of white meat—rabbits, poultry, etc.—which after a burst of energy at high speed soon become exhausted. The red colour of the muscles of hares, game birds and carnivores is due to the presence of iron-containing pigments, which act as catalysts in a highly developed oxidative system. This gives these animals their capacity for sustained effort.

In order to study these complicated chemical processes in detail it is necessary to break up the cells and extract their contents. Some important structural elements, such as the mitochondria, may be preserved in the extract, and it seems fairly safe to infer that the chemical processes going on in the extract are similar to those in living muscle, though the latter are more highly organized and co-ordinated.

Actomyosin, the system of actin and myosin proteins that constitute muscle fibres (see *Microscopic Structure and Function: Myofilaments,* below), will dissolve in strong salt solutions. If such a protein solution is squirted through a fine jet into water, the salt is rapidly diluted and the protein precipitates as a fine thread, or filament. If ATP is added, the thread undergoes a remarkable change in properties—it develops tension and will shorten and lift a weight. At the same time the ATP is hydrolyzed to ADP under the influence of the ATP-ase groups attached to the myosin. These changes can be produced only by ATP and a few very closely related substances.

If the actomyosin threads are made in such a way that the protein molecules are oriented along the length of the thread, the tension developed per unit area is almost as great as in a living muscle. An easier way to obtain a highly oriented structure is to treat a living muscle fibre with glycerol. This kills the fibre, breaks its cell membrane and extracts many enzymes; but it leaves the skeleton of protein filaments intact. The contraction that occurs when ATP is added is similar in many ways to that of a living muscle. Indeed, the evidence is strong, though circumstantial, that actomyosin and ATP form the basic contractile system of muscle.

### C. Muscular Exercise

When a muscle becomes active it needs extra oxygen. The blood vessels in the muscle therefore open up so that more of the total blood flow is diverted into the active region. If the exercise is at all severe there will have to be compensating changes in other parts of the cardiovascular system. Blood vessels in the skin and viscera close down and the heart beats faster and more forcefully in order to circulate the blood more rapidly. The active muscles produce extra carbon dioxide, which stimulates sensitive chemoreceptor cells in the brain; this causes the breathing to become

deeper and quicker so that carbon dioxide is more effectively washed out of the blood and more oxygen is absorbed.

These compensating mechanisms make it possible to transport a much larger quantity of oxygen than usual, though, of course, they have their limits. Even the most athletic man breathing air cannot absorb more than about 4.5 l. of oxygen per minute (this is about 20 times the resting value), and in order to distribute this oxygen to the tissues each half of the heart must pump about 30 l. of blood per minute. Since each litre of oxygen consumed yields about 5,000 cal. of energy, the maximum human rate of continuous energy production is about 1.5 kw. Assuming an efficiency of 25% this corresponds to production of mechanical work at the rate of 0.5 h.p. This is about equal to the value obtained by direct measurement in man during strenuous rowing. Notice that this limit is set by considerations of oxygen transport, not by intrinsic limitation in the muscles. If a high concentration of oxygen is breathed instead of air, the oxygen is more effectively absorbed into the blood stream, and by this means it is possible to work at higher rates without discomfort. The beneficial effect of breathing oxygen only appears when the physiological mechanisms are under strain, *e.g.*, during hard exercise or at high altitude; under normal conditions there is no detectable benefit.

Even a small group of muscles, *e.g.*, the flexors of one arm, can work for a short period at 0.25 h.p. while they are generating energy anaerobically. In a similar way the whole body can work at a much higher rate than 0.5 h.p. for a short time. The metabolic products that accumulate during anaerobic work must ultimately be disposed of by oxidation, so the body will have accumulated an "oxygen debt" that can be paid off later during recovery.

After severe exercise there may be as much as 100 g. of lactic acid in the tissues corresponding to an oxygen debt of 15–20 l. It is not surprising, therefore, that it may take an hour or more to recover from a strenuous bout of exercise, though persons who are physically fit tend to recover more quickly. Indeed, in a trained athlete all the physiological mechanisms involved in exercise appear to function more effectively. The details of this process of adaptation are not yet understood, so athletic training methods continue to be largely empirical.

The steady improvement in athletic performance from year to year results partly from the success of these empirical training methods and partly from improvements in the technique of performance. Knowledge of physiology has certainly transformed mountaineering and it may have played a helpful role in other sports. Runners in particular have developed great skill in setting a high steady pace that utilizes their maximal oxygen income and in so timing the final sprint that it completely uses up the remaining stores of anaerobic energy. It is not understood what makes a great athlete different from a mediocre one of similar physique; skill, economy of movement and tenacity must all play a part. It is difficult enough to find out how any muscle works; subtle differences between individuals are still beyond our methods.

(D. R. W.)

### D. Muscular Systems

Individual muscle fibres usually act in concert with other fibres and with nerves, and often with sense organs and glands as well. The activity of the whole system may produce a movement benefiting the animal. Thus in the smooth muscle system of the intestine, the circular and longitudinal muscle fibres act in a coordinated manner to produce the action known as peristalsis. By means of these rhythmic contractions the contents of the intestine are mixed with digestive juices and slowly impelled down the canal. A much less conspicuous and more delicate component of the intestinal muscular system resides in the intestinal villi. The villi are tiny fingerlike projections that form a naplike surface on the inner lining of the intestine. Each individual villus or projection contains in its core a slender strand of smooth muscle. These act during digestion under the regulation of the nerves that govern the whole system. Contraction of the muscle fibres in the cores retracts the tips of the villi and facilitates mixing and contact with intestinal contents ready for absorption.

The cardiac muscular system is comprised of typical cardiac striped muscle and a modified fibre specialized to conduct rapidly the electrical impulse that excites contraction of the muscle itself. These specialized conducting fibres are called Purkinje fibres, after the great 19th-century anatomist J. E. Purkinje of Prague. The regular contracting cardiac muscle fibres are also capable of transmitting an excitatory impulse to neighbouring regions of the heart musculature, but at a rate slower than that of the Purkinje fibres. The mammalian heart muscle system is composed of a large number of individual cellular domains containing one to ten or more nuclei. Until 1955 it was thought that the heart musculature constituted one vast syncytium. The electron microscope, however, showed that this is not so. One cell is joined to another at specialized attachment areas called intercalated disks. The fibres are wound around the atria and ventricles in spirally disposed layers. The excitatory impulse triggering each heart beat is initiated in the atrial region near the point at which much of the venous blood enters the heart. From this point it is conducted over the atria and into the ventricles, whence it spreads through the Purkinje fibres and the muscle fibres themselves to all parts of the ventricles. The excitatory impulse is followed quickly by contraction. The cardiac muscle system is nicely regulated as to rate and force of contraction by nerves, by hormones such as epinephrine and by the degree of stretching of the heart muscle fibres imposed by the filling of the heart with blood during the period of relaxation between beats. (*See* Circulation of Blood: *The Heart.*)

Skeletal or striated muscle systems of vertebrates are elaborately organized. The performance of a simple movement such as the raising of the arm in man or the swimming of a fish requires elaborate control, regulation and participation of many muscles, nerves and sense organs. Each individual muscle in the system is usually described as having an origin and an insertion. Upon contraction, it exerts a force tending to draw origin and insertion closer together. The origin is usually defined as that attachment of the muscle that is affixed to the less movable or more central or proximal part of the animal, whereas the insertion is taken to be the attachment to the more movable or distal object. Most skeletal muscles originate and insert in bones, but some may attach to skin, mucous membrane, cartilage or connective tissue strands of one sort or another. In many muscular systems it is convenient to speak of two groups of muscles acting antagonistically to each other. Thus one may speak of flexors and extensors of the elbow, or of pronators and supinators of the forearm.

Skeletal muscle systems include nervous control mechanisms that initiate and regulate action and that, as they stimulate contraction of one group of muscles in a set, may inhibit the contraction of antagonistic muscles. The individual muscles and tendons are fitted with special sensory organs that monitor the tension generated by the muscle. The tendon organs are characterized by fairly simple sensory nerve endings intertwined with the tendon fibres. More elaborate sense organs are found in the muscle itself. These intramuscular sense organs are called muscle spindles. They consist of special, short, slender muscle fibres enclosed in a cellular and connective tissue capsule. The tendons of these intracapsular fibres attach to the connective tissue strands within the main mass of muscle. The special slender fibre of the muscle spindle receives a complex sensory and motor nerve supply. Sensory endings spiral around the middle section of the spindle fibre, which is here nearly devoid of contractile elements. This middle portion of the spindle fibre functions as the sensing element of the strain gauge. The two ends of the spindle fibre are well endowed with striated myofibrils and receive a special motor innervation. As the large muscle fibres around the spindle contract, the two muscular ends of the spindle fibre are activated so as to keep the central sensory region taut. This acts to maintain the elastic bias of the strain gauge.

Information sensed by vertebrate tendon organs and spindles is coded and carried by nerves to the central nervous system, where it is processed as in a computer and fed into the output of the motor nerves governing the main fibres of the muscle. This completes a feedback loop, which has an important role in regulating the activity of the muscle system.

Invertebrates also may have elaborate muscle systems. The squid has an extensive smooth muscle system surrounding its mantle cavity. All the muscle of this system is innervated from a single giant nerve fibre, which can conduct an impulse with considerable rapidity. When the squid is alarmed this nerve activates the mantle muscle, which, on contraction, ejects a quantity of water from under the mantle through a narrow orifice. The resulting jet of water squirting through the orifice propels the squid in the opposite direction. At the same moment a quantity of sepia or squid "ink" is expelled by the animal, and its skin pigment cells are contracted so the animal becomes pale and less conspicuous. A predator is thus tempted to pay momentary attention to the prominent cloud of ink deposited at the spot occupied by the squid at the moment of danger, while the inconspicuous pale squid may be able to retire rapidly and unnoticed.

## II. MICROSCOPIC STRUCTURE AND FUNCTION

### A. Organization

**1. Fundamental Organization of Muscle and of Muscle Systems.**—The actual contractile machinery of muscle resides in long threadlike filaments of molecular dimensions. These are called myofilaments, which means "muscle filaments." The myofilaments are very small units of structure and are too slender and too closely packed to be resolved with a light microscope, though they can be studied conveniently with an electron microscope.

In many muscles the myofilaments are arranged in more or less well-organized units of structure called myofibrils, which means "little muscle threads." Myofibrils are bundles of many hundreds or thousands of myofilaments arranged parallel to each other. Each myofibril is separated from its neighbour or from the outer surface of the muscle fibre by intervening material called sarcoplasm. Sarcoplasm, which means "muscle juice," contains a complex array of molecular devices that have a role in supporting, controlling, fueling and sustaining the contractile process executed by the myofilaments themselves. Sarcoplasm is also found between and around myofilaments in muscles in which the myofilaments are not organized in well-defined myofibrils.

In all instances the sarcoplasm and the contractile machinery are part of a cell. In most cases these components comprise the main part of the cell, in which case the cell is termed a muscle cell. Most muscle cells are elongated considerably in a direction parallel to that assumed by their constituent filaments and fibrils. Such elongated cells are endowed with a threadlike appearance and are called muscle fibres. Some of the larger muscle fibres are about 0.1 mm. in diameter and hence are large enough to be seen individually with the naked eye. Others are smaller, perhaps 0.04 mm. in diameter, but can be distinguished with a low-power microscope. Short muscle fibres might be less than 1 mm. long. Some fibres are very much longer, achieving lengths of several centimetres or inches. Some types of muscle fibres are branched.

In some instances muscular contractile filaments are present in only part of a cell, portions of which may be specialized to serve physiological functions other than contractility. For example, cells lining the cavity of the fresh-water coelenterate *Hydra* are called endodermal epithelial cells and serve the important function of absorbing food materials ingested by the animal. A portion of these epithelial cells, however, is fitted with contractile filaments that actuate some of the movements of which the animal is capable. Similarly, in the fresh-water one-celled protozoan *Stentor*, a thin stalklike projection by which the animal can attach itself to some solid object contains a well-defined bundle of contractile filaments that, when exercised, can shorten the stalk and withdraw the main portion of the animal from an exposed position. Such a contractile organelle is called a myoneme; it is really a tiny muscle resident in a single-celled animal that is capable of many varied functions besides that of contractility. As a rule, however, muscle filaments are arranged not in dual or multipurpose cells such as those in *Hydra* or *Stentor* but in specialized muscle cells whose primary physiological function appears to be that of contractility. Such muscle cells or fibres may be combined in large organized groups that act together as a single muscle. In like manner, individual muscles may work together or in a co-ordinated manner as part of a muscle system.

Muscle cells, muscles and muscle systems may be fitted with various auxiliary devices that control, monitor, regulate, supplement and adjust the activity of the muscle and transmit the tension generated upon contraction. These devices vary in complexity and in organizational features throughout the animal kingdom. The control mechanism may be very simple. Some are capable of merely initiating a single muscle twitch, which cannot be regulated as to strength. In contrast, there are also very elaborate control systems involving complex nervous connections and computerlike circuits in a central nervous system. These receive signals from sensory devices—some with variable bias—which act like strain gauges monitoring the tension generated in the muscle or in a tendon. These signals are processed in a nerve centre, whence correcting nerve impulses can be sent to the muscle once more. Chemical substances such as hormones also can participate in the regulation of muscle activity. In many animals nerve circuits are present that permit visual, auditory, tactile or other stimuli to generate signals that can be fed into the regulating mechanism. Thus muscle cells may be part of a complex and elaborately instrumented system involving muscle, tendon, nerve, hormones, blood vessels, sense organs and nerve centres.

**2. General Features of Muscle Cells.**—M. J. Schleiden (in 1838) and Theodor Schwann (in 1839) advanced the general hypothesis that all plants and animals contain or are made up of one or more units of structure known as cells. This cell theory has been very useful in biology. In general, each cell is a unit capable of self-duplication. It is surrounded by a thin delicate membrane, the plasma or cell membrane, which encloses a complement of complex materials and organelles, often highly ordered structurally. These comprise the cytoplasm or juice of the cell. The vast majority of cells possess, in addition, one or more nuclei, which contain genetic material important to the cell. Substances in the nucleus appear to be capable of directing or influencing profoundly the activities of the cytoplasm. Certain cells, such as mammalian red blood cells or nerve cells, may lack one or another of the above features, but these exceptions need not be considered here. (*See* Cytology.)

Muscle cells fall within the general pattern. All muscle cells are surrounded by a very thin membrane, called the sarcolemma, which represents the plasma or cell membrane of the muscle cell. Surrounding the sarcolemma is a thin associated accumulation of extracellular material rich in sugars of high molecular weight (polysaccharides). The sarcolemma encloses the entire muscle cell, whatever its shape, and demarcates the inner living intracellular material from the nonliving extra- or intercellular substance. The cytoplasm of the muscle cells is called sarcoplasm. It encloses the nuclear material and the contractile myofilaments, whether or not the latter are organized in myofibrils. Each muscle cell contains one or more nuclei, each of which has a complement of chromosomes embodying genes characteristic for the species. Many muscle cells contain only a single nucleus. Others, such as the great muscle fibres of human skeletal muscle, may contain many nuclei—often hundreds of them—scattered along the length of the fibre. Such units are multinucleate cells, often called syncytia (joined cells). A syncytium is a mass of cytoplasm containing several or many nuclei but surrounded by a single cell or plasma membrane. As is the case in other cells, the genes in the nuclei of muscle cells have important directing influences on the activity and properties of the fibre. These influences are subject to regulating and triggering signals imposed from sources outside the muscle cell.

Muscle cells embody molecular machinery capable of many functions besides those of contractility. If provided with suitable raw materials from their environment, muscle cells can synthesize and organize their important sarcoplasmatic, sarcolemmatic and contractile components. They are capable of repairing damage by use, wear or injury. They can respond to increased use by synthesizing and organizing more contractile material (hypertrophy). Conversely, they respond to prolonged inactivity or disuse by disassembling part of their machinery and undergoing

hypotrophy, characterized by a loss of contractile material. Muscle cells can store fuel in the form of fat or sugar and convert the fuel to a form of chemical energy convenient for immediate exploitation by the contractile protein filaments. They possess molecular coupling mechanisms whereby this chemical energy can be converted to mechanical energy by the filaments, thus changing their elastic parameters. Muscle cells can regulate the concentrations of salts or ions and other substances within them to fairly close tolerances. They are fitted with instruments for receiving signals from nerves or other information-transmitting devices and for responding to specific signals with contraction or with inhibition as directed by the signal. They can discharge some of their spent chemicals derived from fuels, oxidants, intermediates and component parts and can reprocess some of the spent intermediate chemical carriers of energy exploited during activity.

**3. Units Used in Describing Muscle Structure.**—The dimensions of many of the components of muscle are so small that they cannot be expressed conveniently in the units of measurement of length or of mass customarily used in daily life, any more than the dimensions of this page could be expressed conveniently in miles or kilometres or light-years. For example, the dimensions of the filaments are expressed most conveniently in terms of angstrom units, abbreviated Å. One angstrom unit is one ten-millionth of a millimetre, or $10^{-8}$ cm., or about $\frac{1}{250,000,000}$ in., or about $4 \times 10^{-9}$ in. (four-billionths of an inch). One Å is about one five-thousandth of the wave length of ordinary visible green light, or about two-thirds of the distance between successive carbon atoms in simple carbon chains such as occur in polyethylene, butter or petroleum oil. For somewhat larger structures found in muscle, it is convenient to use the unit of length called the micron, abbreviated $\mu$. One micron is equal to 10,000 Å, or to $\frac{1}{1,000}$ mm., or to $10^{-4}$ cm., or to about $\frac{1}{25,000}$ in., or to about $4 \times 10^{-5}$ in. A micron is equal to about twice the wave length of green light, or to about one-eighth of the diameter of a human red blood cell.

### B. Sarcolemma and Muscle Excitation

The sarcolemma is a strong but delicate membrane with remarkable mechanical, chemical and electrical properties. It is about 75 Å thick and is composed of one or more sheets of proteins to which are applied lipid or fatty molecules arranged very regularly with their long carbon chains packed close together in parallel array, all perpendicular to the plane of the sheet of the sarcolemma. This membrane is mechanically strong and withstands considerable tension without tearing. It is resistant to the passage of ions, glucose (a type of sugar) and many other substances, but permits more ready passage of water and is quite freely permeable to oxygen and carbon dioxide. Simple ions such as sodium or potassium applied to the outside of the sarcolemma gain access to the sarcoplasm inside rather slowly, but once inside they diffuse quickly through many portions of the muscle cell. A considerable ionic concentration gradient exists across the sarcolemma. Thus the potassium ion is concentrated inside the cell, where it may reach, in the sarcoplasm, a concentration of potassium of about 0.55%; outside the cell much lower concentrations exist. In many animals sodium and chloride ions are present outside the muscle cell in concentrations substantially above those inside. For example, in mammalian skeletal muscle the sodium concentration outside the cell may be 0.35%, whereas inside it may be 0.03%. Phosphate and inorganic anions are more concentrated inside the muscle cell than outside. These concentration gradients are maintained in spite of a slow but continuous leakage or exchange of these ions between the outside and the inside of the cell. The maintenance of the gradient is accomplished by means of molecular ion pumps, which bail out sodium ions as they enter and thus maintain the difference in concentration. Potassium ions are correspondingly selectively pumped into the cell and thus concentrated within it.

Accompanying, and apparently as a consequence of, the differences in concentration of ions across the sarcolemma, a voltage or electrical potential gradient exists across the sarcolemma. In a typical muscle the sarcoplasm may be at a potential of −0.050 to −0.10 v. with respect to the fluid outside the cell. That is to say, if a millivoltmeter is connected to two fine wires or salt electrodes, and the end of one wire is placed inside the sarcoplasm (piercing the sarcolemma) and the end of the other wire inserted in the fluid outside, the meter will indicate a potential of 50 to 100 mv. between the ends of the two wires. If the circuit is closed, a feeble current will flow. The voltage across the sarcolemma measured under these conditions with the muscle inactive is called the resting potential of the cell. It is maintained by and depends on the ion pumps mentioned above.

As a consequence of this resting potential, there exists an electrostatic field that tends to drive electrons or anions from the interior of the cell across the sarcolemma to the surrounding fluid, or to draw protons or cations into the cell. The sarcolemma resists this current, permitting only a small leakage that the ion pumps can handle without difficulty. Thus with respect to direct current, the sarcolemma behaves as an insulator with quite respectable specifications, being able to stand up without breakdown in the face of direct current voltage gradients of the order of 100,000 v. per centimetre. In this specification it is superior to many insulating materials used in industry and commerce. It is also an effective capacitor or electrical condenser; this property has important physiological connotations. Its dielectric constant is about 5.4, and this endows it with capacity to transmit high-frequency alternating current.

In many muscles the sarcolemma shows specially modified structure and properties at certain restricted areas. One type of specialized portion of the sarcolemma is usually found at or near the end of the fibre, where the contractile filaments transmit the tension they generate to a tendon or other structure outside the cell. Such a specialized region is called a myotendinal junction. Here the sarcolemma is thickened and into it is inserted the ends of intracellular filaments continuous with the myofilaments, or even the ends of myofilaments themselves. These appear to anchor themselves in the thickened sarcolemma. Opposite this anchorage, on the other side of the sarcolemma, are the ends of extracellular tendinous fibres or, in some cases, another cell on which tension can be exerted directly. These structures are bound to the external surface of the sarcolemma by linkages capable of transmitting the tension.

A second important specialized area of the sarcolemma is found in some muscle cells where motor nerves terminate in close relation to the cell, forming a relationship whereby a nerve impulse reaching the terminus can convey a signal to which the muscle fibre responds by contraction. The complex of motor nerve terminus and specialized muscle receptor area constitutes a motor end plate. These are not found in all muscles but are of physiological importance where present. Biochemical abnormalities of the motor end plates may have severe consequences, as in the disease myasthenia gravis.

The sarcolemma in the region of the motor end plate is normally thickened and folded and lies very close to the plasma membrane of the nerve terminal. When the motor nerve is activated in many types of motor end plates, a simple chemical substance such as acetylcholine is liberated by the nerve terminal. This liberation confronts the adjacent sarcolemma with a sudden bath of acetylcholine, which is sensed by this portion of the sarcolemma as a specific signal. This is ordinarily followed by a series of events culminating in a contraction. Usually the motor end plate is characterized by high concentrations of an enzyme such as cholinesterase, which is capable of rapidly destroying the chemical mediator to which the constituent portion of the sarcolemma is sensitive. This quickly clears the area for a new signal. It is noteworthy that in many muscles only this specialized portion of the sarcolemma is sensitive to the chemical mediator liberated by the nerve terminal. In such muscles, all portions of sarcolemma outside the motor end plate are insensitive to the mediator substance, even if it is applied in high concentration. Moreover, in the motor end plate itself the sarcolemma is sensitive to acetylcholine or other specific mediator only if the chemical is applied to the outer surface of the sarcolemma, where the nerve terminal normally delivers it. If it is applied experimentally by injection

to the inner or sarcoplasmatic surface of the sarcolemma at the motor end plate, no response is produced.

The electrical and ionic barrier properties of the sarcolemma are subject to rapid and reversible transient changes associated with excitation of the muscle fibre. The triggering mechanisms involved in natural physiological activity vary from muscle to muscle but generally resemble in some respects the example provided in the paragraph above. The introduction of a specific chemical mediator (such as acetylcholine, succinylcholine, epinephrine, 5-hydroxytryptamine or norepinephrine) to the outer surface of the sarcolemma is usually involved. Some muscles are fitted with specialized sarcolemmatic receptor sites such as those characterizing the motor end plate. In other muscles wide areas of the sarcolemma are sensitive to the activating chemical agent. Experimentally, excitatory transients in the sarcolemma can be induced in most muscles by any stimulus that "depolarizes" the electrical conditions existing across the sarcolemma. This depolarization can be induced conveniently by appropriate application of an electrical pulse to the sarcolemma. Various arrangements of electrodes and of pulsing circuits can be used. By depolarization is meant a reversal of, or sufficient reduction of, the voltage difference maintained across the sarcolemma by the ionic concentration gradients mentioned above. If at any point along the sarcolemma the normal negative potential of the interior of the fibre is caused to assume a sufficiently low value, a sudden breakdown of the sarcolemmatic ionic barrier can be produced at that point. In a muscle with a resting potential of about −90 mv., these events might be brought to pass by reducing the potential electrically to about −50 mv. The resulting excitatory wave is called an action potential. Sodium ions flow into the muscle cell, electric currents flow between resting and excited portions of the cell, and neighbouring portions of the sarcolemma may in turn be excited. During these ionic surges the inside of the muscle fibre reverses in polarity and may reach a value of +40 mv. with respect to the fluid outside. These action potentials are transient, however. In fast muscles they may last only a few thousandths of a second before the original resting potential is restored. In slower muscles each such transient change may be characterized by a pulse lasting a number of seconds. In many muscles depolarization of one segment of the sarcolemma excites and depolarizes a neighbouring area so that a wave of excitation sweeps over the fibre at speeds up to two metres per second. In others, the electrical disturbance remains localized and does not spread over unstimulated portions of the fibre. In either case the filaments inside the muscle normally sense the depolarization in some way and respond by contracting. The amount of ionic exchange between the outside and inside of the fibre occurring at each impulse is minute, and the original balance can be restored quickly by the pumping mechanisms of the cell. Many muscles can be depolarized and stimulated to contract by measures other than electrical pulses. Application of heat, cold or various mechanical or thermal stimuli may initiate a response.

Electrical pulses associated with muscle excitation can be recorded with suitable amplification from electrodes placed in the muscle or, if considerable distortion and loss of spatial resolution can be tolerated, from electrodes outside the body. The electrolytes of the body fluids are capable of conducting the transient currents from the sarcolemma to the skin. Electrical impulses originating from the heart and recorded in this way constitute the electrocardiogram. Similar electrical impulses can be recorded from skeletal muscle.

In aquatic animals these electrical currents originating from muscle can be transmitted into the surrounding water and give rise to transient pulses that may be detected some distance away. Some fish have sense organs capable of receiving such impulses and thus of transmitting to the fish's nervous system information about the environment based on electrical signals. Such electrical sense organs are highly developed in electric fish.

These fish also have specialized electric organs comprised of large cells derived from muscle cells. These cells have developed very highly the capability of generating the electrical pulses characteristic of muscle cell membrane excitation. The cells are further developed and arranged so as to give a directional component to the ionic surge. The cell membrane, corresponding to the sarcolemma, of these electric organ cells is very elaborately developed morphologically and physiologically and forms a highly effective ion pump. In the electric fish *Electrophorus electricus*, often called the electric eel, many thousands of these units are arranged in series and in parallel so that on simultaneous activation the whole assembly can deliver about half an ampere at 300 or 400 v. In the electric ray *Torpedo*, currents of 60 amp. can be delivered at 80 v. by a similar electric organ. Thus, although ordinary muscle cells are feeble sources of electric current, these electric cells derived from muscle are capable of quite a respectable performance as pulse generators. This is accomplished by special development of the sarcolemma at the expense of the contractile units.

The sarcolemma also influences and regulates uptake and excretion of substances other than ions. For example, many vertebrate muscle cells take up glucose at an adequate rate only in the presence of the pancreatic hormone insulin.

### C. Sarcoplasm

The sarcoplasm consists of the contents of the sarcolemma exclusive of nuclei and of the contractile filaments themselves. The sarcoplasm contains a continuous phase of proteinaceous fluid in which are dissolved and suspended various ions, sugars, nitrogenous compounds, proteins, lipids, gases and waste products. Within this poorly organized liquid are suspended more highly ordered structural elements. The most important of these are (1) the glycogen granules or particles, (2) the fat or lipid droplets, (3) the mitochondria or sarcosomes and (4) the membrane system comprising the sarcoplasmatic reticulum. These components are present in varying amounts and in varying geometrical distribution in muscles of different types.

**1. Glycogen.**—Glycogen is a type of animal starch. It is a substance characterized by polymers or macromolecules comprised of many glucose units bound together in very large molecular units. These form granules, about 200–400 Å across, which can be seen in the electron microscope. Glycogen granules can be regarded as a storage form of glucose, a simple sugar capable of serving as one of the fuels used for energizing muscle contraction. Large amounts of sugar present as monomeric glucose within a cell would make the fluid contents of the cell sirupy and would increase the osmotic pressure of the intracellular fluid so that water would tend to pass into the cell, thus upsetting the ionic and fluid balance of the cell. By stocking glucose in the form of the polymer glycogen, large amounts can be stored with very little influence on the osmotic pressure. The individual glucose units in a glycogen molecule can be processed and detached one by one as they are oxidized by the molecular machinery of the cell. Glycogen is found in variable amounts in muscle. It is frequently abundant in embryonic heart muscle and may be present only in meagre quantities in other muscles. It may become depleted in starvation.

**2. Fat.**—Fat can also serve as a source of fuel and may be found in muscle cells in the form of droplets 0.5 to 2 $\mu$ in diameter, as well as in states of finer dispersion. Such fat droplets may be distributed among the contractile elements, but they vary considerably in size, abundance and distribution according to the species, type of muscle and physiological state of the animal. For example, in migrating fish such as the salmon, large amounts of fat may be laid away in muscle cells during the feeding in salt water prior to entering the river for the spawning run. Much of this stored fat is used as a fuel during the ascent of the rivers. The amount of fat accumulated in the fuel bunkers determines to some extent the length of the upstream migration of which the fish is capable. In a similar manner migratory water fowl may stock large amounts of fat in their muscles during a feeding phase prior to a long migratory flight. The distance the birds can cover in a single flight depends on the fuel they can load at take-off, and an important part of their fuel is the fat in the muscle.

The fuel function served by the fat and glycogen in the muscle fibres themselves is supplemented importantly by reserves elsewhere in the body. Fat cells may be found between the muscle

fibres, and stores of fat and glycogen in organs such as the liver and in body tissue or connective tissue can be mobilized and transferred quickly to the muscle cells when needed.

**3. Mitochondria.**—Glycogen or fat from a suitable storage site is not used directly by the contractile filaments but is processed in special intracellular organelles called mitochondria. Mitochondria are present in almost all cells and appear to perform much the same functions wherever found. This function is to oxidize a primary fuel such as fat or glucose in a controlled manner, converting much of the energy rendered available by this burning or oxidation to chemical bond energy resident in esters or amides of phosphoric acid. Certain compounds containing phosphoric acid, such as creatine phosphate, adenosine triphosphate or arginine phosphate, can be utilized directly as energy sources. Enzymes associated with the filaments can split off a phosphate group from such a compound, coupling the energy thus rendered available for the contractile process. Phosphoric acid compounds capable of yielding energy in this way are said to contain high-energy phosphate bonds. The mitochondria can be thought of as little boilers or furnaces in which fat or sugar is burned in such a way as to convert part of the heat of combustion into high-energy phosphate bonds. Such phosphate bonds provide the immediate energy for contraction and, indeed, for many other reactions in the cell.

Most muscle fibres contain many hundreds or thousands of mitochondria. The mitochondria are distributed widely throughout the fibre and are often especially abundant close to the motor nerve ending or end plate. If they are placed close to the sites of utilization of the energy-rich compounds they produce, the problem of transport of such compounds within the cell is simplified. Muscle capable of prolonged sustained activity, such as hummingbird, pigeon or fly flight muscle or human cardiac muscle, contains very large numbers of mitochondria. Flight muscles of domestic fowls contain few mitochondria and are capable only of short bursts of activity before available stores of energy are exhausted.

The mitochondria of muscle resemble those of other cells in that they contain lipoprotein membranes that are to some extent like those of the sarcolemma; these membranes differ, however, in geometrical organization and in biochemical properties. Each mitochondrion is a separate sausagelike unit perhaps 0.5 $\mu$ in diameter. Some are greatly elongated, reaching lengths of several microns. Some are branched. In all cases they are surrounded by a membrane resembling structurally that comprising the sarcolemma. Inside this delicate sausage-skin-like covering is a second membrane that differs from the outer one in that it is folded extensively, forming crests or brackets or shelves extending into the interior of the mitochondrion. These are called the mitochondrial cristae. The inner mitochondrial membrane encloses a fluid matrix into which the cristae project.

The oxidation and coupling reactions executed by the mitochondria are mediated by organic catalysts called enzymes. These are large protein molecules capable of expediting greatly the chemical processes to which fuels and phosphate compounds and intermediates are subjected. The oxidation of glucose or of fat is accomplished through a definite series of reactions, each catalyzed by a specific enzyme. The enzymes are associated in some manner with the framework of the mitochondria and are probably incorporated in or bound to the constituent membranes forming cristae or inner or outer investment.

These enzymes are exceedingly efficient and speedy in action; they can disassemble or oxidize a sugar or fat so rapidly that it is thought that the enzyme units may be arranged structurally in order like rows of machines in assembly lines at a factory. The substrate, or molecule acted upon by the enzyme, is then passed in regular order from enzyme to enzyme arranged in an array corresponding to the sequence of chemical reactions to which the substrate is subjected.

**4. Reticulum.**—The last important component of the sarcoplasm is a netlike system of intracellular membranes that has come to be known as the sarcoplasmatic reticulum. This network can be impregnated with gold salts and its grosser disposition rendered visible with the light microscope. It then appears as a three-dimensional plexus intertwining with the myofibrils, often showing regular transverse and longitudinal strands repeating geometrically at fairly regular intervals. When examined with the electron microscope, the individual strands of the sarcoplasmatic reticulum are seen to be comprised of slender tubules and enclosed channels, the walls of which are made up of membranes resembling in fundamental structure the lipoprotein membranes of the sarcolemma and of the mitochondria. These membranes wall off a complex maze of channels from the surrounding sarcoplasm and neighbouring myofibrils.

In 1871 the Swedish anatomist G. M. Retzius suggested that the sarcoplasmatic reticulum might serve to conduct an excitatory impulse from the sarcolemma to the myofibrils within the fibre. In many muscles it seems to be ideally distributed to serve such a function, for it sends members that make connection with the sarcolemma from place to place, and it sends other connections to myofibrils and myofilaments within the muscle fibre.

### D. Myofilaments

The contractile mechanism itself resides in slender molecular filaments arrayed parallel to each other and to the direction of tension, spaced laterally from their fellows by distances of 300–500 Å. In some muscles interdigitating thick and thin myofilaments have been described, the thick ones exceeding 110 Å in diameter, the thin ones about half as thick. Even thicker ones, up to 500 Å in diameter, are found in some unusual cases. Myofilaments may range in length from one or two microns to many microns. They contain the important contractile proteins actin and myosin. In most striated muscles the myofilaments, when cut across, appear to be arranged in a hexagonal pattern, as cylindrical rods would pack together with minimal interstices. Molecular cross filaments connecting the filaments transversely can be seen with the electron microscope. In some muscles these repeat regularly every 400 Å along considerable stretches of the muscle. The cross filaments are about 50 Å in diameter and may represent sites of interaction between neighbouring filaments.

### E. Smooth and Striated Muscle

Muscle cells of all animals can be classified as belonging to either of two broad classes. One of these is called smooth or plain muscle, and the other is called striped or striated muscle. Each class of muscle is distributed widely throughout the animal kingdom. Striped or striated muscle fibres are characterized by the presence of regularly repeating transverse markings on the muscle fibre. Smooth muscle fibres lack such markings.

**1. Striated Muscle.**—The cross markings that characterize striated or striped muscle are too fine to be seen with the unaided eye, but they can be studied readily with the light or electron microscope. The cross stripes repeat at regular intervals of two to five microns along the lengths of the fibre. In certain unusual invertebrate striped muscles the pattern repeats at longer intervals, up to 10 or even 50 $\mu$ or more in some exceptional cases.

The cross bandings of striated muscle are manifestations of regularly repeating variations in structure and molecular content along the lengths of the contractile material. The bands are characteristic of each constituent myofibril, which tends to line up parallel to its neighbours with its cross bands in phase with or in register with those adjacent to it. The result is an array of cross bands aligned across the fibre, though imperfections in the lateral alignment are often apparent.

Each set of repeating cross bands along a myofibril is called a sarcomere, which means "flesh part." Thus a myofibril represents many sarcomeres repeating end on end one after another, and the striated muscle fibre contains many such myofibrils side by side. Within each sarcomere are represented examples of each important component of the contractile mechanism of the muscle, and the sarcomere itself is the smallest unit showing the characteristics of the contracting mechanism of the striped muscle.

The various cross bands comprising a sarcomere have names, to which letters have been assigned. The most conspicuous band is the anisotropic band or A band, sometimes called the Q band from the German word *Querscheibe*, meaning "cross disk." A

lighter portion of this in the centre of the sarcomere is called the H band, from the German *Hellscheibe*, "bright disk." Separating the A bands are the isotropic or I bands, each of which is bisected by a so-called Z band, from the German *Zwischenscheibe*, "between disk." By convention, the Z band is regarded as marking the boundary between one sarcomere and its neighbour.

Each of these bands differs from the others in the sarcomere with respect to chemical composition, optical properties, density and staining reactions. Thus the A bands contain most of the myosin, which is one of the important contractile proteins of striated muscle. A second important contractile protein, actin, is found in the I band and in most of the A bands, but not in the H. Very rapid interactions between actin and myosin are triggered when the muscle is excited. These interactions change the elastic constants of the muscle and appear to be important molecular features of the contractile process. Actin, myosin and other important proteins are resident in the myofilaments comprising the myofibrils.

From this description it becomes apparent that the characteristic cross stripes of striated muscle discernible with the light and electron microscopes represent a regular geometric pattern of arrangement of the molecular units responsible for contraction. These units repeat themselves at periodic intervals of two to five or more microns along the course of the fibre. This is in contrast to the situation in smooth muscle, where, as shown below, the contractile molecular units are more randomly disposed along the length of the fibre.

Striped muscle fibres are found in a great variety of vertebrate and invertebrate animals. They are found in some jellyfish (Coelenterata), where they actuate the contractions of the umbrella by which the creature swims. They are seen in some rotifers (wheel animalcules). Striped muscle is rare among worms and mollusks but is found in the heart of snails, in the swimming muscles of arrow-worms (*Sagitta*) and in the fast shell adductor muscles of the scallop *Pecten*. All the muscles of arthropods (insects; spiders and other arachnids; crustaceans, including lobsters, crabs, etc.; and isopods, including centipedes and millipedes) are of the striped variety. Here the striped fibres function as visceral and as skeletal muscles. In vertebrates, striped muscle is found in the heart and in the entire skeletal or voluntary muscular system.

Striped muscle is capable of rapid motions. The flight muscles of an insect or a hummingbird can contract and relax more than 100 times a second. Heart muscle is slower, contracting two or three times a second in large mammals, rather faster in small birds and more slowly in turtles and fishes. Most striped muscle lies between these extremes in capability for fast contraction.

**2. Smooth Muscle.**—As indicated in the discussion of striped muscle, smooth muscle lacks cross striations, and its constituent filaments and molecular contractile components are disposed without periodically repeating geometric patterns. Smooth muscles vary widely in structure from animal to animal. Some—for example, those of the tentacles of the squid and octopus—display definitive myofibrils arranged in spirals within the fibre. In the smooth muscle of earthworms the myofibrils are ribbon-shaped. In many smooth muscles no well-defined myofibrils are recognizable, and the myofilaments lie embedded in sarcoplasm without forming recognizable structural units smaller than the fibre itself.

Smooth muscle forms the greater part of the visceral musculature of vertebrates. It forms coats surrounding the alimentary canal, bile ducts, ureters and bladder. Activity of these fibres propels the contents of the viscera and provides for essential housekeeping needs in the body. Smooth muscle coats are also found around arteries and veins and can regulate the calibre of these vessels, though most of the force that propels the blood is provided by the striated muscle of the heart.

In many animals, however, the entire muscular system is comprised of smooth muscle. In most worms the body and visceral movements alike are dependent on smooth muscle. Smooth muscle is found in the feet of snails, slugs, clams and other mollusks and is used when the animal crawls on a surface. Smooth muscle is found in all phyla of animals.

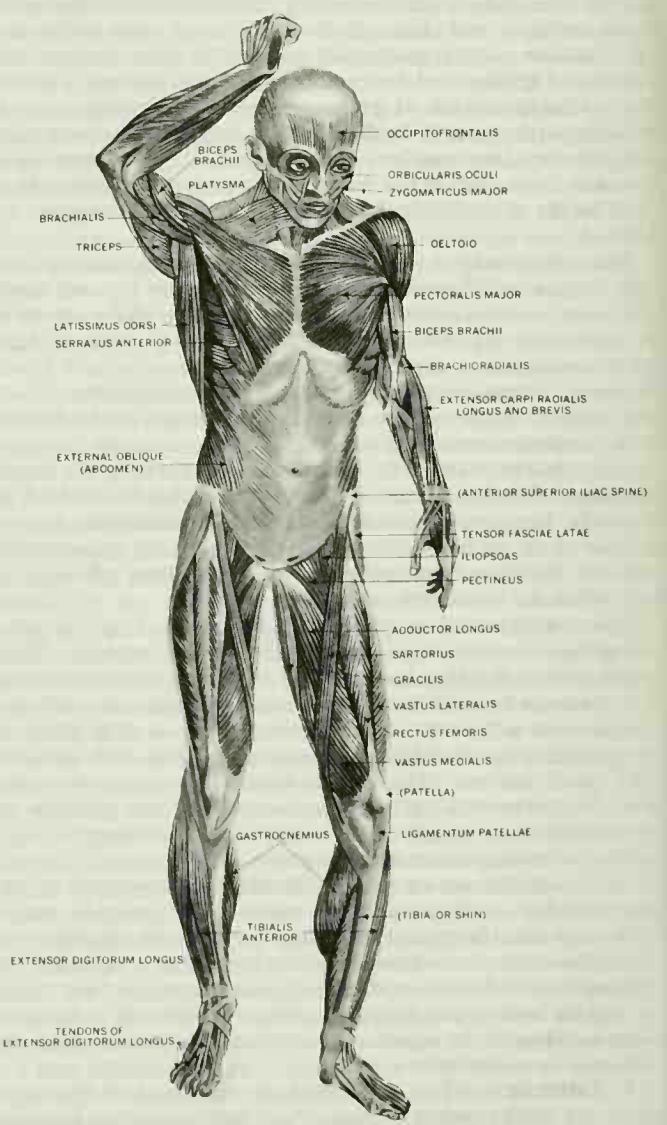
In general, smooth muscle fibres are slower in their action than striated muscle, though there is a considerable overlap and some smooth muscles are capable of very fast response. Thus the cuttlefish, squid and octopus can execute rapid darting movements and can catch fish or crabs, yet this is accomplished with smooth muscle. A worm can retract and pull itself into its burrow very quickly, and does this with smooth muscle. Examples of slow smooth muscles are to be found in snails, where complete contraction may occupy several seconds. The smooth muscle of human viscera is intermediate in speed of reaction. (H. S. Bt.)

## III. ANATOMY

### A. Gross Anatomy of the Human Muscular System

Skeletal, voluntary or striated muscles, comprising about 40% of the total body mass, are the essential "motors" that produce bodily movements. For example, muscle contractions enable bones to act as levers at their joints or may produce compression during defecation and parturition.

During contraction, muscle structure permits active shortening to about 50% of the muscle length with concomitant thickening. For example, when the elbow joint is flexed the biceps bunches up into a ball. Concentrated exercise results in an increased thickness (hypertrophy) of the muscle fibres. However, a muscle may contract without shortening and may rest under some degree of tension, or tonus, as a result of the activity of the motor unit.




FROM R. O. LOCKHART, G. F. HAMILTON AND F. W. FYFE, "ANATOMY OF THE HUMAN BODY," 1959, FABER AND FABER LTD., LONDON

FIG. 1.—ANTERIOR ASPECT OF THE HUMAN MUSCULAR SYSTEM. PLATYSMA REMOVED ON THE LEFT

The action of a muscle is a summation of the contraction of its individual fibres. Although muscle fibres are under the influence of the all-or-none law, this need not apply to a muscle as a whole. Voluntary movements may be graded as regards strength and speed. Thus only a part of a muscle may be brought into play for a particular movement, especially when muscles are assisting each other to produce such a movement. The principal muscles utilized in a given movement are called prime movers, or agonists. The muscles that produce the opposite movement are antagonists and they regulate the action of the agonists. Other muscles (synergists) may have to assist them by steadying intervening joints while yet others (fixators) may be required to fix the proximal parts of a limb or trunk. The same muscle may act as prime mover, antagonist, synergist or fixator under different circumstances.

The names given to muscles are descriptive of their shape (*e.g.*, teres [round], trapezius, deltoid); size and form (*e.g.*, magnus, latissimus, serratus); situation (*e.g.*, pectoralis, temporalis); structure (*e.g.*, biceps, digastric); direction (*e.g.*, rectus femoris, obliquus capitis inferior); action (*e.g.*, extensor digitorum, levator scapulae); attachments (*e.g.*, brachioradialis, sternohyoid), and contrast (*e.g.*, adductor longus, adductor brevis and adductor magnus).

Skeletal muscles present certain common features, which are discussed in the next several paragraphs, that should be noted in the description of any particular muscle.

Each muscle has at least two attachments, usually to bone or cartilage but occasionally to fascia or the skin (see *Muscular Systems,* above). The more fixed, and in the limbs the more proximal, attachment is called the origin; the more movable and distal attachment is called the insertion. The roles may be reversed in different actions. However, muscles never act in opposition to their principal movement in the living body. The body, or belly, of the muscle is usually fleshy. Some muscles are fleshy from end to end but most are fibrous at one end or at both ends. A fibrous end may be either rounded (a tendon) or sheetlike and membranous (an aponeurosis).

A tendon is composed of collagen fibres, is relatively inelastic and is much tougher than are living muscle cells. (*See* also CONNECTIVE AND SUPPORTING TISSUES: *Fibrillar Substance.*) Thus, it can withstand wear and tear when playing over a joint surface. A tendon permits a bulky muscle to attach to a very small area of bone and therefore conserves space and allows for flexibility; *e.g.*, in the wrist and hand. Wherever a tendon is subjected to friction, a sac (bursa) or sleeve (synovial sheath) containing lubricating fluid interposes between it and the surface over which it slides.

Despite the fact that tendon fibres and muscle fibres have unlike origins, they form a single functional unit. Each complements and supplements the other. Long, specialized muscle fibres are expensive energy consumers; tendons permit the use of short fibres. They also enable muscles to act at a distance, as well as in a line different to their own axis, by the use of pulleys round which tendons can play. Usually tendons extend for some distance either within the fleshy muscle or on its surface. The tendon of insertion may extend either along one border of the muscle (unipennate), or through the middle of the muscle (bipennate), or it may be split up into a number of extensions (multipennate). By these arrangements increasing numbers of muscle fibres are inserted into a tendon and thereby exert a stronger pull, so that the multipennate muscles are the strongest of all.

Muscle fibres may also be distributed in longitudinal, parallel rows that converge on the tendon. As muscles act by approximating their insertion to the origin, it is clear that when the fibres are parallel, or nearly so, the full effect of the muscular contraction is available and the maximum range is obtained. However, although a greater amount of movement will result, it is reduced in power. In the pennate arrangements, the larger number of fibres are oblique to the axis of contraction of the muscles involved and the range is diminished while the strength is increased.

In the limbs, the insertions of muscles are usually just beyond the joint upon which they act, so allowing for rapid movement.

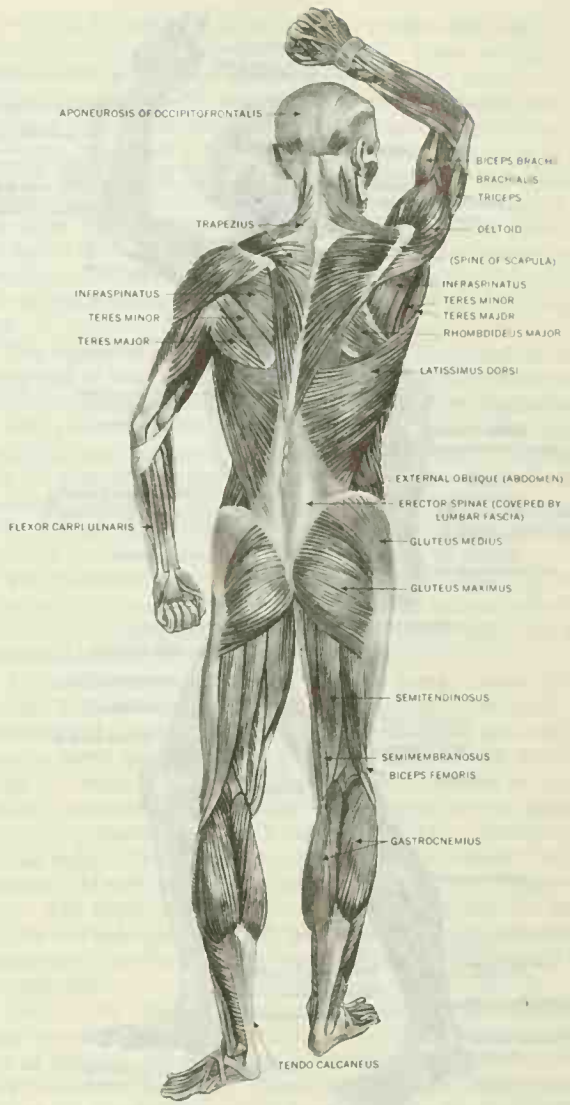



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FIG. 2.—POSTERIOR ASPECT OF THE HUMAN MUSCULAR SYSTEM

When inserted more distally (halfway or farther down), there is greater leverage and strength but less range of movement.

Inasmuch as the disposition of attachments of each muscle determines the action or actions that it can carry out, it must be noted that most actions require the co-ordination of a number of muscles, *i.e.*, group action.

Another common feature is that each muscle has its own motor and sensory nerve supply and is richly endowed with blood vessels (arteries, veins) and lymphatics.

Lastly, every muscle is invested in a fibrous sheath, which, as a rule, sends numerous partitions or septa into the muscle substance or may be attached between muscles to bone. This continuous investment, or deep fascia, affords additional attachment for muscles.

Actions of muscles are described relative to the axes of rotation and position of the joint involved and always relative to the anatomical position, in which the body has its face, palms and toes directed forward (anterior). Flexion involves a decrease of the angle of the bones on the two sides of a joint and is usually a forward-directed movement: *e.g.*, bending the elbow. Extension, the opposite movement, is usually an increase of the angle and a backward-directed movement: *e.g.*, straightening the elbow or backward bending of the wrist. An exception is the knee joint. Abduction and adduction denote the movements away from or toward the midplane of the body: *e.g.*, moving the arm sideways

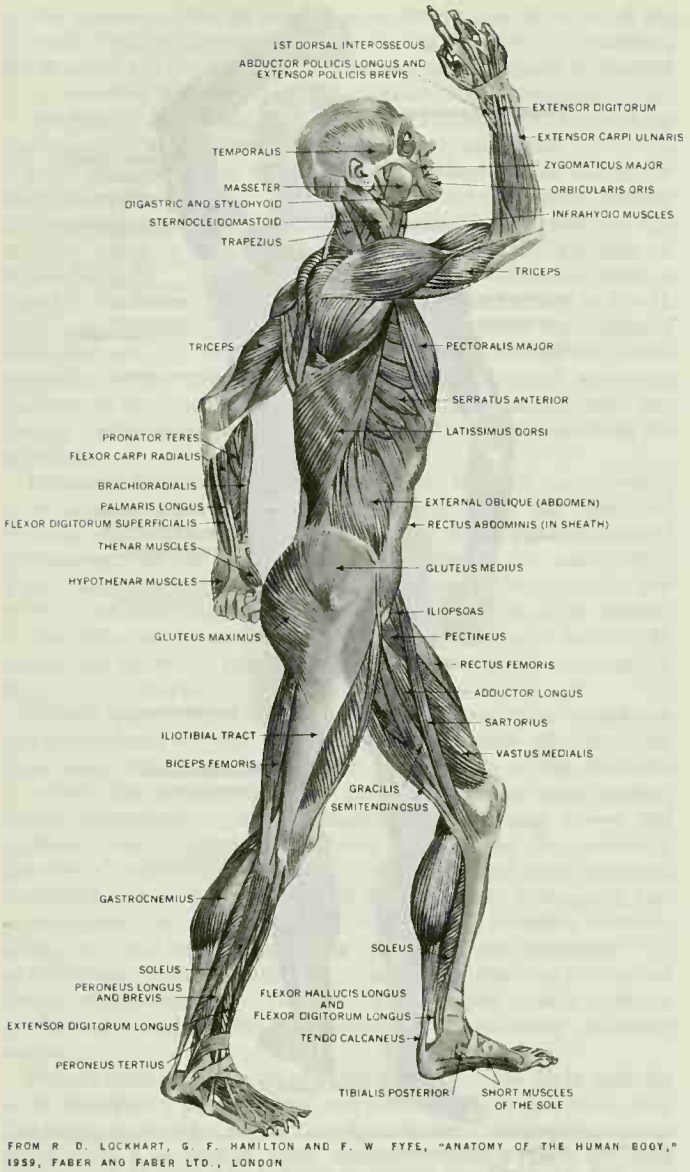


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**FIG. 3.—LATERAL ASPECT OF THE HUMAN MUSCULAR SYSTEM**

away from and to the body respectively. In the case of the fingers and toes, spreading is abduction (away from the centre of the middle finger or second toe) and bringing together is adduction. Medial and lateral rotation are inward and outward (respectively) twisting of a bone around its own longitudinal axis. Circumduction is the combination of the above movements. Certain movements are restricted to a particular region: pronation is an inward rotation of the forearm and hand when the thumb is swung towards the body midline, and supination is the opposite movement into the anatomical position; inversion involves turning the sole of the foot inward and eversion is the opposite movement.

The major muscles and their functions are here described regionally.

**1. Head and Face.**—These muscles may be grouped arbitrarily into: muscles of expression; muscles of mastication (acting on temporomandibular joint); muscles of head movements (acting on atlantooccipital and atlantoaxial joints); and muscles of internal organs—tongue, palate, middle ear.

*Muscles of Expression.*—Disposed in three groups around the apertures of the eye, nose and mouth, they include the occipitofrontalis of the scalp and the little-used ear muscles. The flat facial muscles lie just under the skin of the head and face and one extends down the front of the neck into the upper chest wall. In general, they arise from the skull bones in the region where they are located and are inserted into the skin, which can then be pulled or wrinkled into the various expressions of fear, anger, joy. The major muscles of expression are:

Around the eye: Orbicularis oculi, the sphincter of the eyelids, has an outer orbital part and an inner palpebral part.

Nose: Procerus wrinkles the skin over the nasal bridge. The nasal aperture has compressor, dilator, elevator and depressor muscles.

Mouth: Orbicularis oris, the circular sphincter of the lips into which the other oral muscles are inserted. The upper lip and corners have elevators, while the lower lip and corners have depressors. Zygomaticus major extends from the zygomatic bone into the skin of the mouth corner. Platysma extends in a wide sheet down the front of the neck from the corners and the chin to the skin over the second rib cartilage. Buccinator, the cheek pad muscle, extends from the surface of the mandible and maxilla opposite the molar teeth and the pterygomandibular ligament to the corner of the mouth.

It is readily appreciable how the facial muscles effect emotive expressions. Surprise, consternation, quizzical wrinkling of the forehead involve the scalp, orbital and nasal muscles; sneering draws up the angles of nose and mouth; joy, laughter and elation include drawing the corners of the mouth into the cheeks; the winking of the eye, the sucking and the kissing acts of the puckered mouth utilize at least the respective circular muscles; depression, sadness and suffering are displayed by depression of the lower lip and oral corners and a wrinkling of the skin of the neck. The platysma also resists strangling attempts. The circumoral muscles come into play during eating and the buccinator is an essential part of mastication, whistling, blowing wind instruments and swallowing.

*Muscles of Mastication.*—The masticatory muscles act on the temporomandibular joint formed by the articulation of the base of the skull, located just in front of the ear lobe, and the head of the mandible, which is situated at the upper back end of the vertical portion of the bone.

The quadrilateral masseter is placed vertically on the side of the face below the zygomatic arch. It lifts the mandible, pressing it against the maxilla; it is easily seen and felt when the teeth are clenched and relaxed.

Temporalis has a broad, fleshy origin from the temporal fossa (side of the skull, above and in front of the ear). It tapers rapidly to a thick, powerful tendon attached to the coronoid process of the mandible. This muscle also elevates the mandible and pulls it back when it is protruded.

Medial pterygoid has two heads that arise from the back of the maxilla and the base of the skull. Its fibres run parallel to those of the masseter and it is inserted to the inner aspect of the angle of the mandible.

Lateral pterygoid also has two heads of origin that arise from the skull base. The short, thick muscle passes horizontally backward to be inserted into the neck of the mandible and into the capsule and disc of the temporomandibular joint.

The lateral pterygoids assist in opening the mouth while the medial pterygoids aid the masseters and temporalis in closing it. The force exerted in clenching the teeth is about 530 lb. per square inch. The relaxation of the lateral pterygoid controls the closing of the mouth, which involves a backward gliding of the head of the mandible and the articular disc between it and the skull base. When the medial and lateral pterygoids of the two sides act together they pull the mandible forward so that the lower teeth project in front of the upper. If the pterygoids of only one side are brought into action, that side of the mandible swings forward and to the opposite side, so that by alternating the pull of the left and the right muscles, side-to-side grinding movements are effected as, for example, in trituration of food.

*Muscles Producing Head Movements.*—Two groups of muscles move the head on the spinal column: a superficial group extends between the shoulder girdle and the skull, and a deep-seated series connects various cervical and thoracic vertebrae to the skull.

The superficial group includes the sternocleidomastoid and the trapezius muscles.

Sternocleidomastoid stretches from the upper end of the sternum

and the adjacent upper surface of the clavicle to the mastoid process (behind the ear) and lateral part of the superior nuchal line of the occipital bone. When the muscles on the two sides contract together the head is flexed and the chin brought down to the chest. One muscle acting alone will bend the head toward the shoulder of the same side and turn the face away.

Trapezius has an extensive origin from the medial third of the superior nuchal line and the midline ligaments stretching from the external occipital protuberance to the spinous process of the twelfth thoracic vertebra. The fibres narrow to a triangular wedge attached to the outer part of the clavicle and the adjacent spine of the scapula. Together the two muscles are shaped like a trapezium, and they may extend the head, brace back the shoulders and assist in shrugging the shoulders.

The deep muscles of the back of the neck are disposed in layers and many are upward continuations of the muscles of the lower vertebral column. Splenius capitis, longissimus capitis and semispinalis capitis are functionally, and to some extent structurally, upward prolongations of the massive erector spinae (see *Neck and Vertebral Column*, below). This stretches from the sacrum to the occiput on each side of the midline and, because of its fragmented nature, it has a "zip-up" action on the vertebral column in raising it from the horizontal to the vertical. The three capitis muscles are part of the last upward "relay" and together they actively extend the head backward. There are six small closely packed muscles connecting the atlas, axis and skull—rectus capitis anterior and lateralis, rectus capitis posterior major and minor, obliquus capitis superior and inferior. These muscles flex, extend, rotate or bend the head sideways against resistance or gravity, according to their attachments. They act synergistically with the eye muscles, causing the head to follow the movements of the eyes.

*Muscles of Internal Organs of Face and Head.*—The middle ear muscles, tensor tympani and stapedius, act on the tiny auditory ossicles that enable vibrations to be transmitted from the ear drum of the external ear to the fluid in the internal ear. Usually these muscles act simultaneously and reflexly in response to sounds of fairly high intensity so as to dampen their effect before the vibrations reach the internal ear. For the muscles of the orbit, *see* EYE, HUMAN; for those of the soft palate and throat, *see* THROAT; for those of the tongue, *see* TONGUE.

**2. Neck and Vertebral Column.**—The platysma, sternocleidomastoid and trapezius muscles have been mentioned under *Head and Face*. The deeper muscles in the front of the neck may be grouped into those above and those below the hyoid bone. The deepest layer is closely adherent to the cervical vertebrae.

The four suprahyoid muscles—digastric, mylohyoid, geniohyoid and stylohyoid—elevate the hyoid bone and larynx and the first three also depress the mandible, since they are attached to it from below. All four come into play during the acts of swallowing and vocalizing.

On each side of the midline of the neck are situated the four fairly vertical, straplike infrahyoid muscles. Three are attached to the hyoid bone and the names indicate their attachments: omohyoid (omos = shoulder, *i.e.,* scapula), sternohyoid, thyrohyoid, sternothyroid. Their combined action is essentially to pull down the hyoid bone and larynx, especially after the latter has been elevated during deglutition. In the production of low vocal notes the sternothyroid draws the larynx down, while for high notes it is pulled up by the thyrohyoid.

Extending laterally from the cervical vertebrae is the deeply placed triangular mass of the three scalene muscles, one behind the other—scalenus (= uneven sided) anterior, medius and posterior. The first two are attached below to the first rib while the third inserts into the second rib. When the thorax is fixed, they will bend the neck sideways and slightly forward. When the two masses of muscle act together they will fix the neck like splints. They may also reverse their action and, acting from a fixed neck, will pull on the first ribs during forced breathing.

Between the right and left scalene muscles, and lying on the front of the cervical vertebrae, are the longus colli (= neck) and the longus capitis. The former muscle assists the scalene muscles in rotating the neck to the opposite side while the longus capitis flexes the head during forced inspiration. When one side of the latter muscle acts alone it rotates the head to that side.

The muscles located behind the vertebral column have been outlined during the description of the movements of the head. However, there also are deeply placed muscles that assist in maintaining the position of the vertebrae relative to each other; in addition these muscles may swivel and bend one vertebra upon the other. Because of the complex arrangement of the muscles acting on the vertebral column, as exemplified by the overlapping muscles in the cervical, thoracic and lumbar regions, it is easiest to discuss the muscles acting on the vertebral column as an integrated unit.

The segmental and multicurved nature of the vertebral column, composed of bony vertebrae and compressible intervertebral discs of fibrocartilage, allows for a pillarlike fixture for weight-bearing; it also provides attachment to powerful muscles that facilitate flexibility and locomotion. The cervical and lumbar regions permit the greatest freedom of movement while the thoracic rib cage restricts mobility. The movements between any two adjoining vertebrae are slight, but the summation effect of these movements provides the whole column with a wide range of action.

The movements of the column are produced either by muscles attached to it and acting directly on it or by muscles attached to other bones (head, thorax or pelvis) and acting indirectly on the vertebral column.

The major muscle mass acting on the column, erector spinae, is located behind it, extending from the sacrum to the skull. It is composed of a series of long and short overlapping and end-to-end muscle strips extending across and between all the intervening bony structures. Basically, there are three columns of muscle—lateral, intermediate and medial. The muscle masses form conspicuous projections on each side of the spiny, median furrow of the back. The two erector spinae together extend the spinal column. If only one muscle contracts, the column bends to that side. The upper portion of the muscles, acting with the splenius capitis and semispinalis capitis, will extend the head and neck; but when only one side acts, the head and neck will bend and rotate to that side.

Deep to the erector spinae are a number of other smaller muscles—intertransversarii, multifidus, rotatores, interspinales—that act as rotators and also assist in extending the vertebral column and bending it sideways. These short muscles steady adjoining vertebrae, thereby acting as postural muscles and facilitating the efficient action of the long muscles on the whole column.

Covering these postvertebral muscles are sheets of muscles, which, though arising from the vertebral column, are inserted into the upper extremity: trapezius and rhomboideus muscles in the cervical and thoracic regions, and latissimus dorsi in the thoracolumbar region.

Attached to the front of the vertebral column are its flexors. The longus colli, longus capitis and scalene muscles have been described. The thoracic vertebrae have no intrinsic flexors. In the lumbar regions there are two flexors—the diaphragm (*q.v.*) and psoas major—while a third muscle, quadratus lumborum, assists in extension and sideways bending. Indirect, but important, flexors are the sternocleidomastoid and the vertical, bandlike rectus abdominis, which arises from the top of the pubis and stretches up on each side of the midline to the 5th, 6th and 7th rib cartilages. Forward bending (*e.g.,* touching the toes) occurs primarily at the hip joint and secondarily in the vertebral column.

**3. Trunk (Thoracoabdominal Muscles).**—*Thorax.*—The main intrinsic muscles that act directly on the thoracic skeleton are located between the ribs—the intercostal muscles. Plastered against the inner walls of the thoracic cage are two flat sheets of muscles—transversus thoracis and levatores costarum. These muscles of respiration elevate and depress the ribs in the inflation and deflation of the lungs (*see* RESPIRATION: *Mechanics of Respiration*). The internal height of the thoracic cavity is increased during inspiration by the contraction (*i.e.,* lowering) of the dome-shaped diaphragm. Separating the thoracic cavity from the abdominal cavity, it is attached to the lower part of the sternum

and the inner aspects of the lower six ribs as well as by two elongated fibrous *crura* (= legs) to the upper lumbar vertebral bodies. The diaphragm is the principal muscle of respiration. It is also a powerful synergist in all expulsive actions—sneezing, coughing, vomiting, crying, and expelling feces, urine and, in pregnancy, the fetus.

The extrinsic muscles in the thoracic region are: trapezius and latissimus dorsi on the back, deep to which are rhomboideus major and minor from the upper thoracic spines to the scapula; these, in turn, overlie serratus posterior superior and inferior extending from the spines to the upper and lower ribs respectively. On the front of the chest are pectoralis major and minor, the former attached to the clavicle, sternum and upper six rib cartilages and the latter to the middle ribs. Their insertions are to the humerus and scapula respectively. All of these muscles are, as far as thoracic movements are concerned, brought into play mainly during laboured breathing.

*Abdomen.*—The anterolateral walls of the abdominal cavity are composed of three flat muscular sheets, from without inward: external oblique, internal oblique and transversus abdominis, supplemented in front on each side of the midline by rectus abdominis.

The first three muscles extend between the vertebral column behind, the lower ribs above and the iliac crest and pubis of the hip bone below. Their fibres all merge toward the midline, where they surround the rectus abdominis in a sheath before they meet the fibres from the opposite side at the *linea alba*. Strength is developed in these rather thin walls by the crisscrossing of fibres. Thus the fibres of the external oblique are directed downward and forward, those of the internal oblique upward and forward, and those of the transversus horizontally forward.

Around the rectus abdominis the fibres of the above muscles are all fibrous. In the region of the groin, between the pubic bone and the anterior superior iliac spine, a specialized arrangement of these fibres permits the formation of the inguinal canal. This develops at birth as the testis descends out of the abdominal cavity through its wall into the scrotum. In the female this is replaced by an outward-dwelling fibrous cord from the uterus to the labium majus. This gap is a potentially weak area where inguinal hernias can occur.

The muscles of the abdominal walls perform a variety of functions: (1) They provide a tonic, elastic muscular support for the viscera and by their recoil pull down the rib cage in expiration. (2) They contract against blows to form a rigid protective wall for the viscera. (3) When the glottis is closed and the thorax and pelvis are fixed, these muscles take part in the expulsive efforts of micturition, defecation, parturition, vomiting, and of singing and coughing. (4) When the pelvis is fixed they initiate the movement of bending the trunk forward. Thereafter gravity comes into play, the abdominal muscles relax and the muscles of the back then take on the strain. (5) Conversely, the abdominal muscles come into play in preventing hyperextension. (6) When the thorax is fixed, the abdominal muscles can pull up the pelvis and lower limbs. (7) The muscles of one side can bend the vertebral column sideways and assist in its rotation.

The posterior abdominal wall is formed by the central pillar composed of the lumbar region of the vertebral column. Some of its muscles have already been mentioned—erector spinae, quadratus lumborum and psoas major. In addition the iliacus muscle arises from the shallow hollowed iliac part of the innominate bone and joins the psoas major tendon to form the iliopsoas muscle, which is inserted into the upper end of the femur. This muscle is a powerful flexor, rotator and circumductor of the thigh.

*Pelvis and Perineum.*—The "false" pelvis is lined by the iliacus muscle, while the "true" pelvis has the piriformis at the back (in front of the sacrum) and the obturator internus at the sides. In front the sphincter urethrae and deep transversus perinei form a sheet stretching across the pubic arch. The mobile and supporting "floor" of the pelvis is formed by the levator ani, which stretches from the side walls down to the median plane like a hammock.

The piriformis and the obturator internus are inserted into the top end (greater trochanter) of the femur. They abduct the flexed thigh and laterally rotate the extended thigh.

The levator ani supports the prostate in the male and forms a sphincter around the vagina in the female. In both sexes it is perforated by the urethra and forms a sling around the anus just where it joins the rectum at an angle. Thus when it contracts, it prevents the descent of feces. During defecation the sling is relaxed.

The sphincter urethrae and deep transversus perinei form part of the musculomembranous urogenital diaphragm that closes the front of the bony outlet of the pelvis. Superficial to it lie the external genitalia and behind it is the anus with its sphincter ani externus intimately adherent to the skin around it.

The ischiocavernosus straps the crura of the penis and clitoris against the sides of the bony ischiopubic arch. More developed in the male, it compresses the crus, a continuation of the corpus cavernosum, a honeycomblike mass that becomes turgescent during erection.

In the male, the urethra pierces the urogenital diaphragm and enters the corpus cavernosus in the bulb of the penis, where it is surrounded by the bulbospongiosus. At the end of the act of micturition, when the bladder is emptied, the muscle empties the urethra. It also forces semen beyond the bulbous part of the urethra. In the female, the two halves of the bulbospongiosus are separated by the vaginal orifice, and it extends from the clitoris to the perineal body behind the vagina. The muscle constricts the vagina and contributes to the erection of the clitoris.

In the female the perineal body, a fibromuscular node situated between the vagina and anus, is the site of insertion of fibres of the sphincter ani externus, bulbospongiosus, two superficial and two deep transversus perinei and the levator ani muscles. Not infrequently these muscles are injured ("a tear") during parturition.

**4. Upper Limb.**—The prehensile upper limbs, with their great range of movement, are moored to the thorax at only one small joint, the sternoclavicular. However, the shoulder girdle (clavicle and scapula) with its extensive muscular attachments to the trunk securely anchors the arm to the body.

*Shoulder.*—The muscles of the shoulder region are divisible into three major groups: muscles connecting the upper limb with the vertebral column; muscles connecting the limb with the front and side walls of the thorax; and muscles of the shoulder; *i.e.*, between scapula and humerus.

From the vertebral column stretch the trapezius, latissimus dorsi, levator scapulae and rhomboideus major and minor. The trapezius is inserted into the spine of the scapula and the adjacent posterior border of the clavicle. The extensive fan-shaped latissimus dorsi from the lower half of the vertebral column and iliac crest tapers to a rounded tendon inserted into the front of the upper part of the humerus. The other three muscles, which form a sheet deep to the trapezius and latissimus dorsi, stretch from the lower cervical and upper thoracic vertebrae to the adjacent and parallel border of the scapula. As a group, these five muscles help to steady the scapula and to control its position and movements during the free movements of the arm. The trapezius and rhomboids brace back the shoulders. They also assist in depressing the tip of the shoulder. The levator scapulae and trapezius are important in elevating the scapula, and, with the serratus anterior pulling the lower end of the scapula forward, they help in rotating the scapula so that the shoulder joint is pivoted upward to enable the arm to be lifted above shoulder level.

From the front of the thorax, the broad pectoralis major tapers to the upper end of the humerus, while the pectoralis minor has a rounded tendon inserted into the coracoid process of the scapula, which it can pull down and forward (*see* also *Thorax*, above). The pectoralis major is an active synergist in adduction and medial rotation of the arm. It can also draw the arm across the chest. When the raised arms are fixed (as in mountaineering) it assists latissimus dorsi and teres major in pulling the trunk up. The subclavius helps to secure the clavicle to the first rib. The serratus anterior arises by fleshy slips or digitations from the upper eight ribs and intervening fascia at the side of the thorax. The

fleshy fibres sweep back along the ribs and in front of the scapula to be inserted into its medial border, to the back of which the rhomboids are attached. Most of the fibres attach to the lower angle of the scapula and provide its important rotating action. This muscle, by pulling the whole scapula forward, is a powerful protractor of the shoulder in all punching and pushing movements —hence its nickname, "boxer's muscle."

The spine of the scapula and the adjacent anterior border of the clavicle also act as the origin of the V-shaped deltoid muscle, which caps the front, side and back of the shoulder, narrowing down to its powerful tendon that inserts into the outer side of the humerus about halfway down. The whole muscle powerfully abducts the arm to a right angle. At this level the humerus becomes fixed, so that if the arm is to be raised higher, the whole scapula must rotate and tilt it upward (*see* description above of trapezius and serratus anterior). The front fibres of the deltoid flex and rotate the arm inward, while the posterior fibres extend and rotate the arm outward. The subscapularis extends from most of the hollowed, front surface of the scapula to a rounded area (the lesser tubercle) on the front of the humerus just below its head. The corresponding back area of the scapula, divided by its triangular spine, gives origin to the supraspinatus, infraspinatus and teres major muscles. Another straplike muscle, teres minor, arises from the axillary border of the scapula and is inserted on the back of the humerus just below the head and below the supraspinatus and infraspinatus. The teres major joins the latissimus dorsi and pectoralis major on the front surface of the upper third of the humerus. Thus these three muscles supplement the subscapularis in medial rotation of the arm, while the supraspinatus, infraspinatus and teres minor are their antagonists and rotate the arm outward. The muscles attached to the front of the upper end of the humerus will help in flexion, while those attached posteriorly will act as extensors. All will oppose the deltoid and act as adductors.

*Arm.*—The muscles of the arm are divisible into two groups: those in front of the humerus and those behind it.

The biceps brachii and coracobrachialis are superficial to the brachialis, which is intimately spread over the front of the lower two-thirds of the humerus. One head of the biceps (= two heads) arises within the capsule of the shoulder joint while the other head arises with the coracobrachialis from the coracoid process of the scapula. The coracobrachialis ends in the humerus opposite the deltoid insertion; it is a synergist flexor and adductor of the humerus, while the biceps, inserted into the radius, flexes both the shoulder and the elbow joints. The radius is the "mobile" bone of the forearm, swiveling, with the hand, across the ulna from the supine to the prone position. The main action of the biceps is supination of the forearm. The brachialis covers the capsule on the front of the elbow joint before it is inserted into the upper end (coronoid process) of the ulna. Thus it pulls the whole forearm toward its origin when it contracts; *i.e.*, flexes the elbow joint.

Covering the whole posterior aspect of the humerus is the triceps. One head arises from the scapula and the other two from the back of the humerus. The three heads fuse into a powerful tendon that covers the capsule of the back of the elbow joint before it inserts into the back of the upper end (olecranon process, or "the elbow") of the ulna. It is the extensor of the joint.

*Forearm.*—The muscles of the forearm may be divided into the front group (flexors and pronators) and the posterior group (extensors and supinators). Both groups are further divisible into superficial and deep muscles.

Just below the front of the elbow joint the oblique pronator teres (from inner epicondyle of humerus to outer side of radius about midway) separates the flexors from the extensors. The superficial flexors and extensors form essentially three subgroups —tendons on the radial side, those on the ulnar side and the group between them that provides tendons for the inner four fingers.

The superficial flexors of the wrist and fingers are: flexor carpi radialis, flexor digitorum superficialis and flexor carpi ulnaris. Fairly often an additional tendon, palmaris longus, overlies these in the centre of the forearm. The deep group on the front of the forearm consists of flexor digitorum profundus, flexor pollicis (= of thumb) longus and pronator quadratus. Each tendon of flexor digitorum superficialis is perforated by a corresponding tendon of the profundus muscle, and all are inserted into the phalanges of the fingers. The insertions of all the flexor and extensor tendons of the wrist can be considered together. They are attached not to bones of the carpus, as the names of the muscles suggest, but to the nearest base of the metacarpal bones on the palmar and back aspects respectively.

The vitally important thumb with its specialized movements is well endowed with muscles. It has a long flexor, a long abductor, a long extensor and a short extensor extending from the radius and ulna as well as short muscles from the carpus and metacarpus (see *Hand*, below).

The two pronators on the front (pronator teres and pronator quadratus) are countered by the brachioradialis superficially and the deep supinator, which is tightly coiled around the upper end of radius; these two supinators help the biceps "unwind" the prone forearm, like a cord unwinding a spinning top. The other superficial muscles, extensor carpi radialis longus and brevis, arise with the brachioradialis from the outer border of the lower half of the humerus; they extend the wrist and help steady the elbow joint during flexion and extension. Three more muscles arise from a common origin on the front of the outer epicondyle of the humerus, namely, extensor digitorum, extensor digiti minimi and extensor carpi ulnaris. Besides extending the wrist and fingers they assist slightly in extending the elbow joint.

The deep posterior muscles are mainly destined for the thumb. Besides supinator there are abductor pollicis longus, extensor pollicis longus and brevis and extensor indicis (index finger).

The flexor and extensor tendons on the radial side will co-ordinate to act as abductors of the wrist, while those on the ulnar side will act as adductors. Furthermore, the extensor tendons synergistically may extend the wrist to enable the flexors of the fingers to secure a more powerful grip.

*Hand.*—The thenar (ball of the thumb) and hypothenar (ball of the little finger) groups of muscles each include a short abductor, a short flexor and an opponens; the thumb in addition, has a powerful adductor pollicis. The thumb also receives the abductor pollicis longus, extensor pollicis longus and brevis and the flexor pollicis longus, which arise from the radius and ulna.

In opposition, its most specialized movement, the thumb is brought into contact with the tips of any of the other fingers. The movement is a combination of rotation, adduction and flexion.

The four sardine-shaped lumbricales arise from flexor tendons in the palm and are inserted into the extensor tendon expansions that attach to the backs of the phalanges.

The interossei are located between the metacarpal bones and are arranged in groups of four dorsal and four palmar muscles; they arise from the metacarpal bones and insert into the expansions of the extensor tendons. The dorsal interossei abduct the fingers from an imaginary line drawn lengthwise through the middle of the third finger, while the palmar interossei adduct the fingers. Working in conjunction with the lumbricales, the eight interossei can flex the fingers at the knuckles (carpometacarpal joints) and extend the interphalangeal joints; both movements are used in the upstroke in writing.

**5. Lower Limb.**—*Hip and Thigh.*—The muscles of the hip and thigh may be divided regionally into those of: the gluteal (buttock) region; the anteromedial (front and inner) region of the thigh; the anterolateral (front and outer) region of the thigh; and the posterior (back) region.

The three muscles forming the bulk of the buttock, gluteus maximus, gluteus medius and gluteus minimus, tend to overlap and cover one another from without inward respectively. The largest and most superficial, gluteus maximus, is quadrangular in shape and has an extensive origin from the back part of the outer surface of the ilium, the adjacent sacrum and coccyx and the sacrotuberous ligament (extending between the sacrum and the ischial tuberosity). The fleshy fibres run obliquely out and downward to be attached to the gluteal tuberosity of the femur and the iliotibial tract (deep fascia extending from iliac crest to tibia). This mus-

cle is the most powerful extensor of the thigh, bringing it into line with the trunk. When acting from below (*i.e.*, from its insertion) it is equally powerful in raising the trunk from the stooping position and then in supporting the pelvis and trunk upon the femur. The maintenance of the erect posture is ensured by the balanced tone between (1) the gluteus maximus and synergist extensors and (2) the flexors of the hip joint. Through its tension on the iliotibial tract, gluteus maximus steadies the femur on the extended tibia, especially when the knee extensors are relaxed. The gluteus medius obtains the largest attachment on the middle portion of the outer surface of the ilium and inserts on the greater trochanter of the femur. The gluteus minimus arises from the ilium just in front of the medius and attaches to the greater trochanter anteriorly. Both these muscles are abductors of the thigh and their front portions rotate it inward, while their posterior fibres may act in extension and outward rotation. When the leg of one side is raised off the ground (*e.g.*, in walking or running) the gluteus medius and minimus of the opposite, fixed side act from below and exert a strong pull on the hip bone, even tilting up the unsupported side of the pelvis, which tends to sag when the limb is raised.

In the same deep plane as gluteus minimus, but behind it, are a series of short muscles, all of which extend away from the midline to the greater trochanter or the area below it posteriorly. In order, from above downward, are piriformis, gemellus superior, obturator internus, gemellus inferior, obturator externus (on a deeper plane) and quadratus femoris. While this group is mainly concerned with outward rotation of the thigh, the upper muscles assist in abduction and extension and the lower ones assist in adduction. The piriformis and obturator internus have their origins inside the pelvis.

The muscles on the front of the thigh may conveniently be divided by the ribbonlike sartorius muscle, which extends from the anterior superior iliac spine at the outer end of the groin obliquely across to the inner side of the knee, below which it inserts into the tibia. To the outer side of the muscle lies the quadriceps femoris, composed of rectus femoris, vastus lateralis, vastus intermedius and vastus medialis; these muscles, which are closely packed around the femur, arise from its whole extent and are inserted via the patella (knee cap) and its *ligamentum patellae* to the front of the upper end of the tibia. Just below the iliac crest and on the lateral side of this group is the tensor fasciae latae, which assists gluteus maximus in extending the femur on the tibia in the erect posture.

The sartorius ("tailor's muscle") may simultaneously flex the thigh on the pelvis and the leg on the thigh. The quadriceps femoris extends the knee joint; its subdivisions also have particular actions: the rectus femoris assists in flexing the hip joint and in supporting the pelvis and trunk on the femur; the vastus medialis positions the patella during straightening of the knee.

To the medial (inner) side of the sartorius lie, from before backward, the fleshy pectineus, adductor longus, adductor brevis and adductor magnus muscles, while the straplike gracilis lies along the inner border of the thigh. The adductors arise from the pubis and ischium of the hip bone and then fan out to be attached along the shaft and distal end of the femur. The pectineus and gracilis arise from the pubis. The former inserts into the upper end of the shaft of the femur, while the latter inserts into the tibia just behind the sartorius. As their names suggest, the adductors adduct the thigh and rotate the femur medially when the leg is on the ground and laterally when it is free. This medial group of muscles is brought into play in such movements as gripping a saddle with the thighs and crossing the knees.

The group of muscles on the back of the thigh, the "hamstrings," consists of biceps femoris laterally and semitendinosus and semimembranosus medially. Just above the knee the medial and lateral masses separate to form the hollow (popliteal fossa) at the back of the knee. The biceps arises from both the femur and the ischial tuberosity of the hip bone while the other two muscles arise only from the ischial tuberosity. The biceps inserts on the head of the fibula while the other two are attached to the upper end of the tibia. These muscles cross two joints, as does their antagonist, the rectus femoris. They flex the knee and, acting in the reverse direction, help to support the trunk on the thigh and assist the gluteus maximus in drawing the trunk back from the stooping position. If the thighs are not exercised sufficiently, the stretching of the hamstrings produced by bending to touch the toes while the knees are extended causes a painful sensation behind the knee.

*Leg and Foot.*—The leg may be divided into three muscular compartments; many of the muscles of each compartment are continued into the foot (*cf.* forearm and hand). The shin, or subcutaneous surface of the tibia, has the anterior compartment next to it, the lateral compartment lies around the side of the fibula and behind is the posterior compartment.

The fleshy mass of the anterior compartment can easily be felt when the toes are brought toward the leg (dorsiflexion); this mass resolves itself into a number of tendons above the ankle. The tibialis anterior is directed to the inner side of the big toe and inserts into the tarsal bones there. When the foot is on the ground, the muscle will attempt to haul up the inner border (medial longitudinal arch), thereby arching the convexity of the instep and simultaneously turning the foot inward (inversion). When the foot is free of the ground it assists in dorsiflexion of the ankle joint. It may also act from below in attempting to steady the leg on the ankle, especially during backward overbalancing. The tibialis anterior is commonly affected in poliomyelitis, giving rise to the typical "drop-foot" gait when the leg is raised higher than usual to clear the dragging toes of the plantarflexed foot. All the toes receive long extensor tendons from muscles situated in front of the tibia and fibula and all (except the little toe) receive short extensor tendons from muscles arising at the top of the calcaneus in the foot. Thus the big toe has its own tendons, those of extensor hallucis longus and extensor hallucis brevis, the three middle toes receive tendons of extensor digitorum longus and extensor digitorum brevis, while the little toe receives only a tendon from extensor digitorum longus. The extensor digitorum longus gives off a special slip, the peroneus tertius, which inserts into the base of the little toe and acts with the tendons of the lateral compartment in picking up the lateral border of the foot (eversion).

The lateral compartment contains only two muscles, peroneus longus and peroneus brevis. Both are directed to the lateral border of the foot, where the brevis is inserted. The longus hooks around and then crosses the sole of the foot deep to all the muscles to end in the region where tibialis anterior is inserted. When the foot is off the ground the three peronei evert it. In the erect posture the peroneus longus is particularly important not only in maintaining the transverse and lateral longitudinal arches of the foot but also in keeping it flat on the ground. When acting from below, the muscles assist in steadying the leg on the foot, especially if one stands on one leg, when the weight of the body automatically shifts toward the inner part of the instep.

The muscles of the posterior compartment are subdivided into superficial and deep groups. The superficial group, forming the "calf" of the leg and so characteristic of man's erect form of locomotion, consists of gastrocnemius, soleus and plantaris. The gastrocnemius arises by two heads from the two condyles of the lower end of the femur, the plantaris arises from the lower lateral part of the femur while the soleus arises from the upper end of the tibia and fibula. The plantaris is rudimentary and is often absent or just a fibrous band while the other two muscles form the thickest and most powerful tendon in the body, the *tendo calcaneus* (tendon of Achilles), which is inserted into the bone of that name (the heel). The calf muscles lift the heel and are thus powerful plantarflexors of the foot. The soleus is essentially the steadying muscle of the leg while the gastrocnemius provides the propelling force in walking, running and jumping.

The deep group of posterior muscles—popliteus, tibialis posterior, flexor hallucis longus, flexor digitorum longus—tend to be strapped down to the back of the tibia and fibula by a fascial septum, and the last three muscles have tendons that pass behind the ankle joint between the heel and inner lower end of the tibia (the inner "ankle bone" of popular parlance) to enter the sole of the foot (plantar aspect).

The popliteus spans the triangular gap between the outer condyle of the femur and the upper end of the tibia and thereby is able to "unlock" the extended knee joint at the beginning of flexion. It also pulls on the lateral meniscus (cartilage) of the knee joint, preventing it from being crushed during flexion of the knee.

The tibialis posterior inserts mainly into the navicular on the inner side of the tarsus and is the principal invertor of the foot. It is also important in maintaining the arches of the foot. Like the other muscles of the foot it maintains the balance by acting synchronously with the muscles of the hip joint and vertebral column.

The long flexors to the toes (flexor hallucis longus to the big toe and flexor digitorum longus to the other toes) are joined by short flexors that arise in the sole of the foot and insert in the phalanges in a manner analogous to the superficial and deep flexors of the fingers. The long flexors of the toes also plantarflex the foot. When the foot is on the ground they assist the intrinsic muscles of the sole in keeping the pads of the toes on the ground and in helping stabilize the metatarsal bones, the heads of which act as a fulcrum when the heel is raised during walking and running. Whereas the tendons attached to the dorsal aspect tend to "pull up" the arches of the foot, the long flexors tend to support and maintain them from below.

The muscles intrinsic to the sole of the foot are divided into three masses: those around the big toe, those around the little toe and those in-between. They tend to fall into layers, the deepest of which, the interossei, bind the metatarsals. Of all these muscles, only the flexors are active. The muscle mass as a whole forms an important supporting pad under the bony arches of the foot.

The total musculature of the lower limb is brought into action during progression. As the weight shifts from one limb to the other, the muscles may act now in one direction and then in the opposite direction. These movements are synchronized with those of the vertebral column and abdominal walls. The long flexors of the toes stabilize the fulcrum of the foot and distribute body weight while the calf muscles provide the main propulsive force.

(R. St.)

### B. Embryology

The development of the muscular system is known partly from the results of direct observation and is partly inferred from the study of the part of the nervous system from which the innervation is derived. The smooth muscle is formed from the mesenchyme cells of the somatic and splanchnic layers of the mesoderm (*see* Vertebrate Embryology) but never, so far as is known, from the mesodermal somites. The heart muscle is also developed from mesenchymal cells, though the changes producing its feebly striped fibres are more complicated. The skeletal or real striped muscles are derived either from the mesodermic somites or from the branchial arches.

As the mesodermal somites are placed on each side of the neural canal in the early embryo, it is obvious that the greater part of the trunk musculature spreads gradually around the body from the dorsal to the ventral side and consists of a series of plates called myotomes. The muscle fibres in these plates run in the long axis of the embryo and are at first separated from those of the two neighbouring plates by thin fibrous intervals called myocommata. In some cases these myocommata persist and even become ossified, as in the ribs, but usually they disappear early and the myotomes then unite with one another to form a great muscular sheet.

In the whole length of the trunk a longitudinal cleavage at right angles to the surface occurs, splitting the musculature into a dorsal and ventral part, supplied respectively by the dorsal and ventral primary divisions of the spinal nerves. From the dorsal part the various muscles of the erector spinae series are derived by further longitudinal cleavages either tangential or at right angles to the surface, while the ventral part is again longitudinally split into mesial and lateral portions.

A transverse section of the trunk at this stage, therefore, would show the cut ends of three longitudinal strips of muscle: (1) a mesial ventral, from which the rectus abdominis, pyramidalis, sternohyoid, omohyoid and sternothyroid muscles are derived; (2) a lateral ventral, forming the flat muscles of the abdomen, intercostals and part of the sternocleidomastoid and trapezius; and (3) the dorsal portion already noticed. The mesial ventral part is remarkable for the persistence of remnants of myocommata in it, forming the *lineae transversae* of the rectus abdominis and the central tendon of the omohyoid. The lateral part in the abdominal region splits tangentially into three layers, the external and internal oblique and the transversalis, the fibres of which become directed differently. In the thoracic region the intercostals probably indicate a further tangential splitting of the middle or internal oblique layer, because the external oblique is continued headward superficially to the ribs and the transversalis deeply to them. The more cephalic part of the external oblique layer probably disappears by a process of pressure or crowding out as a result of the encroachment of the serratus anterior, a muscle that, as its nerve supply indicates, is derived from the lower cervical myotomes. The deeper parts of the lateral mass of muscles spread to the ventral surface of the bodies of the vertebrae and form the hypaxial muscles—such as the psoas, longus colli and rectus capitis anterior.

The nerve supply indicates that the lowest myotomes taking part in the formation of the abdominal walls are those supplied by the first and second lumbar nerves; they are represented by the cremaster muscle in the scrotum. In the perineum, however, the third and fourth sacral myotomes are represented; these muscles are differentiated largely from the primitive sphincter that surrounds the cloacal orifice, though they derive partly from vestigial tail muscles. In the head no distinct myotomes have been demonstrated in the mammalian embryo, but as they are present in more lowly vertebrates, it is probable that their development has been slurred over, as often occurs in the embryology of the higher forms. Probably nine cephalic myotomes originally existed, of which the first gives rise to the eye muscle supplied by the third nerve, the second to the superior oblique muscle supplied by the fourth nerve and the third to the external rectus supplied by the sixth nerve. The fourth, fifth and sixth myotomes are suppressed, but the seventh, eighth and ninth possibly form the muscles of the tongue supplied by the 12th cranial nerve.

Turning now to the branchial arches, the first branchiomere is innervated by the fifth cranial nerve, and to it belong the masseter, temporal, pterygoids, anterior belly of the digastric, mylohyoid, tensor tympani and tensor palati, while from the second branchiomere, supplied by the seventh or facial nerve, all the facial muscles of expression and the stylohyoid and posterior belly of the digastric are derived, as well as the platysma, which is one of the few remnants of the skin musculature, or panniculus carnosus, of the lower mammals. From the third branchiomere, the nerve of which is the ninth or glossopharyngeal, the stylopharyngeus and upper part of the pharyngeal constrictors are formed, while the fourth and fifth gill arches give rise to the muscles of the larynx and the lower part of the constrictors supplied by the vagus or tenth nerve. It is possible that parts of the sternocleidomastoid and trapezius are also branchial in their origin, since they are supplied by the spinal accessory or 11th nerve, but this is unsettled.

The limb musculature is usually regarded as a sleevelike outpushing of the external oblique stratum of the lateral ventral musculature of the trunk, and it is believed that parts of several myotomes are in this way pushed out in the growth of the limb bud. This process actually occurs in the lower vertebrates, and the nerve supplies provide strong presumptive evidence that this is the real phylogenetic history of the higher forms, though direct observation shows that the limb muscles of mammals are formed from the central mesoderm of the limb and at first are quite distinct from the myotomes of the trunk. A possible explanation of the difficulty is that this is another example of the slurring over of stages in phylogeny, but this is one of many obscure morphological points. The muscles of each limb are divided into a dorsal and ventral series, supplied by dorsal and ventral second-

ary divisions of the nerves in the limb plexuses, and these correspond to the original position of the limbs as they grow out from the embryo so that in the upper extremity the back of the arm, forearm and dorsum of the hand are dorsal, while in the lower limb the dorsal surface is the front of the thigh and leg and the dorsum (top) of the foot.

### C. Comparative Anatomy

In the Acrania (*e.g.*, the lancelet) the simple arrangement of myotomes and myocommata seen in the early human embryo is permanent. The myotomes or muscle plates are < shaped, with their apexes pointing toward the head end, each being supplied by its own spinal nerve. In the fish this arrangement is largely persistent, but each limb of the < is bent on itself so that the myotomes now have the shape of a ≶, the central angle of which corresponds to the lateral line of the fish. In the abdominal region, however, the myotomes fuse and rudiments of the recti and obliqui abdominis muscles of higher types are seen. In other regions too, such as the fins of fish and the tongue of the lamprey, specialized muscular bundles are separated off and are coincident with the acquirement of movements of these parts in different directions. In the amphibia the limb musculature becomes much more complex as the joints are formed, and many of the muscles can be homologized with those of mammals, though this is by no means always the case, while in the abdominal region a superficial delamination occurs so that in many forms a superficial and deep rectus abdominis occurs as well as a cutaneus abdominis delaminated from the external oblique. It is probable that this delamination is the precursor of the skin musculature of mammals. The branchial musculature also becomes much more complex and the mylohyoid muscle, derived from the first branchial arch and lying beneath the floor of the mouth, is very noticeable and of great importance in breathing.

In the reptiles further differentiation of the muscles is seen, and with the acquirement of costal respiration the external and internal intercostals are formed by a delamination of the internal oblique stratum. In the dorsal region several of the longitudinal muscles that together make up the erector spinae are distinct, and a definite sphincter cloacae is formed around a cloacal aperture. In mammals certain muscles vary in their attachments or presence and absence in different orders, suborders and families so that, were it not for the large amount of technical knowledge required in recognizing them, they might be useful from a classificatory point of view. There is, however, a greater gap between the musculature of man and that of the other primates than there is between many different orders, and this is usually traceable either directly or indirectly to the assumption of the erect position.

The chief causes that produce changes of musculature are: (1) splitting; (2) fusion; (3) suppression, either partial or complete; (4) shifting of origin; (5) shifting of insertion; (6) new formation; (7) transference of part of one muscle to another. In many of these cases the nerve supply gives an important clue to the change that has been effected.

Splitting of a muscular mass is often the result of one part of a muscle being used separately, and a good example of this is the deep flexor mass of the forearm. In the lower mammals this mass rises from the flexor surface of the radius and ulna and supplies tendons to the terminal phalanges of all five digits; but in man the thumb is used separately and, in response to this, that part of the mass that goes to the thumb is completely split off into a separate muscle, the flexor pollicis longus. The process, however, is going further, for man has acquired the habit of using his index finger alone for many purposes, and the index slip of the flexor digitorum profundus is almost as distinct a muscle in man as the flexor pollicis longus.

Fusion may be either collateral or longitudinal. The former is seen in the case of the flexor carpi ulnaris. In many mammals (*e.g.*, the dog) two muscles are inserted separately into the pisiform bone, one rising from the internal condyle of the humerus, the other from the olecranon process, but in many others (*e.g.*, man) the two muscles have fused. Longitudinal fusion is seen in the digastric, where the anterior belly is part of the first (mandibular) branchial arch and the posterior of the second or hyoid arch; in this case, as might be expected, the anterior belly is supplied by the fifth nerve and the posterior by the seventh.

Partial suppression of a muscle is seen in the rhomboid sheet; in the lower mammals this rises from the head, neck and anterior (cephalic) thoracic spines, but in man the head and most of the neck part is completely suppressed. Complete suppression of a muscle is exemplified in the omotrachelian, a muscle that runs from the cervical vertebrae to the acromion process and fixes the scapula for the strong action of the triceps in pronograde mammals; in man this strong action of the triceps is no longer needed for progression, and the fixing muscle has disappeared.

Shifting of origin is seen in the short head of the biceps femoris. This in many lower mammals (*e.g.*, rabbit) is a muscle running from the tail to the lower leg; in many others (*e.g.*, monkeys and man) the origin has slipped down to the femur, and in the great anteater it is evident that the agitator caudae has been used as a muscle slide, because the short head of the biceps or tenuissimus has once been found rising from the surface of this muscle.

Shifting of an insertion is not nearly so common as shifting of an origin; it is seen, however, in the peroneus tertius of man, in which part of the extensor digitorum longus has acquired a new attachment to the base of the fifth metatarsal bone.

New formation of a muscle is seen in the stylohyoideus alter, an occasional human muscle; in this the stylohyoid ligament has been converted into a muscle.

Transference of part of one muscle to another is well shown by the human adductor magnus; here the fibres that pass from the tuber ischii to the condyle of the femur have a nerve supply from the great sciatic instead of the obturator, while in most lower mammals the fibres are a separate part of the hamstrings known as the presemimembranosus.

*See* also references under "Muscle and Muscular System" in the Index. (F. G. P.)

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**MUSCLES, DISEASES OF.** Each of the three types of muscle tissue of the human body is subject to a variety of diseases. The term diseases of muscles, however, generally refers to affections of the striated (skeletal) muscle, which comprises about 40% of the weight of the human adult male body and is disposed in more than 400 separate muscles. (For the anatomy, *see* Muscle and Muscular System.) This article is confined, therefore, to diseases of the skeletal muscles. Diseases of smooth muscle (the contractile tissue in the wall of stomach and intestinal tract, bronchi, ureters, uterus, etc.) are discussed in separate articles relating to diseases of those organs. Disorders of the cardiac muscle, a special form of striated muscle, are dealt with in Heart, Diseases and Defects of.

An orderly conception of these muscle disorders is provided by the following classification.

1. Muscle atrophies resulting from denervation. These include progressive muscular atrophy, amyotrophic lateral sclerosis (*q.v.*), progressive bulbar palsy, infantile muscular atrophy and various forms of diseases of the spinal cord and peripheral nerves.

2. Muscle disorders caused by abnormalities of neuromuscular

transmission and of muscular membrane irritability. Under this may be considered myasthenia gravis, familial periodic paralysis and congenital myotonia.

3. Primary myopathies. These include progressive muscular dystrophies, polymyositis and dermatomyositis and other metabolic diseases such as glycogen storage diseases.

The muscle tissue, the effector apparatus of the body, is also deranged in its function by diseases of the brain, manifesting themselves as paralysis, spasm, convulsion, tremor, athetosis, chorea, myoclonus and dystonia; but these are not generally regarded as diseases of the muscle.

**Denervation.**—In denervation atrophy, the muscle or muscles are deprived of all nervous control. Weakness (paresis) or paralysis of all movement, reflex as well as voluntary, is the immediate result. The muscle fibres gradually become atrophied, losing 75% of their bulk within three months. The atrophied fibres survive for long periods, months or years; exhibit a "spontaneous" individual contraction (shown as a small brief action potential, also called fibrillation) which can be detected by inserting electrodes into the muscle and amplifying them by means of a cathode-ray oscilloscope (electromyogram); and are capable of regaining organized function if new fibres regenerate and effect junction with them (reinnervation). (*See* also ATROPHY; POLIOMYELITIS.)

**Abnormality of Neuromuscular Transmission.**—In disorders of neuromuscular transmission the main effect is paralysis or spasm, depending on whether the transmitting apparatus is subnormally irritable or excessively excitable. The disturbance is chiefly one of function and can be demonstrated by measurement of biochemical changes in the blood, by the finding of altered electrical excitability and by the clinical test of reduced power of contraction. The muscles do not atrophy to any significant degree and there are no unequivocal changes to be seen under the light microscope. Correction of the chemical aberration restores power.

**Primary Myopathies.**—The primary myopathies include all morbid conditions in which a disease process destroys the muscle fibres or their sheaths. There are many forms of myopathic disease; only the commonest and most serious ones are mentioned here.

*Muscular Dystrophy.*—Muscular dystrophy is a relatively rare disease characterized by wasting and enfeeblement of the muscles of trunk and limbs. It usually begins in childhood or adolescence and progresses over a period of 5 to 20 or more years. The first muscles to be affected are those of the pelvis and thighs or the shoulders, upper arms and face. Attention is usually attracted to the person who is developing the disease by delay in beginning to walk, if its onset is early in life, or by frequent falls, a waddling gait, failure to arise from a recumbent position without the use of the hands, clumsiness in walking and running or inability to lift the arms above the head. In some cases, especially those beginning in childhood, the muscles first become large and firm, a condition known as pseudohypertrophy. In the late stages of the disease extreme wasting occurs, and power of movement and even the tendon reflexes are abolished. Mental function and the senses remain normal.

The cause of the disease is unknown. Presumably it is based on an inherited abnormality in the chemistry of the body which results in a primary degeneration of the muscle cells. Microscopic examination reveals a loss of many muscle fibres, atrophy, degenerative changes and hypertrophy in some of those which remain and an increase in connective tissue and fat cells. There are no important changes in the nervous system.

On the basis of the type of inheritance, the distribution of muscle involvement and associated findings, four subtypes of the disease have been delineated. These are the pseudohypertrophic muscular dystrophy of Duchenne; the facioscapulohumeral dystrophy of Landouzy-Dejerine; the limb-girdle dystrophy of Erb; and the myotonic dystrophy of Steinert. The latter is remarkable because of unusual persistence and slow relaxation of strong muscle contractions (myotonia) and an association of cataracts and atrophy of the testes.

There is no specific treatment, but corrective and remedial measures are helpful.

*Polymyositis and Dermatomyositis.*—Polymyositis is an inflammatory disease of unknown cause which involves the connective tissue and leads to destruction of the muscle fibres. Affection of the skin (dermatitis) may be conjoined, in which case the term dermatomyositis is applied. The proximal limb (upper arm and thigh) and trunk muscles bear the brunt of the disease, but the small muscles of larynx and pharynx also may be involved. The principal symptoms are weakness and atrophy with reflex impairment, in direct proportion to the degree of paralysis, difficulty in swallowing (dysphagia) and change in voice (dysphonia). The condition is painless. In approximately one-half of the cases polymyositis or dermatomyositis is only part of a more general noninfective inflammation of the connective tissues of the body presented as rheumatic fever, rheumatoid arthritis, scleroderma or lupus erythematosis. (*See* also CONNECTIVE TISSUE, DISEASES OF.)

Diagnosis is substantiated by two biochemical tests, by characteristic changes in the electromyogram and by muscle biopsy (excision of a small piece of muscle for microscopic examination). The latter test reveals the destruction of muscle fibres and the inflammatory reaction.

Treatment consists of adrenal steroids and aspirin. Physiotherapy, to prevent stiffness and contracture, is also helpful; however, the condition may subside spontaneously. Since muscle can regenerate to some extent, partial or complete recovery is the rule.

(R. D. A.)

**MUSCLE SHOALS,** the name applied to a section of the Tennessee river in northwestern Alabama that was formerly a major hazard to navigation on the river and became celebrated because of the national controversy that developed over the disposal of nitrate plants and dams built there during World War I. The worst of several shoals and other obstructions in the "great bend" of the Tennessee river lay to the east of the towns of Sheffield and Florence. Flinty, jagged rocks occurred near the surface, and rapids resulted from the fact that the fall of the river was about 130 ft. in 37 mi. Since mussels were abundant along these shoals it is presumed that the name "Muscle Shoals" represents merely a variation in spelling that became accepted.

The advent of steamboating in the early 1800s made the Tennessee river a major channel of transportation, extending about 650 mi. from Knoxville in eastern Tennessee to the Ohio river in Kentucky, and connecting with the Mississippi. But for a hundred years Muscle Shoals defied repeated efforts to make them easily navigable. Canals and locks were tried first. A canal built by the state of Alabama and opened in 1836 was not a success. Between 1875 and 1890 the U.S. army corps of engineers built an improved canal with a railroad alongside, but these improvements did not entirely remove navigation handicaps. Early in the 20th century emphasis shifted from canals for navigation only to dams that could also be used for hydroelectric power. But efforts of private corporations to build a power plant at Muscle Shoals were halted by Pres. Theodore Roosevelt in 1903. Recognizing the prospects for long-distance transmission of electric power, Roosevelt suggested that the government should not give away the increasingly valuable power resources of the streams that had been or might be improved at public expense. Electric power could be the means of reimbursing the government for the costs of improvement.

With the outbreak of World War I, concern for an adequate supply of nitrates led congress in 1916 to authorize the government construction and operation of two nitrate plants and a dam for electric power as a national defense measure. The site selected by Pres. Woodrow Wilson was Muscle Shoals. Although not completed until 1925, the Wilson dam, as the structure was named, finally put a lake over Muscle Shoals. A low dam, 2½ mi. below Wilson, was built two years later, further improving navigation.

The period from 1921 to 1933 was one of debate over the future use of the two dams and nitrate plants. Private corporations and Henry Ford made offers to use, lease or buy them but all the offers were rejected. Two bills introduced by Sen. George W. Norris for government operation were vetoed by presidents Coolidge and Hoover.

The question was settled in 1933 by turning over the Muscle

Shoals properties to the Tennessee Valley authority (TVA), an independent government corporation created that year by congress to promote navigation, flood control, reforestation and other improvements for the whole Tennessee valley. (*See* TENNESSEE VALLEY AUTHORITY.) The plan was based on recommendations made by the U.S. army corps of engineers in 1930. It ended the controversy over Muscle Shoals. The TVA built or completed a series of navigation and flood-control dams, and provided a nine-foot navigation channel the full length of the Tennessee river. With the completion of Wheeler dam, 16 mi. above Wilson, and Pickwick dam, 52 mi. below Wilson, Muscle Shoals as a navigation problem disappeared.

There is no longer a Muscle Shoals in the original meaning. The term is sometimes used for the TVA complex of operations centring in the Wilson dam area. It is also the name of a village near Sheffield.

*See* Donald Davidson, *The Tennessee,* 2 vol. (1948); J. H. Kyle, *The Building of TVA* (1958). (C. H. SH.)

**MUSCOVITE,** a common rock-forming mineral belonging to the mica group. As the mica is obtainable in thin, transparent sheets it was used in Russia for window panes and known as Muscovy glass; hence its name. It is an aluminosilicate with potassium and hydrogen and with some substitution of sodium, magnesium, iron, lithium and silicon. Muscovite, most common of the micas, is a principal constituent of the fine-grained sediments, many of the metamorphic rocks and some classes of siliceous igneous rocks. It is especially common in the granites although absent in the extrusive equivalents. Muscovite is important in gneisses and schists and persists to the higher grades of metamorphism. Large crystals are often found in veins and pegmatites. One crystal measured $9\frac{1}{2}$ ft. by 7 ft. and nearly 3 ft. thick. Muscovite develops secondarily after feldspar, nephelite, topaz, corundum, kyanite and other aluminosilicates.

Muscovite and its fluorine analogue, fluoromuscovite, have been synthesized. Large sheets and ground natural material are used in the electrical and electronics industry, paper and paint manufacturing and as a lubricant, dusting powder and filler and in special decoration effects.

Muscovite is usually colourless; however, it may be gray, brown, pale green, lavender or ruby in colour. The lustre is vitreous to pearly. Crystals are tabular with a hexagonal or pseudohexagonal outline; commonly lamellar and in aggregates. Muscovite is known to occur in at least three polymorphic forms. The single-layer polymorph forms mixed-layer structures with montmorillonite and is then called illite. When fine grained, muscovite is generally referred to as sericite or white mica. The basal cleavage is perfect and yields thin elastic laminas; two secondary partings are known. The hardness is 2.5 to 3; the specific gravity ranges from 2.76 to 3.00; and the index of refraction is between 1.55 and 1.59, although it may be as high as 1.66 in iron-rich varieties. Birefringence (double refraction) is very strong and the dispersion distinct. Muscovite is not decomposed by acids. It alters to kaolinite or gibbsite with quartz. On weathering the mica is leached of its potassium and hydrated. Addition of fertilizers will reverse this process in some soils.

The chemical composition is close to $KAl_2(AlSi_3)O_{10}(OH)_2$ with some Na substituting for K; Mg, $Fe^{+3}$ and Li for the first Al; and Si for the second Al. For further discussion of composition and the relation of structure to cleavage *see* MICA.

(H. S. Y.)

**MUSCOVY COMPANY,** or Russian company, a body of English merchants trading with Russia. The company originated in 1552–53 and still exists. The original intention of its influential founders was to seek a northeast passage to China and the East Indies. On the first expedition (1553) only one of the three ships reached Archangel; its captain, Richard Chancellor (*q.v.*), made his way to Moscow and secured from the tsar Ivan IV a letter promising liberty of trade to the English merchants. In England a charter was granted in 1555 incorporating the company of merchants trading with Russia and giving it a monopoly of the traffic. It was organized as a joint-stock undertaking until about 1630 but thereafter functioned on a "regulated" basis (*see* CHARTERED COMPANY). Although persistent efforts to open up an overland commerce with Persia and India via Turkestan ended in failure, the company was able to develop a flourishing trade in Russia, where for nearly a century most of the long-range trade in the northern half of the country was in English hands. The basis of its traffic lay in the export of woolen cloth, metals and Mediterranean goods from England and the shipment of hemp, wax tallow, cordage and other Russian products in return. Its main port of entry continued to be Archangel, though it took a part, never quite up to expectations, in trade through Narva until the Russians lost this outlet to the Baltic in 1581. The tsar Alexis abrogated its privileges in 1649, its trade declined steeply and Dutch merchants supplanted the English. Following attacks in parliament, the company lost its monopoly in 1698 and became merely one of the most important among many companies trading with Russia. It survived as an influential City of London institution and shared in the revival of Anglo-Russian trade in the 18th century.

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**MUSCULAR DYSTROPHY:** *see* MUSCLES, DISEASES OF: *Primary Myopathies.*

**MUSES** (Gr. *Mousai, Moisai*), a group of goddesses of obscure but ancient origin, the chief centre of whose cult was Mount Helicon in Boeotia, Greece. Allegedly they came from Pieria in Macedonia, but it is doubtful if this statement, first made by Euripides, is not a misunderstanding, the real Pieria being somewhere in Greece. Very little is known of their cult, but they had a festival every four years at Thespiae, near Helicon, and a contest (*Museia*), presumably—or at least at first—in singing and playing. There can be little doubt that they were originally the patron goddesses of poets (who in early times were also musicians, providing their own accompaniments), although later their range was extended to include all liberal arts and sciences; hence, their connection with such institutions as the museum (*Mouseion,* seat of the muses) at Alexandria, and occasionally with the *gymnasia,* since physical training was part of a liberal education. There were nine muses as early as the *Odyssey,* and Homer invokes either a muse or the muses collectively; *e.g.,* in the *Iliad* on one occasion he calls on simply "a goddess" and on another asks all the muses to prompt him, because they know everything and men do not, while in the *Odyssey* he uses the name *Mousa* and adds that she is a daughter of Zeus. It would appear that to begin with they were one of those vague collections of deities, undifferentiated within the group, which are characteristic of certain, probably early, strata of Greek religion (*see* H. J. Rose in *Harvard Theological Review,* li, pp. 22 ff., 1958).

Differentiation is a matter rather of mythological systematization than of cult and begins with Hesiod, who mentions the names of Clio, Euterpe, Thalia, Melpomene, Terpsichore, Erato, Polymnia, Urania and Calliope, who was their chief. Their mother was Mnemosyne (Memory), a patent bit of allegorizing not uncommon in Hesiod, and a not unplausible etymology of the name *Mousa* would connect it with the root which appears in the Latin *monere* (to warn) and make it mean "reminder"; but this is quite uncertain. Although Hesiod's list became canonical in later times, it was not the only one; at both Delphi and Sicyon there were but three muses, one of whom in the latter place bore the fanciful name Polymatheia ("much learning"). All the Hesiodic names are significant; thus Clio is approximately "the proclaimer," Calliope "she of the beautiful voice," Erato "the lovely," Urania "the heavenly" and so on. Since dancing was a regular accompaniment of song, it is not remarkable that Hesiod calls one of his nine "the whirler of the dance," Terpsichore. This again is characteristic of him: compare for instance the names of the Nereids, all of which have some relation to travel by sea, weather conditions, the seashore or trade and its results.

The muses are often spoken of as virgins or at least unmarried,

but are repeatedly referred to as the mothers of more or less famous sons, such as Orpheus, Rhesus, Eumolpus and others connected somehow either with poetry and song or with Thrace and its neighbourhood or both. In other words, all their myths are secondary, attached for one reason or another to the original vague and nameless group. Hence there is no consistency in these minor tales—Terpsichore for example being named as the mother of several different men in various authors, and Orpheus generally being called the son of Calliope but occasionally of Polymnia.

Statues of the muses were a popular decoration in long galleries and similar places; naturally, sculptors did not make them all alike but gave each a different attribute, such as a lyre, scroll, etc. This may have contributed to the fanciful distribution of the individual muses among the different arts and sciences; *e.g.*, Clio as muse of history, Erato of love poetry, Urania of astronomy. The lists which have come down are all late and disagree widely with one another; that they are without authority is clear from the way the names of individual muses are employed by classical authors. For instance, Apollonius Rhodius and Virgil called on Erato to inspire an epic poem, while Horace mentioned Clio, Calliope, Euterpe, Melpomene and Polymnia all in connection with lyrics. In Latin, when the name is not simply transliterated, the equivalent of *Musa* is *Camena*. As the functions of the *Camenae* are obscure, so also is the reason for the equation.

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**MUSETTE,** the name of a musical composition in the 18th century, deriving from the instrument of the same name, a small French bagpipe (*q.v.*), favoured in court circles during the reigns of Louis XIV and Louis XV. The musette was a slow dance, pastoral in character, performed on a pedal bass or drone over which delicate figurations were played. It was originally played on the musette accompanied by the vielle, and later on other instruments. Early examples were the *Oeuvre de Musette* by Jean Baptiste Anet (*c.* 1661–1755) and *Loisirs du Bercail* by J. B. Boismortier (1691–1755). The name was adopted by J. S. Bach for movements in his English suites, no. 3 and 6; by Handel; and by N. Dalayrac in his *Nina ou La Folle par amour* (1786) as the title of an operatic aria.

**MUSEUM ARCHITECTURE.** While there are many differing types of museums ranging from modest places for the display of curios to imposing shrines for the housing of great arrays of treasures, the majority fall under two categories: art museums and science museums. Both have the primary function to assemble and care for material worthy of exhibition and to present it to the public for education and enjoyment. Specialization in diverse types of exhibits and services brought further definitions within these categories, such as civic museums, historical museums, museums of modern art, museums of archaeology, museums of decorative arts, college museums, children's museums, zoological museums, marine museums, planetariums, etc., each presenting special demands for architectural treatment.

Art museums, being dedicated to the fine arts, serve to display and store collections of paintings, sculpture, architecture, craftsmanship and related works. Initially, imposing old palaces, mansions or historically significant buildings were converted to this use—a convenient practice that has been continued. An identifiable museum architecture developed when buildings were erected especially to house the collections of art treasures that had accumulated in the capitals and centres of European culture and wealth in the early 19th century. As a consequence of the role museums played in national prestige and civic pride, the character of these edifices was monumental and imposing. They were located in prominent positions on major avenues or in parks, and the architectural treatment of sites and buildings strove for a grandiose effect. Architects relied on colonnades and arches, high vaulted interiors, vast flights of stairs outside and inside, and rich decoration in sculpture and carving to achieve the desired quality of impressiveness. The monumental character of these edifices and their classic or historic styles were imitated in the design of the U.S. civic museums that were built to house the collections of wealthy donors and to serve as memorials to them. This approach to museum design, which gave pre-eminence to architectural embellishment commonly at the expense of the impressiveness of the exhibits, prevailed into the early 20th century and continued in evidence in Nazi Germany and the U.S.S.R.

Science museums serve as storehouses of a vast variety of exhibits from the fields of natural history, ethnology and discovery. The objects displayed are highly diverse in nature, appearance, size, rarity and monetary value. Lacking the imposing prototypes and demand for expression of wealth associated with the housing of art treasures, science museums are more modest in architectural character.

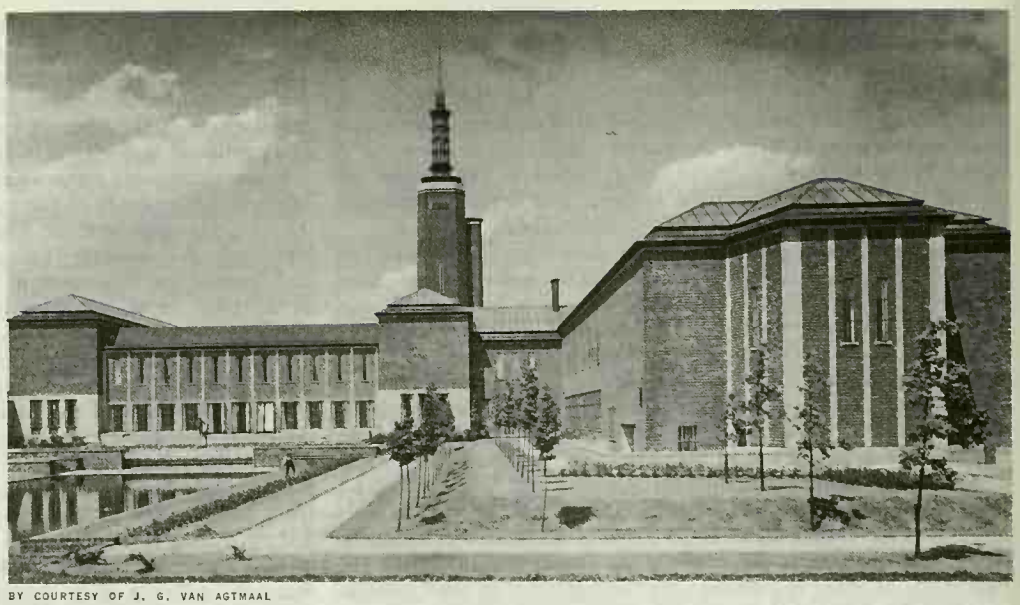
With the beginning of the 20th century in Europe, and a few decades later in the United States, an awareness arose of the functional inadequacies of traditional museum architecture. A growing consciousness of the deficiencies in buildings that in their design followed the dictates of styles rather than the needs of exhibitions brought architectural changes. However, the liberation from the dogmas of historic styles progressing in all fields of architecture affected museums much later than most other types of buildings. With the need for stricter obedience to functional demands, galleries were shaped and illuminated to improve the display of exhibits, varied in size and form in keeping with the effect of intimacy or grandeur demanded by the displays, and arranged for a less tiring and boring effect on the visitors. The appearance of museums became less pompous and formal. Distracting and meaningless architectural embellishment gave way to the simpler treatment and plain surfaces associated with modern architecture. The inventiveness and individuality of modern architects led to projects based on complete departures from traditional planning, such as the stepped pyramid proposed by the architect Le Corbusier for the Musée Mondial (1929) and a flat-

BY COURTESY OF THE SOLOMON R. GUGGENHEIM MUSEUM

INTERIOR OF THE SOLOMON R. GUGGENHEIM MUSEUM OF NON-OBJECTIVE ART, NEW YORK CITY, SHOWING SPIRAL RAMP GALLERY. FRANK LLOYD WRIGHT, ARCHITECT, 1959

tened version of it suggested for a "Growing museum" (1938); Paul Nelson's design for a circular museum with a roof suspended by cables conceived for the 1937 Paris exposition; and Frank Lloyd Wright's galleries of spiral ramps for the Solomon R. Guggenheim museum in New York city.

**Development of Art Museums.**—When collections were first opened to public view, existing buildings that no longer served their original purposes were remodeled to meet the new requirements. Of this type were museums such as the Louvre, Luxembourg, Cluny and Carnavalet in Paris, most of the Italian museums, the Belvedere in Vienna and others. In the United States, conversions on a more modest scale were carried out; *e.g.*, for the Isabella Stewart Gardner museum in Boston, Mass.



BY COURTESY OF J. G. VAN AGTMAAL

EXTERIOR OF THE MUSEUM BOYMANS, ROTTERDAM. A. VAN DER STEUR, ARCHITECT, IN COLLABORATION WITH D. HANNEMA, 1935

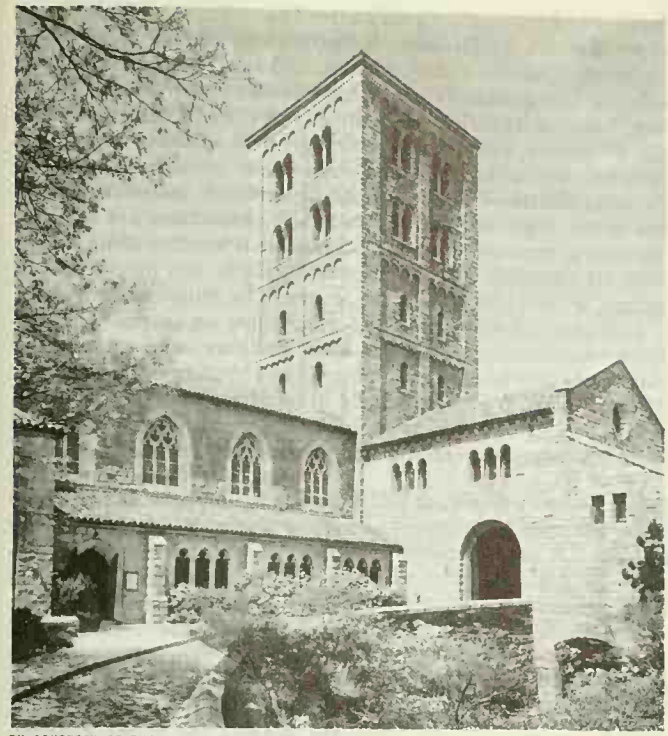
Museums built during the 19th century were usually two stories high, with services in the basement, and with an imposing entrance hall leading to a central monumental stairway. On the entrance floor were the collections of sculpture (though occasionally placed in a courtyard covered by a glass roof) and other galleries of lesser importance, all lighted by windows. The upper and principal floor was devoted to the picture galleries lighted by skylights. The circulation flowed usually from room to room, with an opportunity to make a circuit tour of the galleries. Representative museums of this type were: the Altes museum of Berlin, by K. F. Schinkel (1822–30), the Glyptothek at Munich, by Leo von Klenze (1830), the British museum, by Sir Robert Smirke (1825–27), the National gallery in London (1838), the Dresden museum (1850), the museums at Vienna and Marseilles and many others. Their architecture along with many of the features of other great museums of Europe, such as the Louvre in Paris, the Prado in Madrid, the Vatican gallery in Rome and the Uffizi in Florence, influenced the design of the older art museums in the United States—the Metropolitan Museum of Art in New York city, the Brooklyn (N.Y.) Institute of Arts and Sciences, the Toledo (O.) Museum of Art, the Corcoran Gallery of Art, Washington, D.C., and many others of less prominence.

**20th-Century Developments.**—Many innovations appeared in 20th-century museum planning. Galleries became more varied in size and character, some smaller spaces were included for a better display of intimate works of art, and rooms were designed to harmonize with exhibits representative of historic periods. Such features were exemplified in the museums of Germany in Munich and Darmstadt (Alfred Messel, architect) and in the United States at the Detroit (Mich.) Institute of Arts (Paul Cret and Zantzinger, Borie and Medary, architects). The formality of the design of the façade deemed desirable for public buildings was combined with some informality in the treatment of certain portions to allow for the varied fenestrations demanded by smaller and period rooms. Courtyards served for outdoor displays and as gardens for the relaxation of spectators. Such are found in the Cleveland (O.) Museum of Art, the Detroit Institute of Arts and the Freer Gallery of Art, Washington, D.C.

Two Dutch buildings illustrate further progress in museum design—the Gemeente museum at The Hague, with its unusual lighting features, and Museum Boymans at Rotterdam, for its harmony in the size of the rooms and the exhibits. Also significant for their contributions to museum architecture of the second quarter of the 20th century were two museums built in Paris in 1937, one on the site of the Trocadéro (Carlu, Boileau and Azema, architects) and the other a double structure flanking an imposing courtyard embellished by neoclassic colonnades, known as the Musée des Arts Modernes (Donel, Aubert, Viard, Dastugue, architects). The Museum of Modern Art of New York (Goodwin and Stone, architects, 1939) indicated significant departures from established patterns. Fixed partitions between exhibition spaces were almost completely absent in the original plan, but permanent fireproof walls were added after a fire in 1958. Also the winning design presented in a competition for a new Smith-

BY COURTESY OF THE MUSEUM OF SCIENCE AND INDUSTRY

SECTION OF "SHOWCASE FOR STEEL" EXHIBIT, THE MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO, SHOWING THE USE OF BALCONIES AS LEVELS FOR VIEWING EXHIBITIONS



BY COURTESY OF THE METROPOLITAN MUSEUM OF ART, THE CLOISTERS COLLECTION

EXTERIOR OF THE CLOISTERS, A BRANCH OF THE METROPOLITAN MUSEUM OF ART, NEW YORK CITY

sonian Gallery of Art in Washington, D.C., 1938 (Eliel and Eero Saarinen, Robert Swanson associates), illustrated the trends in the development of a new museum architecture. Classic motives had been abandoned in the façade treatments, symmetry of plan and the succession of fixed galleries placed on an axis had disappeared, and unbroken interior spaces were substituted to allow for an infinite variety of divisions by temporary partitions.

As museums progressed from mere storehouses of treasures to active cultural forces in communities, galleries for temporary exhibitions, study galleries, reserves, loan departments, lecture rooms and classrooms, etc., were added. The consequent growth of buildings combined with the increasing amount of material on display forced the attack on the problem of museum fatigue. Avoidance of monotony in the arrangement of displays, aided by variations in the space forms, the treatment and colour of backgrounds, the creation of special settings for important pieces, the improved design of showcases and the insertion of gardens or planted courts served to make a museum visit less tiring. Excellent installations for sculpture were made in the garden court of the Museum of Modern Art and in the Whitney museum in New York (remodeled 1958–59). Additions made to the Cleveland Museum of Art in 1954 (Byers Hayes, architect) and proposed for the Detroit Institute of Arts in 1959 (Minoru Yamasaki, architect) ingeniously expanded old galleries. At Wellesley college, Paul Rudolph designed the Jewett Arts centre (1958) with fine spaces. The great progress in display techniques furthered by the many international expositions held in most European countries and the United States helped to enliven exhibits and benefited museums in general and the science and industry museums in particular.

**Science Museums.**—Because of special demands arising in the showing of exhibits from the fields of natural history, mineralogy, ethnology, technology, inventions and a miscellany of subjects of public interest, many departures from the routine patterns of galleries occurred. Installations with realistic settings for exhibits known as habitat groups became major attractions. An interesting arrangement of zoological galleries was made by Messel in the rear galleries of the Darmstadt museum. The Deutsches museum of Munich (G. and E. Seidl, architects, 1908) incorporated many new features that furnished inspiration to science and industry museums throughout the world. There, the displays were given a live character through great realism, and through the opportunity for manipulation of exhibits by the public. The U.S. National museum (Hornblower and Marshall, architects) in Washington, D.C., must be mentioned, and for sheer size the Chicago Natural History museum (Graham, Anderson, Probst and White, architects, 1927) was outstanding; an area 350 by 700 ft. was filled by exhibits representative of many fields, with a quantity of specimens presented realistically by means of accurate and artfully contrived habitat groups.

**Museum Planning.**—Circulation of visitors demands that the galleries be easily accessible from the main entrance and that an orderly tour of the building or of individual sections is possible. Offices are placed so the public can readily find them. Storage rooms and repair shops usually occupy the ground floor or basement and allow for the transfer of bulky objects from the shipping platform to any of the exhibition halls with a minimum of effort and danger to the exhibits. Preparation departments are near mechanical shops and accessible from the curatorial offices without traversing exhibition halls. Lecture halls and auditoriums often have separate entrances from the street, permitting their use when other parts of the museum are closed.

With the exception of small museums, most institutions are divided into departments, each with its own exhibition space, curatorial offices, study rooms, workrooms, storage space and mechanical shops if needed. A central library or a series of departmental libraries is accessible to both visitors and the museum staff. For the issuing of publications and illustrations often required as a museum service, printing plants are installed and photographic workshops are set up. Large museums find it economical to build their own exhibition cases and furniture and therefore require workshops. Art museums have facilities for restoring paintings, casting and cleaning sculpture and renovating other objects. Science museums require shops for taxidermist, modelmaking and similar functions incidental to the installation and care of exhibits.

The size, shape and character of the galleries depend on the exhibits and their installation. They are designed to give free

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART, THE CLOISTERS COLLECTION

INTERIOR OF THE CLOISTERS SHOWING THE ARCADE AND GARDEN COURT

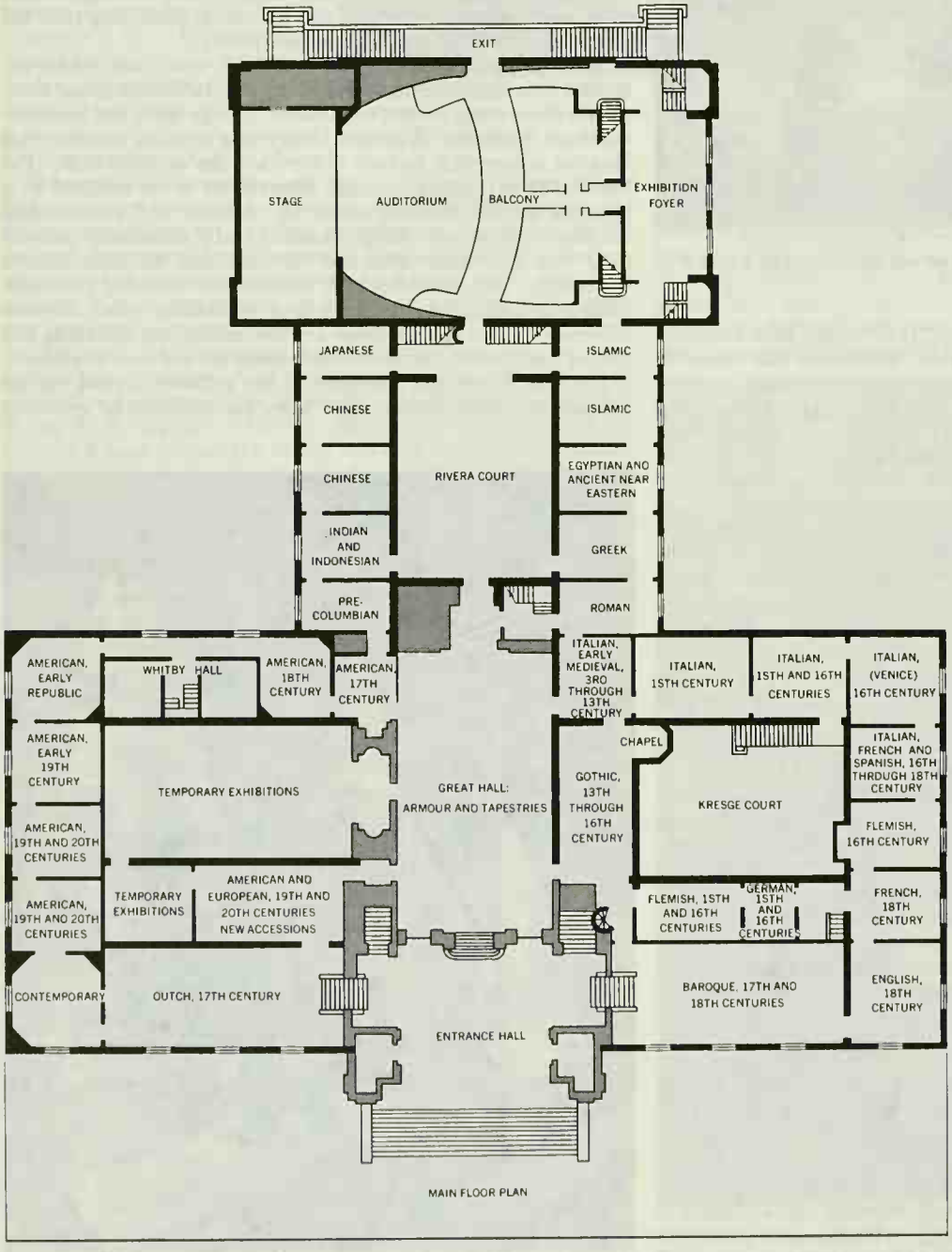
rein to the showmanship demanded of museum directors and curators for the creation of displays that stir the interest and imagination of the spectators. Since many exhibits require special treatment and frequent rearrangement, a great amount of flexibility is provided for in the planning and construction of museum buildings. Most museums are built with a definite program of expansion in view.

The interrelation of the galleries is determined by the established sequence for the treatment of subjects; by the successive steps necessary to convey a message through the exhibits; or by architectural considerations, such as the placing of picture galleries where they can be skylighted and the grouping together of objects of similar size or type. Crowding of galleries with a profusion of exhibits of little interest to the spectators is avoided, and excess material is relegated to well-organized study or reserve collections, where it may be examined on request.

The modern museum no longer restricts its activities to interesting the casual visitor who comes to its doors but organizes constructive educational programs extending to the schools and many types of civic organizations. It supplies loan exhibitions, sends out lecturers, furnishes motion pictures and lecture material for outside use and spreads its educational message by radio and television. Within its building it maintains an efficient guide service to the collections, appointing certain hours for children and young persons. Its lecture halls and auditoriums furnish opportunities for talks illustrated by the surrounding museum material. Chamber music, organ recitals and theatrical productions are common features of museum activity. Organizations working along similar lines are encouraged to use museum facilities, and many types of nature, art and hobby clubs are promoted by museums.

College or school museums, of which there are several types, require relatively little exhibition space but may have a number of classrooms and laboratories and a more complete library service. If the museum is engaged chiefly in supplying material for use in the schools its building may consist almost entirely of workshops in which collections are prepared, packed and shipped.

Outdoor exhibitions and outdoor museums provide for a variety of activities, from the display of collections in a museum courtyard to completely detached shows in the open air. For example, the outdoor collection of growing plants maintained by the Agricultural and Commercial museum in Rio de Janeiro augments the exhibits inside the galleries. The garden of the Museum of Modern Art in New York serves the display of sculpture. The Cloisters in New York, a branch of the Metropolitan Museum of Art, with an herb garden and medieval courtyards, gives through the architecture of the building, the treatment of the landscape and planting, the exhibits in painting, sculpture and craftsmanship a complete portrayal of the art and culture of the middle ages.




MAIN FLOOR PLAN OF THE DETROIT INSTITUTE OF ARTS SHOWING WINDOW LIGHTING OF ROOMS AND GEOGRAPHIC AND CHRONOLOGICAL DISTRIBUTION OF EXHIBITS, 1961

**Museum Lighting.**—The design of windows and skylights as well as the type of artificial illumination chosen affects the effectiveness of the displays and the architectural quality of the interiors. A great amount of research has been carried out for the purpose of preventing reflections on showcases and paintings and to determine the kind of light best suited to bring out the colour, form and detail of the exhibits. Overhead natural light requires skylights, an attic as mixing chamber for the light, and galleries with glass ceilings. Since natural light varies with the movement of clouds and the sun, there are considerable advantages in artificial illumination, allowing walls of galleries and exhibits to be lighted constantly with even intensities. However, some kinds of exhibits, notably relief sculpture, do not always appear to best advantage under artificial light; moreover, the constancy of this type of illumination may produce

an effect of monotony. Hence, in spite of tremendous technological developments offering infinite possibilities for the lighting of galleries or exhibits directly or indirectly by incandescent or fluorescent lights, natural illumination is still desirable in certain places. Both types of lighting are used by architects to make the interiors of buildings pleasant and the exhibits stimulating. The advance in artificial illumination was perhaps the most important influence the technological progress of the first half of the 20th century brought to museum architecture. *See* also MUSEUMS AND GALLERIES; MODERN ARCHITECTURE.

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**MUSEUMS AND GALLERIES** are places in which collections of objects are exhibited for their particular interest. Some deal with one or several general subjects, such as art, history, science and industry; some are limited to special material, such as a particular industrial object (Glass museum, Corning, N.Y.) or the work of one artist (Rodin museum, Paris). However diverse the aims of present-day museums and however old the habit of mankind of collecting objects, the museum as it is now known originated in Italy during the Renaissance.

This article is organized as follows:

I. Purposes and Activities
  1. Educational Function
  2. Museum Staff
II. Collections
  1. Acquisitions
  2. Care
  3. Presentation
III. History
  A. General Development
    1. Greek and Roman Origins
    2. Middle Ages
    3. Renaissance
    4. Baroque Period
    5. Late 18th and Early 19th Centuries
    6. Development of Decorative Arts Museums
    7. Late 19th and 20th Centuries
  B. History Museums
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    1. General Development
    2. United States
    3. Europe
  D. Industry Museums
    1. General Development
    2. United States
    3. Europe

## I. PURPOSES AND ACTIVITIES

Three elements are involved in any museum at any time: the owner, the object and the public. But just as basic philosophies of life have evolved through the centuries, so have the purposes of the museum and the relationship between the three elements continually changed. In any case, the most important fact to be determined about a museum is its purpose. The way in which it fulfills that purpose may be a result of its history, both general and specialized, rather than its present stewardship.

Education may be considered the foremost purpose of the museum. The museum cannot accomplish this purpose without research work by its staff on its own collections, as well as on material it wishes to acquire. The extent of this task varies according to the size and means of the museum, but even the smallest museum must have individual and independent thinking by a curator trained in museum practice and scholarly work. The educational purpose is by no means the only requirement for a collection. There must also be an appeal, particularly an aesthetic appeal. This requirement is not confined to the art museum alone; it is essential in any museum. A museum must also serve as an archive for objects that must be protected from destruction or loss because they are precious, rare, significant or indispensible for research. Although these three objectives may conflict, each is important; it is the responsibility of the curator, in the selection of a new object and in the arrangement of display, to reconcile them.

In addition to the selection and exhibition of objects, the curator must engage in a number of activities designed to acquaint the public with the museum and its collection. These activities vary with the size and contents of the museum. Printed material published by the museum ranges from mimeographed sheets to bulletins and expensive catalogues. In general, European museums, more than museums elsewhere, tend to publish complete catalogues of their collections, even at a financial loss.

Special exhibitions are helpful in stimulating interest in the museum; they also provide a service to the public. In most of these exhibitions, loans from private owners or dealers are essential for success. After World War II, when many European museums were suffering from war damage and objects were stored for safekeeping, it was comparatively easy to secure loans. This tendency received further impetus from publicity agencies of European tourist centres, which considered exhibitions a means of attracting tourists. A drawback was the fact that tourists were often disappointed to find a masterpiece away on loan. More important, old paintings and other works of art should not be exposed to the rigours of travel. Experts no longer favour international loan exhibitions unless scholarly interests are furthered, either by a one-man show or an exhibition which stimulates special studies.

**1. Educational Function.**—Every museum must develop an appropriate program for the education of the community it serves. Educational efforts are directed at two groups—student and adult—and each must be treated in a different way. In educating students, museums can follow classroom methods as long as the student groups have the same educational background, the same urge to increase their knowledge and the same desire for promotion. If the museum can provide teachers from its own staff, or train schoolteachers to introduce the museum to students, and if it keeps in close touch with local school authorities, student education does not offer difficult problems. In regard to adult education the situation is somewhat different. The adult audience is elusive; adults are not required to visit a museum. Diligent effort is required to attract them, and far more effort is required to hold them. Here the time element is important, since the museum faces tremendous competition for the visitor's time. One of the accepted methods to attract and hold the visitor's interest is to make him feel that acquiring knowledge is a pleasant experience and that the museum has made every effort to convey ideas and information in the fastest and most attractive way. Visitor behaviour must be taken into consideration. Museums have recognized that the visitor will not inspect a large museum if it is unattractively arranged and if no opportunity is afforded for him to rest his eyes and feet. On the other hand, in a time when more and more people seem to be reluctant to work for an intellectual goal and are often satisfied with answers at second hand, museums sometimes may be guilty of coddling visitors. The visitor to the museum, to make his visit worthwhile, must learn not to accept every label he reads without devoting any thought of his own to the subject.

The use of the best exhibition techniques available is obviously most important in making museums attractive. But first it is necessary to make a wise selection of which objects are to be exhibited and which are better suited for a study collection. This decision must be made in a small as well as in a large museum. The educational duties of the art museum are especially difficult because art objects, when separated from their context, *e.g.*, the church, the public building, the house, lose some of their effect and may become more difficult to understand, though they may be enhanced aesthetically. Lengthy labels will not help the casual visitor, since lack of time may prevent his reading or, more important, digesting them. Some museums have offered a room of art interpretation, with temporary exhibitions treating various

topics. Undoubtedly this is a stimulating method, but it is open to question whether the advantages are not offset by the disadvantages. Since such educational displays must be presented in an oversimplified way, they tend to offer solutions that are too easy. The art museum, more than the other types, must rely on adult visitors whose knowledge is based on their own studies in classes, in seminars or perhaps in conducted gallery tours.

Since museums are not always conveniently reached from all parts of a city, a number of practices have been instituted to overcome the problem of inaccessibility. Branch museums have been established, and loan exhibitions have been held in suitable civic centres, in suburbs or in industrial settlements. Exhibits have been prepared for regular circulation at schools. The presentation of original objects is, however, fraught with danger, so protective measures must be taken. Films, for television or other purposes, are an effective and lasting means of attracting visitors. They may be especially valuable for outdoor museums at historical sites to inform visitors about the general scope of the project. Colonial Williamsburg, Va., uses such a film to give visitors a general orientation in the area. A convenient device for the interpretation of museum objects to visitors is the recorded message or lecture, relayed to listeners by portable earphones furnished by the museum; *e.g.,* National Gallery of Art, Washington, D.C.

Museum objectives can be advanced by the maintenance of regular and harmonious relations with the press and other public communication media. Some newspapers will feature museum news; others are reluctant to do so, often because the museum does not provide suitable material. It is the responsibility of the museum to see that material for the press is interesting, in good taste and dignified. It is also important that a museum be aware of activities throughout the museum field; one means of doing so is to have staff members attend annual meetings of museum organizations. In the U.S., for example, there are the American Association of Museums, the College Art association and others. Published reports of these meetings, as well as annual sales reports, directories of dealers and other reference material, should be included in all museum libraries. A specialized library is necessary to every museum, whatever its size.

**2. Museum Staff.**—The staff of a museum may vary in number from 3 to 300. While in the smaller museums staff members may be required to fulfill a variety of duties, certain offices require specialized training: the business manager, who is in charge of museum finances; the registrar, whose office keeps full and complete records of all museum objects; the curator, whose duty it is to care for, study and interpret objects under his jurisdiction. The director of the museum must carry out museum policies and direct all its activities. He is usually responsible to a board of trustees, who, with the director, determine the policies of the museum. Trustees are, for the most part, interested persons of wealth, who are frequently expected to take an interest in the financial situation of the museum. The president of the museum must be a man sufficiently interested to assume the sometimes precarious task of keeping the institution on an even keel as regards finance as well as policy.

In Europe most museums are governed by public authorities; in the U.S. they are usually privately administered.

To qualify for museum work in most countries on the continent an applicant either should have a university degree and credit in additional special courses or must have served an apprenticeship. Neither in England nor in the U.S. is there any prescribed method of education for museum work; but the British Museums association sponsors a training program leading to a diploma or certificate. In the U.S. the American Association of Museums has worked toward the development of a similar project. Special courses are offered by some museums in conjunction with universities. Since the number of museums in the U.S. is constantly increasing, a museum career offers excellent opportunities, though salaries tend to be lower than in other educational institutions.

In addition to technical workers, such as painters, cabinetmakers and the many kinds of engineers required by all public institutions, museums employ photographers and conservators. The museum photographer photographs all objects for the archives; there are also many requests from outside the museum for photographs. The conservator and his assistants are responsible for the constant care of objects in the collection and the restoration and repair of damaged or neglected works. There is probably no museum which has kept abreast of the work necessary in preservation. Museums of science require special workshops, staffed with artists, taxidermists and others, to prepare exhibits and to create dioramas, charts, etc. Museums of industry need even more equipment to deal with the ever-increasing number and size of exhibits. Often these museums receive help from the industry or agency to be represented in the exhibit.

## II. COLLECTIONS

**1. Acquisitions.**—Collections in most European museums have grown through the centuries; the U.S. museum collection usually owes its existence to the munificence of one or several individuals. The most important element of a gift to a museum is the provision of adequate funds, not only to enlarge or improve the collection but to operate it effectively. Donors anxious to perpetuate their names on museum labels are not always willing to donate funds for a purpose as inconspicuous as maintenance.

Although most U.S. museums are younger than their counterparts in Europe, their growth has been phenomenal, and a number of them can be compared to old established European museums. The foremost example is the National gallery in Washington, D.C. The original nucleus of 30 pictures given by Andrew Mellon inspired other donors, such as J. E. Widener, Samuel H. Kress and Chester Dale, to give their collections, thus confirming the rule that an important collection, once started, will attract donors. The fact that such bequests to nonprofit institutions can be deducted from taxes has undoubtedly been a contributing factor.

The museum must constantly watch for suitable purchases. An important source for European museums is the auction, but U.S. museums rarely buy at auction, since purchases must usually be approved by committees of trustees and it is difficult to secure the approval of a purchase before the auction. Most U.S. museums buy through dealers and watch the markets throughout the world. All dealers will send objects to a museum on approval; and if a price cannot be met, the dealer will sometimes agree to a trade, but in the long run this practice is not profitable for the museum. Objects from collections willed to the museum may duplicate objects already in the museum collection or may not be quite up to the standard required. The best means of disposing of such objects is a more or less public sale. It is neither customary nor practical for a museum to dispose of works of art created by living artists or given by donors who are still living.

In considering objects for purchase, certificates of authenticity are not sufficient guarantees of merit. Laboratory tests may have to be made, but even these must be considered with stylistic, historical or other factors to establish a conclusive opinion. It is unfortunate that so often the public is misled by reports of great art finds which later, after thorough examination, turn out to be of little or no value.

**2. Care.**—All museum acquisitions are inspected by the registrar, the curator and the conservator. The registrar, noting the condition of the object on arrival, assigns it a number and records the object in his files. The conservator and curator, after careful examination of the object, plan any necessary treatment. The object, before exhibition, will be given to the photographer and then to the restorer or craftsman required for its care. After the object is placed on exhibition, precautions, *e.g.,* controlled atmosphere and cleaning, must be taken to safeguard it.

The extent to which a museum can and will adhere to all these requirements varies greatly, but its responsibility to do so is implicit in the acquisition of important objects. If its maintenance funds do not allow proper protection of objects, the museum is seriously neglecting its duty.

It is obvious that museums need elaborate protection against burglary, theft and unexpected attacks on objects by fanatics. Less obvious, and not always duly considered, is the need for protection against the deterioration of objects through neglect or decay. It is not easy to hold to a middle line between overprotec-

tion and wrong or careless treatment. In any case, before normal housekeeping can begin, it is necessary to restore objects to the point at which cleaning, dusting or other routine measures cannot hurt them.

After World War II the protection of museums in wartime became a major consideration. The policy during World War II was to take safety measures for immovable objects and to evacuate certain collections from cities in the danger zones. Caves and dry obsolete mines were proved to be safe storage places for those treasures. Skeleton collections were left in museums for the benefit of the public during the war period. Monument officers attached to the armies took care of precious objects found in the theatres of war. The possibility of atomic warfare has changed the picture. The course to be followed in any future war would depend largely on the definition of danger zone and on how far ahead warning could be given of enemy action.

There seems to be scant hope that any practical measures could be taken to save museum objects in case of an armed conflict between world powers.

**3. Presentation.**—While museum structures are discussed in MUSEUM ARCHITECTURE, it should be noted that museums in Europe have been successfully housed in churches, *e.g.*, the Schnütgen-Museum in Cologne; in monasteries, *e.g.*, Augustiner Kloster Museum, Freiburg im Breisgau, Ger.; and especially in palaces; *e.g.*, the Louvre in Paris, the Pitti palace in Florence, the Palazzo Bianco in Genoa, Hampton Court near London, and Schleissheim near Munich. In 1957 an 18th-century palace, the Capodimonte in Naples, was turned into one of the most impressive modern museums in Europe without essentially altering its structure. While the traditional or romantic atmosphere of historic buildings lends itself to the accommodation of art or historical collections, new buildings are more appropriate for museums of science and industry.

Whatever structure houses a museum, it must offer exhibition space, storage facilities, offices, workshops and lounges for the public; thus it sometimes happens that less space is devoted to exhibition space than to the rest of the museum.

Museum visitors of previous generations were less demanding than those today. The public now expects from the museum the same attention to its convenience and welfare as it expects from commerce and industry. Visitors are entitled to adequate lighting, wise presentation of objects, and easy-to-read, conveniently located labels. Despite rapidly changing trends, which compel museums to be particularly discerning in their exhibition methods, the underlying idea of every good museum installation is still the one defined by G. B. Goode (*q.v.*) in 1888, "It must be made with the strictest attention to system." An order need not be followed pedantically; it can and should be modified if there are good reasons to do so. Chronological order is the one followed in most history and art museums, though the functions of the objects in these two types of museums are quite different. Order by material or species may be followed in decorative arts and science museums, though in both cases additional group exhibits, demonstrating the affinity, diversity or evolution of objects, may be arranged. In the museum of decorative arts, objects might be selected for display on the basis of their similarity of form, purpose, colour or some other quality. In the 1930s the Museum of Decorative Art in Cologne was arranged in this fashion.

*Labels.*—The question of labels is one of the most troublesome. Certainly labels are not as necessary in the art museum as in other museums which must explain their objects to the visitor. Frequently there is a lack of introductory labels telling why certain objects are brought together to form a unit or to exemplify a theme, such as baroque style, electricity or U.S. Civil War. There are no predetermined rules governing all labels; it is necessary to determine the proper label for each case. Whether a label is short or long, made by script, print, engraving or photography, it is essential that it be legible to everyone, including the great number of persons with impaired vision. Labels should not be hidden, as they often are, for aesthetic reasons. What is gained in appearance is lost in convenience.

*Study Collections.*—The steady accumulation of objects has made it impossible to continue the early practice of displaying everything in the collection; most museums, therefore, divide their collections into objects for exhibit and objects in storage. The idea of this dual arrangement was advanced by K. F. Schinkel when the Berlin museum opened in 1830. About the middle of the 19th century this system was introduced in science museums in England and in the U.S., and around 1903 Francis A. Bather recommended it for art museums. The difficulty is that in long-established museums, space is at a premium, and it is difficult to arrange for study collections. A notable example of a building planned to solve the problem is the Fitzwilliam museum in Cambridge, Eng. The ideal method of putting a study collection to use is to make it accessible to visitors without requiring them to apply for admission. If a study collection is provided, its multiple uses must be considered. In natural history museums, for example, many visitors besides the naturalist may be interested in special objects. Thus if it is possible to arrange a study collection, it is neither necessary nor desirable to have all parts of the permanent collection constantly on view. There can be a rotation of objects or a succession of planned exhibitions, as was done at the Danzig Historical museum at Oliva; the Museum of Costume in New York; and others.

Even in the study collection it is not possible to keep every object that has entered the museum. The upkeep of each item in the museum is costly; the study collection must be screened from time to time in order to eliminate objects that have become useless to the museum. Although the study collection represents a storage of sorts, it is also necessary to provide general storage space for other objects which must be kept.

*Art Museums.*—The manner in which objects in art museums are presented tends to reflect the style of interior decoration or window dressing generally fashionable. Though both the architect and the window dresser have ways of presenting objects attractively, the museum has its own essential methods of display, and only occasionally, in planning special exhibitions, will outside help be used. Eccentric showmanship should not be used for the routine installation of permanent collections. An art museum object should be effective for its own merit, not for its manner of display. Proper preparation is necessary for satisfactory presentation. Damaged pieces must not look shabby; the amount of restoration to be executed involves technical considerations and matters of integrity. With paintings the question of frames must be decided. Uniform frames have been used (Kroeller Mueller museum, Otterloo, Neth.) but not satisfactorily. While period frames could probably be used more frequently, copies of them, such as the plaster of paris imitations of the Louis XV style that often adorn Impressionist paintings, should be avoided. Frames consisting of bare strips of wood were used successfully at the Galleria di Palazzo Bianco at Genoa. There has been a tendency toward the adoption of this style; however, it should be used with caution. For the display of single small objects, a variety of methods has been used; glass trays, standard blocks or brackets attached to the wall of the case, and others.

Formerly the museum case was one of the most important pieces of museum furniture and was so standardized that the visitor became fatigued by platoons of similar cases. With newer and less rigid methods of exhibition, the standard case has dropped out of fashion, and museums have tended to use cases according to individual needs. If it consists of a thin metal skeleton with shelves, the case itself is inconspicuous, it permits a convenient view of objects and it allows frequent changes in exhibition material. Cases are often built into walls, or walls are constructed with large openings in which objects may be placed. Open shelves are sometimes used to great advantage, but they present problems of security and cleanliness. The customary three shelves of the standard case have given way to blocks or shelves of varying sizes so that objects can be shown at different levels. If this system is carried to extremes, however, the visitor will not know where to focus his attention or where to begin the story that the contents of the case have to tell. Whatever the practice, the more it is standardized and follows set rules, the sooner it will seem dated and lessen the appeal of the object.

While exhibition techniques in art museums are relatively simple, proper lighting presents problems. In Europe there is a tendency to prefer daylight (side and skylight), whereas in the United States artificial light is more the rule. Both are acceptable, but it should be remembered that a room in daylight can be very restful after artificially lighted rooms, and, moreover, a painting viewed in the sparkle of sunlight may reveal qualities not visible under artificial light.

The way in which works of art are installed varies with the fashion of the day. Whether to crowd them or place them sparsely and whether to use symmetry or balanced asymmetry depends on the purpose and possibilities of the exhibit and on the sense of measure of the person who installs it. The same can be said for the background, which can be a neutral colour or a sharply contrasting one, of monk's cloth or of precious velvet; it may create an environment, or it may isolate the object. Virtually everything has been in and out of fashion, and a successful installation in one museum will result in imitations by many others.

*Decorative Art Museums.*—Museums of decorative arts have a special difficulty, since they deal with such a great number of diversified objects which must be brought together to depict either the style of a period or the way of life of a particular era. In the 1930s it was believed that the period room might be the solution. However, this method did not prove practical. The subsequent tendency was to combine products of one period and to let these combinations, arranged to suit the modern view, follow each other in chronological order (Victoria and Albert museum, London; Rijksmuseum, Amsterdam). This method of exhibiting decorative art objects probably comes closest to fulfilling the museum's purpose of contributing to the understanding of earlier phases in the development of civilization.

An excellent solution to the problem of exhibiting the period room, but one which cannot be easily duplicated, is found at the Art Institute of Chicago. Precise reproductions in miniature of rooms, halls and other interiors, both European and American, are arranged in chronological order. The room itself, the decorations and furniture are copied from the best available models and are made exactly to scale. Mrs. James Ward Thorne was not only the originator of this ingenious scheme but, with a staff of well-trained craftsmen, carried it out successfully. These model rooms were exhibited throughout the United States and though entirely of modern manufacture, convey as well as, if not better than, any genuine period room the idea of past modes of life.

In addition to rooms illustrating the development of various styles, the museum of decorative art usually shows special collections illustrating the history of certain products; *e.g.*, glass or china. It may also provide a study collection for research work for the museum staff itself, as well as for visitors seeking information. Museum material need not be kept exclusively for one particular purpose. How flexibly it may be used can be seen in the way the Cluny museum in Paris was reorganized in 1952. This museum was a treasure trove of medieval riches of every conceivable kind, where the visitor could enjoy himself by selecting those items in which he was particularly interested and, with each successive visit, be surprised and delighted with new discoveries. The museum changed its character completely, however, and was arranged to serve as an illustrated textbook to interpret the civilization of the middle ages. Without question this is an effective way to present the contents of the museum; however, if such a radical method is chosen, it should be supplemented by other exhibits for the benefit of those whose interests go beyond the theme of the main exhibition.

*Historic Houses and Restoration Projects.*—Only the museum aspect of historic sites, *i.e.*, the means by which they are interpreted to the visitor, will be dealt with here. Projects of this type vary from the enormous undertaking at colonial Williamsburg, Va., to the site of an Indian stockade at Sitka National monument, Alaska. In every case two requirements must be met: the meaning of the project must be explained; and the site must be presented in such a way as to hold the visitor's interest. The explanation may be given throughout the museum, in a film or in a small display. The site may consist of an area or a house, restored or reconstructed, or it may consist of newly built structures. *In situ* objects may be supplemented by additional material. In the historical house the period room is a necessity for its special historical significance; here it is also useful in illustrating trends in the decorative arts.

*History, Science and Industry Museums.*—For history, science and industry museums the problems of presentation are not very different from those of the art museum. These museums, however, face the formidable task of finding adequate designers. Not all scholarly curators are good showmen, and it is sometimes necessary to engage an artist or architect to arrange exhibits. Primarily the task is to find a person who knows how to interpret the data correctly and in the best taste. If this is done, technical helps are available to produce fascinating exhibitions by the use of habitat groups, dioramas, photographs, mechanisms, laboratory experiment setups, replicas and objects of all kinds. Such exhibitions may be static, or they may be operated by visitors or demonstrators. There are immense difficulties involved in combining all the factors in an exhibit, such as educational purpose, technical accuracy, attractiveness and co-ordination with neighbouring objects. Moreover, developments must be presented logically, beginning with fundamentals and proceeding step by step to a higher level. If demonstrators are used, they can make exhibits far more effective; they can hold the attention longer than any label could, particularly if they assume that the visitor is not informed on the subject under discussion. Part of the effectiveness of the demonstrator can be attributed to the fact that the appeal is both to the sight and the hearing of the visitor, rather than to the sight alone.

In science and history museums, exhibits consist of special, original objects with the addition of technical devices for explanation; the history museum, however, is not bound to display as many original items of a specific type. The history museum may select objects as they become available or seem suitable for interpretation of a certain topic. One item can be substituted for another as long as its character as a symbol is maintained and it lends adequate support to the story. If pictorial material is not authentic, it should be so labeled; however, authentic material should be used as much as possible. This kind of display may be a collection of heterogeneous objects, but a well-defined, interpretive arrangement will account for and explain the objects presented. Unfortunately, history museums with well-planned, systematically organized collections, such as the Musée de l'Homme in Paris, are the exception rather than the rule.

## III. HISTORY

### A. General Development

**1. Greek and Roman Origins.**—In its original sense the Greek word *mouseion* was applied to a sanctuary dedicated to the muses of Greek mythology. In the 3rd century B.C. the term designated that part of the palace of the Ptolemaic kings in Alexandria, Egy., that housed the library of Alexander the Great and was known as a place for learning. Yet though the term *mouseion* was not used to denote a collection of works of art, the idea of a public collection did exist in Greece. The Greek writer Pausanias (2nd century A.D.) said that in a building adjacent to the Propylaea on the Acropolis at Athens there was one hall called Pinakotheke, containing a collection of paintings, which was open to the public (hence the name of the Munich Pinakothek). No such collection is known in ancient Rome, but it is known that Roman generals plundered Greece and that many sculptures of Greek origin adorned public grounds and private houses. Throughout the early Christian centuries following the Hellenistic era, the idea of the museum as a place of inspiration or learning was lost, as was the institution of the Pinakotheke, though certainly the human habit of collecting never ceased. The history of collecting in general, however, does not form part of this outline; collecting is dealt with here only as a part of the history of museums.

**2. Middle Ages.**—The idea of visualizing spiritual forces in works of art, as a source of knowledge and inspiration, was recreated by the Christian church. In effect but not in name the medieval church was a museum not entirely unlike those of mod-

ern times. From the time of early Christianity, when symbols were drawn on the walls of the catacombs of Rome to fortify and inspire the faithful, through the middle ages, when richly carved portals and stained-glass windows told stories from the Scriptures, the church was the place where knowledge was conveyed not only by word but by visual aids as well. Two typical examples were St. Mark's in Venice, where the walls were covered with narrative mosaics and where fabulous treasures were displayed on special occasions, and the cathedral at Halle, Ger., where Cardinal Albert of Brandenburg, Luther's antagonist, established an extraordinary collection of relics, set in sumptuous cases and provided with a printed and illustrated catalogue (*Heiltumsbuch*, 1510).

**3. Renaissance.**—It was not until the 16th century that the Greek term *mouseion* was used in Italy in its italianized form, *museo*. During the Renaissance, Italian princes and noble families began to take an interest in the arts and in all branches of human knowledge. They brought out from their treasure vaults, called *guardaroba*, the rare artifacts which, up to then, had been stored for protection rather than for enjoyment. It added to the prestige of a great and learned man to be seen surrounded by precious or curious objects, which he generously allowed his friends to inspect. Obviously the collections kept in these studies or writing cabinets, called *museo*, *studiolo*, *scrittojo* and other names, were of a heterogeneous character—stuffed animals and botanical rarities being mingled with works of art, freaks, artifacts and curios of every sort.

Among the ruling families of Italy who displayed their collections in such fashion were the Medici of Florence, the Gonzaga of Mantua, the Este of Ferrara and the Montefeltro of Urbino and Gubbio, all of whose treasures became the focal points of later museums. The panels made to cover the walls of the *studiolo* of Federigo of Montefeltro, duke of Urbino, at Gubbio after 1482, are the most representative of their type. Their intarsia shows symbols and allegories of the arts and sciences; these are now in the Metropolitan Museum of Art, New York city. An even richer decoration adorned the *studiolo* of Alfonso d'Este in Ferrara, which was decorated with paintings by the foremost artists of the period. One of these paintings, "The Feast of the Gods" by Giovanni Bellini, was acquired by the National gallery in Washington, D.C. Besides the great princes there were the scholars, such as Bishop Paolo Giovio (1483–1552) in Como, who specialized in collecting portraits of famous personalities, while Ulisse Aldrovandi of Bologna (1522–1605) and, somewhat later, Lodovico Settala (17th century) were famed for large scientific collections.

Across the Alps the *museo* was known by a variety of names. In France, Francis I (1494–1547) had a *cabinet de curiosité* at Fontainebleau, and Jean Baptiste Gaston, duke of Orléans (1608–60), among others, had one at the Palais du Luxembourg in Paris. In the old Holy Roman empire and throughout Scandinavia the term *Kunst und Wunderkammer* was used. One of these, belonging to Archduke Ferdinand of Austria (1529–95), at Ambras in the Tirol, was later inherited by the museum in Vienna; the *Kunstkammer* of Albert V of Bavaria (1528–79) became part of the Munich collections. In Copenhagen the most famous collection was that of the physician Ole Worm (1588–1654). In England the Tradescants, father (d. 1637?) and son (1608–62), established their Musaeum Tradescantianum (later incorporated in the Ashmolean museum at Oxford), defined by a contemporary as an "arch of novelties."

All of these *museos* from Bologna to Copenhagen were similar in character and were among the curiosities that the scholars or the gentlemen on the grand tour visited. Although the Italian *museo* of the Renaissance might contain small pieces of art, such as bronzes, medals, carvings, portraits and, occasionally, a small still life or nude (a cabinet piece), it was not the place where large pictures of mythological or religious subjects were kept. These were placed in a long *galleria*. By the end of the 16th century these galleries were an integral part of the residences of Italian princes. They also served for indoor exercise. It is possible that Sebastiano Serlio (1475–1554), the architect, was the first to suggest this type of building, at the beginning of the 16th century. The one best known, and still in existence, is the gallery built by Bernardo Buontalenti about 1581 on the top floor of the Uffizi palace in Florence. This type of promenade gallery, hung with pictures and adorned with sculpture, came to be an element in princely palaces throughout Europe. It represents the immediate predecessor of the art gallery of the 19th century, the principal difference being that the latter structure was lighted by skylights, following the example of the Louvre galleries (opened to the public in 1793), rather than by windows along one side.

The *museo* and the *galleria* were the two ancestors of the present-day art museum, which came into being around 1800, when the contents of the *museo* and *galleria* together were put on view to the public. There were, however, other types of collections. One was the accumulation of antique sculpture, such as that given to the city of Rome by Pope Sixtus IV in 1471. The antique statuary unearthed at every excavation in Rome had to be disposed of in some expedient way. These sculptures, later placed in the Capitoline museum, were set up, or stored, in the front loggia and under the arcades of the Palazzo dei Conservatori on the Capitoline hill. Later, under Pope Julius II, the Belvedere court of the Vatican was arranged to receive a collection of sculptures (hence the name "Apollo Belvedere"), which was much admired and studied by all artists who came to Rome. Undoubtedly these Roman collections of antique sculpture later inspired other art lovers to form similar collections, which they housed in galleries or buildings erected for that purpose (Antiquarium, Munich, after 1584; Arundel house, London, before 1618; Temple of Antiques, Potsdam, Ger., 1768).

**4. Baroque Period.**—Eventually it was obvious that some system was necessary for an orderly arrangement of these accumulations. In 1565 Samuel van Quiccheberg, a Flemish doctor in the service of Albert V of Bavaria, wrote a treatise on the subject under a lengthy title beginning *Inscriptiones* . . . According to Quiccheberg the ideal museum should represent the universe by means of a systematic classification of all subject matter. His treatise was widely read and even 100 years after its publication was used by John Tradescant when he catalogued his collection of scientific objects, which is now part of the Ashmolean museum at Oxford.

The most important among the theorists who followed Quiccheberg was C. F. Neickelius. His *Museographia*, published in 1727, was the first handbook in the field of collecting and museography. With such literature available, collecting was no longer reserved for the few; an increasing number of persons became interested in the subject and in the possibilities collections offered for study. It was a propitious moment for the collection owned by Sir Hans Sloane to be given to the British nation; his house in Bloomsbury, with all its contents, was opened to the public by act of parliament in 1759. This collection formed the nucleus of the British museum. Even earlier (1739) the Vatican collections had been opened to the public, and a part of the French royal collections could be seen at the Palais du Luxembourg after 1750, but in all these cases public admission was much restricted. Of the private art galleries which were started in the 17th century a very small number are still in existence; among those open to the public are the Galleria Doria-Pamphili in Rome and the Count Schönborn collection in Pommersfelden, near Bamberg, Ger.

**5. Late 18th and Early 19th Centuries.**—It took an event as momentous as the French Revolution to transform the basic character of the museum into an institution for education. It was only after that revolution that it was recognized that the study of collections should be allowed to the many and not just to the privileged few. In order to make such study possible, however, better organization of collections was necessary, and this reorganization called for specialization. The efforts of the French Encyclopaedists in classifying human knowledge and making it accessible had been a step in this direction. Presently art treasures were taken from the old curio cabinets and placed with those already in galleries, thus creating the art museum; scientific objects were gathered in the newly established museums of natural history, though a clear definition of such a museum did not come until later.

For nations with colonies, ethnology became an important subject, and somewhat specialized collections in this field were already established in the 18th century. In Great Britain the subject was covered by the British museum; Holland also had an early example in the Teyler's Museum in Haarlem, which opened in 1778.

The history museum as it is known today was not an early creation. Around 1800, certain classes of art monuments, such as tombstones, portraits, coins, medals and seals, began to be considered of historic interest, but they were placed in art museums. By and large, the art museum was foremost in the evolution of the modern museum, and its pattern was followed by the others. Its development, therefore, deserves special attention.

During the French Revolution most of the collections owned by the French nobility were dispersed, the art market shifted to London and art objects streamed into English private collections. To prevent the export of French art and to care for the treasures which were endangered, a commission was formed under Alexandre Lenoir. He established the Musée National des Monuments Français at the cloister of the Petits Augustins, which he planned to make "picturesque, educational and tasteful." It remained in existence until 1815, when it was dissolved during the Bourbon restoration. More spectacular than Lenoir's efforts were the decrees that provided for the creation of a national museum in the old palace of the Louvre, later known as the Musée Napoléon, under the most capable direction of Dominique Vivant Denon. A tremendous number of confiscated works of art seized by Napoleon from all parts of Europe made up this museum, which, though short-lived, was one of the marvels of its time. The public, which was admitted without restriction, enjoyed immensely the privilege of seeing the finest art treasures of the world gathered under one roof. Richly illustrated publications by Count Clarac, Jean Seroux d'Agincourt, Conte Leopoldo Cicognara and others exploited the extraordinary opportunity of recording and making available to the peoples of Europe their heritage of great art. In ushering in the era of comparative studies, particularly of European art treasures, the Musée Napoléon was of great importance, but since it consisted of the spoils of war, Napoleon's victors very correctly insisted on returning as many of the stolen objects as possible to the rightful owners. As a consequence, there was an awakening of public interest in the heritage of national art, and efforts were begun to found museums on a national basis.

These public museums differed greatly from the earlier ones, which, for better or worse, had reflected the tastes of their private owners. For example, under Louis XV, antique works of art and those of the Italian Renaissance that the king disliked had been placed in the Palais du Luxembourg in Paris, where the king would not see them. In his gallery in Potsdam, Frederick the Great collected paintings by Watteau and his school, which at that time were out of favour with the art world. Later he added certain late 17th-century paintings which suited his personal taste. Catherine II of Russia bought several private collections of paintings because, in the age of enlightenment, she felt it her duty to do so.

Vienna, with its huge collection, was exceptional, since there was little interference by the emperor. There the artist Christian von Mechel, who was director of the art collection, in 1781 arranged the paintings in chronological order by schools, and his system became the pattern for the newly established public museum. The print room, as it is known today in most large art museums, also originated in Vienna. There had been famous collections of prints ever since the 15th century, but only when Adam Bartsch was put in charge of the collection of Albert, duke of Saxe-Teschen (hence the name of the Albertina collection), was a collection systematically organized. The extraordinary quantity and quality of prints in this collection induced Bartsch to go one step further and establish *oeuvre* catalogues (inventories of works produced by an artist) of the masters of print-making. As Bartsch based his work on other collections, as well as the Albertina, he came to be considered the Linnaeus of prints, creating the basis for future systematic work on prints.

In the new spirit of order and objectivity and with the aim of serving the public, art collections were started wherever they could be afforded or wherever enlightened rulers were willing to give up some of the treasures accumulated in their palaces. Such galleries were established in Budapest (1802), Prague (1818), Madrid (1819), London (1814), Berlin (1830), Munich (1836) and elsewhere. In all these collections Italian Renaissance and Dutch and Flemish 17th-century paintings dominated; far less attention was paid to sculpture. Little effort was spent in rounding out existing collections; acquisitions generally came only through bequests, perhaps from an extinct branch of the reigning house. Officers in charge of museums were high court officials or public servants, sometimes eminent connoisseurs or artists, but rarely scholars. In the decades after the middle of the 19th century most galleries limited their efforts to the presentation of objects in historical order, and, following the fashion of the day, they were arranged in a rather crowded manner.

**6. Development of Decorative Arts Museums.**—Before going further into the history of the museum, a digression concerning the decorative arts in museums is necessary. The conception of decorative arts presumes a conception of the fine arts (*q.v.*). The idea that some arts are fine or major and distinguished from others that are merely decorative or minor originated in the 17th century, when royal academies were established for the education of painters, sculptors and architects. Those who wished to master design and crafts were left to their own initiative or to training by guilds and their masters. The dividing line between the two categories, always somewhat artificial and never clearly defined, became more real and perhaps more justifiable during the early part of the 19th century, when objects produced by mechanical methods began to make their appearance, such as Sheffield plate, Wedgwood ware or lacquer products. These objects not incorrectly were thought of as works of decorative art. But then, by some strange method of simplification, a gold cup by Benvenuto Cellini or a stained-glass window were included in this same category with furniture, ceramics, glass, textiles and other items. This classification would have been of little importance had it been only a matter of convenience or terminology. But unfortunately it tended to create a scale for evaluating works of art which was completely unreasonable, and tended to make objects in the field of the decorative arts appear less desirable for collectors. Therefore, at a time when collectors were, for the most part, busily trying to find the medieval paintings brought to light by the French Revolution and the Napoleonic era, it was indeed rewarding to concentrate on a collection of church furnishings, household objects and other items which had been in use through the past ages. The first important collection of this type was made by Alexandre du Sommerard in Paris around 1830 and consisted of works primarily of medieval art. This collection was taken over by the French government in 1842 and was the nucleus of the present Cluny museum.

While Du Sommerard had started his collection because of his personal interest, the first public museum for decorative art owed its existence to completely different reasons. The Crystal Palace exhibition held in London in 1851 had demonstrated that in the age of the machine good design was sadly lacking in the products of craftsmen, as well as those of industry. To improve the situation the Victoria and Albert museum was established. It was felt that a systematic collection arranged according to material, such as glass, wood and others, consisting of the best examples of the old craftsmanship, would provide the patterns which were so needed. Similar museums were established in Berlin, Munich, Vienna, Paris, Brussels, Stockholm, New York, etc.

Toward the end of the 19th century, when modern trends were introduced in art and when copying old patterns and forms was no longer in fashion, these collections lost much of their importance for craftsmen. Nevertheless they retained their value as sources of inspiration and as records of technique or treatment of material and even won new recognition as collectors' items. Certainly the great collectors of the 19th century, such as the members of the Rothschild family, Sir Richard Wallace, Prince Anatoli Demidov, Frédéric Spitzer, Georg Hirth and J. Pierpont

Morgan, had always been in competition with museums of decorative art. But with the museums' expanding their collections and with more thorough knowledge gained through the increase of research work, there were growing numbers of connoisseurs and collectors who were acquiring decorative arts as eagerly as paintings had been collected earlier. When it became the style to decorate interiors by mixing modern furniture with antiques, even more lovers of such objects appeared.

After 1900 the endless collections of decorative arts material assembled in Kensington cases (the once famous glass cases on turned feet, usually painted black) were no longer appealing. Because of this lack of appeal and because interior decoration dealt so much with styles of the past, it was thought expedient to assemble decorative arts material in so-called period rooms. However, results were not what had been anticipated. Too many compromises had to be made; often substitutes were included. On the whole, the period rooms seemed static and did not give a true idea of the past or how people had lived.

After J. Pierpont Morgan gave his collections to the Metropolitan museum in New York and the Wadsworth athenaeum in Hartford, Conn., decorative arts objects were accepted in the U.S. as worthy of museum collections, but no special museums like those in Europe were established. The one exception was the Museum for the Arts of Decoration in New York, founded in 1896 and copied after the Musée des Arts Décoratifs in Paris.

**7. Late 19th and 20th Centuries.**—As the 19th century progressed, specific trends in museum work became marked. Following the pattern of the Victoria and Albert, which had given its collections a universal character, the idea that the museum should be representative of art in all its manifestations was generally accepted. When the French Impressionist painters and their followers became interested in Oriental and primitive arts, collectors and museums turned to this new realm, and representative pieces of exotic cultures were accepted in museums. As collections grew and knowledge in these new fields became highly specialized, museums showing non-European art were established. As scholarship in various fields of collecting grew, museums came to be recognized as valuable sources for serious study, and museum workers became experts in their fields. This development created definite and strong dividing lines between the various kinds of museums. Toward the end of the 19th century there were four distinct groups of museums: those concerned with art, with history, with science and with industry. The science group included museums of natural history, ethnology and anthropology. In all of these there was a tendency, throughout the entire second half of the 19th century, to make museums repositories for scholarly study rather than places of enjoyment. As museums grew and expanded, little thought was given to making them more inviting, and almost no thought at all to the interpretation of the contents for the public.

Recognition of the museum as an active educational institution began in a small way when John Ruskin stated that a museum should not only exhibit objects but should make some effort to interpret them to the public. These ideas were incorporated in plans which Ruskin brought before a parliamentary commission in 1857 to improve the taste and recreational habits of the working classes. Later Ruskin's ideas were embodied in the Sheffield museum, Yorkshire, Eng., opened in 1875. Another approach to the same goal was made when the British museum, under the direction of Sir William Flower, divided its collections into introductory and systematic series and a study collection. Francis A. Bather, president of the British Museum association in 1903, endeavoured to transform "mere repositories into stimulating museums." Though other museums in England and on the continent (in Hamburg through Alfred Lichtwark) pursued such educational ideas, no general effort was made in Europe to solve these problems. In the United States the educational role of the museum began at an early stage, and during the first decades of the 20th century such museums as the Museum of Fine Arts, Boston, the Metropolitan Museum of Art in New York and the science museums in Cambridge (Mass.), New York, Washington and Chicago took the initiative in active interpretation from the art museum. U.S. museums realized the need to interpret the wealth of treasures they were accumulating so rapidly with their great financial resources. The museum was to appeal to a wide and diversified public, far less prepared to enjoy or understand its exhibits than was the European public, for which museum contents formed part of the past of their own nations.

Science museums also turned to the new task of interpretation and no longer considered their only duty to be merely to inventory species. Throughout the 20th century, museums in the United States were assuming an important place with other educational institutions.

Until World War I, museum work in Europe was conducted in a conservative and traditional way; decades passed without any changes. The one exception was Germany, where the dynamic personality of Wilhelm von Bode (1845–1929), the director-general of the museums in Prussia, influenced a change in the status of museums in Germany and abroad. Then, too, after the Russian, German and Austrian revolutions in 1918, when many of the art treasures of princely houses changed hands, new methods had to be applied to museum work. Because of the general instability a constant movement of art objects began, which continued long after World War II. This led to the great art exhibitions which, as mentioned earlier, gained such wide public appeal. Exhibitions of this kind required showmanship techniques, which were adopted by museums; many of them, in various parts of the world, were remodeled on a vast scale. Such changing activities, problems and purposes may well prevent museums from ever again stagnating as they did around 1900, when they were frequently referred to as mausoleums or morgues and were held in low esteem by the public.

*United States.*—In the United States throughout the first half of the 19th century the public generally expected museums to be "depositories of curiosities to amuse an idle hour." But with the American Industrial exhibition held in New York city in 1853, there was a change, and new lines of thinking were initiated. Benjamin Silliman, Jr., the well-known Yale chemist, who had complained that neither the federal nor state governments had done anything to establish galleries and museums, hoped that the creation of such educational institutions would result from this exhibition. Even before such ideas were launched, private art collections owned by Henry Abbot and Thomas J. Bryan had been bequeathed to the New York Historical society. Patrons, such as William Blodgett, J. J. Jarvis, Henry Tuckerman and Charles C. Perkins, required two more decades, however, to convince the public that an art gallery comparable to the great European collections was worthy of any "great civilized metropolis." Their efforts were fulfilled in 1870, when the art museums in New York city and Boston, Mass., were started, and the thriving era of U.S. museum development was initiated. One of the reasons for the astounding growth of this type of museum was its constant attention to the needs and wishes of the public. As U.S. museums grew in importance, some of them, like their European counterparts, began to specialize in certain fields. In New York city, for example, the Whitney Museum of American Art concentrated on the art of the 20th century, the Museum of Modern Art collected international modern art of the late 19th and the 20th centuries, and the Solomon R. Guggenheim museum limited itself primarily to abstract art. Institutions like the National gallery in Washington, D.C., and the Metropolitan Museum of Art in New York city devote their activities to many periods of art, though some may stress certain periods; *e.g.*, medieval and far eastern treasures at Boston, the Impressionists at Chicago, ecclesiastical riches at Cleveland and ceramics and early Dutch paintings at Philadelphia. Gradually U.S. museums evolved their own pattern, and in establishing educational features, they were more successful than European institutions. Besides the great museums in such cities as Baltimore, Boston, Chicago, Cincinnati, Cleveland, Detroit, Kansas City (Mo.), Minneapolis, New York, Philadelphia, San Francisco, St. Louis, Toledo, Washington (D.C.) and Worcester (Mass.), excellent smaller ones were established in Andover (Mass.), Buffalo (N.Y.), Cambridge (Mass.), Dallas, Denver, Hartford (Conn.), Houston, Indianapo-

lis, Los Angeles, New Haven (Conn.), Portland (Ore.), Providence, Raleigh (N.C.), Richmond, Sarasota (Fla.), Seattle, Springfield (Mass.) and many other cities. A special development was the growth of college museums, two of the best being at Smith college, Northampton, Mass., and Oberlin college, Oberlin, O.

Some universities have organized expeditions and established institutes for studying the results. Among the most important museums which have been added to their universities are those at Philadelphia and Chicago. The University Museum of the University of Pennsylvania in Philadelphia (founded in 1889) ranks among the foremost museums of ethnology and archaeology, with outstanding collections of material about North and South America and Asia, most of which was acquired in field work done by the museum. The same is true of the Oriental Institute of The University of Chicago, which specializes in the near east and employs a staff to publish the results of its expeditions.

The picture of the U.S. art museum would not be complete without a word about the private collections that have been given to the public, particularly the magnificent Mellon bequest. In Europe most private collections which were not dissolved were co-ordinated in some way with existing museums; rarely did their owners leave their collections as museums, as in the case of the Wallace collection in London, the Musée Jacquemart-André in Paris, the Six house in Amsterdam and the Rath museum in Budapest. In the United States a number of outstanding collections were left to existing museums, but more frequently a collector, wishing to perpetuate his memory, would leave his collection to his favourite city with the condition that it remain more or less unchanged. Such are the Walters collection in Baltimore, the Isabella Stewart Gardner museum in Boston, the Frick collection in New York, the Huntington collection in San Marino, Calif., and the Ringling collection in Sarasota, Fla. Andrew Mellon, however, planned for his collection to form the nucleus of a national gallery of art to be established in Washington, D.C. No such collection existed in the capital because it had never been the policy of the federal government to expend tax money on art. At the time Mellon began gathering his collection it seemed almost impossible that a collection of paintings rivaling those in Europe ever could be put together. The success of Mellon's plan placed Washington among the foremost cities with high-ranking art collections. When the gallery opened in 1941, western painting from its origin to well into the 19th century was splendidly represented. Later the gallery attracted other donors, and the Widener, Kress and Dale collections rounded out the already overwhelming array. The National Gallery of Art also became the centre for international art projects and related activities.

Peculiar to the U.S. are the community or civic centres, most often in middle-sized towns, and children's museums. In community centres, interest in art is usually, but not always, the focal point around which the various activities are grouped. Loan exhibitions and shows by local artists are often the highlights of the annual programs. Art and crafts classes may be given, and photography, music and drama groups may be organized. The Des Moines (Ia.) Art centre is a typical institution of this kind. History is the special field of the Detroit Historical museum. A very general program is conducted at the Corning Museum of Glass.

A junior division may form part of the centre, or a special children's museum may be provided. The first children's museum was established in Brooklyn in 1899, and there have been many since then. Very active programs for children are conducted at the Rochester (N.Y.) Museum of Arts and Sciences and the Buffalo Museum of Science. The Metropolitan Museum of Art reorganized its children's museum in 1958. Children's museums usually try to convey general, rather than specific, information, linking together various matters in ways understood and appreciated by children. Children are often given the opportunity to acquire or enlarge their skills in workshops and studios.

The development of U.S. museums continued at full swing through the mid-20th century, giving great promise of further development and improvement.

*Great Britain.*—After World War I the Fitzwilliam museum in Cambridge was one of the first British museums to rebuild completely; at the same time, the very important National Museum of Wales in Cardiff was reorganized. Following World War II, the National gallery, Victoria and Albert museum and the Tate gallery were completely rearranged to present to the visitor convenient portions of the tremendous collections which had accumulated. Old established museums in Edinburgh, Glasgow, Birmingham, Leeds, Liverpool and Manchester continued to be active through the mid-20th century; some of them took on new duties in preserving and making accessible the mansions in their neighbourhoods no longer used as residences.

*British Commonwealth.*—In the British Commonwealth, Canada has been very active in the museum field. A notable museum is the one in Ottawa, Ont., which has gained in importance through the acquisition of prominent paintings. In applied art and far eastern art the museum in Toronto, Ont., is outstanding. The National Gallery of Victoria in Melbourne, Victoria, Austr., successfully built up a collection which includes European masterpieces beginning with Jan van Eyck. In the Union (later Republic) of South Africa, which left the commonwealth in 1961, important art museums were founded in Cape Town and Johannesburg. The oldest museum of art and ethnology in India is the Victoria and Albert museum in Bombay. The National Museum of India in New Delhi (founded in 1948) collects Indian antiquities; the Baroda Museum and Picture gallery was concerned with European art. Pakistan's museums are located in Karachi, Lahore and Peshawar.

*France.*—In France art museums are largely concentrated in Paris; the Louvre, with frequent donations of great private collections, grew to be one of the most precious treasure houses of art in the world. Like other major museums the Louvre has made great strides in reorganizing its collections. Its sculptures have been placed to better advantage and appropriate, often dramatic, lighting has been installed to allow for evening openings, which have become famous and are well attended. Paintings, particularly those of great size, are no longer crowded on the walls and can be seen to greater advantage. The arrangement of pictures of smaller size against a background of elaborate period material is less fortunate.

The Cluny museum has been so reorganized that only the very finest objects of its collections are shown, and these are arranged according to themes, often of sociological character. All the overflow has been stored and is not easily accessible. Old palaces, mansions and the buildings from the exhibition of 1900 were for a long time considered adequate for various Parisian collections. But with the need for more space and adequate protection for museum objects, and with the exhibition of 1937 giving a stimulus, the Palais de Chaillot was erected to house the splendidly organized Musée de l'Homme and the Musée National des Monuments Français, a collection of plaster casts of old French sculptures. The latter museum was one of the few of its kind to remain in existence, since plaster casts had fallen into general disfavor. The Musée National d'Art Moderne also acquired a new building, providing ample space for its collection. After World War II, provincial museums in France (Bourges, Dijon, Le Havre, Lyons, Nice, Reims, Tours, etc.) were reorganized according to a general plan and their contents and presentation greatly improved.

French museum work was extended to Africa, where active museums in Algiers and Tunis have steadily increased their collections.

*Germany.*—The stimulus given to museums under the leadership of Wilhelm von Bode has been mentioned. The state museums in Berlin were so greatly improved that they rose from secondary importance to ranking position and dealt not only with European but also with oriental and U.S. art. Bode made acquisitions of considerable quality, and his improved exhibition techniques have been internationally accepted. World War II and the separation of Berlin into east and west sections completely disrupted this kind of work. But even before this development, activities in all German museums had been rudely cut off by the Nazi regime. Museums were deprived of works of art to which

the Nazis were opposed and were used for indoctrinational purposes by presenting objects in a prejudicial manner. These practices were continued in East Germany after World War II by the Communists. An example of this type of museum is the one located in the former *Zeughaus*, "armory," of Berlin, which demonstrates the course of German history as it is seen behind the "iron curtain."

After World War II a building in West Berlin which Bode had planned as a study-storage building was found to be most useful to house what was left of the collections once placed on the museum island, now cut off from the west. A wing was added, and the building was used for collections of old paintings, sculpture, prints, drawings, ethnology and archaeology. Modern paintings were placed in Charlottenburg palace, along with the only historical rooms, formerly inhabited by the kings of Prussia, remaining in Berlin. The remnants of the badly damaged Museum of Decorative Arts are also displayed in this place.

Hardly a city in Germany failed to rebuild or reorganize its museum, usually in an attractive and efficient manner. The picture gallery in Munich, the so-called Alte Pinakothek, was reconstructed. The Bayerisches Nationalmuseum, badly damaged during World War II, was rebuilt and considerably enriched, as was the case with the city museum in Munich, which received an extraordinary number of Kandinsky paintings as a gift. The old Wallraf-Richartz-Museum in Cologne was rehoused in a very modern museum, built by Rudolf Schwarz. Also in Cologne, the Schnütgen-Museum, showing religious art, made clever use of an old church for its collections. The Folkwang Museum, formerly in Hagen, was once one of the few privately owned and endowed museums in Germany; it is now owned by the city of Essen. It played a leading role in the introduction of modern art. Though this museum, and others showing "degenerate art," lost valuable paintings by Cezanne, Van Gogh and the German Expressionists during the Nazi period, some of these have been replaced.

East German museums, including those in Berlin, suffered enormous losses after World War II, when their collections, which had been either in safekeeping or left in museums, were confiscated by Soviet authorities. However, unknown to the western art world, these treasures were given good care in Leningrad, Moscow and Kiev. Some had been damaged, but while in custody many of them were restored with great skill and infinite patience. In 1955 the Soviet government decided to return the works of art that had been held in the Soviet Union. The Dresden Picture gallery was the first to benefit, after which other important collections from Berlin, Gotha, Leipzig, Dessau, Wörlitz, Meissen (7,000 molds owned by the porcelain manufactory) and other places were returned. The magnitude of this task is apparent when it is realized that the Hermitage museum alone housed more than 500,000 objects from German museums; it has been estimated that more than 300 boxcars were needed for the return operation. The objects once owned by the Berlin museums, among them the Pergamum altar, were restored to East Berlin. Since the museums once located on the museum island were destroyed or heavily damaged, the return of these collections necessitated an acceleration of the rebuilding of museums. The old palace in the centre of Berlin, the so-called Schloss, which housed the museum of decorative arts and other collections, was wantonly destroyed after the war; its loss was severely felt. The Kaiser Friedrich museum, later called the Bode museum, and the old National gallery were among the most important old buildings that were, in part, made accessible again. The museums in Altenburg (a good collection of old Italian paintings), Arnstadt, Bautzen, Halle, Karl Marxstadt (the former Chemnitz) and Weimar became very active after World War II; many of them held exhibitions and even extended their collections.

*Italy.*—In Italy almost every city of any importance has a museum, and such cities as Florence, Milan, Naples, Rome, Turin and Venice have a number of first-rate ones. In addition, innumerable churches throughout the country constitute museums in themselves. Italy played a leading role in the post-World War II effort to reorganize museums; for example, the startling installation of pictures at the Palazzo Bianco in Genoa (1950) was widely discussed. In Milan the Brera gallery of old paintings, heavily damaged during the war, was newly installed in a more conservative but still pleasing fashion. In Milan, also, the collection of paintings, sculpture and decorative arts at the Castello Sforzesco was presented in a somewhat unorthodox and fanciful way, not always avoiding the danger of too rich background material. The collections of paintings and decorative arts, as well as some suites of historical rooms, at the Capodimonte palace (Naples) were opened in 1957. This museum was installed with great care and attention to detail. Lighting effects were arranged to provide even light at all times, and every effort was made to prevent museum fatigue and to provide as much aesthetic pleasure as possible. Capodimonte thus became one of the most delightful and efficiently arranged collections to be found anywhere. The Civico Museo Correr (decorative arts), the Cà Rezzonico, and the picture gallery at the Accademia, all in Venice, and the Uffizi gallery, in Florence, have been carefully reorganized to present their collections in the best possible way. However, the Bargello, the world-famous sculpture museum in Florence, remained in a most unsatisfactory condition for many years. One of the most remarkable facts about Italian museums is the excellent way in which many small galleries and museums have been reorganized and installed; *e.g.*, Aquileia, Lodi, Viterbo.

*Other European Countries.*—All of the capitals and some of the large cities of the Scandinavian countries, such as Copenhagen, Stockholm, Oslo, Göteborg, Lund and Malmö, possess art collections, many of which are of great importance and date from the 18th century. The National museum in Helsinki, Fin., is rich in ethnography and also owns a fine collection of pottery from the southwestern United States.

The Netherland's wealth of fine art is represented in museums in Amsterdam, Arnhem, Haarlem, The Hague, Rotterdam, Utrecht and many other cities. Belgium's store of art is housed in museums in Antwerp, Bruges, Brussels, Ghent, Liège and other places. Switzerland's best-known art museums are located in Basel, Berne, Fribourg, Geneva, Lausanne, Winterthur and Zürich.

Perhaps nowhere else in Europe is the great art inheritance of the past so concentrated and so well represented by the most superb paintings as in the Museo del Prado in Madrid, to which some of the best paintings of the Escorial have been added. The museums at Barcelona and Vich magnificently supplement the Prado in the Spanish medieval period. In Portugal the National museum in Lisbon is outstanding; the National Coach museum in Belém is of interest as one of the best of the specialized museums in Europe.

Austria was able to preserve most of the immense treasure inherited from the days of the monarchy. Museums are found in Vienna (Art museum, Museum of Fine Arts, Belvedere museum, Albertina Graphic Arts collection) and at Graz, Innsbruck, Klagenfurt, Linz and Salzburg.

Poland's great collection is in the National museum in Warsaw, which also houses works of art from Silesia formerly owned by museums in the eastern part of Germany. Other important Polish museums are in Cracow, Poznan and Gdańsk (Danzig).

In Czechoslovakia, Prague offers collections of art and science at the National museum. Other museums of note are in Brno, Olomouc and Bratislava. In Hungary the National museum at Budapest is famous for a collection of old masters. In Yugoslavia, Belgrade is the centre of the Slavic tradition, which is represented in several museums. Collections pertaining to Slovenian history and art are shown in Ljubljana and those pertaining to Croatian culture in Zagreb. The great tradition of Greece can be studied at the museums in Athens and Delphi.

*Soviet Union.*—In the U.S.S.R., old paintings are extraordinarily well represented in the Hermitage collection in Leningrad, originally a court museum. The collection now also includes modern European paintings, western decorative arts, as well as Scythian art and ancient objects from Greece and the near and far east. Icons and Russian art are shown at the State Russian museum in Leningrad. In Moscow the State Tretyakov gallery is representative of Russian art.

Until the mid-1950s the State Pushkin Museum of Fine Arts

was very reluctant to show its rich collection of modern art from the Shchukin and Morozov collections. However, this policy changed, and paintings by Van Gogh, Cezanne, Matisse and others were put on view, together with a selection of paintings by old masters.

After 1956 the Kremlin was open to the public; its churches, some of its buildings and the fabulous collections of treasures, mostly of western art once owned by the tsars, were made accessible. The most important historical collection is at the State Historical museum in Moscow.

*Near East.*—In Turkey the museums in Ankara and Istanbul are rich in archaeological treasures. The Topkapu Palace museum in Istanbul houses a collection of decorative art, paintings and manuscripts. In Iraq there is the famous museum of archaeology in Baghdad, established in 1923. The national collection of Israel is in the Bezalel National museum in Jerusalem. Iran organized the Archaeological museum in 1936 and the Anthropological museum in Tehran in 1938. The museums in Cairo, Egy., own a wealth of Egyptian, Islamic and Coptic art.

*Japan.*—In Japan the Tokyo National museum, replacing the former Imperial Household museum, offers the best survey of Japanese art. Kyoto's Municipal museum is a branch of the former Imperial Household museum and shows old Japanese art. In nearby Nara the National museum, as well as many shrines in the temple district, display treasures of old Japanese art; especially noteworthy are the Hōryūji temple and the Shōsō-in Treasure depository.

*South America.*—Mexico is particularly active in the museum field. Notable are the National Museum of Anthropology and the National Historical museum in Mexico City. There are also museums of importance in Morelia, Guadalajara and Oaxaca.

In Argentina, besides the museums in Buenos Aires, there is a museum of note in Córdoba. In Rio de Janeiro, Braz., there is a Museum of Modern Art, housed in a completely modern building. The art museum in São Paulo has become well known for its fine collection of old and modern masters, probably the most representative of European art in South America. In Bolivia, the National museum "Tihuanacu" in La Paz is important. Chile's museums are concentrated in Santiago. Ecuador has a museum of note in Quito. Peru owns a number of museums in Lima and a collection in Cuzco. In Venezuela, Caracas offers several museums.

### B. History Museums

**1. General Development.**—The purpose of the principal collection of the history museum should be to illustrate themes or visualize ideas. As long as the principles guiding the arrangement of a display are clearly defined and one exhibit follows the next in logical sequence, there is no objection to presenting certain specialized collections having to do with a historic event, a great man or something similar. But any digressions should be made clear so that the visitor never loses track of the idea running through the entire show. The essential difference between the purposes of the art museum and the historical museum is that the art object eventually must speak for itself, whereas a historical object, the sword of a hero, for example, must be evaluated in a very different way. What is important is its character as a symbol (though it may also have interest as a piece of art) and the sequence of thoughts this symbol may induce. The visitor cannot be expected to start this chain of thinking; therefore, it is the duty of the museum display to weave the objects that are shown into the story it wishes to tell. If this is not done, the object is nothing more than a curio, such as those in the medieval curio cabinets. Today a contemporary photograph of the Confederate Libby prison in Richmond, Va., is considered more impressive than a genuine brick from Libby prison, which used to be among the objects seen in historical society museums. It should not be forgotten that when history museums tell their stories they risk the danger of being accused of indoctrination; a case in point is the proper presentation of the American Civil War. Controversial issues must be presented in an unprejudiced way, with fairness to all the issues involved.

**2. United States.**—In the United States the history museum had a promising beginning. A native of Geneva, Switz., Pierre Eugene du Simitière (1736–84), who settled in Philadelphia, opened a curio cabinet in the city sometime prior to 1776. More important than the establishment of the cabinet was Du Simitière's idea of collecting all documentary evidence pertaining to the American Revolution. In this he aimed directly at what came to be held as one of the main purposes of the historical museum; *i.e.*, to illustrate a thesis or theme. After his death Du Simitière's collection was scattered, part going to Charles Willson Peale for the museum he opened in Philadelphia in 1785. This museum, like others in New York (Tammany society, Scudder's) and in Boston (Jeremy Belknap's museum), prospered briefly but then lagged. This situation changed when Phineas T. Barnum began in 1842 to monopolize the museum as a business. Soon people were much entertained by his "most pleasant and attractive place of public amusement on the continent." Barnum's renown was so great that even such distinguished citizens as Henry Ward Beecher, Horace Greeley and William Cullen Bryant thought that Barnum would be the right man to head a national museum. They sponsored a petition on his behalf and Pres. Andrew Johnson endorsed the plan. However, on March 3, 1868, fire destroyed Barnum's collection before the plan could be carried through. When in 1869 the American Museum of Natural History in New York was founded, with J. Pierpont Morgan as one of the committee, the final quietus was put on the plan. From this period on, the development of the historical museum was based mainly on the activities of historical societies, many of which established museums. Like those in Europe, these societies accumulated a great deal of material, but it was not organized in a manner to inspire and educate the public. At that time one event aroused far more interest than any historical society could possibly do. In 1859 the Mt. Vernon Ladies' association gained control of George Washington's country home and made it a national shrine. This, together with the earlier acquisition of Washington's headquarters at Newburgh, N.Y., established an early precedent for the designation of historic sites and was the beginning of the preservation movement. Preservation is an activity intimately related to the responsibilities of the historical museum. Temporary exhibitions were successful and stimulating in this respect. The Centennial exposition, held in Philadelphia in 1876, gave rise to the idea of restoring Independence hall and advertising it as a site of national significance. When the Smithsonian institution organized a division of history as a part of the United States National museum, it was a promising beginning, but the department was never very active.

On the federal level a new basis for matters pertaining to the appreciation and understanding of history was established in 1906 with the passage of the Antiquities act, which concerned the preservation of antiquities situated on government lands; in 1935 was added the Historic Sites act, which authorized the government to acquire and preserve historic sites. With the aid of these acts and the branch of history of the National Park service, established in 1935, the government was able to protect historic monuments, to do justice to the historical past and to develop a good deal of educational work. The branch of history immediately set to work to define categories of archaeology and historic sites and structures illustrating the rise of American civilization. Guided by these definitions, sites for protection were selected and developed as historic areas. Frequently historical museums pertaining to a certain area, so-called trailside museums, were added for better interpretation. The sites which have been established, *e.g.*, Ocmulgee National monument, Salem Maritime National Historic site, or whose establishment is planned, represent a very impressive national museum of American civilization. (*See* National Parks and Nature Reserves.) On the state level a number of programs for historic houses have been developed in California, Illinois, New Jersey and other states. The Abraham Lincoln homestead in Springfield, Ill., is an example. Private initiative also worked toward the preservation and interpretation of the historic past in establishing colonial Williamsburg (Va.), Greenfield village (Mich.), Old Sturbridge village (Mass.), La Purisima

Concepción mission (Calif.) and many others. One museum which cannot be classified easily is the Henry Francis du Pont Winterthur museum in Winterthur, Del. The founder of this museum intended to collect the most outstanding examples of American arts and crafts, as well as objects of everyday usage, in order to illustrate the history of American civilization. The objects were placed on display in their natural environment. The effect was intensified by making the collections available to the public only through conducted tours by guides capable of informing the public about every possible detail of the collection. Another museum based entirely on the collection of American material, including the presentation of objects placed in the open air, *e.g.*, steamboat, covered bridge, was established at Shelburne, Vt., by Mrs. J. Watson Webb.

The development of the motorcar and the road system made the countryside more accessible and increased interest in historic house museums, structures notable because of their historic associations or their artistic qualities. The idea was not new; Isaac Newton's birthplace at Woolsthorpe, Lincolnshire, Eng., and other places of similar interest had been shown to visitors in the 18th century. The intention was to make the historic house and its furnishings as authentic as possible. After the German revolution in 1918 some of the former royal palaces were refurnished on the basis of old inventories to resemble as much as possible their appearance in their heyday. Later the same was attempted in French palaces and in many English mansions which were opened to the public.

In the United States the idea received wide acclaim, and hundreds of such houses, dating from the 17th century (Paul Revere house, Boston) to the 20th century (Vizcaya, Miami, Fla.), were opened for inspection. Two trends in the visualization of history are evident. The more conservative one is represented by the historical museum, which has evolved from the tradition of the historical-society collection. The other derives from the historical-house movement, which goes back to 1859, when Mt. Vernon was established as a site. The latter is also related to the open-air museums of Scandinavia.

**3. Europe.**—History museums date from the period when romantic ideals, which were born at the time of the French Revolution, and national ambition, which thrived after the Napoleonic Wars, inspired the peoples of Europe to recall the glory of bygone days, especially those of medieval chivalry. Thus national historical collections were started with the aim of gathering the remainders of the heroic past. In the group of these historical museums the Germanisches Nationalmuseum in Nürnberg, founded in 1852 by Hans von Aufsess, was apparently the first. In the closing days of the Holy Roman empire and before the second *Reich* had been established, Aufsess created an institution to collect objects of historical importance and to study and interpret the civilization of the German-speaking peoples. This idea, it is well to note, was rooted in romanticism, rather than the chauvinism of later pan-Germanism. In the course of its growth the Germanisches Nationalmuseum tended to lose sight of its original purpose and began to resemble an art museum, a course which was later avoided but which many other historical and applied art museums followed to their detriment. Museums built more or less on the principle of the Germanisches Nationalmuseum were later established in Prague (National museum); Munich (Bayerisches Nationalmuseum); Amsterdam (Rijksmuseum); and Zürich (Schweizerisches Landesmuseum).

Peasant life, folk art and folklore at first seemed to be simple and unromantic topics and were largely neglected by the national museums. It was in this field that Nordiska Museet in Stockholm under Arthur Hazelius took the lead in the 1870s. Having become interested in the entire field of folklore after a study of ethnographical problems, Hazelius planned to start folk-art centres and open-air museums. Hazelius' undertaking came at a decisive moment, for the machine age already had begun to threaten the continuance of folkways. From the time of Hazelius, Scandinavian countries have led in the movement that he originated. While Nordiska Museet, with its archives and study material, remained the centre of the movement, open-air museums were started at Skansen in Stockholm (1891); at Bygdoy (1804) and at Maihaugen, in Lillehammer, Nor.; at Aarhus (1909) and Lyngby (1901), Den.; and in Finland. Folk and folklore collections were also started in most European countries (Berlin, 1889; Cardiff, 1907; Paris, 1937). In the U.S., open-air museums were started in several places, such as Dearborn, Mich. (1928); Sturbridge, Mass. (1936); Cooperstown, N.Y. (1899); and Shelburne, Vt. (1953); an international folk-art museum was established in Santa Fe, N.M. (1953).

Outside Scandinavia, historical societies, along with the national museums, played the important role. Many of these societies maintained city or regional museums. Most of these were overcrowded; they lacked system; and sentimental and personal points of view were overemphasized. The educational value of these institutions was open to question, and, after much controversy, it was recognized that this type of museum could best serve its purpose by using its objects to tell a story or to interpret a theme. When the Rheinisches Museum (historical), Cologne, opened in 1936 and the Musée de l'Homme (ethnographical), Paris, in 1937, both followed a pattern of displaying their objects according to a sequence of ideas rather than to a system of classification. The most important historical collection in Russia is the State Historical museum in Moscow. In Warsaw, historical collections were placed in buildings newly built behind historical façades (1954).

### C. Science Museums

**1. General Development.**—The museum of science, perhaps more than any other, was in a period of transition at mid-20th century; the period of concentration on the survey of nature was ending. Science had reaped an extraordinary harvest from the tremendous accumulation of material that museums had arranged so prodigiously for more than a century. The time had come for museums to benefit from the results science had achieved and to visualize the problems with which man is faced wherever he turns.

Answers were sought to many questions in the fields of biology, physiology and ecology, to name only a few. The interest of the public was directed toward complex situations and was no longer satisfied with a presentation of unrelated facts or collections of specimens, however complete they might be. Presentations explaining conquest of the air or soil erosion draw the attention of the visitor and help him understand the problems that must be faced in everyday life. Museums of science embrace activities in an extraordinary variety of scientific and other fields, such as economics. Among other subjects the relationship of man to nature requires continual re-examination, and the all important theme of protection of natural resources must be brought to everyone's attention. Museums which grasped the new conception of their purpose found a following eager to learn and understand.

When the Paris Musée National d'Histoire Naturelle (Jardin des Plantes) was reorganized in 1793, its name expressed its activities—the study of geology and biology. Since that time, however, museums of natural history have embraced the entire field of pure science, so that the name science museum has come to be a more suitable one. In the United States some of the greatest institutions have taken the somewhat confusing name of museum of science and industry, though their field in general is applied science—the application of science to industry and to the activities of man. In Europe the situation is similar, since museums concerned with pure science have no specific name indicating their purpose. For matters of classification it is necessary to distinguish the museums of natural history, science, anthropology, and ethnology from the museums of applied science in industry and company museums. As was seen earlier, the museum of natural history, originating in the *museo* or curio cabinet, began to take its own course after such scientists as the Comte de Buffon and Linnaeus made their great inventories of nature and when, following these, collections of specimens were made. The problem of evolution was introduced, and in time Darwin's ideas took hold on museums. After science "turned from picking apart to putting together" (Coleman), the public became less interested in species than in their relationship. The science museums of the

TABLE I.—*Selective List of Museums in the United States*
(A=Art; H=History; I=Industry; S=Science)

| City | Museum |
|---|---|
| Albany, N.Y. | Albany Institute of History and Art (1791, A H) |
| Albuquerque, N.M. | Museum of Anthropology (1928, S) |
| Andover, Mass. | Addison Gallery of American Art (1930, A) |
| Ann Arbor, Mich. | Museums of the University of Michigan (1837, S) |
| Baltimore, Md. | Baltimore Museum of Art (1914, A) |
| Baltimore, Md. | Walters Art galleries (1931, A) |
| Birmingham, Ala. | Birmingham Museum of Art (1951, A) |
| Bloomfield Hills, Mich. | Cranbrook Institute of Science (1930, S) |
| Bloomfield Hills, Mich. | Bloomfield Museum of Cranbrook Academy of Art (1930, A) |
| Boston, Mass. | Institute of Contemporary Art (1936, A) |
| Boston, Mass. | Isabella Stewart Gardner museum (1900, A) |
| Boston, Mass. | Museum of Fine Arts (1870, A) |
| Boston, Mass. | Society for the Preservation of New England Antiquities (1910, A) |
| Brunswick, Me. | Bowdoin College Museum of Fine Arts (1894, A) |
| Buffalo, N.Y. | Albright Art gallery (1905, A) |
| Buffalo, N.Y. | Buffalo Museum of Science (1861, S) |
| Cambridge, Mass. | Museum of Comparative Zoology (1859, S) |
| Cambridge, Mass. | William Hayes Fogg Art museum (1895, A) |
| Charleston, S.C. | Charleston museum (1773, S H) |
| Chicago, Ill. | Art Institute of Chicago (1879, A) |
| Chicago, Ill. | Chicago Historical society (1856, H) |
| Chicago, Ill. | Chicago Natural History museum (1893, S A) |
| Chicago, Ill. | Museum of Science and Industry (1926, I S) |
| Chicago, Ill. | Oriental institute (1931, A) |
| Cincinnati, O. | Cincinnati Art museum (1880, A) |
| Cleveland, O. | Cleveland Museum of Art (1913, A) |
| Cleveland, O. | Cleveland Museum of Natural History (1920, S) |
| Colorado Springs, Colo. | Colorado Springs Fine Arts centre (1919, A) |
| Columbus, O. | Ohio State museum (1885, H S) |
| Cooperstown, N.Y. | National Baseball Hall of Fame and museum (1939, H) |
| Cooperstown, N.Y. | New York State Historical association (1899, A H) |
| Corning, N.Y. | Corning Museum of Glass (1951, I) |
| Dallas, Tex. | Dallas Museum of Fine Arts (1902, A) |
| Davenport, Ia. | Davenport Municipal Art gallery (1925, A) |
| Dayton, O. | Dayton Art institute (1913, A) |
| Denver, Colo. | Denver Art museum (1917, A) |
| Denver, Colo. | Colorado Museum of Natural History (1900, S) |
| Detroit, Mich. | Historical museum (1928, H) |
| Detroit, Mich. | Detroit Institute of Arts (1884, A) |
| Doylestown, Pa. | Bucks County Historical society (1880, A H I) |
| Ft. Worth, Tex. | Ft. Worth Art museum (1910, A) |
| Hartford, Conn. | Wadsworth athenaeum (1842, A) |
| Honolulu, Hawaii | Bernice P. Bishop museum (1889, S) |
| Honolulu, Hawaii | Honolulu Academy of Arts (1922, A) |
| Houston, Tex. | Museum of Fine Arts of Houston (1925, A) |
| Indianapolis, Ind. | John Herron Art museum (1883, A) |
| Kansas City, Mo. | William Rockhill Nelson Gallery of Art (1915, A) |
| Lawrence, Kan. | Thayer Museum of Art (1928, A) |
| Los Angeles, Calif. | Los Angeles County museum (1911, A S) |
| Los Angeles, Calif. | Southwest museum (1903, A H S) |
| Louisville, Ky. | J. B. Speed Art museum (1925, A) |
| Manchester, N.H. | Currier Gallery of Art (1915, A) |
| Milwaukee, Wis. | Milwaukee Art institute (1888, A) |
| Milwaukee, Wis. | Milwaukee Public library, art department (1897, H S) |
| Minneapolis, Minn. | Minneapolis Institute of Arts (1883, A) |
| Minneapolis, Minn. | Walker Art centre (1930, A) |
| Newark, N.J. | Newark Museum association (1909, A H I S) |
| New Haven, Conn. | Peabody Museum of Natural History (1866, S) |
| New Haven, Conn. | Yale University Art gallery (1831, A) |
| New London, Conn. | Lyman Allyn museum (1932, A) |
| New Orleans, La. | Isaac Delgado Museum of Art (1910, A) |
| New Orleans, La. | Louisiana State museum (1906, A H S) |
| Newport News, Va. | Mariner's museum (1930, I) |
| New York, N.Y. | American Museum of Natural History (1869, S) |
| New York, N.Y. | Brooklyn museum (1889, A S) |
| New York, N.Y. | Brooklyn Institute of Arts and Sciences (1823, I S) |
| New York, N.Y. | Frick collection (1915, A) |
| New York, N.Y. | Hispanic Society of America (1904, A) |
| New York, N.Y. | Jewish museum (1947, A H) |
| New York, N.Y. | Metropolitan Museum of Art (1870, A) |
| New York, N.Y. | Museum of the American Indian (1916, H S) |
| New York, N.Y. | Museum of the American Numismatic society (1908, A) |
| New York, N.Y. | Museum for the Arts of Decoration (Cooper Union) (1896, A) |
| New York, N.Y. | Museum of the City of New York (1923, H) |
| New York, N.Y. | Museum of Modern Art (1929, A) |
| New York, N.Y. | Solomon R. Guggenheim museum (1937, A) |
| New York, N.Y. | New York Historical society (1804, A H) |
| New York, N.Y. | Pierpont Morgan library (1924, A) |
| New York, N.Y. | Whitney Museum of American Art (1930, A) |
| Northampton, Mass. | Smith College Museum of Art (1881, A) |
| Oberlio, O. | Dudley Peter Allen Art museum (1917, A) |
| Omaha, Neb. | Joslyn Art museum (1931, A) |
| Philadelphia, Pa. | Academy of Natural Sciences of Philadelphia (1812, S) |
| Philadelphia, Pa. | Atwater Kent museum (1939, H) |
| Philadelphia, Pa. | Commercial museum (1894, I) |
| Philadelphia, Pa. | Franklin Institute of the State of Pennsylvania (1824, I) |
| Philadelphia, Pa. | Historical Society of Pennsylvania (1834, H) |
| Philadelphia, Pa. | Pennsylvania Academy of the Fine Arts (1805, A) |
| Philadelphia, Pa. | Philadelphia Museum of Art (1875, A) |
| Philadelphia, Pa. | University Museum of the University of Pennsylvania (1889, A S) |
| Pittsburgh, Pa. | Carnegie Institute Department of Fine Arts (1896, A) |
| Pittsburgh, Pa. | Carnegie museum (1895, S) |
| Pittsfield, Mass. | Berkshire museum (1903, H S) |
| Portland, Ore. | Portland Art museum (1892, A) |
| Princeton, N.J. | Art museum (1889, A) |
| Providence, R.I. | Rhode Island School of Design, Museum of Art (1877, A) |
| Richmond, Va. | Virginia Museum of Fine Arts (1919, A) |
| Rochester, N.Y. | Museum of Arts and Sciences (1914, H I S) |
| Rochester, N.Y. | Memorial Art gallery (1913, A) |
| Sacramento, Calif. | E. B. Crocker Art gallery (1885, A) |
| St. Louis, Mo. | City Art museum (1912, A) |
| Salem, Mass. | Essex institute (1848, A H) |
| Salem, Mass. | Peabody Museum of Salem (1867, H I S) |
| San Diego, Calif. | Fine Arts Society of San Diego (1925, A) |
| San Francisco, Calif. | California Academy of Sciences (1853, S) |
| San Francisco, Calif. | California Palace of the Legion of Honor (1924, A) |
| San Francisco, Calif. | M. H. de Young Memorial museum (1895, A) |
| San Francisco, Calif. | San Francisco Museum of Art (1921, A) |
| San Marino, Calif. | Henry E. Huntington Library and Art gallery (1919, A) |
| Santa Barbara, Calif. | Santa Barbara Museum of Art (1938, A) |
| Santa Fe, N.M. | Museum of International Folk Art (1950, A H) |
| Santa Fe, N.M. | Museum of New Mexico (1909, A H) |
| Sarasota, Fla. | John and Mabel Ringling Museum of Art (1946, A H) |
| Seattle, Wash. | Seattle Art Museum (1906, A) |
| Springfield, Mass. | Museum of Fine Arts (1933, A) |
| Syracuse, N.Y. | Museum of Fine Arts (1896, A) |
| Toledo, O. | Toledo Museum of Art (1901, A) |
| Tucson, Ariz. | Arizona State museum (1893, H S) |
| Tulsa, Okla. | Philbrook Art centre (1939, A) |
| Washington, D.C. | Corcoran Gallery of Art (1869, A) |
| Washington, D.C. | Dumbarton Oaks Research Library and collection (1940, A) |
| Washington, D.C. | Freer Gallery of Art (1923, A) |
| Washington, D.C. | Army Medical museum (1862, S) |
| Washington, D.C. | National Collection of Fine Arts (1906, A) |
| Washington, D.C. | National Gallery of Art (1937, A) |
| Washington, D.C. | Phillips collection (1918, A) |
| Washington, D.C. | Textile Museum of the District of Columbia (1925, A I) |
| Washington, D.C. | U.S. National museum (1875, A H I S) |
| Wellesley, Mass. | Farnsworth Art museum (1875, A) |
| Williamsburg, Va. | Colonial Williamsburg (1931, A H I) |
| Williamstown, Mass. | Lawrence Art museum (1927, A) |
| Winterthur, Del. | Henry Francis du Pont Winterthur museum (1951, A H) |
| Worcester, Mass. | Worcester Art museum (1896, A) |

United States sensed these trends quickly and caught the interest of the public to an extent which was rarely equaled abroad. Inasmuch as science museums made it their business to visualize complex problems and relate topics to each other, the dividing lines between the branches of science, such as natural history, biology, ethnology and anthropology, could not be drawn closely, nor did it appear necessary to do so.

**2. United States.**—In the United States the first museum of natural history was founded in Charleston, S.C., in 1773 (incorporated in the Public museum after 1907). That this museum was established at such an early date is due to the fact that the southern part of the eastern seaboard had by that time been explored by scientists like Mark Catesby and John Bartram. Moreover, the marked European interest in the fauna and flora of the new continent may have called for similar attention in the colonies. With his short-lived curio cabinet established in Philadelphia, Du Simitière followed Charleston shortly after 1773. Best known of all early museums was Charles Willson Peale's establishment, which opened in Philadelphia in 1785. It contained some objects of historic interest and many portraits of famous Americans, painted by Peale; there was also a large collection of scientific objects, among them the mastodon Peale himself had excavated. Peale gave talks interpreting his museum. P. T. Barnum considered museum work a business requiring showmanship. In addition to these, there were collections such as those established by the Academy of Natural Sciences of Philadelphia (founded 1812) and the Boston Society of Natural History (1830). Both museums still rank high and contain valuable material. The great era of the U.S. natural history museum was initiated under the leadership of Louis Agassiz, through the foundation of the Museum of Comparative Zoology, as a part of Harvard university in 1859. Agassiz' great plan to establish a museum with working collections for the specialists and scientifically arranged displays for general instruction was carried out. Theories concerning displays changed as times changed, but the museum remained active and was able to adhere to the fundamental idea of its founder.

*U.S. National Museum.*—The story of the United States National museum in Washington, D.C., is an involved one. It dates from a collection of objects included in the Smithson bequest of 1826. There were abortive efforts to create a national institute for the promotion of science in 1846. The present name was not legally adopted by the government collection until 1876, when the Centennial exhibition was held. Prior to this, Spencer Baird, the secretary of the Smithsonian institution, had been

"keeper of the cabinet," and it was due to his influence that the cabinet was made a national museum and a new building dedicated in 1881. George Brown Goode became assistant director in 1887 and until his death in 1896 was in full charge of the museum. Goode was an extraordinarily able administrator and an inspired museum man who recognized the needs of his time and who abounded in ideas that he knew how to put into effect. In the course of its development the Smithsonian institution created a number of subdivisions, some of which were dedicated to the fine arts (United States National museum, National Gallery of Art, Freer Gallery of Art), others being concerned with specialized scientific fields (National Air museum, Astrophysical observatory, Bureau of American Ethnology and others).

*American Museum of Natural History.*—The founding of the American Museum of Natural History in New York in 1869 marked an important step in U.S. museum history because with this event the interest of the public in the museum as an institution was definitely recognized. The city of New York provided the building and its maintenance, while the scientific work was taken care of by private funds, a system which later was adopted elsewhere. True to its policy, the museum developed "the study of natural sciences, advanced the general knowledge of kindred subjects and furnished popular instruction" to an untold number of visitors. To continue to enjoy such popularity it was necessary at times to modify the original concept of the museum. The museum embraces all branches of natural history and anthropology, as well as the whole field of ecology. It also has become a centre for the study of many scientific problems of world concern.

*Chicago Natural History Museum.*—This museum was founded at the close of the World's Columbian exposition of 1893 with the aid of Marshall Field, for whom it was originally named. It has expanded in an extraordinary way. By the early 1950s the museum had sent out more than 400 expeditions to all parts of the world, thus receiving much important material. Keeping close contact with the Chicago school system, the museum provides schools with unusually fine circulating exhibits.

*Other U.S. Museums.*—Among the other museums, the Buffalo Museum of Science (organized in 1861) deserves special attention, since it began to arrange its exhibits with special reference to educational needs at a very early date. The museum also became well known as a training centre for museum workers.

**3. Europe.**—In selecting some of the most important museums of science in Europe, it seems appropriate to begin with the Jardin des Plantes in Paris, which possibly is the oldest one in existence. It was founded in 1626 as an herb garden for medical purposes; its present collections include specimens collected by Buffon around 1739. From the early 18th century the Jardin des Plantes served as an educational institution, gradually extending its activities until it comprised a huge conglomeration of experimental gardens, living specimens of animals, and large collections in which courses were given and to which the public was admitted. In 1793 the institution was reorganized as a kind of public university of science based on its manifold collections.

Throughout the 19th century, science museums with general interests or with special interests in anthropology and ethnology were established all over the world. The French geographer Edmé François Jomard was the first to point out the possibilities of museums of ethnology, his ideas being carried out in Copenhagen in 1841.

The oldest science museum in Great Britain is the Ashmolean museum, established in 1683 by the University of Oxford to house the Tradescant collection given by Elias Ashmole. In 1925 the museum was completely reorganized as a museum to illustrate the history of science. Great Britain's most important natural history museum, a branch of the British museum, originated in the science material of Sir Hans Sloane. It occupied premises at South Kensington in 1881–86. The museum is supplemented by the Geological museum, Kew gardens (*q.v.*), with its herbarium and other botanical collections, and the Royal College of Surgeons' museum, which is devoted to anatomy.

Among the privately organized museums are two that deserve special attention. One, the Pitt River museum (now part of Oxford university), is unique in that it illustrates the evolution of civilization without regard to race and thus admits material not always found in museums of ethnology. The other is a local museum but one which proved without precedent in its far-reaching influence as an educational institution. This is the Haslemere museum, founded by Sir Jonathan Hutchinson in 1888. It was Hutchinson's idea to create a local museum which would illustrate for the layman the history of man and the natural sciences. It was arranged so that visitors could see the material at close range and, if possible, handle it; they could also see growing plants in the museum garden and study birdlore. Charts, such as comparative schedules of geology and human history, form substantial parts of the collection.

In Germany the Berlin Museum of Ethnology was one of the outstanding museums of its kind. Under the leadership of Adolf Bastian it accumulated extraordinary collections, particularly from the Americas and Asia. The building and much of its valuable collections were destroyed during and after World War II. What was left of the collections is shown in Dahlem (West Berlin). Most countries, in all parts of the world, have natural history museums. Usually they are the last to be reorganized to suit modern needs.

The planetarium and the aquarium also became accepted institutions much favoured by the public. The oldest aquarium is in Naples (established in 1872). The first planetarium was constructed by Carl Zeiss in Jena, Ger., between 1919 and 1924 for the Deutsches Museum in Munich; the first one to be opened in the United States was the Adler planetarium in Chicago (1930).

### D. Industry Museums

**1. General Development.**—The museum of science and industry is concerned with spreading knowledge about the application of science to industry and what this means in the pattern of our civilization. During the early years of the museum of science and industry questions were raised as to whether these new museums would merely represent the wonders of industry without rendering educational service and without implying any social aspects. These questions were answered in the guidebook of the Chicago Museum of Science and Industry, which stated as early as 1936 that the museum would be concerned with man as a social being. As long as museums of industry recognized the social implications of progress in industry they would never become exhibitions promoting industry for its own sake. Museums of science and industry do not try to illustrate fully and comprehensively all of their subject. To a certain extent this task is done by so-called company museums. These are museums created by industry in which the history of particular products is recorded. One of the earliest of this type of museum was the Button museum of the Waldes company in Prague, Bohemia (now Czech.), established in 1916, which included models of all the fastening devices of the world and which even published a scholarly bulletin. Specialized museums of this kind were created throughout Europe and the U.S. Other specialized museums owe their existence to the interest of collectors, to communities or governments wishing to foster commercial products. Some museums of this type are: carving (Oberammergau, Ger.); ceramics (Faenza, Italy; Sèvres, France); circus (Sarasota, Fla.); coaches (Belém, Port.; Compiègne, France; Nymphenburg, Ger.); farming (Cooperstown, N.Y.; Cassville, Wis.); glass (Corning, N.Y.); iron (Rouen, France); lacquer (Cologne, Ger.); steel (Worcester, Mass.); taxes (Freudenstadt, Ger.).

**2. United States.**—The Franklin institute in Philadelphia, Pa., was founded in 1824 for the "study and progress of the mechanical arts and applied science" and is one of the oldest institutions in the United States. It was housed for nearly a century in a building on Seventh street and was moved to its present structure in 1923. The building houses the library of the institute and the Fels planetarium, as well as the museum. Many of its exhibits represent the most modern techniques employed in the science museum field. It exhibits both the basic physical sciences and their applications in industry. Its first industrial exhibition was held in

TABLE II.—*Selective List of Museums Outside the United States*

| Country and City | Museum |
|---|---|
| Algeria | |
| Algiers | Musée National d'Alger (1930, paintings, sculpture, minor arts) |
| Argentina | |
| Buenos Aires | Museo Argentino de Ciencias Naturales (1823, science) |
| | Museo Histórico Nacional (1890, colonial, 19th-century art) |
| | Museo Nacional de Bellas Artes (1895, modern paintings) |
| Australia | |
| Adelaide | National Gallery of South Australia (1881, paintings) |
| | South Australian museum (1856, science) |
| Brisbane | Queensland museum (1855, science) |
| | Queensland National Art gallery |
| Melbourne | National Gallery of Victoria (1859, paintings, minor arts) |
| Sydney | Australian museum (1827, science) |
| | National Art Gallery of New South Wales |
| Austria | |
| Vienna | Gemäldesammlung der Akademie der Bildenden Künste (1820, old masters) |
| | Kunsthistorisches Museum (1891, oriental, ancient art, old masters, minor arts) |
| | Naturhistorisches Museum (1889, science) |
| | Österreichische Galerie (1923, old masters, modern paintings) |
| | Österreichisches Museum für Kunst und Industrie (1863, minor arts) |
| Belgium | |
| Antwerp | Kninklijk Museum voor Schoone Kunsten (1810, mostly old masters) |
| Bruges | Musée des Beaux-Arts (old masters) |
| Brussels | Musée Royal du Congo Belge (1897, science) |
| | Musée Royal d'Histoire Naturelle de Belgique (1842, science) |
| | Musées Royaux d'Art et d'Histoire (1835, ancient art, historical objects, minor arts) |
| | Musées Royaux des Beaux-Arts de Belgique (1830, old masters, modern paintings) |
| Liège | Musée des Beaux-Arts (1819, paintings of all periods) |
| Bolivia | |
| La Paz | Museo Nacional "Tihuanacu" (1925, archaeology, science) |
| Potosí | Museo Nacional de la Casa de Moneda de Potosí (1938, colonial and minor arts) |
| Brazil | |
| Pará | Museu Goeldi de História Natural e Etnografia (1871, science) |
| Rio de Janeiro | Museu de Arte Moderna (1951, paintings) |
| | Museu Histórico Nacional (1922, historical objects, minor arts) |
| | Museu Nacional (1818, science) |
| | Museu Nacional de Belas Artes (1816, Brazilian paintings) |
| Bulgaria | |
| Sofia | National museum (1893, art of all periods) |
| | Natural Science museum (1889, science) |
| Canada | |
| Halifax | Nova Scotia museum (1868, science, historical objects) |
| Montreal | Montreal Museum of Fine Arts (1860, paintings, minor arts) |
| Ottawa | National Gallery of Canada (1880, paintings of all periods) |
| | National Museum of Canada (1842, science) |
| Toronto | Art Gallery of Toronto (1900, European, American paintings) |
| | Royal Ontario Museum (1912, science, archaeology) |
| Chile | |
| Santiago | Museo Nacional de Bellas Artes (1880, Chilean paintings) |
| | Museo Histórico Nacional de Chile (1911, anthropology, historical objects, minor arts) |
| | Museo Nacional de Historia Natural (1830, science) |
| China (Formosa/Taiwan) | National Palace museum |
| | National Central museum |
| China (People's Republic) | Museum of Historical Relics |
| | National Peking Palace museum (Chinese art) |
| Colombia | |
| Bogotá | Museo de Arte Colonial (1942, colonial art) |
| | Museo de Bellas Artes (European, colonial paintings) |
| | Museo del Instituto de la Salle (1905, science) |
| | Museo Nacional (1824, historical objects, art) |
| | Museo Nacional de Etnología y Arqueología (1931, science) |
| | Museo del Oro (1936, native gold objects) |
| Costa Rica | |
| San José | Museo Nacional (1885, archaeology, industrial arts, science) |
| Cuba | |
| Havana | Instituto Nacional de Investigationes Científicos y Museo (science) |
| | Museo Nacional (1913, archaeology, art) |
| Czechoslovakia | |
| Prague | National museum (1818, prehistory, archaeology, art, science) |
| | National Technical museum |
| Denmark | |
| Copenhagen | Danske Folke Museum (1870, folklore) |
| | Kunstindustrimuseet (1894, minor arts) |
| | Nationalmuseet (1807, prehistory, archaeology, ethnography, ancient art) |
| | Naturhistorisk Museum (1921, science) |
| | Ny Carlsberg Glyptothek (1888, ancient art) |
| | Rosenberg Slot (minor arts, old paintings) |
| | Statens Museum for Kunst (1760, art of all periods) |
| Frederiksborg | Det Nationalhistoriske Museum (1877, historical objects, paintings) |
| Dominican Republic | |
| Santo Domingo | Galería Nacional de Bellas Artes (art) |
| Dominican Republic | |
| Santo Domingo—Cont. | Museo Nacional (1927, archaeology, ethnography, paintings, minor arts) |
| Ecuador | |
| Quito | Museo Unico Nacional (1916, colonial, contemporary paintings, minor arts) |
| | Museos de la Universidad Central del Ecuador (science) |
| Egypt | |
| Cairo | Arab Art Museum (1881) |
| | Coptic museum (1908) |
| | Egyptian museum (1900) |
| | Geological museum (1898) |
| El Salvador | |
| San Salvador | Museo Nacional (1883, science and industry) |
| | Museo Nacional de El Salvador (1940, archaeology) |
| Finland | |
| Helsinki | Kansallismuseo (1893, archaeology, ethnology, history) |
| France | |
| Amiens | Musée de Picardie (1854, old masters, minor arts, historical objects) |
| Chantilly | Musée de Chantilly (1885, old masters, minor arts) |
| Colmar | Musée d'Unterlinden (1847, old masters, sculpture, Grünewald paintings) |
| Dijon | Musée des Beaux-Arts (1799, old masters, sculpture, minor arts) |
| Lille | Musée des Beaux-Arts (1801, old masters, archaeology) |
| Lyons | Musée des Beaux-Arts (1801, old, modern masters, minor arts) |
| Paris | Musée des Arts Decoratifs (1880, minor arts) |
| | Musée du Conservatoire Nationaal des Arts et Métiers (1794, models of machines) |
| | Musée Guimet (1883, art and religion of orient and far east) |
| | Musée National d'Histoire Naturelle (1635, science) |
| | Musée de l'Homme (1937, ethnography) |
| | Musée du Louvre (1793, all periods of art) |
| | Musée National des Monuments Français (1882, plaster casts of French sculpture) |
| | Musée National d'Art Moderne (1937, modern paintings) |
| | Musée National des Arts et Traditions Populaires (1937, folklore) |
| | Musée des Thermes et de l'Hôtel de Cluny (1844, mediaeval minor arts) |
| Rouen | Musée des Beaux-Arts et de Céramique (archaeology, ancient art) |
| St. Germain-en-Laye | Musée des Antiquités Nationales (1862, archaeology) |
| Strasbourg | Musée des Beaux-Arts (1803, old masters, sculpture, minor arts) |
| Tours | Musée des Beaux-Arts (1790–93, old masters, sculpture, minor arts) |
| Versailles | Musée National d'Histoire de France (1837, paintings) |
| Germany (West) | |
| Augsburg | Staatliche Gemäldesammlung (1835) and Schaezler Haus (1854, old masters, sculpture) |
| Bamberg | Staatliche Gemäldesammlung (old masters) |
| Berlin (West) | Museum Dahlem (1951, paintings, sculptures, prints and drawings of all periods, minor arts, far eastern art, ethnology) |
| | Schloss Charlottenburg (minor arts, temporary exhibitions) |
| Bremen | Kunsthalle Bremen (1823, paintings of all periods) |
| Brunswick | Herzog Anton Ulrich-Museum (1754, old masters, minor arts) |
| Cassel (Kassel) | Hessisches Landesmuseum (1580, paintings and sculpture of all periods, minor arts, historical objects) |
| Cologne | Wallraf-Richartz-Museum (1824, paintings, sculpture of all periods) |
| | Rheinisches Museum (1936, history, folklore) |
| | Schnütgen-Museum (1906, religious art) |
| Darmstadt | Hessisches Landesmuseum (1790, old masters, sculpture, historical objects, etc., sciences) |
| Donaueschingen | Fürstlich Fürstenbergische Sammlungen (1868, old masters) |
| Dortmund | Museum für Kunst und Kulturgeschichte (1883, old masters, minor arts, historical objects) |
| Düsseldorf | Kunstsammlungen der Stadt Düsseldorf (paintings of all periods, sculpture and minor arts) |
| Frankfurt | Städelsches Kunstinstitut (1817, paintings all periods) |
| | Städtische Museen (paintings, sculpture of all periods, minor arts, historical objects) |
| Hamburg | Kunsthalle (1869, paintings, sculpture of all periods) |
| | Museum für Kunst und Gewerbe (1874, minor arts) |
| | Hamburgisches Museum für Völkerkunde und Vorgeschichte (1850, ethnology, anthropology, prehistory) |
| Hanover | Niedersächsisches Landesmuseum Hannover (1856, old masters and sculpture) |
| Karlsruhe | Staatliche Kunsthalle (1803, 18th century, paintings of all periods) |
| Lübeck | Staatliche Museen (1824, paintings, sculpture of all periods, minor arts) |
| Mainz | Römisch-germanisches Zentralmuseum (1852, prehistory, archaeology, ancient art) |
| Mannheim | Städtische Kunsthalle (1909, art of all periods) |
| Munich | Bayerische Staatsgemäldesammlungen (1825, paintings of all periods) |
| | Bayerisches Nationalmuseum (1855, minor arts, old paintings and sculpture) |
| | Deutsches Museum (1903, industry, science) |
| | Wissenschaftliche Sammlungen des Staates, München (science, ethnology, anthropology) |
| Nürnberg | Germanisches Nationalmuseum (1852, historical objects, minor arts, old paintings and sculpture) |
| Stuttgart | Württembergische Landeskunstsammlungen (prehistory, art of all periods, historical objects) |
| Wiesbaden | Nassauisches Landesmuseum (1821, paintings of all periods, minor arts, science) |

TABLE II.—*Selective List of Museums Outside the United States—Cont'd.*

| Country and City | Museum |
|---|---|
| Würzburg | Mainfränkisches Museum (1913, sculpture, paintings, minor arts) |
| **Germany (East)** | |
| Altenburg | Lindenau museum (old Italian masters) |
| Berlin (East) | Staatliche Museen zu Berlin (1830, ancient, oriental and Egyptian art, paintings of all periods, sculpture) |
| | Museum für Deutsche Geschichte |
| Dresden | Deutsches Hygiene Museum |
| | Staatliche Kunstsammlungen Dresden (art) |
| | Staatliche Museum für Völkerkunde (ethnography) |
| | Museum für Volkskunst (folk art) |
| Leipzig | Museum der bildenden Künste (1837, paintings of all periods) |
| | Museum für Völkerkunde Leipzig (ethnography) |
| | Städtisches Kunstgewerbe Museum (1837, minor arts) |
| Weimar | Staatliche Kunstsammlungen (1923, paintings of all periods) |
| **Great Britain** | |
| Barnard Castle | Bowes museum (1869, European art, mediaeval to 19th century) |
| Birmingham | Museum and Art gallery (1867, paintings, archaeology, science) |
| Cambridge | Fitzwilliam museum (1816, paintings of all periods, minor arts, ancient, Egyptian art) |
| Cardiff | National Museum of Wales (1907, archaeology, minor arts, folklore, science) |
| Dulwich | Dulwich College gallery (1626, old masters) |
| Edinburgh | National Gallery of Scotland (1859, paintings of all periods) |
| | National Museum of Antiquities of Scotland (1780, prehistory, ancient art, archaeology) |
| | Royal Scottish museum (1854, archaeology, minor arts, science, technology) |
| | Scottish National Portrait gallery (1882) |
| Glasgow | Art Galleries and museum (1856, paintings of all periods, minor arts, science) |
| Greenwich | National Maritime museum (1934, maritime history) |
| Hull | Municipal museum (archaeology, minor arts, industry, science) |
| Leeds | Leeds City museums (1820, archaeology, science) |
| Liverpool | Liverpool Public museums (1851, science, archaeology) |
| | Walker Art gallery (1877, mainly English paintings) |
| London | British museum (1753, archaeology, ancient, oriental, far eastern art, books) |
| | British museum (Natural History) |
| | Geological museum (1835, geology) |
| | Imperial War museum (1917, historical objects) |
| | National gallery (1824, paintings of all periods) |
| | National Portrait gallery (1857) |
| | Royal College of Surgeons' museum (1813, science) |
| | Science museum (1857, science and industry) |
| | South Kensington Imperial institute (1887, industry) |
| | Tate gallery (1897, British paintings from 17th century to contemporary) |
| | Victoria and Albert museum (1852, minor arts, sculpture) |
| | Wallace collection (1900, paintings, minor arts from the Renaissance to 18th century) |
| Manchester | Manchester museum (1821, archaeology, science) |
| Oxford | Ashmolean museum (1683, archaeology, ancient, oriental art, paintings of old masters, minor arts) |
| | Pitt River museum (1883, ethnology) |
| **Greece** | |
| Athens | National Archaeological museum (1866, archaeology, art) |
| **Guatemala** | |
| Guatemala city | Museo Nacional de Historia y Bellas Artes (1935, historical objects, works of art) |
| **Haiti** | |
| Port au Prince | Musée National (1938, historical objects) |
| | Musée du Peuple Haitien (1950, archaeology, folklore) |
| **Honduras** | |
| Tegucigalpa | Museo Nacional (1925, science, archaeology) |
| **Hungary** | |
| Budapest | Hungarian National Historical museum (1802, art, history, science) |
| | Hungarian Museum of Fine Arts (1896, all fields of art) |
| | Hungarian National Museum of Natural History (1820, science) |
| **Iceland** | |
| Reykjavik | National museum (1863, archaeology) |
| | Museum of Natural History (1889, science) |
| **India** | |
| Baroda | Baroda Museum and Picture gallery (1894, European art, science) |
| Bombay | Victoria and Albert museum (1855, Indian archaeology, science) |
| Calcutta | Indian museum (1814, 1867, science and industry) |
| New Delhi | National Museum of India (1948, Indian archaeology, art) |
| | National Gallery of Modern Art (1956) |
| **Indonesia** | |
| Jakarta | Museum of Archaeology (1868) |
| **Iran** | |
| Teheran | Anthropological museum (1938) |
| | Archaeological museum (1936) |
| **Iraq** | |
| Baghdad | Iraq museum (1923, archaeology, near eastern art) |
| **Ireland, Republic of** | |
| Dublin | National museum (1731, archaeology, art, industry, science) |
| **Israel** | |
| Jerusalem | Bezalel National museum (1906, Jewish religious art) |
| | Museum of Jewish Antiquities (1941, archaeology) |
| Tel Aviv | Tel Aviv Museum of Art (1931, modern art) |
| **Italy** | |
| Bergamo | Galleria dell'Accademia Carrara (1796, old masters) |
| Bologna | Museo Civico (1881, archaeology, old masters, minor arts) |

| Country and City | Museum |
|---|---|
| Bologna—cont. | Museo di Storia Naturale (1884, science) |
| | Pinacoteca Nazionale (1808, old masters) |
| Faenza | Museo Internazionale delle Ceramiche (1908, minor arts) |
| Ferrara | Pinacoteca Civica (1836, old masters) |
| Florence | Galleria dell'Accademia (end of 18th century, old masters) |
| | Galleria Palatina (Pitti) (17th century, old masters) |
| | Galleria degli Uffizi (16th century, old masters) |
| | Museo Nazionale (Bargello) (1865, Renaissance sculpture, minor arts) |
| Genoa | Galleria di Palazzo Bianco (1892, old masters) |
| | Museo Civico di Storia Naturale (1867, science) |
| Milan | Museo Civico (Castello Sforcesco) (1900, archaeology, sculpture, old masters, minor arts) |
| | Museo Poldi Pezzoli (1887, old masters) |
| | Pinacoteca di Brera (1809, old masters) |
| Modena | Galleria, Museo e Medagliere Estense (15th century, old masters) |
| Naples | Museo Nazionale (1800, ancient art) |
| | Museo Nazionale di S. Martino (1872, minor arts) |
| | Museo e Gallerie Nazionale di Capodimonte (1738, old and 19th-century masters, minor arts) |
| Palermo | Galleria Nazionale della Sicilia (old masters) |
| Parma | Galleria Nazionale (1752, old masters) |
| Rome | Galleria Nazionale d'Arte Antica (1895, old masters) |
| | Galleria Nazionale d'Arte Moderna (1883, 19th-century paintings) |
| | Musei Capitolini (1734, ancient sculpture) |
| | Musei e Gallerie di Pittura del Vaticano (ancient and Renaissance art) |
| | Museo e Gallerie Borghese (1901, old masters) |
| | Musei del Laterano (1843, ancient art, early Christian art, ethnology) |
| | Museo Nazionale Romano (1889, ancient art) |
| | Museo di Palazzo Venezia (1921, old masters, sculpture, minor arts) |
| Siena | Pinacoteca Nazionale (1930, old masters) |
| Turin | Galleria Sabauda (1832, old masters) |
| | Museo di Antichità (19th century, prehistory, archaeology) |
| Urbino | Galleria Nazionale delle Marche (1912, old masters) |
| Venice | Gallerie dell'Accademia (1756, old masters) |
| | Civico Museo Correr (1830, minor arts) |
| | Raccolte del Settecento Veneziano a ca' Rezzonico (1936, minor arts) |
| **Japan** | |
| Kyoto | Kyoto National museum (1889, mostly paintings from temples) |
| Nara | Nara National museum (1895, mostly sculptures from temples) |
| | Hōryūji temple (paintings and sculpture) |
| Tokyo | National museum (1873, all fields of eastern art) |
| | National Science museum (1931) |
| **Lebanon** | |
| Beirut | National Museum of the Lebanon (1920, archaeology) |
| **Mexico** | |
| Mexico City | Museo Nacional de Artes Plásticas (1947, modern art) |
| | Galerías Nacionales de Pintura y Escultura (colonial and European paintings up to 19th century) |
| | Museo de Arte Popular (folk art) |
| | Museo Nacional de Historia (1822, historical objects, paintings, minor arts) |
| | Museo de Historia Natural (1915, science) |
| | Museo de Flora y Fauna Nacional (1937, science) |
| | Museo Nacional de Antropologia (1825) |
| **Monaco** | |
| Monte Carlo | Musée Océanngraphique (1899, science) |
| **Netherlands** | |
| Amsterdam | Rijksmuseum (1808, painting, sculpture, minor arts, historical objects) |
| | Stedelijk Museum (1895, modern paintings) |
| Arnhem | Rijksmuseum voor Volkskunde "Het Nederlands Openluchtmuseum" (1918, folklore) |
| Haarlem | Teyler's Museum (1778, science) |
| The Hague | Gemeentemuseum (1883, minor arts, modern paintings) |
| | Koninklijk Kabinet van Schilderijen (Mauritshuis) (1821, old masters) |
| Leiden | Rijksmuseum van Natuurlijke Historie (1820, science) |
| Rotterdam | Museum Boymans (1847, old masters, modern paintings, minor arts) |
| Utrecht | Centraal Museum der gemeente Utrecht (old masters, minor arts, archaeology) |
| **New Zealand** | |
| Auckland | Auckland Institute and Museum (1852, science) |
| Wellington | Dominion museum (1865, science) |
| **Nicaragua** | |
| Managua | Musen Nacional de Nicaragua |
| **Norway** | |
| Bygdøy | Norsk Folkemuseum (1894, folklore) |
| Oslo | Kunstindustrimuseet i Oslo (1876, minor arts) |
| | Nasjonalgalleriet (1837, paintings of all periods) |
| | Universitetets Etnografiske Museum (1857, science) |
| Trondheim | Folkemuseet (1913, folklore) |
| **Pakistan** | |
| Karachi | National Museum of Pakistan (1950, Indian archaeology and art) |
| Lahore | Central museum (1864, Indian sculpture and paintings) |
| Peshawar | Museum (1907, Ghandara sculpture) |
| **Panama** | |
| Panama city | Museo Nacional de Panamá (1925, science, archaeology, ethnology, historical objects) |
| **Paraguay** | |
| Asunción | Museo de Historia Natural y Etnografía (1929, science) |

TABLE II.—*Selective List of Museums Outside the United States—Cont'd.*

| Country and City | Museum |
|---|---|
| Peru | |
| Lima | Museo Nacional de la República (archaeology, anthropology, colonial art) |
| | Museo Nacional de Bellas Artes (1947, paintings of all periods) |
| | Museo de Historia Natural "Javier Prado" (1918, science) |
| Philippines | |
| Manila | National Museum (1901, historical objects, science) |
| Poland | |
| Cracow | National museum (1879, art of all periods) |
| Poznan | Museum of Natural Science (1903, science) |
| Warsaw | Museum Zoologicum Polonicum (science) |
| | State Archaeological museum (1928, archaeology) |
| | National museum (1862, paintings, minor arts) |
| Portugal | |
| Lisbon | Museu Nacional de Arte Antiga (1883, art of all periods) |
| | Museu Nacional de Historia Natural (science) |
| Rumania | |
| Bucharest | Museum of Art and Archaeology (1912) |
| | Natural History museum (1834, science) |
| Spain | |
| Barcelona | Museo de Bellas Artes de Cataluña (Arte Antiguo) (1934, mediaeval paintings and sculpture) |
| Madrid | Museo de Ciencias Naturales (1771, science) |
| | Museo Etnológico (1875, science) |
| | Museo Arqueológico Nacional (1867, archaeology) |
| | Museo del Prado (1819, paintings of all periods, sculpture) |
| South Africa, Republic of | |
| Bloemfontein | National museum (1877, history) |
| Cape Town | South African museum (1855, science) |
| | South African National gallery (1871, paintings) |
| Sweden | |
| Göteborg | Göteborgs Museum (1861, art of all periods, historical objects, science) |
| Lund | Kulturhistoriska Museet (1882, archaeology, art, science, historical objects) |
| Malmö | Museum (1841, art, science) |
| Stockholm | Nationalmuseum (1792, paintings of all periods) |
| | Naturhistoriska Riksmuseet (1819, science) |
| | Nordiska Museet (1873, etbnology, minor arts, folklore) |
| | Skansen (1891, folklore) |
| Switzerland | |
| Basel | Museum für Völkerkunde und Schweizerisches Museum für Volkskunde (1892, ethnology, folklore) |
| | Oeffentliche Kunstsammlung (1662, paintings of all periods, minor arts) |
| Bern | Kunstmuseum (1879, paintings of all periods) |
| | Naturhistorisches Museum (1694, science) |
| Geneva | Musée d'Art et d'Histoire (1910, paintings of all periods, minor arts) |
| | Musée d'Histoire Naturelle (1811, science) |
| Winterthur | Kunstmuseum (1866, paintings and sculpture from 18tb century to tbe present time) |
| Zürich | Kunsthaus (1787, paintings from 15th century to the present time) |
| | Schweizerisches Landesmuseum (1890, prebistory, bistorical objects, minor arts) |
| Syria | |
| Damascus | National museum (1919, archaeology, minor arts) |
| Thailand | |
| Bangkok | National museum (1926, archaeology, minor arts) |
| Tunisia | |
| Tunis | Musée du Bardo (1888, archaeology and art) |
| Turkey | |
| Ankara | Archaeological museum (1923, archaeology, ancient art) |
| Istanbul | Archaeological Museums of Istanbul (1869, ancient and oriental art) |
| | Topkapu Palace museum (1924, minor arts) |
| U.S.S.R. | |
| Kiev | Museum of Russian Art |
| | Museum of Western and Eastern Art (old and modern masters) |
| Leningrad | State Hermitage museum (1764, old and modern masters and archaeology) |
| | Museum of the History of Religion |
| | State Russian museum (Russian art) |
| Moscow | Farm Kuskowo Museum of Ceramics (near Moscow) (glass, ceramics, 18th-century paintings) |
| | State Historical museum |
| | Kremlin museum (decorative arts, carriages, armor) |
| | State Museum of Anthropology |
| | Museum of Modern Western Art |
| | State Museum of Eastern Cultures |
| | State Museum of the U.S.S.R. Peoples |
| | State Pushkin Museum of Fine Arts (old masters, minor arts) |
| | Museum of the Revolution |
| | State Tretyakov gallery (Russian art) |
| | Ostankino palace (near Moscow): Museum of Works Done by Serfs (18th-century paintings) |
| Uruguay | |
| Montevideo | Museo Histórico Nacional (1900, historical objects) |
| | Museo de Historia Natural (1837, science) |
| | Museo Nacional de Bellas Artes (1911, Uruguayan paintings) |
| Venezuela | |
| Caracas | Museo de Arte Colonial (1942) |
| | Museo de Bellas Artes (1938, Venezuelan and European paintings) |
| | Museo de Ciencias Naturales (1940, science) |
| Yugoslavia | |
| Belgrade | Ethnographical museum (1901, science, folklore) |
| | Belgrade Natural Science museum (1901, science) |
| | Museum of Art and Archaeology (1901) |
| Ljubljana | National Art gallery (1918, old masters, especially Slovenian) |
| | National museum (1821, prehistory, archaeology) |
| Zagreb | Croatian National museum (1880, science, history) |

1824 and was aimed at the encouragement and development of the country's early industries. This initial exhibition was so successful that it was repeated annually for a number of years, and these were the first major industrial exhibitions in the United States. In addition to its exhibits on pure and applied science, many of which are visitor-operated, historical exhibits in sea, land and air transportation and other fields are on display. Its publication, *Franklin Institute Journal,* first published in 1826, has always maintained a high standard, being devoted to developments in the fields of science and their applications to industry. Lectures on pure and applied science have been given since 1824. The institute's library houses an outstanding collection of scientific literature.

The Museum of Science and Industry in Chicago owes its existence to the interest of Julius Rosenwald who had seen the Deutsches Museum in Munich and wished to see a museum of this type established in the U.S. In spite of its relatively recent origin (1916), this museum has attained an outstanding position and attracts several million visitors a year by its dynamic and ever growing installations. Its subject matter includes the basic physical sciences and their application to various industries. Neither a repository for historic materials nor a research institution, it devotes all its efforts to serving the general public and school groups as an educational institution. No uniform method of display is utilized. Each exhibition area is individually designed to present to the visitor a sequential, educational story. Extensive use of visitor-participation devices and demonstrations is made. Among the exhibits, sometimes of enormous size and scope, there are a full-sized coal mine, an operating foundry, a typical farm with full-sized farmhouse, silo, barn, milkhouse and a brooder with live baby chicks. Areas of from 5,000 to 10,000 sq.ft. are devoted to exhibits on such subjects as the automobile, electricity, lumber, rubber, etc. Extensive exhibits in the fields of physics, chemistry and medicine are displayed. The museum is constantly changing, no exhibit being considered permanent. When, as the result of new developments in science and industry or the availability of better exhibition techniques, an exhibit begins losing its interest for the public, it is brought up to date or replaced entirely. Because of its large audience and educational effectiveness, it is heavily supported by industry.

The Museum of Science in Boston (1947; formerly the New England Museum of Natural History) also developed rapidly and showed great promise.

**3. Europe.**—The Musée du Conservatoire National des Arts et Métiers of Paris, founded in 1794, is the world's oldest technical museum and has accumulated a large collection of technical objects. While this state institution, covering 97,000 sq.ft. of floor space on three floors, has kept its traditional austere arrangement as a repository for many years, the Palais de la Découverte answers the need to explain ideas and facts to the public. Based on the ideas of Henri de Jouvenel, this museum presents problems of applied science in an artistic setting and in a highly spirited way.

The Science museum in London became administratively independent in 1909. A government institution under the ministry of education, its function is to serve as a repository for the preservation of objects important in the progress of science or in the history of invention. It also aims at presenting information on the basic laws of the physical sciences and their applications through the exhibition of scientific instruments, apparatus, machines and other objects. Many of its installations follow more recently developed exhibition techniques, temporary exhibits being held regularly.

While the Deutsches Museum in Munich (founded in 1903)

was opened as late as 1925, it turned out to be the most progressive of its kind and became the pattern for a number of others which were founded later, such as the Museum of Science and Industry in Chicago. The museum owed its existence entirely to the extraordinary initiative of Oscar von Miller, who convinced industry and government authorities of the usefulness of his idea and then started to build up this museum of technology over a period of two decades. The museum owned extremely valuable collections in the history of technology, as well as in the basic physical sciences. A considerable part of these objects were destroyed during World War II. It was, however, rebuilt. Miller was an early leader in developing visitor-operated and demonstration techniques, which, once they had been applied and made use of, could be and were developed by other museums in many directions. Tekniska Museet in Stockholm is one of several museums that followed Oscar von Miller's intentions but later developed methods of its own.

Many countries have old established museums of science and industry of sorts, *e.g.*, Calcutta, established 1814, or have started or reorganized industry museums along the pattern of the Deutsches Museum. In 1956 Czechoslovakia opened its first museum for science and industry, in Prague. In all instances museums of science and industry have turned out to be among the most popular ones. If visitor figures are regarded as decisive, then one might say that science museums have won in the competition with the older and once all-important art museum. It should be remembered that however important figures may seem they alone do not count. What matters is the effect the museum has on the visitor. How deep this goes and in what it results cannot be analyzed.

*See* also BOTANICAL GARDENS; LIBRARY; ZOOLOGICAL GARDENS; and references under "Museums and Galleries" in the Index.

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**MUSHET STEEL:** *see* STEELS, ALLOY; TOOL STEEL; TUNGSTEN STEEL.

**MUSHROOM** in a general sense refers to the familiar umbrella-shaped fruiting body (sporophore), as well as the entire underground threadlike network (mycelium), of any of the more than 5,000 kinds of fungi of the order Agaricales, the agarics or gill fungi. Members of this group bear thin bladelike gills on the underside of a usually conspicuous cap (pileus) that is carried on a stalk (stipe).

Popularly, "mushroom" is often used to identify any of the edible sporophores of fungi in several other families of the class Basidiomycetes, the club fungi; "toadstool" is usually reserved for the inedible and poisonous sporophores. In a much restricted sense "mushroom" indicates the common edible fungus of fields and meadows (*Agaricus campestris* or *Psalliota campestris*); a very closely related species, *A. bisporus*, is the mushroom grown commercially and seen in the markets.

Mushrooms, truffles and other edible fungi have, since antiquity, figured prominently in the folklore of many peoples. They have been especially closely associated with eastern European cultures from the earliest times; the ancient Greeks and Romans prized them as food delicacies, considering them food of the gods. They have been equally highly regarded in other parts of the world as well. Because of their sudden appearance and rapid decay, mushrooms have come to symbolize anything ephemeral or short-lived. They have been thought of as the provender of Mother Earth, embodiments of fertility. Their mysterious appearance has also inspired many local legends of dark meaning.

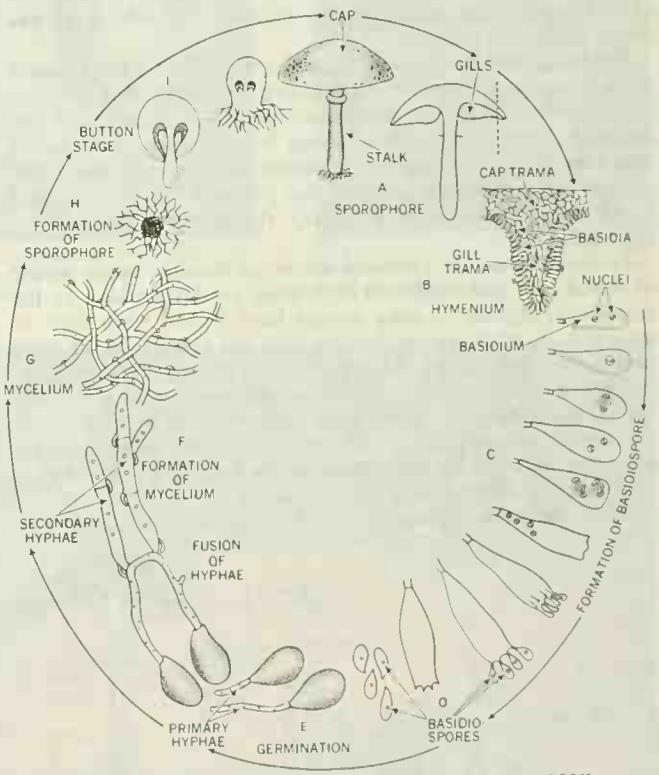



FIG. 1.—LIFE CYCLE OF A TYPICAL WILD AGARIC MUSHROOM

(A) Sporophore at left, longitudinel section at right (broken line indicetes cut made to give the following section); (B) microscopic section through edge of cap; (C) stages leading up to basidiospore formation (fusion of nuclei and subsequent nuclear division till a total of four nuclei are present); (D) basidium and its four recently discharged spores; (E) spores germinating by sending out slender, multinucleate primary hyphae; (F) fusion of two separate primary hyphae, giving rise to secondary hyphae, each cell of which contains a nucleus from each parent hypha; (G) interweaving secondary hyphae forming a mycelium; (H) mycelium becoming denser prior to formation of fruiting body; (I) button stage and young sporophore, longitudinal sections. (B, magnified; C–H, greatly magnified)

## OCCURRENCE AND LIFE CYCLE

**Spawn.**—The place where a wild mushroom is found is determined by the behaviour of the mycelium or spawn, which consists of an inconspicuous subterranean network of fine tubular threads (hyphae) that arose from a spore. If the mycelium attacks dead wood, the fruiting bodies are found on or very near a piece of dead wood. If it attacks dead leaves, the fruiting bodies occur on the forest floor where fallen leaves have accumulated. If it lives on material in the soil, the fruiting bodies arise anywhere a mycelium can become established. Many fungi live in a very close association with the living rootlets of trees (resistance on the part of the tree restricts the "infection" to the rootlets). This combination of rootlet and fungus, called a mycorrhiza, is a mutual-aid relationship. Some investigators regard it as limited parasitism, the benefit to the tree being incidental. Not all fungi form mycorrhizae. There are many instances in which a certain species of fungus forms mycorrhizae with only one genus or one species of tree. Some knowledge of these specific relationships is important to the mushroom hunter. This specificity also explains why the fungi in a pine forest, for example, are different from those in a beech-maple forest.

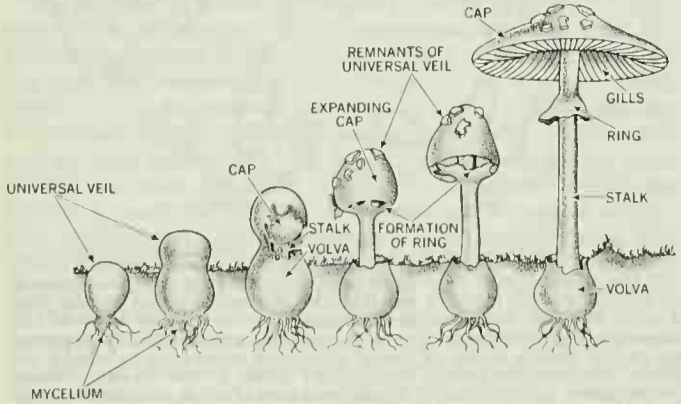
Since the spawn lives over in the same place from year to year, as long as food is available, one can go back to the same place each year to obtain a desired kind of mushroom. Mushroom mycelia may live for hundreds of years or may die in a few months, depending on the available food supply.

When a mushroom spore alights on a substrate favourable for growth, germination takes place. The spore gives rise to hyphal threads. As growth proceeds from the hyphal tips, cross walls are formed, dividing the threads into sections. Branching occurs and is frequently pronounced. These hyphae digest their way through the medium (decomposing vegetable matter) that serves as their food. The spawn uses up most of its food supply but stores some as a reserve.

**Fruiting Body.**—Eventually, under the proper circumstances of moisture and temperature, exacting conditions that are not known with certainty, the mycelium organizes the stored food into incipient sporophores. These young button stages then rapidly transform into the conspicuous emergent fruiting body, consisting of stem (stipe) and cap (pileus), that produces the spores (called basidiospores in the Basidiomycetes), the reproductive agents of the fungus plant.

Fruiting bodies are produced whenever there is ample supply of stored food and conditions of weather are favourable. In the laboratory, mycelia of some species have fruited when only 10 days old; in other species fruiting may not take place till more than a year has passed, though 20 to 30 days is the period for many. In nature fruiting often occurs only once a year (for many species in the autumn), when a particular series of weather events triggers the process. Early autumn spells of warm, wet weather often are followed by the burgeoning of fruiting bodies; such a fruiting is commonly referred to as a "break."

After the young sporophore or button has emerged, it may elongate and expand to maturity in a matter of hours or a week or two, depending on the species, the prevailing temperature and moisture. Most species of *Agaricus* mature their fruiting bodies in less than a week. The reason why fruiting bodies appear to grow so fast is that in the young button stages barely breaking the soil surface all the parts of the sporophore are already formed, but the individual hyphal cells are all very small, about 10 microns ($\mu$) long and 3 $\mu$ thick. When the fruiting body enlarges, most of these cells merely increase in size, to about 100 by 30 $\mu$. Expansion takes place more rapidly in some species than in others; moreover, in some, considerable increase in the number of cells accompanies the increase in cell size.




ADAPTED FROM W. H. GIBSON, "OUR EDIBLE MUSHROOMS AND TOADSTOOLS"; REPRODUCED BY PERMISSION OF HARPER & BROTHERS

FIG. 2.—DEVELOPMENT OF THE SPOROPHORE OF THE POISONOUS FLY AMANITA (AMANITA MUSCARIA)

Fruiting bodies of certain mushrooms occur in arcs or rings called fairy rings. The mycelium starts from a spore falling in a favourable spot. The hyphae grow out from the spore in all directions; hence a circular mat of underground hyphal threads is formed. In certain species the fruiting bodies are produced some distance back from the growing edge of the mycelium. Thus, when they come up, the sporophores are arranged in a slightly smaller circle than would be outlined by the growing edge of the mycelium. Gradually the mycelium at the centre of the circle dies out. In the so-called fairy-ring mushroom (*Marasmius oreades*), which grows in lawns, it is believed that the fruiting bodies produce a growth-stimulating substance that causes the grass to be more luxuriant in this zone. Another possible explanation is that the advancing mycelium attacks proteins and other nitrogenous substances in the soil, converting them into nitrates and ammonia for its own use; the excess nutrient substances are absorbed by the roots of grass plants in the immediate area. Fairy rings persist year after year, with the diameter gradually increasing and segments dying out till the ring form can no longer be discerned.

## IDENTIFYING CHARACTERS

Mushrooms may be identified by several characters of the fruiting body. The spawn shows very few morphological differences when species are compared. Certain features of the fruiting body can be observed with the naked eye but others can be examined only with the aid of a microscope.

**Gross Features.**—The character that places a fruiting body in the mushroom, or agaric, group is the presence of radiating gills (lamellae) on the underside of the pileus. The pileus, the vase-like to umbrellalike expansion at the top of the stipe, is readily visible on most mushrooms. Some kinds, as *Agaricus bisporus*, have a thin layer of tissue, the inner veil, which, in the button stage, at first extends from the pileus margin to the stipe and finally breaks away, leaving a ring (annulus) on the stipe. Other mushrooms have an outer, or universal, veil entirely covering the button stage. When this outer veil breaks, it may or may not, depending on its texture, leave a cup (volva) at the base of the stipe. Many species of *Amanita* have both a volva and an annulus.

The preceding features in addition to the following are important gross characters used in identification: (1) the colour of the pileus, lamellae and stipe; (2) the colour changes when any part is bruised; (3) the odour and taste of the raw flesh; (4) the condition of the cap surface, *i.e.*, whether slimy, sticky or merely moist to dry; (5) the colour of the spore deposit; and (6) the presence of scales or fibrils anywhere on pileus or stipe.

**Microscopic Features.**—*Stipe and Pileus.*—The fruiting body of the mushroom, like the mycelium, is made up of hyphae. In the stipe the hollow hyphal threads are enlarged and arranged mostly parallel to each other. These large "pipes" are bound together by narrower, crooked, interlacing hyphae to form a rather firm structure that serves both for support and conduction of vital fluids. In large stipes there may be a central region or pith in which organization is lacking, or the stipe may be hollow.

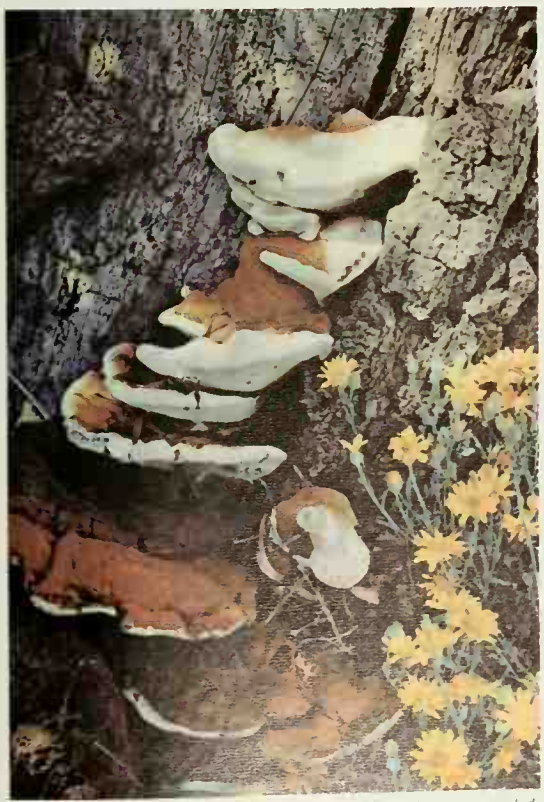
The flesh of the pileus is composed of a tangled mass of hyphae, but the surface layer (cuticle or cutis) bears certain important features. If the pileus is coloured, the pigment usually occurs here in the cuticle; it may be dissolved in the columnar cells or incrusted on or in the walls of cells. There are many arrangements of hyphae on the pileus surface. In some species a thick

*Amanita muscaria* (fly agaric); poisonous. Found in aspen, pine and spruce woods

*Amanita virosa* (destroying angel); poisonous. Grows singly and in small groups, especially in aspen woods and hazel brush

*Phallus impudicus* (stinkhorn); poisonous. Found in open meadows and grassland

*Russula veternosa.* Strong, pungent taste; not recommended. Found in hardwood and conifer forests



*Ganoderma lobatum.* Tough woody texture; not recommended. Found growing on the side of hardwoods, particularly oak

*Clitocybe illudens* (jack-o'-lantern); poisonous. Grows in clusters around the base of hardwood trees and old stumps. Luminescent in certain seasons

INEDIBLE MUSHROOMS

PHOTOGRAPHS, (TOP RIGHT, CENTRE) HERB TWEEDIE—PUBLIX, (OTHERS) WILLIS PETERSON

# MUSHROOM

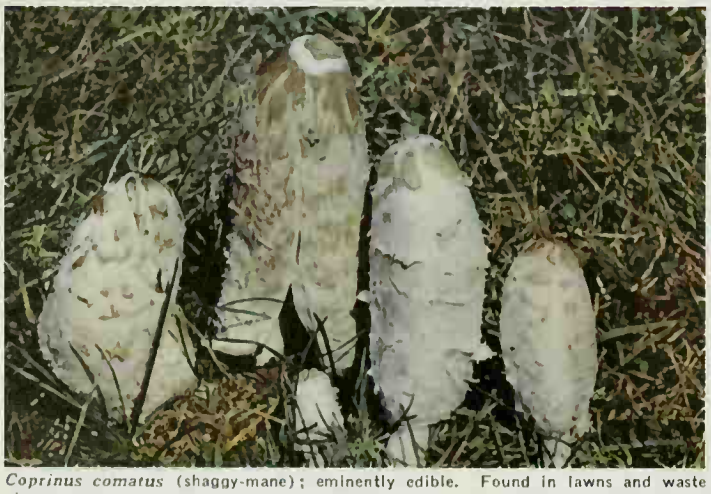
*Coprinus atramentarius* (inky cap); edible, choice. Found around the stumps of shade trees

*Suillus elegans* (yellow boletus); familiar edible species. Found under larch

*Scleroderma aurantium* (puffball); edible but not recommended. Found in open, grassy meadows and among hardwood trees and brush

*Morchella esculenta* (morel); edible, choice. Found in orchards and near open hardwoods

*Clavaria flava;* edible but tough. Found under conifers



*Coprinus comatus* (shaggy-mane); eminently edible. Found in lawns and waste places

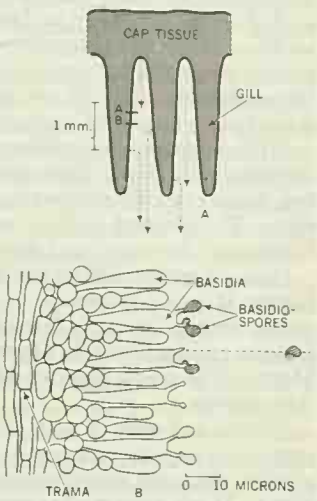
*Hypomyces lactifluorum;* edible but not recommended. Found on forest floors

## EDIBLE MUSHROOMS

PHOTOGRAPHS (TOP RIGHT, CENTRE LEFT) RUTHERFORD PLATT, (CENTRE, BOTTOM LEFT) HERB TWEEDIE—PUBLIX (OTHERS) WILLIS PETERSON

layer of narrow gelatinous repent hyphae overlies the pileus surface; such caps are slimy or sticky to the touch. In other species gelatinous hyphae occur in a manner resembling a lawn turf—upright but short and branched.

*Gills.*—In a sectional view each gill is somewhat wedged shaped, with the widest portion closest to the tissue of the pileus. The surface of the gill consists of a covering layer (hymenium) of spore-producing cells (basidia) and sterile cells. The interior of the gill, the trama, consists of hyphae in a distinctive arrangement. Since the gills grow down from the underside of the pileus, the hyphae are generally oriented downward. If the hyphae extend from the flesh of the cap to the gill edge in an almost perpendicular manner and are not tangled, the gill trama is called parallel. If the hyphae become tangled, the arrangement is called interwoven. Much intergradation between these types occurs. The highest degree of specialization is found in the bilateral type, in which there is a central strand of parallel to interwoven hyphae, but from each side of it (in cross sections of a gill) hyphae either diverge toward the hymenium (divergent type) or large cells from near the hymenium project inward and downward (convergent type).




FROM M. L. JOHNSON, M. ABERCROMBIE AND G. E. FOGG, "NEW BIOLOGY 18"

FIG. 3.—DETAILS OF GILL STRUCTURE IN CULTIVATED MUSHROOM: (A) TANGENTIAL VERTICAL SECTION OF CAP. THICK BLACK LINE REPRESENTS THE HYMENIUM. DOTTED LINES SHOW TRAJECTORIES OF DISCHARGED SPORES. LINES A AND B DELIMIT A PART OF THE HYMENIUM SHOWN IN B; (B) DETAILS OF HYMENIUM. ONE SPORE IS SHOWN IN COURSE OF DISCHARGE AND ITS SISTER SPORE IS ABOUT TO BE SHOT AWAY

In many species additional cells, strikingly different from basidia in shape, and never bearing spores, are present. These are cystidia (pleurocystidia if on the gill face, cheilocystidia if on the gill edge). The size, shape, thickness and colour of the walls of these cells and the appearance of the contents are all important characters for recognizing species. (When stomach contents are sent to a specialist for the purpose of identifying a mushroom that caused a case of poisoning, the investigator often can base his identification on spores and cystidia.)

*Spores.*—Spore characters are of greatest importance in identification. Although spores serve to reproduce the species just as seeds reproduce seed plants, their structure is entirely different from that of seeds. As already indicated, spores are produced by basidia that form the hymenium on the surface of each gill. Usually each basidium produces only four spores (cells producing one, two, three, six and eight spores have been observed, however). The basidiospores are minute (about 1/2,500 of an inch long). They are forcibly ejected from their point of attachment when mature, and, being heavier than air, fall slowly unless caught up by air currents. After discharge, the majority of the spores fall free of the tissues of the fruiting body, though it is true that many become lodged on the upper part of the stipe and on the cap margin because of air currents. Since the spores are readily discharged from the basidia it is a simple matter to collect them.

To make a spore print (*see* fig. 4) the stipe should be cut at the level of the gills and the pileus placed in its natural position (gills down) on a sheet of white paper. The cap should be covered so that air currents will not disturb the spore fall. In about an hour a powdery deposit consisting of millions of spores will have accumulated; it will show a particular colour depending on the species. A large number of mushrooms give a truly white deposit, among them, unfortunately, both edible and deadly poisonous species. Many mushrooms provide a cream-coloured deposit; others yield yellow, yellow-brown, rusty brown, pink, wine, chocolate or black spore prints. *Lepiota molybdites,* a dangerously poisonous species, has an olive-green spore deposit. The pigment is usually located in the spore wall and is visible under the microscope except for those species in which the deposit is very pale.

The detailed structure of the spore is considered more important than the colour in classifying species because of the wide variation in design and structure shown by the various species. The simplest spore type is ellipsoid to globose and has a thin, colourless wall. Typically these appear white to yellowish in spore prints. This type of spore is short-lived, perhaps because it has no protection against drying out. Not all spores are so delicate. Many have hard, somewhat thickened walls, and some of these have a thin spot at the apex through which germination takes place. Such a thin spot, a germ pore, is an important identifying character. Spore ornamentation is constant for each species and is used in classifying them into groups. Many spores are beset with raised lines, warts or spines, and some have thick walls penetrated by numerous narrow canals.

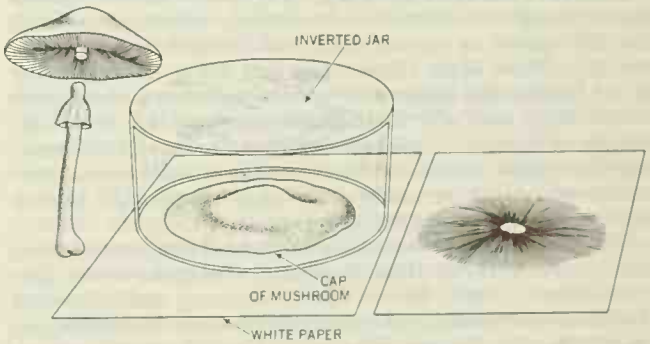
## MUSHROOMS AS FOOD

**Food Value.**—Nutritionally, mushrooms are vegetables of insignificant food value; in no way do they take the place of meat. Their chief worth is as a succulent specialty food of delicate, subtle flavour and unusual agreeably resistant texture. They may be eaten alone, prepared in a variety of ways, or in combination with many other dishes, especially meat entrees. As food adjuncts they provide a gourmet touch, lending nuances of flavour and texture to ordinary fare.

By fresh weight, the common commercially grown mushroom is more than 90% water, less than 3% protein, less than 5% carbohydrate, less than 1% fat and about 1% mineral salts and vitamins.

**Mushroom Poisoning.**—Poisoning by mushrooms may be fatal or may produce merely mild gastrointestinal disturbance or slight allergic reaction. The variables of dose, physical condition and size of the victim and individual tolerance account for the wide variation in severity of poisoning. Some of the most dangerous species, such as the destroying angel (*Amanita verna* and *A. virosa* are both called by this name), are abundant in mushroom-collecting regions, so there is real danger of their being encountered by casual collectors. Poisoning by the destroying angel, fatal in over 50% of known cases, is characterized by delayed appearance of symptoms (8 to 12 or even 24 hours after ingestion of the mushroom), which include severe abdominal pains, vomiting and retching, diarrhea, physical collapse and a feeling of anxiety. Poisoning by the fly amanita (*A. muscaria*) and related species is characterized by an almost immediate onset of symptoms ($\frac{1}{4}$ to 4 hours), which include general excitation, temporary blindness, acceleration of pulse, dilation of pupils and hallucinations.

Many species cause mild to severe gastrointestinal symptoms such as diarrhea, vomiting, abdominal pains and a feeling of lassitude. Rarer are the hemolytic types of poisoning, characterized by jaundice, cramps of the voluntary muscles, vomiting and diarrhea. A curious type of poisoning is said to occur in some people who eat the usually edible and choice inky cap (*Coprinus atramentarius*) and drink alcoholic beverages at the same time; the




FROM CLYDE M. CHRISTENSEN'S "COMMON EDIBLE MUSHROOMS"; UNIV. OF MINNESOTA PRESS, MINNEAPOLIS, © 1943 BY UNIV. OF MINNESOTA

FIG. 4.—MAKING A SPORE PRINT: THE CAP, CUT OFF AS SHOWN, IS PLACED ON WHITE PAPER, GILLS DOWN, AND IS PROTECTED FROM DRAFTS; THE RESULTING SPORE PRINT IS SHOWN ON THE RIGHT

symptoms include redness of the face, bloodshot eyes and the general aspect of intoxication, with incoherent speech and loss of emotional control.

It is clear from the above discussion that if a physician is to help a person with mushroom poisoning he must know what species are involved. If the patient has eaten a mixture of several kinds of mushrooms, the work of the attending physician is greatly complicated.

**Cautionary Advice.**—There are many more edible wild mushrooms than poisonous ones, but since several harmful species are common, the probability is that collectors will find some of them. Edible wild mushrooms can be collected from the time morels (*Morchella* species) appear in the spring, on through the summer and fall until early winter. Because the dangers are great to persons who collect and eat wild mushrooms indiscriminately, beginners are urged to learn well each species they wish to sample by collecting and observing it several times before they eat any of it, and then to eat only one kind at a time. Only firm, clean young mushrooms should be gathered. Arbitrary "tests," such as putting a silver spoon in the dish to see if it tarnishes, are unreliable. Since persons differ markedly in their tolerance to mushroom poisoning there is no single reliable artibrary test short of very judicious sampling.

*See* also AGARIC; AMANITA; FUNGI: *Basidiomycetes* (*Club Fungi*); STINKHORN.

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**MUSI,** the main river of south Sumatra, Indonesia, about 325 mi. long and with a drainage area of 24,500 sq.mi., largest of the island. Its source is in the western mountain range, near Kaba volcano in Bengkulu, at 2,200 ft. elevation. Its course is first south-southeast, then northeast, breaking through the mountains in the upper Palembang district and entering the Tertiary hill zone at Tebingtinggi. In the rainy season river steamers can travel up the Musi as far as the confluence with the Rawas, its largest tributary. Farther downstream, on the right, enters the Lematang. From there to the sea, the river is over 300 yd. wide and winds through the flat, swampy and forest-covered Sumatra plain. The Musi, together with the Ogan and Komering, which join the main river at Palembang and adjacent Pladju (petroleum refineries), has formed a large delta to the north, divided by several distributaries. The river has great depth from Palembang downstream, but near the mouth of the main navigation channel (Sungsang, the western branch) ocean vessels need pilots to avoid shallows at low water. (J. O. M. B.)

**MUSIC (ARTICLES ON).** The article MUSIC discusses the beginnings and evolution of musical art in the western world, the development of various genres and their relationship to the cultural patterns of the eras in which they arose. Among articles on the broad, social categories of musical performance are CHAMBER MUSIC; CHURCH MUSIC; FOLK MUSIC; and FOLK SONG, U.S.; articles on forms of music include OPERA; SONATA; SYMPHONY; and VARIATIONS. These articles outline the history of social categories and musical forms and the scope of the principal subdivisions of each.

The subdivisions are treated in greater detail in separate articles. For example, CHURCH MUSIC is supplemented by ANTHEM; CANTATA; CAROL; CHOIR; HYMN; MASS; ORATORIO; and PLAINSONG. Topics connected with OPERA are treated in ARIA; LEITMOTIV; and OVERTURE. Articles related to SONATA and SYMPHONY include CONCERTO; RONDO; SCHERZO; and SUITE. Related to the forms mentioned above, but somewhat apart, are FUGUE; INCIDENTAL MUSIC; PROGRAM MUSIC; and SONG.

Musical theory is described in such major articles as COUNTERPOINT; HARMONY; MELODY; MUSICAL FORM; PITCH, MUSICAL; RHYTHM; and SCALE. Aspects of performance are described in CONDUCTING; EXPRESSION, MUSICAL; and SINGING, which is supplemented by VOICE.

Articles associated with the recording of music in visual symbols include MUSICAL NOTATION; SCORE; and TONIC SOL-FA. Teaching is dealt with under MUSIC, TEACHING OF; centres of learning, societies for the propagation of music and other bodies are listed in MUSICAL SOCIETIES AND INSTITUTIONS.

The article MUSICAL INSTRUMENTS discusses the categories of instruments and their classification. Supplementary articles include ELECTRONIC MUSICAL INSTRUMENTS; PERCUSSION INSTRUMENTS; STRINGED INSTRUMENTS; WIND INSTRUMENTS; and articles on each instrument—*e.g.,* BASSOON; BUGLE; CLARINET; DRUM; HARPSICHORD; HORN; ORGAN; PIANOFORTE; VIOLIN FAMILY. Articles on related topics include BAND and ORCHESTRATION.

Articles discussing the mechanical reproduction of music include BROADCASTING; HIGH-FIDELITY SOUND SYSTEMS; TAPE RECORDING, MAGNETIC; PHONOGRAPH: *Phonograph Music;* and TELEVISION. The physical basis of music is treated in ACOUSTICS OF BUILDINGS; HEARING; and SOUND.

Music of earlier civilizations is described in BYZANTINE MUSIC; GREEK MUSIC (ANCIENT); and MUSIC IN ANCIENT CIVILIZATIONS. Oriental music is described in ORIENTAL MUSIC and in the separate articles CHINESE MUSIC; INDIAN MUSIC; and JAPANESE MUSIC. The article AFRICAN MUSIC deals largely with ethnological researches.

The life and work of each of the prominent figures in music—composers, theorists and executants—are dealt with in biographical articles under each person's name; *e.g.,* BACH, JOHANN SEBASTIAN; MELBA, DAME NELLIE; STRADIVARI, ANTONIO; WALTER, BRUNO; WOLF, HUGO.

The lists given above are intended merely as examples of the arrangement of material. For a comprehensive list of articles, also sections of articles, dealing with each topic, the Index should be consulted.

**MUSIC.** The word "music" comes from the Greek *mousike* by way of the Latin adaptation *musica.* The Greek word is itself derived from *mousa,* "muse," and hence was applied to all branches of art over which the muses were supposed to preside. In the instruction of the young, *mousike* was roughly equivalent to what in modern times would be called a liberal education, as opposed to *gymnastike,* which was concerned with the development of the body (the modern "gymnastics"). This conception survived in the Roman world, so that *ars musica* could mean either music or poetry; but it did not prevent "music" from being used in the specific sense now given to it. The use of a comprehensive term of this kind implied particularly a close connection between music and poetry that has survived to the present day. We still speak of the "music" of verse, and the word "rhythm" (from the Greek *rhythmos,* meaning "regular motion") is common to both arts. It is characteristic that St. Augustine's treatise *De musica,* in the form in which it has come down, is concerned almost entirely with metrics.

This article is divided into the following five main sections:

I. The Phenomenon of Music
II. The Language of Music
III. The Rise of Music in the Western World
IV. The Evolution of Musical Style
V. Music in the 20th Century

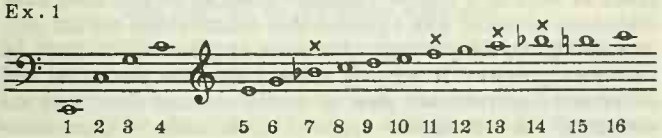
## I. THE PHENOMENON OF MUSIC

Augustine defines music as *ars bene modulandi,* and this definition was repeated by several medieval theorists. The verb *modulor,* which has nothing to do with the modern use of "modulation" as a technical term, implies the observance of some kind of measure: hence it was applied to dancing and also to singing and playing. Augustine's definition means that music is the art of controlling (or organizing) sounds properly; *i.e.,* not merely in a way that is technically correct but in a manner that satisfies the moral sense. This art, he says, should also be called *scientia,* since it is not sufficient to be able to do a thing: one must know why one

does it. This is the distinction between the performer who sings by ear and the trained musician. The definition may seem in some ways too narrow, in others too broad. It appears to lay more stress on the exercise of intellect by the performer than on the enjoyment derived by the listener (though Augustine does not wholly exclude this in his subsequent discussion), and it emphasizes morality in a field we should be inclined to regard as proper to aesthetics. It also leaves out of account the question of invention, which might be considered fundamental in any discussion of music. At the same time, by insisting on "control" it does establish a principle that underlies the art of music throughout the history of civilized man. This principle is all the more important since the raw materials of music exist already in nature and can be analyzed in mathematical terms.

The science of acoustics was formulated by the Greeks, though they were not necessarily the first to discover it. It was accepted by the Romans and from them passed on to the medieval theorists, whose treatises devote what might be considered a disproportionate amount of space to the subject, though their mathematics were not always impeccable. The basis of all acoustical study is that sound is produced by the impact of vibrations on the ear. These vibrations may be produced by elastic material—such as a stretched string, a taut skin or a solid body—by a column of air in a pipe, or by electricity. The rate at which vibrations occur will depend on a variety of factors: in the case of elastic material these will include length, thickness, tension and density. A short string of the same thickness, tension and density as a longer string will vibrate faster and produce a note of a higher pitch. But a string does not vibrate only as a whole: it also vibrates in sections, each of which produces a different note, though these are not normally heard independently of the principal note unless they are artificially isolated. These notes fall into a series, the members of which are progressively closer to each other as the sections get smaller. The first 16 members of the so-called harmonic series are as follows:

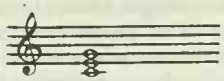
Ex. 1




The relationship of one note to another—the interval between them—is expressed in terms of a fraction composed of the numbers assigned to them in the series. Thus the interval of an octave (the first two notes in the series) is $\frac{2}{1}$ or 2, the interval of a fifth is $\frac{3}{2}$, a fourth is $\frac{4}{3}$, and so on. The addition of one interval to another involves the multiplication of their ratios: thus the addition of a fifth to a fourth produces an octave: $\frac{3}{2}\times\frac{4}{3} = \frac{12}{6}$ or 2.

This is straightforward enough, and it is easy to see that what is known as the major triad:

Ex. 2

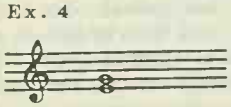


composed of a fifth divided unequally into a major third:

Ex. 3

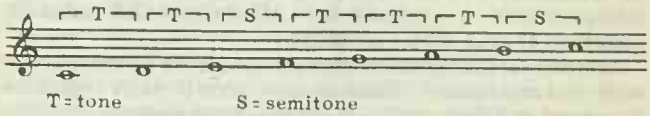
and a minor third:

Ex. 4



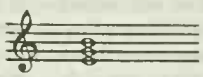
occurs as no. 4, 5 and 6 of the harmonic series. But the relationships are not always so simple as this. Some of the notes in the series, marked with a cross in the example above, are out of tune with the diatonic scale (composed of an irregular sequence of tones and semitones), which is the basis of western music:

Ex. 5



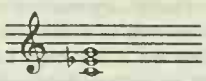

Furthermore, the first two intervals of the diatonic scale (C–D, D–E) have different ratios in the harmonic series: C–D is $\frac{9}{8}$, D–E is $\frac{10}{9}$, though when multiplied together they produce $\frac{10}{8}$, or $\frac{5}{4}$, which is the ratio of the major third. It is also noticed that though the minor third (E–G) occurs as the ratio $\frac{6}{5}$ and the minor triad:

Ex. 6



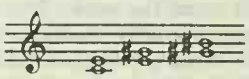
occurs as no. 10, 12 and 15 of the series, neither of these include the fundamental C or its octave; in other words, the minor triad with C as its lowest note:

Ex. 7



cannot be derived from the harmonic series. Even greater difficulties occur if three major thirds are added together:

Ex. 8



The combined ratios will be $\frac{5}{4}\times\frac{5}{4}\times\frac{5}{4}$ or $\frac{5^3}{4^3} = \frac{125}{64}$, whereas C–C (which is the same as B♯ on the piano) is 2 or $\frac{128}{64}$; in other words, B♯ is flatter than C.

The last example is an extreme case, since the identity of B and C properly exists only on keyboard instruments and is not normally accepted by orchestral players, who make a minute distinction between the two notes. But even if equal temperament, that is the tuning of all the semitones in the octave to the same ratio (*see* TEMPERAMENT, MUSICAL), is left out of account, it is evident that musicians have never been tied to the materials offered them by nature. They make a selection from those materials on principles that are governed not by mathematics but by the human ear. The fact that oriental musicians use scales different from those of the west does not weaken the argument: on the contrary it strengthens it by showing that more than one kind of selection is possible. Selection is, therefore, the primary way in which human beings control the raw material of sound. But control goes further than this. If music is to be anything but indiscriminate sound there must be an ordered arrangement (1) of single sounds in succession, which is called melody; (2) of sounds in combination, which is harmony; and (3) of sounds, whether single or combined, in a temporal association that constitutes rhythm. The choice of medium, whether vocal or instrumental, is a further example of necessary arrangement, but it is subordinate to the other three since it cannot exist without them. The purpose behind such ordered arrangement is to make music intelligible, since art is not merely self-expression but communication. Like all other human activities it has a social function and cannot operate in a vacuum. But the artist aims at more than intelligibility. He seeks also to create something beautiful and in doing so to stir the emotions of others. Music can do this more effectively than any other art, since its impact is direct. It does not

normally rely on any association with the world around us nor does it employ the familiar concepts of language. The "meaning" of music cannot be expressed in extra-musical terms, since it resides in the music itself. It follows that the progress of any piece of music must be logical. But the logic does not consist, as in language, of a series of propositions that commend themselves to reason: it is rather a form of coherence that makes the succession of ideas appear inevitable.

This does not imply the immediate acceptance of any piece of music by every listener. There are many ways in which sounds can be ordered, and these vary from age to age and from one composer to another. The greatest stumbling block to appreciation is an unfamiliar idiom. This is true not only of contemporary music but of a good deal of the music of the past. The man who has never heard any music earlier than Bach may very well be puzzled by a 16th-century madrigal and will almost certainly find it difficult to come to terms with a 13th-century motet. Since music must be intelligible before it can be enjoyed, there are many cases where the listener cannot be content with a passive attitude but must himself make an effort to come to terms with the composer. Even then there is no guarantee that he will appreciate what others find beautiful. Reactions to music depend on a variety of factors, some of which have no connection with music at all. The common acceptance of certain composers as great masters has led to the illusion that every music lover has an obligation to enjoy their music; but temperamental differences may very well make this impossible.

It is a platitude, but a necessary one, to say that music is sound. The greater part of literature is meant to be read. The reader may hear mentally what he is reading, but the sounds are not audible. The fact that music employs symbols on paper makes it possible for expert musicians to get an approximate idea of the sounds those symbols represent; but reading a score is no substitute for hearing the actual sound. Furthermore, no two performances of the same work, even if given by the same performers in the same hall, will sound the same. It is one of the disadvantages of the phonograph record (and also of electronic music) that it perpetuates a single performance and does not allow the listener the stimulus that comes from hearing a different interpretation. No doubt in theory there is only one ideal interpretation of any piece of music and composers sometimes imagine that they know what it is; on the other hand their performances of their own works often diverge considerably from the requirements that they themselves have laid down, or alternatively they ignore or exaggerate elements that an impartial observer would regard as of greater or less importance. Composers depend on interpreters, since this is the only way in which the sounds they have imagined can be made alive to others. In the act of composition they often act as their own interpreters, testing their ideas by playing over what they have written or stimulating their imagination by improvisation. The emotional impact made on the listener by any piece of music derives from two sources—from the composer's ideas and from the concrete form they assume in performance.

It follows that the ear is of prime importance, not only for the listener but also for the composer. And since all composers hear a great deal of music before they embark on serious composition themselves, tradition plays an important part in the development of music as an art. The basic materials of western music have never changed. Though the resources of the diatonic scale have been enormously extended in the course of centuries, it still remains a fundamental element in musical thought. Attempts have been made to exploit the use of intervals smaller than a semitone, but these have remained mere experiments that have had no influence on composers in general. However far back we go in written records we meet with music employing materials that are intelligible today; and the survival of folk songs, sometimes for several centuries, is sufficient indication of the way in which melodic formulas can appeal to successive generations, whatever social changes may have come between. For this reason it is tempting to go further and pursue the history of music to its remote origins. The attempt is doomed to failure because there is no certain evidence other than written records, and the earliest of these date from several centuries after the birth of Christ, apart from a mere handful of examples of Greek music that convey virtually nothing. The fact that music is widely cultivated by primitive tribes suggests, what would in any case be probable, that such cultivation goes back to a period far remote in time. But even the most primitive societies existing represent a relatively advanced stage of human development, which means that even dubious analogy is insufficient to help in determining the part played by music in the lives of our savage ancestors. All that remains is an unlimited field for conjecture.

These difficulties have not prevented historians from tackling the problem of origins. The solutions they offer range from the improbable to the plausible. Was music originally vocal or instrumental? Arguments are not wanting to prove either proposition. Since birds sing, it has been suggested that human beings made efforts to imitate them. But there is no direct connection between birds and man in the scale of evolution, and the mammals nearest to man do not produce intelligible sounds. Nor is there any evidence that song originated in mating cries, as Charles Darwin believed, and hence played its part in sexual selection. Song may have had its origin in loud cries appropriate for battle or the chase, but it is not clear how such cries developed into a continuous fabric of sound. The fact that pitch is of prime importance in many languages today, to the extent of affecting the meaning of words, may suggest that speech and song have a common origin. Against this it is argued that rhythm is a fundamental element in music and that speech is not naturally rhythmical. Regular rhythm would be suggested by bodily functions, particularly by the natural tendency to walk in step. Hence if primitive man discovered the possibilities of producing sound by hitting resonant bodies it would be natural for him to organize these sounds into rhythmical patterns similar to those he observed in his daily activities. Nor does the importance of rhythm exclude a vocal origin, since labour can be lightened by singing and it is easier to work to a regular rhythm. Theories of this kind have often been advanced with a passion that assumes they are the only true answers to the problem. But none of them can claim to be scientifically exact. It is by no means impossible that vocal and instrumental performance grew up side by side and developed imperceptibly into the various types of music, some of them complex, that are found among primitive peoples today.

The practices of such peoples are now so fully documented that it is possible to formulate some generalizations about them. But such generalizations can easily lead to false conclusions. Types of primitive melody range from recitation on a single note to tunes with wide skips, abrupt descents from a high note to a low one, imitation of various kinds and polyphonic structures. It would be tempting to arrange these in an evolutionary order, on the assumption that the simple is older than the complex; but there is no means of deciding whether this is a correct analysis, and the experience of later music, where a complex style is often succeeded by a simpler one, suggests that the principle has no validity. What is common to all primitive music is a close association between words and music, where words exist, and an element of magic. The association between words and music is found also in the field of European folk song. A folk singer is normally incapable of reciting the words of a song without the music: for him text and music form an indissoluble complex, and this remains true even if the words become corrupted or modified by faulty tradition. (*See* FOLK MUSIC.) There is also a close association between a song and the circumstances in which it is sung. Singers from primitive tribes are reluctant or even unable to record a song in a studio because the conditions are divorced from the world to which the song belongs. The element of magic is closely bound up with these associations. For primitive man music is not merely recreation or a form of self-expression but is an integral part of the world in which he lives—not merely the physical world that he sees around him but the spirit world that is symbolized for him by trees, rocks, animals and all natural phenomena. Through music he finds a link with the supernatural. The playing of instruments is a part of this identification. It creates more

than the natural excitement of the dance: it produces a kind of mystical intoxication and hence may demand the most complex rhythms. In all this there is a large element of improvisation. But constant repetition and the hardening of tradition will help to establish formulas that become common property; and in polyphonic music, particularly where strict imitation is employed, there is inevitably an element of deliberate design and conscious creation. Furthermore, modified repetition will create varied melodic cadences that will help create an intelligible structure.

These characteristics of primitive music have to some extent disappeared in the music of western civilization. The element of magic is the origin of music in religious rites: the fact that the word "charm" is derived from the Latin *carmen* (a song) is a reminder of this association. But this element vanished when religious services were conducted according to an established formula. Music became an accompaniment to religious observance—an enrichment of it, perhaps, but not in itself a means of attaining ecstasy. However beautiful it might be, it came to be regarded as a way of emphasizing the religious message; *i.e.*, as a form of edification. For this reason throughout the history of the Christian Church, whether Catholic or Protestant, there has been constant suspicion that music might produce results other than an inclination to holiness. When St. Augustine found himself enjoying the music in church, he was conscious of having sinned, because it took his mind away from holy things. Something of the same kind may have been in Handel's mind; he is reported to have said of a performance of *Messiah* that had been described as a "noble entertainment": "I should be sorry if I only entertained them, I wish to make them better."

Milton, in *Il Penseroso,* equates the pleasure to be derived from hearing music in church with religious experience:

> There let the pealing Organ blow,
> To the full voic'd Quire below,
> In Service high, and Anthems cleer,
> As may with sweetnes, through mine ear
> Dissolve me into extasies,
> And bring all Heav'n before mine eyes.

On the other hand Pepys, ravished by the sound of wind music in the theatre, was reminded of the time when he was in love with his wife. The truth would seem to be that the emotions music excites may be channeled in various directions according to the listener's temperament or environment. The intensity of experience that music can create may lead us to become better citizens or even saints, or it may encourage an irresponsibility that regards all moral restrictions as mere pedantry. There may be occasions when it produces something like the intoxication of primitive man. But this is not a common experience. As Shelley says, "Rarely, rarely comest thou, spirit of delight." For the most part, music merely provides pleasure. The simplest kind of pleasure comes from hearing the sound of an instrument or a voice, irrespective of what is being performed. For some people this is the height of enjoyment, provided the music presents no problems. But it is neither a substantial nor a lasting pleasure, and it is limited by the endowments of individual performers. At a more advanced level there is the pleasure afforded by a melodic line reinforced by harmonies that may not be fully understood but nevertheless contribute to the pleasure insofar as they do not, by capriciousness or unfamiliarity, disturb appreciation of the melody.

Many listeners go little further than this in their enjoyment of music. Their appreciation of a large-scale work depends on their ability to isolate agreeable melodies from the texture and to recognize them when they recur. The trained listener, however, expects more than this. He takes pleasure in the interweaving of melodic strands, in harmonic progressions that lead decisively from one point to another, in the relevance of one section of a composition to another, and in the impression that a piece of music as a whole is a complete work of art, organized with meticulous care for detail by a master craftsman.

The composer's task lies precisely in this work of organization. In Wagner's opera *Die Meistersinger,* Walther, who is young and impetuous, cannot see why mere beauty of sound is not enough:

> Ein schönes Lied, ein Meisterlied:
> Wie fass ich da den Unterschied?
> (A beautiful song, a Mastersong:
> How shall I tell the difference?)

Hans Sachs explains the hazards of inspiration: it may seem sufficient when you are young but it is an insecure foundation on which to build a creative life. For the composer, ideas, wherever they come from, are only the beginning. They have to be shaped into something that is coherent and consistent and will afford aesthetic pleasure precisely because the music has an inner logic that makes its progress seem inevitable. Music exists in time and hence the composer has the peculiar problem of organizing a sequence of sound patterns that he and his listeners can hear only as a succession. He cannot, like the painter, stand back from the work he is creating and see it simultaneously as a whole. For him, and for his listeners, there must be links that accept the fact that music is a succession of sounds; the links will turn this limitation into a positive advantage. It is here that there is to be found a connection between the methods of music-making in primitive and in modern civilized societies. The repetition of patterns, the variation of those patterns and the power of rhythm to unify diverse materials are fundamental to the art of music at any stage. To these may be added the principle of contrast, which does not necessarily figure in primitive music but is essential in any work not based on a single formula.

The ordering of musical material in accordance with these principles constitutes the *ars bene modulandi* or, as Augustine further defined it, the *scientia modulandi.* To this essential knowledge is commonly given the name "technique" (from the Greek *techne,* which originally meant the skill of a handworker). It might also be called "craft," which originally meant "strength" (as the German *Kraft* still does), or even the obsolete sense of "cunning" (from the verb "can") might be revived. But "cunning," in spite of the psalmist's "Let my right hand forget her cunning" and Milton's "With wanton heed, and giddy cunning" (applied specifically to music), has generally acquired a sinister significance; and "craft" is also applied to activities that may involve skill but do not properly belong to the sphere of art. Technique is knowing how. The composer acquires it in two ways: from studying the work of others and from his own experience. There are no rules in art, there is only practice. Hence the work of other composers is a sound guide to procedure, not as a mere model for imitation but as a demonstration of the way in which certain practices have proved again and again to be artistically satisfying. No one can learn from studying earlier music how to get out of difficulties, since the finished work presents us with something in which all difficulties have been resolved. If we want to go into the composer's workshop and stand by his side we shall have to study sources like Beethoven's sketchbooks; and sources of this kind are not always available. What can be learned from completed works is the way in which an experienced composer achieves coherence and consistency by methods that he has proved by experience will guarantee success. The fact that idioms change from one century to another does nothing to weaken the value of such study, since the handling of any idiom involves problems and it is the solution of those problems that provides the necessary lesson. The composer learns also from his own experience; *i.e.*, from a process of trial and error that eventually gives him the assurance that he can do what he wants to do. The impatient student is apt to think, like Walther in *Die Meistersinger,* that originality is all that matters. But his own ideas, however fruitful they may be, will not teach him the lessons he will learn from the past. He learns how to be truly himself by studying the ways in which his predecessors expressed their personality in terms over which they had complete control. For this reason Schoenberg insisted that his pupils should have a firm grounding in "traditional harmony," and many other teachers in the 20th century agreed that this was an essential part of a composer's equipment.

Improvisation, which plays such an important part in primitive music, has never disappeared entirely from music-making. It not only helps to stimulate the composer's invention; it also offers opportunities to the performer in the ornamentation of operatic

arias in the 17th and 18th centuries, in the cadenza of the classical concerto, and in modern works that supply the interpreter with the equivalent of spare parts and leave him to assemble them as he wishes. (*See* IMPROVISATION; ORNAMENTATION.) But by far the greater part of the music of the western world tells the performer more or less precisely what he is to do, and it does this by a system of written symbols. The use of such symbols came into existence as a matter of practical necessity. The notation employed by the Greeks seems to have been forgotten in the early centuries of the Christian era and for a time nothing was found to replace it. As long as the activities of the western church were confined to a fairly limited area, the music of the liturgy could be handed on by oral tradition, and as a result it became familiar through constant repetition. But as Christendom extended its borders it became increasingly important to ensure that the tradition was accurate. For this purpose a series of symbols borrowed from the Greek accents (acute, grave and circumflex) was used to remind singers of the contours of melodies they had already learned by ear. By placing these symbols at different heights the copyists found a more precise way of indicating these contours, and the ruling of one or more lines served as a further guide to the eye. For a long time the use of such notation seems to have been confined to the church, but by the 13th century it had been adopted also for secular music, long the jealous preserve of itinerant musicians. By this time also it had been found advisable to find a means of indicating rhythm, an absolute necessity when two or more parts were being sung at the same time. In this way musical notation developed by gradual stages until it gave a clear picture of what the performers had to do. (*See* MUSICAL NOTATION.) A later refinement which developed in Italy in the 17th century was the indication of speed and dynamics, principally for instrumental music, where such details were likely to be less obvious. From Italy this practice spread over Europe, with the result that Italian terms remained the lingua franca of music, though later composers of other countries have often used their own language, either through patriotism or through indolence. In the late 18th century the use of expression marks (*piano, forte, crescendo,* etc.) became much more frequent, and from the 19th century onward developed into the detailed annotation of every bar of the music with a view to securing the interpretation the composer had in mind. The scores of Mahler, for example, are lavishly sprinkled with indications that not only tell the performers what to do but frequently warn them against doing something the composer had not intended; *e.g.,* injunctions such as *nicht eilen* (do not hurry) and *nicht schleppen* (do not drag) are constantly occurring. (*See* EXPRESSION, MUSICAL.)

In spite of this precision, which extends in more recent compositions to refinements of rhythm that the ear can hardly appreciate, a good deal still depends on the interpreter. It is his task not merely to observe the more or less mechanical instructions provided by the composer but also to discover and recreate the emotions implicit in the music. To do this adequately demands a very high degree of sensitivity. It also calls for an intimate knowledge of varying styles and an understanding of the circumstances for which music was composed. The older the music, the more difficult is the interpreter's task, not merely because indications of tempo and expression will be sparse or wholly lacking but because the whole aesthetic of a past age will be unfamiliar. The interpreter needs to have a historical sense—to discover, for example, by prolonged study and by the exercise of his own imagination what Beethoven's symphonies meant to his contemporaries. Ideally the listener should approach music in the same way, though very few music lovers are able or willing to make the attempt. At the same time mere historical accuracy will not ensure a good performance. It is inevitable that some of the atmosphere in which the music of the past was created should be irretrievably lost. We listen to Beethoven with ears that are familiar with a great deal of later music and cannot be expected to rid our minds wholly of these associations. But since all great works of art have the capacity to excite later generations, the interpreter has the task of making his performance as vivid as possible, without willfully imposing his own ideas on the music or weakly accepting artistic conventions of a later age. Insofar as he is the medium through which the written symbols are translated into sound he is the servant not of the public but of the composer.

Much of the music of the past was written to supply a demand. The demand might come from an established organization like the church, from a ruler who needed entertainment for his court, or from the public who merely wanted to hear something new. The enormous mass of church music, operas and symphonies that survives is evidence of the extent to which the art was dependent, until the 19th century, on patronage of one kind or another and on commercial exploitation. To some extent this system helped to establish a common denominator of taste and to encourage the belief that contemporary music was the best, except in the church, where tradition served to maintain a certain amount of older music in use. In the course of the 19th century conditions changed. The old sources of patronage declined, and composers came more and more to regard the composition of music as a means of self-expression, though without ignoring the possibility of pleasing the public. This does not mean, however, that the older composers were unaware of the demands of expression. Their constant activity, the equivalent of a kind of musical journalism, perfected their technique and kept them in practice; but it did not stultify their imagination, and since most of them were also active as performers and conductors they led in many ways a fuller life than the modern composer who is occupied exclusively with creation. There is no single recipe for the production of a masterpiece. The stimulus may come from a commission or arrive unbidden from the brain; but whatever its origin it cannot lead to anything worthwhile unless it is pursued with a live imagination and a reliable technique.

The quality of a piece of music depends on a variety of factors; but it is not to be measured by size. A Beethoven symphony may appear more imposing than a song by Henry Purcell and it is bound to make greater demands on the listener. But there is only one standard of perfection and it may be as difficult to achieve in a miniature as in a large-scale work. The smaller the canvas, the more serious is the problem of achieving a perfect balance between form and matter. This balance is the most serious task that faces the composer. It can never be a mechanical operation because the matter to a large extent determines the form. Though the basic principles of musical composition remain unchanged, as has been shown, there are innumerable ways of applying these principles to a particular work. Many 18th-century symphonies have a family likeness, but they are not mere copies of a stock pattern. The genuine composer does not construct a blueprint and then proceed to fill it with sound. The material he has invented will itself suggest the way in which it is to develop, and this development may also lead imperceptibly to the invention of further material that had not been foreseen at the outset but supplies a logical extension of the original ideas. In all this the composer relies on the listener's capacity to remember what he has heard and so to associate one part of the composition with another. This is particularly necessary where there is a recapitulation of material. Such recapitulation is not mere repetition: it must come to the listener with the force of something that is already part of his experience. It was a great part of Wagner's achievement to realize more completely than any of his predecessors how strong the emotional impact of such recollection could be and to exploit this association in opera. The extension of his methods to purely instrumental music proved successful when it was based on a truly musical impulse. Where composers tried to establish an association between their material and extra-musical ideas it was unfruitful, unless this concrete association was a side issue that could be disregarded. It is possible in music to imitate a limited number of the sounds of the everyday world, but this is not its function. Its principal service to humanity has been to establish an emotional link between the composer and his fellow men; and this remains true whether it has been written for the glory of God or merely for entertainment. As Beethoven wrote over the Kyrie of his *Missa solemnis: Von Herzen—Möge es zu Herzen gehen* ("From the heart—may it reach the heart").

## II. THE LANGUAGE OF MUSIC

Strictly speaking, it is false analogy to talk of the language of music. Music is made up of individual notes just as spoken language is made up of individual words. But the notes, unlike the words, do not have any significance in themselves. Words like "house" and "love" have associations, whether they form part of a sentence or not. But a single note played on the oboe has no "meaning" at all, though the beauty of the playing may provoke an emotional response. The same is true of chords. The most familiar of all chords—the major triad—conveys nothing in isolation. We are accustomed to hear it as the final chord of a composition, but there are many other ways in which it can be used, and it is not possible for the listener to grasp its significance until he hears where it is going or what it has followed. A C major triad can be equally the tonic chord in the key of C major:

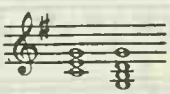
Ex. 9

the dominant chord in the key of F major or F minor:

Ex. 10

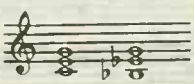
or the subdominant chord in the key of G major:

Ex. 11



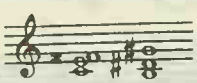
and these simple examples by no means exhaust its possibilities. Apart from its obvious uses within the orbit of the diatonic scale, it can be made to pivot on one of its notes like this:

Ex. 12



or by an enharmonic change (*e.g.*, writing G as F 𝄪) it can be turned in a wholly unexpected direction:

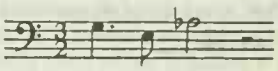
Ex. 13



Chords may, of course, suggest associations to the experienced listener, and strongly dissonant chords may stir an emotional reaction in the mind—a fact that has often been exploited by opera composers. But they do not mean anything by themselves. It is true that many words have more than one meaning. Without the context we do not know whether "bank" means the side of a stream or a countinghouse. But this does not alter the fact that words in isolation do have a meaning, whereas notes and chords have to be heard in succession.

In a series of notes or chords the resemblance to language is closer. Certain melodic and harmonic formulas can acquire such wide currency that they have something like the same effect as familiar phrases composed of words, though the number of such formulas is necessarily limited at any one period. Just as we often know what a person is going to say after hearing the opening words, so it is often possible to foresee the direction in which a composer is going. But there is no equivalent in music to the moods of language or to the difference between question and answer. It is quite impossible to construct a musical phrase that suggests an imperative or asks a question. Many composers have found ways of setting questions to music in a way that matches the direction of the words. But it is not possible to do this with any certainty in instrumental music. There is nothing in Schumann's *Warum?* that would lead one to suspect the title of the piece. Beethoven wrote the words *Muss es sein?* ("Must it be?") under a phrase in the last movement of his string quartet in F major, op. 135:

Ex. 14




but without the inscription it would not be possible to know that a question was implied. Superficially the longer phrases used in music may appear to be the equivalent of language; but they do not convey information or state propositions—they are self-sufficient. Nor is it true that music is an international language, though there have been periods when the music of a particular country has been widely accepted. National temperament often rebels against music conceived in a different climate; what seems notable and dignified to one race may strike another as merely pompous, and music that is thought in one country to be infectiously gay may be regarded elsewhere as frivolous.

The three basic elements of music are melody, harmony and rhythm. Melody, as it is known in western music, consists of a series of single notes deliberately arranged in a pattern and chosen from a pre-existing series that has been handed down by tradition or is accepted as a convention. It need not be in a regular rhythm, but it is impossible for it to be entirely unrhythmical, since notes have duration in time and some are likely to be shorter than others. The existence of a pre-existing series, which is called a scale, is characteristic of civilized or sophisticated music. Historically, however, melodic formulas precede scales, and awareness of a scale develops only when a number of melodic patterns of the same kind are compared and analyzed. The individual character of a scale is derived from the order in which its intervals occur.

Greek music of the 4th century B.C. was based on a descending scale of four notes, hence known as a tetrachord (*see* GREEK MUSIC [ANCIENT]: *Theory*). The form most familiar to us may be represented in modern notation as follows:

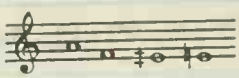
Ex. 15

This was known as the diatonic tetrachord. The superimposition of a similar tetrachord a fifth higher resulted in a complete scale covering an octave. Two other forms of tetrachord were also in use, the chromatic ("coloured"):

Ex. 16

and the enharmonic (the sign 𝄲, employed here, indicates that the first E is a quarter tone higher than the second):

Ex. 17

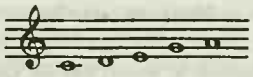


There was also an older form of the enharmonic tetrachord, which omitted the quarter tone interval:

Ex. 18

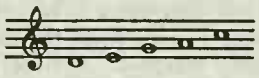
The last three examples all contain gaps wider than any interval of two consecutive notes in the modern diatonic scale. Melodies employing what is often called a "gapped" scale occur frequently in primitive music. A particular form of such a scale is one that has no semitones and is known as "pentatonic" because, apart from the duplication of the lowest note an octave higher, it has only five notes. These five notes occur in various orders, *e.g.:*

Ex. 19



or

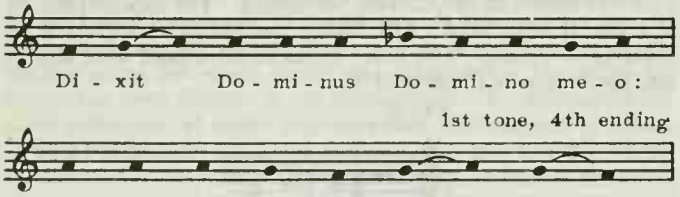
Ex. 20



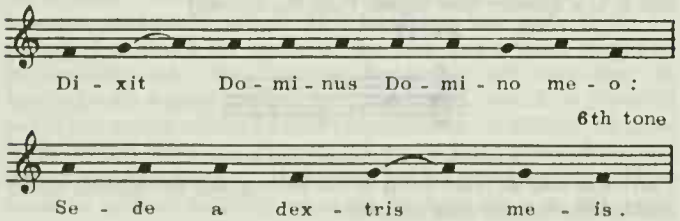
and in one form correspond to the intervals between the black notes on the piano. Pentatonic melodies are found in the traditional music of countries as far apart as China and Scotland and in the earliest forms of a number of Gregorian chants. It is important to realize that though the scales on which they are based may be described as "gapped" there is no gap in the sense that anything is missing. The scales are complete in themselves and merely have fewer notes than the diatonic scale. (*See* SCALE.)

Melody implies rise and fall. A succession of notes of the same pitch is not a melody, though it can be effective if accompanied by changing harmonies: it is simply recitation. Musical recitation of this kind plays a large part in many religious observances. It is the basis of what is almost certainly the oldest Christian music surviving—the singing of the psalms, which ultimately derives from Jewish practice. The formulas to which the psalms are sung in the Catholic Church are traditionally grouped into a series of eight (known as psalm tones), some of which have a number of alternative endings. Three of the tones have A as the reciting note, three have C, one has F and one has D. This limited selection may itself suggest a pentatonic origin. The simple reciting note is modified (1) by an initial rise from below in the first verse of the psalm, (2) by an inflection in the middle, and (3) by the cadence (which, as the word implies, descends) at the end, *e.g.:*

Ex. 21

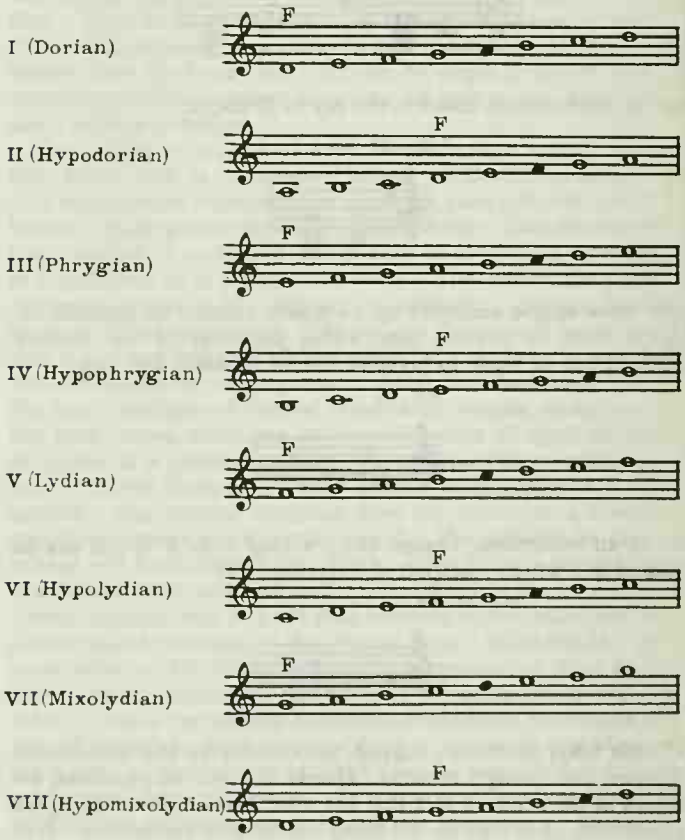



Ex. 22



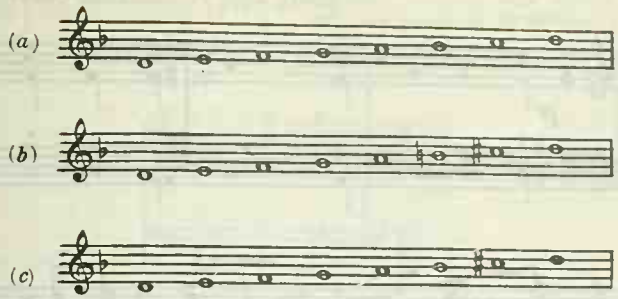

The two examples quoted have a close similarity, due to the fact that they have the same reciting note and move within a narrow range. The more elaborate melodies that form the bulk of the plainsong repertory have a much wider range and lay far less emphasis on the reciting note, which is, rather, a pivot round which the music is constructed. The character of a plainsong melody of this kind is determined by the note on which it ends. By the end of the 8th century the interval patterns resulting from these different endings had been classified into four groups, called respectively *protus, deuterus, tritus, tetrardus* (from the Greek names for "first," "second," "third" and "fourth"). The first group had its final note on D, the second on E, the third on F, and the fourth on G. These were the main (or "authentic") groups; but subsidiary (or "plagal") groups were also recognized, the melodies of which had a lower range than those of the "authentic" groups but ended on the same final notes. By the 10th century this classification had settled down into a systematic series of eight scale patterns, which were not only numbered consecutively but also mistakenly given Greek names. In each scale pattern (or mode) one of the notes (marked in black in the following table) was theoretically identified with the reciting note of a psalm tone. B was avoided as a reciting note on account of its ambiguous relationship to F (*see* MODES, MUSICAL). The complete table is as follows (the final of each mode is marked F):

Ex. 23



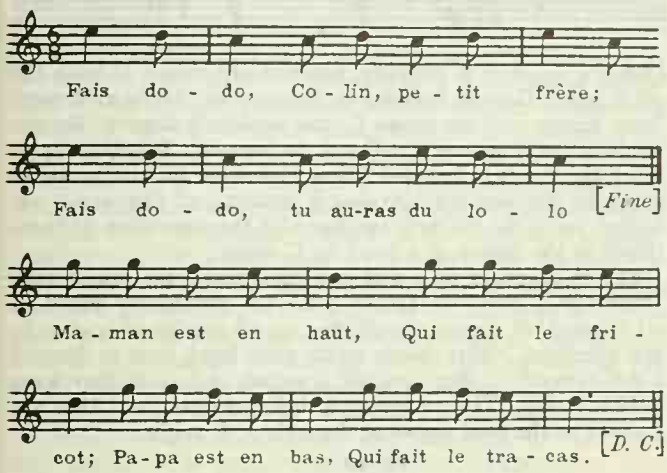

The sequence of intervals peculiar to each mode gave it its flavour; but in the course of the middle ages this flavour was more and more modified by the introduction of accidentals. In plainsong it was by no means uncommon to alter B to B♭ in the first and fifth modes, turning one into the modern minor scale and the other into the major scale, which in any case was well-known in popular music. In secular music, particularly in polyphony, the seventh degree of the first and seventh modes was frequently sharpened to give a smoother transition to the octave of the final, and this also helped to bring the modes nearer to the modern minor and major scales. By the time this process was complete, only two modes survived—the major and the minor, though the minor retained some of its medieval ambiguity and could exist in three forms:

Ex. 24




The psalm tones are not alone in moving largely by step. The same tendency is found in simple folk melodies; *e.g.*, in this cradle song from France:

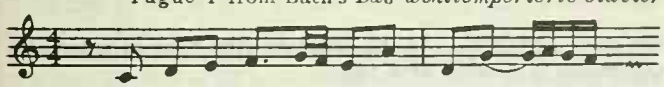
Ex. 25




It has sometimes been suggested that movement by step suggests tranquillity. It may very well do so; *e.g.:*

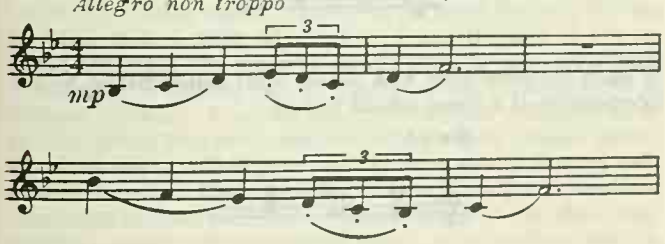
Ex. 26

Fugue I from Bach's *Das wohltemperierte Clavier*



Ex. 27

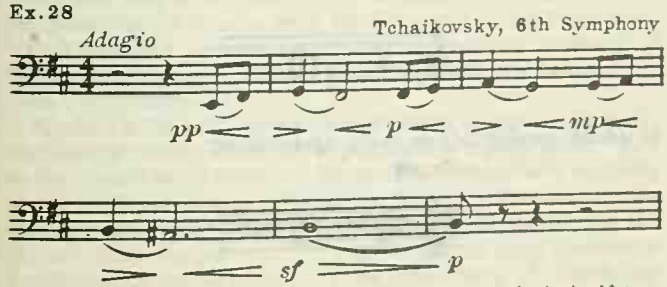
*Allegro non troppo* Brahms, 2nd Piano Concerto




But it may equally suggest an inability to get free, particularly in a minor key; *e.g.:*

Ex. 28

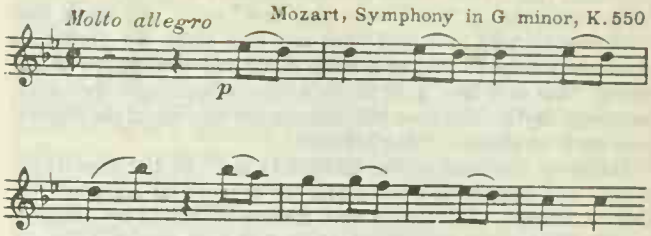
*Adagio* Tchaikovsky, 6th Symphony




and in a fast tempo it may suggest agitation, particularly if two notes alternate, as in the following:

Ex. 29

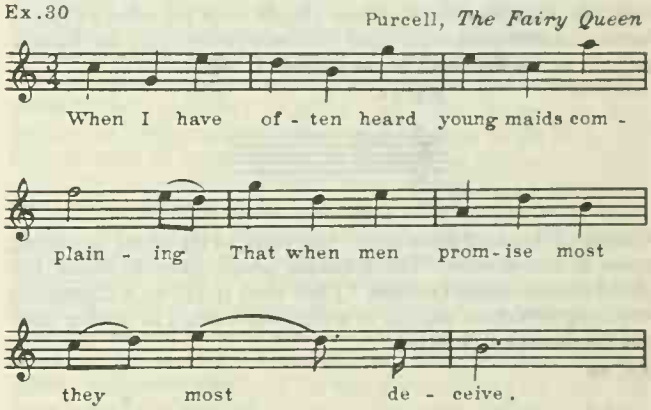
*Molto allegro* Mozart, Symphony in G minor, K. 550




The presence of other intervals, however, will inevitably affect the impression made by stepwise movement. In the last example, for instance, the rising sixth in bar 3 makes a powerful contribution to the feeling of agitation. It is the contour of a melody as a whole that gives it its character rather than the predominance of this or that interval; and, as in the Mozart example, this character may be further affected by the tempo. Intervals like the fourth and the fifth may suggest triumph or defiance because they recall the natural horn or trumpet, which are capable of playing only the notes of the harmonic series; but this is a matter of association rather than direct suggestion. A wide-ranging melody is just as able to suggest tranquillity as one that moves mainly by step. There is nothing incongruous in the tune that Purcell has set to the words "When I have often heard young maids complaining" from *The Fairy Queen;* there is rather a feeling of archness:

Ex. 30

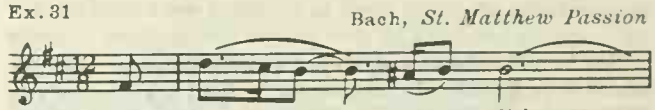
Purcell, *The Fairy Queen*




On the other hand a rising skip followed by a stepwise descent can convey a sense of pathos, because it somehow suggests an effort to reach what is unattainable; *e.g.:*

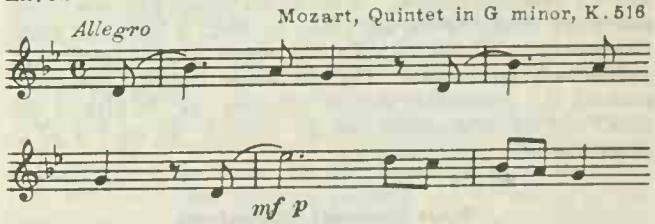
Ex. 31

Bach, *St. Matthew Passion*



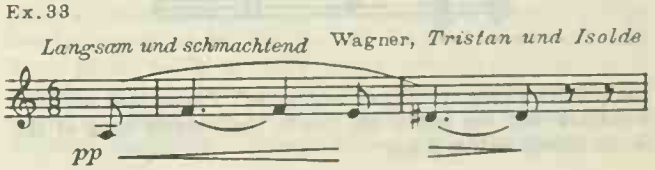

Ex. 32

*Allegro* Mozart, Quintet in G minor, K. 516




Ex. 33

*Langsam und schmachtend* Wagner, *Tristan und Isolde*

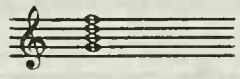


No doubt this is true largely because we think of pitch in physical terms, speaking of "high" notes and "low" notes, and music that rises purposefully to a high note and then sinks can produce a sensation similar to that of a lump rising and then falling in the throat. But even here, as in the other examples, tempo, dynamics, harmony, rhythm and even instrumentation may affect the impression made on the ear. (*See* MELODY.)

Harmony may well be the decisive factor. In any case its influence on a composition as a whole can be more far-reaching than that of melody. The length of a melody is limited by practical considerations: the ear cannot grasp it if it is extended beyond a reasonable limit. When it has had its say it must either give place to something else or be subjected to variation or development. Harmony, on the other hand, does not have to be tailored in this way. Though its progress over a long stretch must be logical, the ear tends rather to hear it in sections and then to link the sections together. Like melody it thrives on contrast: too much insistence on a few related chords can produce monotony, though this can be relieved by a vivacious melody or a spirited rhythm. And just as the tension of an upward leap in melody can be relieved by a stepwise descent, so the expressive power of dissonant harmony can be enhanced by following it with a simple consonance.

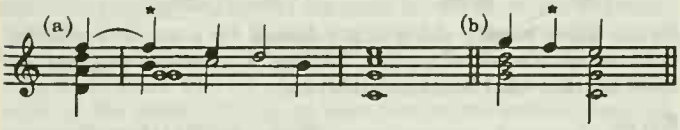
Dissonance and consonance, it should be added, are purely relative terms. Once a dissonance has become familiar it ceases to jar and at moments of tension it calls for a still stronger clash of sounds. The extent to which the ear can accept an unbroken series of such clashes depends, as in all listening, on familiarity with the idiom. Some chords once regarded as dissonances are now accepted virtually as consonances; *e.g.*, the diatonic seventh on the dominant of the key—in C major:

Ex. 34



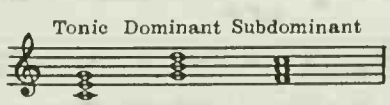
Chords of this kind arose in the first place as the result of passing notes or suspensions. The following progressions introduce the chord quoted above (marked *) but treat it (a) as a dissonance requiring resolution and (b) as a dissonance heard in passing from one consonance to another:

Ex. 35



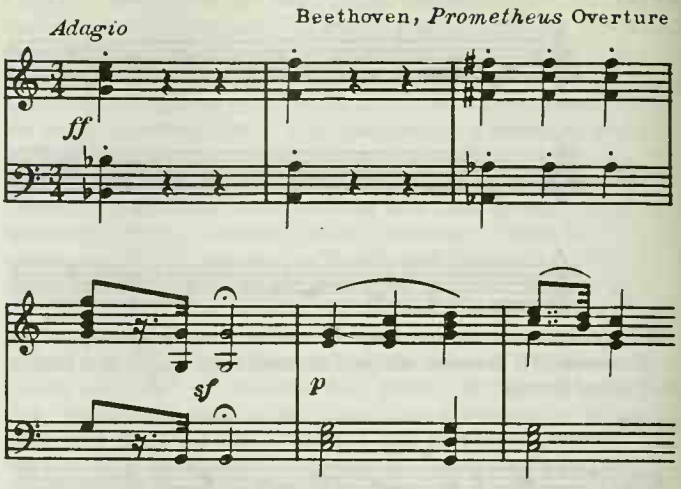

Chords, as has been seen, do not exist in isolation; they are related to each other. In other words, a chord is a function and its character and significance will change according to the direction in which it moves. Furthermore, by the extent to which it helps to establish or obscure the basic harmony of a piece it serves a structural purpose. A key in traditional harmony is not established simply by the key chord or tonic: it has to be made clear by the association with the tonic chord of other chords that are felt to be related to it. The two chords that most effectively establish this relationship are the dominant (on the fifth of the scale) and the subdominant (on the fourth). In the key of C major the three basic chords are:

Ex. 36




The tonality of the opening of Beethoven's *Prometheus* overture is obscure until the end of the fourth bar, because none of the chords clearly defines a key:

Ex. 37



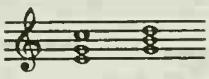

Once the sequence is complete, however, the unison G leads the ear to expect C major harmony in the next bar. If the movement began simply with the unison G, this would not happen: the ear would naturally assume that G was the keynote. It is the way in which the chords in bars 1–4 follow each other that helps one to grasp the direction the composer is taking; and this would not happen unless the ear were familiar with the association of these chords in the course of a piece in C major.

Chords consisting of a fifth and third above the lowest note (known as $\frac{5}{3}$ chords in figured bass) are particularly suited to act as points of repose, though they are all capable of leading in new directions. Other chords, on the other hand, seem to demand a step forward: if they conclude a section or a piece they seem to lack finality. There is always a choice of direction. Thus the $\frac{6}{3}$ chord on the third degree of the scale of C major:

Ex. 38

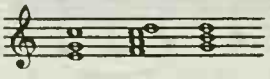
can move purposefully to the dominant (the basis of a familiar convention in classical horn parts):

Ex. 39



or reach the same point with almost equal determination by the interposition of a chord related to both:

Ex. 40

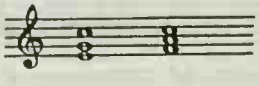


or plunge dramatically into a dissonance:

Ex. 41

or subside comfortably on to the subdominant:

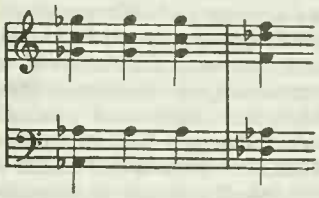
Ex. 42



Furthermore, as has already been seen, the expected progress of

any chord can be avoided by enharmonic change. If the chord in the third bar of Beethoven's *Prometheus* overture were written with a G♭ instead of an F♯ it could be expected to lead to a chord of D♭ instead of G:

**Ex. 43**



Devices of this kind are often used for modulation; *i.e.*, for changing from one key to another. But a mere progression of this kind will not establish a new key; to do that it will be necessary to create a new environment, to establish associations in the new key analogous to those that existed in the old.

All that has been said so far applies to music that is based on the diatonic scale, using chromaticism as a decoration or enrichment of the diatonic foundation but not as basic material for expression. In late romantic music, however, the diatonic foundation is sometimes so obscured by chromaticism that it virtually ceases to exist, at least temporarily. This has encouraged 20th-century composers to reject diatonic harmony altogether and to establish new relationships founded on the complete chromatic scale of successive semitones. This necessarily involves the abandonment of key but not the destruction of harmony as an element in the structure of a composition. Whatever idiom a composer uses he is compelled to relate harmonies to one another, even if the principles are entirely of his choosing, and he can hardly neglect the use of harmony to create tension or to suggest relaxation. The fact that the listener may not be able to grasp the principles on which chords follow each other does not mean that their succession is purely arbitrary. (*See* HARMONY.)

So far harmony has been dealt with merely as a series of complex and related sounds used to enrich a melody, to intensify its natural expression and to clarify its direction. But the harmony itself may be woven from melodic strands that imitate each other or are combined to create contrasts. Counterpoint, far from being merely an ingenious way of combining separate melodic lines, is a vital element in all music, even if it consists of nothing more than devising an independent and significant bass to a melody. The origin of the term is the Latin *punctus contra punctum* (point against point) and it was used originally to describe music in which two or more parts moved together in the same rhythm; but the inventive skill of medieval musicians found the way to a more varied treatment—by grouping several notes in one part against a single one in another and by combining two or more parts in different rhythms. From this practice developed various methods of composition that have remained valid down to modern times: motets in which added parts are skilfully woven round a pre-existing melody, canon (or strict imitation), fugue (where the theme that receives imitation is the foundation of the whole composition), songs and instrumental pieces on an *ostinato* bass (a short figure constantly repeated throughout the piece), double counterpoint (where what was at first the upper part becomes the lower, and vice versa) and so on. In all music of this kind the composer's problem is to weld his different melodic lines into a logical harmonic sequence and to secure sufficient diversity of rhythm to give clarity to his melodic lines and avoid stagnation. (*See* COUNTERPOINT.)

Rhythm is the third of the basic elements of music. It is not the same as metre, which, as in poetry, is a regular pulse. Just as the accents in poetry do not necessarily coincide with the beats of the metre, so in music, though the listener will be aware of a regular pulse, if only subconsciously, there is no reason why the rhythm should be tied to it. In fact there is far more freedom in music than in poetry because of the opportunity of introducing shorter note values than would be possible within the framework of metrical verse. If rhythm is identical with metre, the result may be monotonous, or it may be stimulating; it depends on other factors in the composition. Schubert's song "Der Musensohn" has an accompaniment that is in virtually the same rhythm from start to finish, but the effect is to make the listener share in the exuberance of the wandering minstrel. On the other hand, the maintenance of a constant rhythm in much popular music does nothing but emphasize the poverty of the composer's melodic and harmonic invention. Even where a continuous rhythm in the accompaniment threatens monotony, the danger can be avoided by variety in the melodic line—for example, in the waltz, where the melody may assume various rhythmical shapes that are not identical with the accompaniment that supports it.

Some 20th-century composers, revolting against what they call "the tyranny of the bar line," used bars of different lengths to establish accents that differ from those of the prevailing metre. This is, however, not a revolt against tyranny but rather an acceptance of it. A large number of the passages in 20th-century music that involve frequent changes of bar lengths could be written without any change and made vivid and intelligible simply by indicating the accents. This is not to deny that there may well be cases where the metre changes for a shorter or a longer period: indeed, changes of this kind occur in music of widely different styles.

Rhythm can strengthen an undistinguished melody or debase a good one (good, that is to say, from the point of view of the placing of its intervals). It can also give point to harmony, though that will also be governed largely by metre; the treatment of dissonance in 16th-century church music, for example, is controlled by the metrical pulse, however complex may be the rhythms that occur within that framework. (*See* RHYTHM.)

To combine melody, harmony and rhythm into a purposeful whole is the composer's principal task. He can use the tone qualities of instruments or voices to give colour to his ideas, and his treatment of harmony will necessarily be affected, to some extent, by the medium for which he is writing; *e.g.*, a dissonance that is relatively mild on the piano may sound unpleasantly harsh on the organ. He may even use orchestral colour as a vital element in his structure. He may pass the individual notes of a melody from one instrument to another or write an elliptical harmony that leaves the listener to imagine the missing link for himself. But whatever method he uses, whatever idiom he employs, he cannot avoid coming to terms with the three basic elements outlined above. He cannot command the vast vocabulary of the poet; but there is virtually no limit to the possible permutations and combinations of the material at his disposal.

### III. THE RISE OF MUSIC IN THE WESTERN WORLD

Apart from a few fragments of Greek music, the oldest western music of which written records have survived was composed for the services of the Christian Church. The reason for this is obvious. Secular songs were easy to remember and could be handed down by oral tradition. Singers may also have been jealous of recording songs they regarded as their property, quite apart from the fact that most of them were uneducated and incapable of writing or reading music. Even Latin songs, which were presumably sung by men with some smattering of education, were still being copied in the 13th century (in the so-called *Carmina Burana*) in a primitive notation that had long been disused by the trained scribes in the monasteries.

The first Christians were Jews and so they adopted the practices to which they were accustomed in the synagogue and the temple at Jerusalem—in particular, the antiphonal singing of the psalms (*i.e.*, with one group answering another) and the singing of the word "Alleluia" as an expression of praise. As Christianity spread over the near east other influences made themselves felt. The pagan supplication "Kyrie, eleison" (Lord, have mercy), used by Greek communities as a supplication to a ruler, was transformed into a prayer to Christ. The oriental religions also made their contribution to the forms of Christian worship and encouraged the use of instruments, to which the fathers of the church offered strenuous opposition. Though various eastern languages were

employed in the services, Greek (the lingua franca of the Levant) came more and more to assume a dominant position, which was established by the creation in A.D. 324 of Byzantium (Istanbul) as the capital of the eastern Roman empire. Even in Rome, Greek was for a long time the normal language of worship, and even after Latin came into general use toward the end of the 3rd century Greek was often used in alternation with Latin, particularly at Easter.

There is no certain means of knowing what Jewish chant was like at the birth of Christianity. But it is significant that the music of the Yemenite Jews (in southern Arabia), who lived in isolation from the main Jewish communities for many centuries, shows many points of resemblance to Christian chant. It seems likely, therefore, that Christian chant is the inheritor, at least in part, of a very ancient tradition. This is confirmed by the fact that St. Ambrose, bishop of Milan in the 4th century, is said to have instituted the custom of singing hymns and psalms "in the oriental manner"—a phrase that is generally held to imply antiphonal singing. Milan was one of the chief centres of western Christianity, and what is called Ambrosian chant is still sung there, though there are no means of knowing how far it actually represents what was sung in the 4th century. The maintenance of an independent tradition was not peculiar to Milan. In France a version of the plainsong known as "Gallican" survived the efforts of Pepin (751–68) to suppress it and did not finally disappear until the reign of Charlemagne (768–814). In Spain the Visigothic rite, known after the Moorish invasion (711) as "Mozarabic" (from *mosta'rib,* the name given to the Christians by the Moors), lasted until the 11th century, when it was supplanted by the Roman rite. In the meantime an attempt had been made at Rome to bring some system into the prevailing diversity and to reorganize the *Schola cantorum,* whose function was to teach the music to singers. This development is associated with Pope Gregory I (540–604), from whom the Roman chant derives the name "Gregorian." In time this standard version of the church's music became widely disseminated, largely through missionary activity; its maintenance owed much to monastic centres such as St. Gall in Switzerland and St. Martial at Limoges in southern France. Through its steady propagation it became the official music of the western church, though in England a variant known as the "Sarum rite" (from Salisbury, its principal centre) maintained an independent existence until the Reformation.

The simplest form of plainsong is the music of the psalms, sung to the so-called "psalm tones," which are a form of musical recitation. The psalm was originally amplified by the addition of a refrain (with related text) that was sung before and after the complete psalm and between successive verses. From the practice of singing the psalms antiphonally this refrain was known as an antiphon (*q.v.*). In the course of time the practice of singing the antiphon between the verses was abandoned, and it was sung only at the beginning and after the doxology. A further restriction is normally observed in modern times: only the beginning of the antiphon is sung before the psalm, the complete text being reserved for the end. The psalms, with their antiphons, are the principal music of the daily Office of the Hours (known more simply as the Office). The early Christians met at night and in the early morning and kept watch through the hours of darkness in expectation of the second coming. Once Christianity was officially recognized there was no longer any danger of persecution, and worship in the monasteries was extended throughout the day, beginning with Matins before sunrise and ending with Compline after dark.

All this music is basically simple. The music of the Mass, on the other hand, shows a wide variety. The texts that are sung are divided into those that are invariable (known as the Ordinary) and those that are peculiar to the day or season (known as the Proper). In the following table the items of the Proper are printed in italics:

*Introit* (for the entrance of the priest)
Kyrie eleison (Lord, have mercy)
Gloria (Glory to God in the highest)
*Gradual* (after the Epistle)
*Alleluia* (immediately after the Gradual)
Credo (I believe in God—after the Gospel)
*Offertory* (during the offering of bread and wine)
Sanctus (Holy, holy, holy)
Agnus Dei (O Lamb of God)
*Communion* (after communion)

The simplest chants of the Ordinary are those of the Gloria and the Credo. The Kyrie, Sanctus and Agnus Dei are more elaborate. For all these texts a number of different chants have been preserved, some of which appear relatively late in the history of plainsong. The Introit is one verse of a psalm with an antiphon. The Offertory and Communion are antiphons without a psalm. The Gradual and Alleluia are "responsorial"; *i.e.,* chants in which a soloist is answered by the main body of singers. Both of them are elaborate and can never have been intended for congregational singing. All chants, whether simple or elaborate, have the same basic tendency to rise to a climax and then subside, with the possibility of intermediate fluctuations according to the significance of the words. As far as rhythm is concerned, earlier writers make an exact distinction between long notes and short notes, but 13th-century theorists distinguish between plainsong and the metrical structure of polyphonic music. The interpretation officially sanctioned by the church in the 20th century was rhythmical (of necessity, since melody cannot be shapeless) but not metrical; *i.e.,* it does not admit a system of regular barring. At the same time it seems very likely that hymns, which have poetical texts, were sung in a regular rhythm and would still be effective if sung in this way. (*See* CHURCH MUSIC; AMBROSIAN CHANT; GALLICAN CHANT; MOZARABIC CHANT; PLAINSONG.)

The inventive church musicians were not satisfied with the rich repertory of liturgical melodies. Even before the time of Gregory they had tried their hand at extending them, and this process continued for several centuries. A particular opportunity was offered by the Alleluia of the Mass, which consists of the word "Alleluia," a verse with a text appropriate to the day, and a repetition of "Alleluia." The final syllable of "Alleluia" was habitually set to a long melisma, and when this came for the second time (at the end of the piece) it was extended still further. Such an extension was known as a *tropus* (literally a turn, hence a figure of speech and also a tune). By the 8th century the popular term *sequentia* (from Latin *sequor,* "I follow") was in use for this extension because it followed the Alleluia proper. The practice of fitting words to these sequences on the principle of one note to a syllable grew up in the following century. By the 11th century this had developed into a new art of composition, with poetic texts set to original melodies. These sequences became enormously popular: the texts were often translated into the vernacular or replaced by purely secular verses. The vogue of the sequence continued until all but four were suppressed by the Council of Trent in the 16th century; a fifth, the "Stabat mater," was readmitted in the 18th century. The practice of adding words to liturgical melodies was also applied to the Kyrie; and so strong is tradition that the melodies to which the Kyrie is sung in modern times are still known by the initial words of the texts that were once fitted to them. A by-product of this extraliturgical activity was the dramatization in the 10th century of a trope for Easter Day that was in the form of a dialogue between the three women and the angel at the sepulchre. This was so successful that it developed into a play with additional characters and led to the invention of similar musical dramas dealing with the birth of Christ, the Epiphany, subjects from the Old Testament and the lives of saints.

In spite of the early objection to the playing of musical instruments in church the organ became widely accepted in western Europe once it had been imported from the east. It is not known for certain when the first organs were built in the west, but the instrument was certainly well known by the 8th century. The construction of a series of pipes of different sizes enabled a single player to produce not only octave doublings but also fifths. It is possible that this composite sound encouraged singers to imitate it; in any case octaves would result from the combined singing of boys and men. Support is given to this view by the fact that such combined singing, suitable for voices of high, low and medium range, was popularly known as organum (*q.v.*), which, though

obviously not a technical term in origin, very soon became one. The earliest surviving written examples of such duplication of a plainsong melody in parallel lines occur in a theoretical treatise of the late 9th or early 10th century. Presumably the author's examples are not his own invention but represent a well-established practice. He also illustrates a more varied type of part-singing, in which the voices begin and end on the same note but move to wider intervals in between. This can clearly have nothing to do with the organ, nor need it be regarded as a development of the form that had strictly parallel movement. Singing in parts was found in many primitive societies in the 20th century and it is not in the least improbable that it existed in a traditional form in Europe, in which case the church may have taken a leaf out of the secular book and adapted popular practice to its own uses. Whatever the origins of liturgical polyphony may have been, it became firmly established as an enrichment of the plainsong melodies and even in its simplest form could be wonderfully effective in a resonant cathedral or abbey. During the 11th and 12th centuries it steadily developed in complexity, both in France and in Spain. An important feature of this development was to give the added part (in two-part writing) a freely melismatic character by writing several notes to each single note of the plainsong. This necessarily meant that the plainsong had to be sung slowly; and in the music associated with the cathedral of Notre Dame in Paris in the late 12th and early 13th centuries the composers' invention often took such a florid form that a single note of the plainsong was sustained for a very long period—so much so that it has often been suggested that the *cantus firmus* (the original plainsong) was played on the organ (*see* CANTUS FIRMUS). Variety was also given to these compositions by including sections (known as clausulae) in which the plainsong moved more briskly in a regular rhythm, to which the added part or parts conformed. Furthermore, a complete piece included sections of unharmonized plainsong, to which the harmonized passages made an effective contrast.

No doubt it was the effectiveness of the clausulae, with their rhythmical pulse, that encouraged the performance of them as separate pieces with texts fitted to the added parts. The part immediately above the plainsong had been called duplum in the organum, and the part above that triplum. The triplum (from which the word "treble" is derived) retained its name in the new form, but the duplum was called *motetus* (presumably from the French *mot,* since it was supplied with words). The *motetus* came to give its name to the piece as a whole, known in English as "motet." The earliest motets had Latin texts, and variety was achieved by assigning different texts to the upper parts. But French secular texts were also used for one or both parts, though the piece was still constructed above a plainsong tenor, so called because in the organum it was the voice that held (Latin *teneo*) or sustained the given melody. From the protests uttered by Pope John XXII in the early 14th century it appears that motets with secular texts were actually sung in church, to the scandal of religion; but there can be little doubt that most of them were designed for an audience at banquets or similar festivities. (*See* MOTET.)

The motet, the principal musical form of the 13th century, derived from the organum, but its added melodies were also strongly influenced by a wealth of secular song in the vernacular that had grown up in the meantime. There are examples of secular Latin songs from as early as the 10th century, but relatively few survive with music. The greatest contribution to this form of art was made by the troubadours of southern France, who are first heard of about 1100, and the trouvères of northern France, who appeared a little later (toward the end of the 12th century). These songs constitute a unique marriage between poetry and music. It may well be that some at least of the melodies were written by the traveling musicians and acrobats known as jongleurs, but this does not alter the fact that verse and tune nearly always form a complete unity. The charm of these songs, ranging from the simplicity of folk tunes to the subtlest form of melodic invention, is as potent today as it was then; and it inspired a similar type of artistic expression in the *Minnesinger* of Bavaria and Austria. In Spain there is no secular counterpart; but the songs that record the miracles of the Virgin (*Cantigas de Santa María*), collected by Alfonso X (king of Castile and León from 1252 to 1284), breathe the same spirit, though the melodic idioms often have a strongly national flavour. Italy also had its religious songs, the *laudi spirituali,* which were sung by lay brotherhoods. (*See* TROUBADOURS; TROUVÈRES; MINNESINGER.)

Since the motet was built upon a plainsong tenor, it was hardly possible to incorporate complete troubadour or trouvère melodies, though refrains from rondeaux could be inserted without much difficulty. But though the motet did not normally borrow from the repertory of secular song, the melodies written for the *motetus* and the triplum were often very similar in outline. The tenor no longer had any special significance: the notes of the plainsong were chopped up into rhythmical segments that served merely as a foundation for the composer's invention. It was the upper parts, with their graceful melodic lines, that claimed attention. Polyphony was no longer the preserve of the church; it was a form of artistic expression that sought to give pleasure without any thought of edification. And in doing this, composers found new ways of exercising ingenuity—for instance, by imitation between the *motetus* and triplum, a practice known in later ages as canon (*q.v.*), though in the 13th century it was rarely exploited at any length. The one form in which canon was employed throughout was the rota or round, the best-known example of which is the English setting of "Sumer is icumen in" (*q.v.*).

Practically all 13th-century polyphony was based on the assumption that the beat was divisible into three, which means that modern transcriptions can conveniently be written in 6/8 time. The various possible divisions, known as "rhythmic modes," corresponded to poetic metres: thus is similar to the trochee ( –∪ ), to the iambus ( ∪– ). The dactylic rhythm ( –∪∪ ) should properly be written in the equivalent of 2/4 time— —but this would have made it impossible to combine it with a trochaic or iambic rhythm in another part. For this reason the last note was lengthened and the shape became , which means that it can be written in 6/8 time. The earlier motets are rigidly faithful to these rhythmic patterns, but in the course of the century the habit of writing more words for the triplum than for the *motetus* led to the use of groups of short notes that obscured the rhythmical pattern and eventually broke its domination, particularly through the use of even shorter notes represented in modern transcriptions by semiquavers (sixteenth notes).

In the 14th century a new and more liberal art of music-making appeared, known as *ars nova* (*q.v.*) from the title of a treatise by one of its exponents, Philippe de Vitry (1291–1361). It is not merely that rhythms become more varied and more subtle. The division of the beat into two (the modern 2/4 time) also becomes accepted side by side with the old division into three, and melodic lines were enriched by the introduction of sharps and flats which gave a new flavour to the harmony. The freedom that came with these changes must have made composers feel the need for some organizing principle to replace the old-fashioned rule of the rhythmic modes. This new principle was rhythmical too but it was also structural. A rhythmical pattern designed to cover the equivalent of several bars (in a modern transcription) was repeated throughout a composition, with changes of tempo, if necessary, indicated by the use of shorter note values. The melody might coincide with one or more of these rhythmic segments or it might overlap. Composers began applying this principle (to which the name isorhythm has been given in modern times) to the tenor on which a motet was founded, but it was also extended, to a greater or less degree, to the other parts of the composition. The result is a tightly organized scheme; the listener does not consciously hear the scheme but it inevitably gives him the impression of an artistic unity. (*See* ISORHYTHM.)

The most distinguished French composer of the 14th century was Guillaume de Machaut (*c.* 1300–77), who continued the tradi-

tion of the trouvères by being both poet and musician. Though he wrote a Mass (the first known complete setting by a single person), his chief activity seems to have been in the field of secular music. In his motets he is faithful to the isorhythmic principle outlined above, but his other works—ballades, virelais and rondeaux—derive their form mainly from the poetical structures to which they are allied. Here the melodic line of the upper part is pre-eminent, and most of the pieces are in fact solo songs with instrumental accompaniment, a form that was to develop fruitfully in the 15th century. Ingenuity, however, is not lacking. Canon was used by Machaut, as it was by other French composers of the century (particularly in the form known as *chace*). The Italian equivalent of the *chace* was the *caccia* (*q.v.*), which also implies a connection with hunting. Hunting scenes do in fact figure largely in these pieces but they are not exclusively the subject matter. The Italian composers of the 14th century, of whom the most eminent was the blind Francesco Landini (1325–97), were even more subtle than their French contemporaries in their handling of varied rhythms, and this subtlety was imitated by the later French composers of the 14th century. Though the melodic lines of their songs are often florid, there is a genuine feeling for the poetry they set. This sophisticated secular art is the chief glory of Italian music of the 14th century.

### IV. THE EVOLUTION OF MUSICAL STYLE

Idiom is personal. Style may be common to a number of different composers. The nearer music is to the listener's own day, the more conscious he is of individual idioms. Few experienced listeners in the 20th century would confuse Ravel and Debussy or mistake Schumann for Mendelssohn. Yet it is quite possible to be uncertain whether an 18th-century divertimento is by Haydn or Mozart or by some less familiar composer. And the further back we go in history the more the distinctions tend to become blurred. This is not to say that they do not exist; but the recognition of them often calls for exceptionally detailed study. At all periods there have been composers whose idioms are so strongly marked that they suggest a breakaway from the prevailing style. But they may very well have such a powerful influence on others that they help to form the material of a new style that becomes widely accepted; or alternatively, having no lasting energy in themselves, they fall into disuse and become no more than a historical curiosity. In general the outstanding composers are not revolutionaries; more often than not they achieve greatness by seeing possibilities in a prevailing style that others have only dimly perceived.

Style changes for various reasons—to meet the wishes of connoisseurs who are weary of tradition, to obey the commands of a ruler who wants something new, to suit the tastes of a new order of society, or simply because accepted methods of expression have become obsolete and cease to stimulate the invention of creative artists. The change may be from simple to complex or vice versa. It is never continuously in either direction; if it were, music would either become completely unintelligible or dissolve into such an elementary state that it would neither merit serious consideration nor attract the ear. There may also be differences of style between one country and another at the same period. This is not simply due to the influence of folk song, which in any case attracted little attention from composers before the 19th century. National character necessarily affects the arts, and language in particular may influence both melody and rhythm. In France the lack of a tonic accent has left its mark on recitative and aria and through them on instrumental music as well. In Italian music, on the other hand, the prevalence of feminine endings in the language has helped to produce a more decisive type of melody, and here too instrumental music has imitated the accents of song. National styles, however, are not by any means confined to the countries in which they originate. The English madrigalists of the 16th century imitated Italian models, even to the extent of setting texts in the same rhythm; and the popularity of opera in the 17th century carried Italian music all over Europe and helped to create what might be called an international style. Though the French remained largely impervious to this influence, they in their turn had a strong influence on German composers of the early 18th century, largely through the admiration the German princelings had for the court at Versailles. French and Italian influence might even appear in the same work. Bach's first Brandenburg concerto begins with a typically Italianate movement but ends with a minuet in the French style.

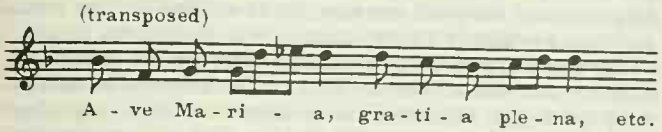
The complexity of French and Italian music in the 14th century led inevitably to a reaction in the 15th century. This was partly due to the influence of English composers, several of whom—notably John Dunstable (d. 1453)—were active on the continent and were well known there. English composers seem to have remained largely immune from the tendencies that were noticeable in the work of Machaut and his immediate successors. They did not despise subtlety: they continued to write in canon, they exploited the structural advantages to be derived from using isorhythm, and they found new ways of employing a *cantus firmus* by transferring it from one voice to another. But on the whole they were much more concerned with sonority than with ingenuity, however artistic, and in particular they maintained a tradition of harmonic suavity that goes back at least as far as the 13th century. It was this sweetness of sound that seems particularly to have attracted composers in northern France and the Low Countries. They used it in church music and in secular songs, in both of which the affecting chromaticism that is so often a feature of 14th-century music is largely replaced by a smoothly diatonic harmony. Little secular music by Dunstable survives; but Gilles de Binchois (d. 1460) and Guillaume Dufay (d. 1474), who were slightly younger contemporaries, were particularly active in this field. In both there is a tendency to set a simple melody for solo voice against an accompaniment that sounds less complex than it looks. They not only imitate the English suavity but also show a feeling for harmonic associations, which in the work of later composers became one of the most important elements in musical structure.

For the greater part of the 15th century a three-part texture was favoured for secular songs; but in church music four or five parts came to be generally accepted. The practice of writing one or more parts whose principal function was to complete the harmony is further evidence of the importance that was attached to completeness of sound. Church music also became more independent of preexisting melodies, following the lead of secular music, much of which had for long constituted an art of wholly original composition. The use of a *cantus firmus* was not abandoned: in fact it was continued throughout the 16th century and even later. But side by side with this survival of tradition are found works that are wholly independent or use an ornamented version of plainsong in the upper part (a process known as "paraphrase") or take as a model an existing part-song or motet by the same or another composer. The latter process was applied to complete settings of the Mass: a setting of this kind came to be known as a *Missa parodia* or "parody Mass," a term that is liable to be misunderstood unless its implications are fully grasped. Where a *cantus firmus* was used it was normally in an inner part, so that the *contratenor bassus,* written below it, came to be the foundation of the harmony—in fact, a bass, as it is now known. Furthermore the range of the voices was considerably extended, particularly in the work of Jean d'Okeghem (*c.* 1425–*c.* 1495). Apart from the use of canon, which was often ingenious and elaborate, imitation between voices was not common, at least in church music. Composers sought a unity of mood rather than a close interrelationship between the component parts. They did, however, unify the various sections of a Mass by the use of an initial melodic phrase that appeared in some or all of the sections. A further means of unification was the use of the same *cantus firmus,* whether taken from plainsong or from secular song, throughout an entire Mass. Since the various sections of a Mass are not sung continuously, any form of unification was necessarily less artificial than it might appear on paper.

Composers born in the latter half of the 15th century, *e.g.,* Jakob Obrecht (1452–1505) and Josquin Després (*c.* 1440–1521), were familiar through their upbringing with traditions that were well established by their time. But they were not content to follow blindly in the steps of their predecessors. Among the dis-

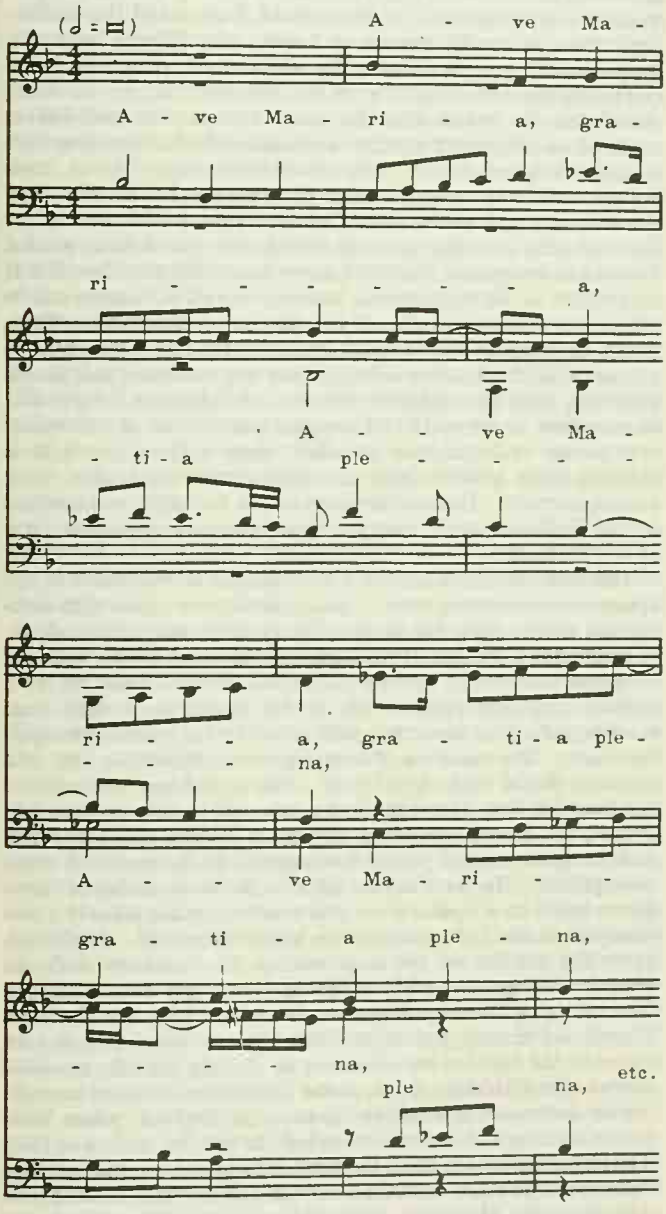
coveries of Josquin was the part that imitation could play in church music, not merely as an occasional device but as an element of structure that was valid for an entire composition. The motet whose opening is quoted below (ex. 45) is based on the following plainsong melody:

**Ex.44**




The following example shows (1) how the original melody is extended and varied and (2) how imitation between the voices, entering successively, binds the music into a coherent whole:

**Ex.45**




The motet then proceeds to deal with the other sections of the melody in the same way, with what English musicians came to know as a series of "points"; *i.e.*, melodic figures that could be developed by imitation. The results of this method of composition were far-reaching. It not only provided a standard practice that was followed by composers of church music throughout the 16th century and long afterward; it was also adopted in instrumental music and provided a model from which the fugue emerged as a form of composition. Furthermore, through the influence of Heinrich Isaak (*c.* 1450–1517), a Flemish contemporary of Josquin who traveled widely and was for some time in the service of the emperor Maximilian I, the new style of polyphony became established in German-speaking countries, both in church music and in secular part-songs with German texts. Another important characteristic of Josquin's style was the contrast of sonorities between groups of upper and lower voices. This too was a practice that was widely adopted by later composers, not only in vocal music but also in instrumental chamber music; *e.g.*, in Mozart's string quintets.

In England a more conservative, but by no means simple, style of church music was cultivated in the late 15th and early 16th centuries. Contrast was achieved by alternating passages for a group of solo voices (often only two) with others for the full choir in five or more parts. Within the choral sections much of the part writing is designed, in the earlier manner, to create movement within a simple harmonic framework, and imitation appears only sporadically. Much of the vocal writing, while graceful to sing, is extraordinarily elaborate, and the total effect is often as impressive as anything achieved at this period by continental composers. In Scotland Robert Carver (1487–*c.* 1550) applied the same methods to a motet in 19 parts.

The invention of music printing in the latter part of the 15th century led to a wider dissemination of music, particularly of secular songs. The first publication issued by Ottaviano de' Petrucci (1466–1539) of Venice was a collection of part-songs (mostly French) by composers from the Low Countries (a term that includes northeastern France as well as what later became Belgium and Holland). The fact that such a collection could be published in Italy indicates the repute these composers enjoyed in that country; several of them were in fact well-known there through employment in princely courts or in the papal chapel. Possibly as a reaction against this domination by foreigners Petrucci issued between 1504 and 1514 eleven collections of *frottole*—simple strophic part-songs with Italian texts that could be sung either by a group of voices or by one voice with instrumental accompaniment. The *frottola* (*q.v.*) actually came into vogue at the end of the 15th century; but its popularity dates from its appearance in print. Though some of the earlier examples were written, like the French *chansons*, by composers from the Low Countries, the form was rapidly adopted by Italian composers, who thus emerged from an obscurity that had lasted, as far as is known, for roughly 100 years. Since the *frottola* was so suitable for solo singing, in view of the simplicity of the lower parts, it was also arranged for voice and lute. The effect of this was to establish a convention of simple harmonic progressions that could be used to support an unfettered melodic line. It was not long before Spanish composers, beginning with Luis Milan in 1535, embarked on the composition of original songs with lute accompaniment. In France a new type of part song, similar to the *frottola* in its harmonic structure, came to supplant the older type with largely polyphonic structure, and this too was arranged for voice and lute.

The reaction against the 15th-century part-song was followed in Italy by a further reaction against the *frottola*. Literary men in the early 16th century felt that the strophic form of the *frottola* did less than justice to the claims of poetry. They wanted to see a closer unity between poetry and music, and this could be achieved only by having a setting of a single stanza that was complete in itself. The sonnet was ideal for this purpose, and, as it could be divided into a first section of eight lines and a second section of six, it afforded opportunities for two main contrasts of mood, quite apart from the advantage of being able to concentrate on only one set of words; but other poems of comparable length were equally suitable, and in fact musicians were presented with a considerable variety of texts. The result of this literary movement was the 16th-century madrigal (*q.v.*), a musical form that came into existence about 1530 and is distinct from the poetic form current in the 14th century. In its early stages it was often

similar in texture to the *frottola* and was written largely by composers from the Low Countries who were resident in Italy. But it was rapidly taken up by Italian composers and developed as an art of imitation borrowed from the existing practice in church music. It thus became a characteristically Italian form, though this did not prevent composers of other nationalities from writing works of the same kind. Orlandus Lassus (*c.* 1532–94), born at Mons and known in Italy as Orlando di Lasso, wrote Italian madrigals as well as French *chansons* and German part-songs; and later still Italian madrigals figure among the works of Hans Leo Hassler (1564–1612) and Heinrich Schütz (1585–1672).

In the course of the 16th century the madrigal not only developed a polyphonic texture: it also became more subtle. Changes of mood came to be more sharply distinguished, and individual words were singled out for musical illustration. Such illustration might range from the distinction between "high" and "low" to representations of nature and the imitation of physical movement. Representation had already invaded the French *chanson* (*q.v.*) in the shape of bird calls and the sounds of battle, for instance in the works of Clément Janequin (*c.* 1480–*c.* 1560), but in the hands of Italian composers it was employed as an embellishment of the text rather than as the basic material for a composition. The emphasis on words also led to a more emotional style in which chromaticism and abrupt chord changes were used to intensify the sentiments expressed by the poet. In the madrigals of Luca Marenzio (1553–99), Carlo Gesualdo, prince of Venosa (*c.* 1560–1613), and Claudio Monteverdi (1567–1643) the most intense forms of musical expression were used to illustrate the text, without however destroying the structure of the composition as a whole. The words were felt to be so important that polyphony became only one element in the composer's setting and a simple homophonic texture (with all the voices moving simultaneously) was often used in the interest of clear enunciation of the text. The consequence of this was that madrigals sounded more and more like solos with vocal accompaniment, so that it was comparatively easy for composers to change, as Monteverdi did, to solos or duets with a simple keyboard background.

In England there was a tradition of simple part-songs dating from the early years of the 16th century. Later in the same century the practice arose of writing solo songs with a polyphonic accompaniment for a string ensemble. At the same time both the French *chanson* and the Italian madrigal were becoming known to connoisseurs. This encouraged William Byrd (1543–1623) to fit words to the string parts of his solo songs, so that they were able to masquerade as madrigals. But the first original English madrigals were published by Thomas Morley (1557–*c.* 1603) in 1594. The life of the English madrigal was comparatively short and only a limited number of them show the passionate absorption in the text that is characteristic of the later Italian examples of the form. This was due partly to the influence of the French *chanson* and partly to the natural conservatism of English composers. The lute song, roughly contemporary with the madrigal, also came late to England; but in its short existence it often achieved a remarkable subtlety in the marrying of words and music, not least in the works of John Danyel (*c.* 1565–*c.* 1630), whose accompaniments show some of the characteristics of the older songs with string ensemble.

Catholic church music of the 16th century continued to observe the traditions of polyphony established by Josquin and his contemporaries from the Low Countries. It was practised equally by Italians, by Spaniards and by men of other nationalities, so that something like a basic international style emerged, though with many local variants. There was, however, a certain amount of criticism by church authorities, partly of the music itself, which was felt to be too elaborate for its purpose, and partly of methods of performance. The work of Giovanni Pierluigi da Palestrina (*c.* 1525–94), which inclined toward simplicity and restraint, was felt by those who wished to reform church music to provide a suitable model for other composers. A characteristic of his work is the alternation of straightforward homophonic passages (as in Josquin) with a polyphony that combines smoothness of sound with an expert interweaving of parts. In the Spanish composer Tomás Luis de Victoria (*c.* 1548–1611) this style found more passionate expression and in Lassus a closer attention to the emotions suggested by the words. Just as the polyphony of the madrigal had developed from the polyphony of church music, so now the expressive content of secular music was transferred to the motet. There was, however, no sudden change. Old and new persisted side by side; and such was the reputation of Palestrina that for long afterward his music was regarded as an ideal solution of the problem of writing in a style appropriate to its function.

The emergence of the Protestant churches did not involve any radical break with musical tradition. The Reformation in Germany led to the widespread use of simple melodies (some borrowed from secular sources) that could be sung by a congregation. The word *Choral* (commonly spelled "chorale" [*q.v.*] in English), which originally meant "plainsong," was now used as a generic term for these melodies. But polyphony, far from being abandoned in the Lutheran church, came to be used as a means of providing music for the choir, the *Choral* melody serving the purpose of a *cantus firmus*. In Switzerland, France and the Netherlands the rigorous Puritanism of Calvin, who allowed only congregational singing in church, did not prevent composers from publishing harmonized settings of the Genevan melodies for devotional use, and before long they came to treat the melodies as material for polyphonic motets. In England the Reformation took a rather different course. Anglican church music did not come fully into its own until the reign of Elizabeth I. By that time the elaborate style of the older Catholic music, for instance in the work of John Taverner (*c.* 1495–1545), was out of date, so that even when composers like Byrd wrote music for the Catholics it was nearer to the style current in Italy, though with many subtle differences in detail, particularly in the use of dissonance. Composers of Anglican church music had from the first been urged to aim at simplicity, but this did not in any way exclude a polyphonic style, any more than it had in the work of Palestrina. A peculiar development in the early 17th century was the use of solo voices with strings or organ (the so-called "verse anthem") in a style that has some affinities with the older secular song with string accompaniment. The full development of this style was checked by the Civil War, but it emerged again in a more up-to-date form at the Restoration.

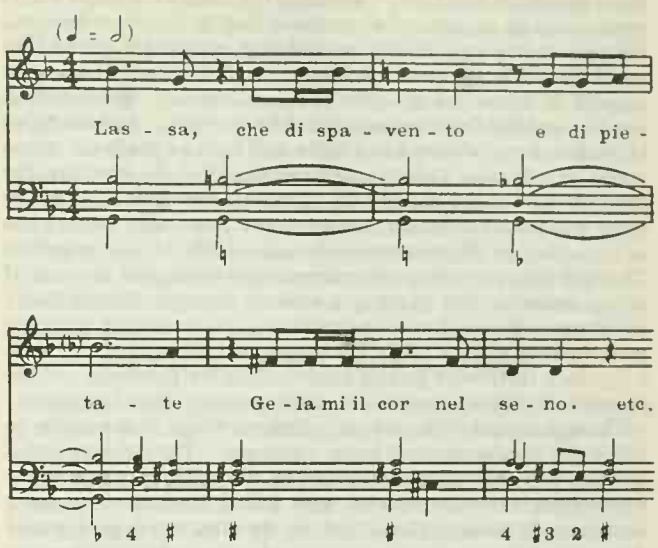
The 16th century also saw a considerable development in the sphere of instrumental music. Dance music was popular throughout the middle ages, but comparatively little was written down. A considerable number of transcriptions of vocal works, both for keyboard instruments and for ensembles, survive from the 15th century and even earlier; but, as far as can be judged from records, very little music was written solely for instrumental performance. The tradition of transcription continued in the 16th century. Vocal works of all kinds, both sacred and secular, were arranged for lute, harpsichord or organ, and madrigals were performed on instruments. But side by side with this activity is found a great mass of purely instrumental works, many of which were printed. In the Catholic Church the composition of organ pieces based on a *cantus firmus*, of which there are already a few examples in the 15th century, was widely developed. It also became the practice to use such settings in alternation with the choir in settings of the Mass, the Te Deum and the Magnificat. The use of a *cantus firmus* was also adopted by the Lutheran Church in Germany, and the tradition of pieces based on a chorale, either in the form of variations or as a single prelude, persisted down to the 20th century. A *cantus firmus* was also used in works for an instrumental ensemble, notably in England, where composers continued to write pieces called "In nomine" as late as 1680. The plainsong used in these English compositions was the antiphon "Gloria tibi Trinitas," and the name "In nomine" was derived from a transcription of part of the Benedictus of the Mass *Gloria tibi Trinitas* by John Taverner, beginning at the words "in nomine Domini" (*see* IN NOMINE). Secular songs were also used as material for variations, particularly by Spanish, English and Dutch composers. Variations for a solo instrument served the double purpose of embroidering a familiar tune and giving the player an opportunity to display virtuosity.

A great deal of dance music was written in the 16th century, not simply for popular festivities or for court entertainments but also in a stylized form designed to give pleasure to listeners and performers. Composers also borrowed from popular practice the habit of linking two contrasted dances, one slow and the other brisk—for instance, the pavane and galliard. The influence of the dance further appeared in the use of the simple basses of traditional pieces—notably the *passamezzo* and the *Romanesca*—as material for extended compositions in variation form (*see* GROUND BASS; DANCE FORMS IN MUSIC). The influence of vocal music is evident in the composition of instrumental works using the same technique of imitation and the interweaving of independent lines: such pieces came to be generally known as *ricercar* (meaning the "search" for the development of thematic material) or fantasia (*q.v.*) and were written both for ensembles and for solo instruments (lute, harpsichord, organ). The early examples often followed vocal models so closely that they could be sung (though without words) as well as played; but it was not long before an awareness of instrumental possibilities led composers to extend the range of their parts and to write music that was inextricably associated with the medium. The increasingly expressive treatment of the madrigal also led them to write instrumental pieces with a similar emotional content. Just as the mood of the music changed in the madrigal in accordance with the sentiments of the text, so in instrumental works there would be alternations of cheerfulness and pathos, sometimes so clear-cut that they resulted in more or less independent sections. Finally, the increased emphasis on virtuosity encouraged the composition of works for solo instruments that followed no prearranged plan but aimed at providing opportunities for brilliant execution, with or without the alternation of similar passages for the sake of contrast.

The changes in the style of the madrigal, mentioned above, were partly due to a growing respect for the poetry that was set. The logical outcome of this attitude was to abolish polyphony altogether in setting poetry to music. If the words were sung by a single voice every detail of the text would be clear: at the same time harmonic progressions similar to those used in the madrigal could be supplied by a keyboard instrument. Provided the accompanist had the voice part in front of him, the singer had no obligation to keep strict time. The result was a kind of musical declamation in which the stresses and rhythm of the words were faithfully observed and the voice could rise and fall as it would in speaking. Since the accompaniment must not on any account interfere with the clear enunciation of the words there was no need to write it out in full. A system of figures, indicating the harmonies to be played above the written bass, was sufficient. This style of writing, which came into existence at the end of the 16th century, came to be known as "recitative" on account of the importance assigned to the text. In spite of the difference in texture it did not mark a complete break with the madrigal, from which it borrowed many of its melodic and harmonic progressions and the practice of using cadences as a form of punctuation.

It must have been obvious that recitative was particularly suitable for dramatic performances in which the words are all-important. Hence a group of connoisseurs at Florence decided to use it as a medium for re-creating Greek drama, which they believed to have been sung throughout. Music had been used extensively throughout the 16th century in pastoral plays, masques and similar entertainments—but only as an incidental element. It now assumed the task of sustaining the whole of a stage performance. The new type of music drama, which first appeared in 1597, was given various names before it finally came to be known simply as "opera" (short for *opera in musica*, a musical work). The earliest examples were faithful to the pastoral tradition of the 16th century and for this reason introduced a limited number of songs and dances. But the main burden of the drama was borne by recitative, which at moments of crisis could use all the resources of madrigalian harmony in the interests of dramatic expression. This may be illustrated by a short passage from the opera *Euridice* by Jacopo Peri (1561–1633), which was first performed in Florence in 1600. It comes from the scene where a nymph announces the death of Euridice:

Ex. 46




The new form spread rapidly to other cities, notably Rome and Venice, where the first public opera house was opened in 1637. Greek mythology continued to supply most of the material for the plots until Monteverdi's *L'incoronazione di Poppea* (1642), based on the life of Nero, introduced the practice of using a historical background. This was not the only change. The rich instrumental resources of private courts were not available at Venice: in consequence a string orchestra came to be the standard ensemble in the opera house, supplemented by any wind instruments that might be required for particular occasions. A similar standardization, for the purposes of ballet, occurred about the same time at the court of Louis XIII in France. The greater incisiveness of the violin family (violins, violas and cellos), already used in Monteverdi's *Orfeo* in 1607, made them more suitable for the theatre than an ensemble of viols; and the need for an ample sonority suggested the practice of having more than one player to a part. In the setting of the text recitative was not abandoned; but there was a growing feeling in the early years of the century that a dramatic spectacle needed more variety. Hence songs were introduced without the excuse of a pastoral environment, and comic episodes were interpolated for relief, as they had been in Shakespeare's plays. These developments did not involve the creation of any large-scale forms, but they did force composers to consider various ways of achieving symmetry and continuity. One device, equally suitable for a lament or a love duet, was borrowed from the field of instrumental music—the practice of using a repeated bass figure, or *basso ostinato* (literally "obstinate bass"), as the foundation of a vocal composition. Though virtuosity had not been excluded from the early recitative, since singers were expected to embroider the simple line provided for them, there were even more opportunities in the new type of opera song (or aria), which could also be varied by the alternation of voice and orchestra. By the latter part of the 17th century the *da capo* aria in three sections, the third section of which repeated the first with improvised ornamentation, was in regular use. Recitative continued to be the principal medium for explaining the action and it rapidly acquired conventions that did not, however, inhibit individual treatment. For especially dramatic scenes the orchestra was introduced into recitative, but this practice did not become fully established till the early years of the 18th century. These conventions were adopted also in oratorio, whether in Latin or in the vernacular. (*See* OPERA.)

The 17th-century emphasis on a clearly defined melodic line made itself felt also in instrumental music—particularly in the sonata for violin and keyboard, in the trio sonata (for two violins with accompaniment) and the sonata for trumpet and strings. This did not mean that polyphony was abandoned: it was active particularly in organ music. But the whole harmonic structure of music tended to rest more upon the bass, so that harmony itself

had a structural function. The natural division of a dance movement into two sections, the second ending in the tonic key and the first ending in a closely related key, supplied a model that was followed by composers in more extended pieces. It was also possible to imitate the structure of the *da capo* aria, in which both the first and the third sections ended in the tonic. In both types of structure modulation away from and back to the tonic was a means of achieving variety and so emphasizing, by contrast, the principal key of the movement. Contrast was also obtained by using a group of solo instruments (most frequently, two violins and a cello) to alternate with the main body of the orchestra. Thus the term *concerto grosso* came to lose its original meaning of a large ensemble and to imply a work in which a chamber music group was contrasted with the orchestra. The contrast was even more striking when a single instrument was set against the main body: here there were greater opportunities for virtuosity and the resemblance to the operatic aria was very close. (*See* CONCERTO.)

Throughout the 17th and early 18th centuries it is possible to follow the development of larger structures. The old association between two contrasted dances led to the suite, in which dance forms from various countries were linked together to make a homogeneous whole. The sonata, on the other hand, grew out of the sectional fantasia: the sections now became independent movements but the polyphony of the fantasia still survived in at least one movement, often called by the name canzona (*q.v.*), which originally meant an instrumental piece on the model of the French *chanson*. The original distinction between suite and sonata became blurred in the course of this period, since sonata movements were also frequently written in dance forms. The keyboard instruments had their own repertory of preludes, fugues, capriccios, toccatas and so on, in addition to sharing the forms employed in ensemble music. The toccata (literally, a "touched" piece) often had no regular organization. It might exist primarily to display virtuosity or, in the case of organ music, take advantage of the sustained tone of the instrument to exploit dissonance. Examples of the latter type occur in the work of Girolamo Frescobaldi (1583–1643). In the orchestra the harpsichord was regularly employed to complete or enrich the harmony, and this may explain why keyboard instruments made a relatively late appearance as solo instruments with an instrumental ensemble—for instance, in the fifth Brandenburg concerto of Johann Sebastian Bach (1685–1750) and in the organ concertos of George Frederick Handel (1685–1759). The most original use of the harpsichord in the early 18th century is to be found in the so-called "sonatas" of Domenico Scarlatti (1685–1757), which not only make extreme demands on technical skill but also introduce a new element of local colour—the result of the composer's long residence in Spain. (*See* SONATA.)

Church music could not escape either the brilliance or the emphasis on pathos that characterizes the secular music of this period. In Italy, France, Germany and England the association of soloists, chorus and orchestra produced a mass of works that could be both pompous and expressive. Most striking of all these forms was the church cantata in Germany, which not only linked elaborate choral writing with imitations of the operatic recitative and aria but also gave point to the text and the occasion for which the work was designed by including chorale melodies, either in four-part harmony as independent items or as *cantus firmi* in large-scale movements. Passion music, where the text of the recitative was taken from the Gospel narrative, used the same resources and reached its height of development in Bach's *St. Matthew Passion* (1729), which uses a double chorus, double orchestra and two organs. In England Handel combined the traditions of the English anthem and court ode (a ceremonial cantata) with his own experience of continental church music to produce the English oratorio—a concert work in dramatic form, with a wealth of solo music derived from his own long experience of writing Italian opera. (*See* ORATORIO.)

Throughout the period from the 17th to the middle of the 18th century French music remained largely aloof from foreign influences. Opera continued many of the traditions of the ballet and was sometimes combined with it. The works of Jean Baptiste Lully (1632–87) employ a statuesque kind of recitative that derives from the declamation of French actors, and the same quality appears in the more vivid, more consciously dramatic works of Jean Philippe Rameau (1683–1764). This type of music was not easily exportable. On the other hand, French dances were imitated abroad, and the characteristic French overture, with its stately introduction followed by a fugal movement, was often adopted by composers in other countries—for instance, in England in the odes and dramatic music of Henry Purcell (*c.* 1659–95) and in Handel's oratorios. By the middle of the 18th century, however, music of this kind was out of date. The more vivacious Italian opera overture (or sinfonia) in three movements (quick, slow, quick) was so popular that it was performed independently and led to the composition of a new type of orchestral music that supplanted the old *concerto grosso* and was enthusiastically adopted by German and Austrian composers. Polyphony was now largely confined to church music. Aristocratic taste demanded a simpler form of music in which clear-cut melodies in a lively rhythm were supported by a simple harmonic accompaniment. Slow movements were naturally less vivacious and took as their model the more sentimental operatic arias. Graded dynamics were playing a more and more important part in opera and these were also introduced into orchestral music, particularly at the court at Mannheim. A new style of orchestration also became established. Wind instruments which had previously had independent lines were now largely employed in providing a harmonic background. Keyboard instruments were no longer essential in the orchestra and eventually dropped out of use altogether as a reinforcement of the ensemble. The keyboard concerto, on the other hand, was increasingly used, particularly as the piano proved to be a more expressive instrument than the harpsichord and came to supplant it.

There was a growing realization that instrumental music could be as dramatic as opera. This is evident in the symphonies of Carl Philipp Emanuel Bach (1714–88) and Joseph Haydn (1732–1809). And since comic opera enjoyed enormous popularity at this time, there was equal opportunity for humour in instrumental music, together with a simple gaiety that was not always as naïve as it appeared. Side by side with these larger structures is to be found a great quantity of music designed purely for entertainment—divertimenti and the like—that naturally included dance movements. Haydn began by writing works of this kind that could be performed either by an orchestra or by a chamber music ensemble, and from these he progressed to music designed from the first for a string quartet. The development of this form is evidence of his growing maturity as a composer; it also had an enormous influence on other composers, not least on Wolfgang Amadeus Mozart (1756–91). The structure of these works, as also of Haydn's symphonies and piano sonatas, shows a variety of influences—influences that appear generally in the instrumental music of the late 18th century. The tonal relationships of the old dance movements now provided the basis for an extended movement, in which the modulation from the related key back to the tonic offered the opportunity for a "development" or varied treatment of the thematic material of the initial "exposition" (the section ending with the related key); and the return to the tonic was made the excuse for a "recapitulation" of the material heard in the exposition. The recapitulation, however, was not identical with the exposition, since everything was now in the tonic key and could be followed by a "coda" (or tailpiece) that brought the movement to a decisive end. This type of structure was not rigid, since it did not dictate the number of themes (there was sometimes only one) or their character, and the extent to which they were used or alluded to in the development was open to considerable variation. This structure was normally used in the first movement of a sonata or symphony, but it might also appear in others, except in the minuet and trio (a survival from the divertimento), which were, in fact, a pair of dances with the first repeated as in a *da capo* aria. Furthermore, Haydn did not, like so many of his contemporaries, exclude polyphony from his instrumental works: it appears frequently in the shape of movements that are either wholly fugal in structure or make extensive use of contrapuntal technique. And polyphony is the very essence of the

finale of Mozart's "Jupiter" Symphony. It was Mozart, too, who in his piano concertos successfully combined the old principle of an orchestral ritornello with the newer structure of the sonata.

The dramatic element in the symphony was intensified by Ludwig van Beethoven (1770–1827), whose instrumental works are in many respects more dramatic than his only opera, *Fidelio*. The courtly conventions of the 18th century broke down before a new impact, which owed some of its force to the growing collapse of feudal society and the widespread adoption of liberal ideas. In the process the tonal structure of sonata and symphony was widened and development became a more intense reworking of the themes announced in the exposition. Opera in Italy was little affected by these tendencies: it still set great value on fine singing, and even comic opera demanded virtuosity. In France the simple intensity devoted to serious opera by Christoph Willibald Gluck (1714–87) had brought new life into that statuesque form. But the 19th century, instead of following in his footsteps, developed a type of music drama that was increasingly spectacular and earned the name "grand opera." Meanwhile comic opera, which had begun as a popular entertainment, became more sentimental in tone and more serious in intention, particularly under the influence of the horrors of the French Revolution. In Germany a new type of romantic opera was inaugurated by Carl Maria von Weber (1786–1826) in 1821 and established a tradition in which the supernatural, the glorification of the middle ages (in the manner of Sir Walter Scott's novels) and the representation of homely country scenes played an important part. Franz Schubert (1797–1828), Weber's contemporary, was not successful in opera, but in more than 600 songs he showed how the simplest strophic ditty could become a masterpiece of imaginative insight.

The new freedom won by Beethoven did not bear immediate fruit, partly because he was so much revered by his successors. Many composers of the mid-19th century were content to imitate his methods without showing the same force of character. Furthermore, there was a growing emphasis on lyrical invention. Song composition became more and more popular, and this was matched by a large output of piano pieces of a similar character. Many of these works were designed for domestic performance by amateurs, but a considerable amount of keyboard music of this period called for great virtuosity. Composers like Franz Liszt (1811–86) and Frédéric Chopin (1810–49) exploited the possibilities of the piano —now a more sonorous and more subtle instrument—in ways that previously had been only dimly imagined. Brilliant improvisation encouraged the composition of rhapsodies and variations, but this did not blind composers to the necessity for formal organization of their material. Inspired by the example of Beethoven, Liszt showed how themes could be developed by various forms of transformation and how in a "symphonic poem" they could be associated with specific ideas. Richard Wagner (1813–83), in his later operas, showed how effective such association could be in the theatre and by treating the orchestra in a symphonic style created a new kind of continuity. The growth of the orchestra at this period was stimulated by his demands and encouraged by the inventive skill of instrument makers. After a cautious start composers were quick to grasp the possibilities offered by horns and trumpets that commanded a complete chromatic compass. A new orchestral sonority was created; it relied not simply on increased volume of sound but much more on the variety to be achieved by new contrasts and new combinations. Italy, where opera still dominated the scene, was slow to develop this new art, and it was only in his later works that Giuseppe Verdi (1813–1901) acquired a subtlety in handling the orchestra that marked a new epoch in Italian music. He also showed, without imitating Wagner, how the old conventions of recitative and aria could dissolve into a fluid and convincing continuity.

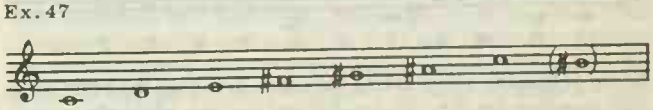
In Germany and Austria the symphony was still respected, though composers were often hard put to use it as a medium for romantic ideas. Johannes Brahms (1833–97) showed considerable resource in combining a lyrical impulse with formal unity on a large scale. Anton Bruckner (1824–96), aiming at the grandiose, was less successful. But respect for the past was not the whole story. Everywhere a new spirit was stirring. The political ambitions of peoples who were oppressed by a foreign yoke or were newly conscious of their national traditions led to a lively interest in folk song—in Russia, Bohemia and Norway in particular. With the rediscovery of national idioms composers found a new source of inspiration for their own work. The inventiveness of Wagner had also led to a further exploration of harmonic colour—for example, in the songs of Hugo Wolf (1860–1903), who also attempted a more intimate relationship between text and music, and in the symphonic poems of Richard Strauss (1864–1949), who while still a young man showed a mastery of the orchestra equal to Wagner's and a skill in developing material that was superior to Liszt's. It was a period of excitement and adventure that was bound to lead either to a reaction or to an even more subtle exploration of new resources. *See* ORCHESTRATION; SYMPHONY.

## V. MUSIC IN THE 20TH CENTURY

The main developments of 20th-century music might be summed up as an extension of romantic idioms and resources and a reaction against them. The reaction took several forms. For that reason it is convenient to consider first some of the ways in which romantic traditions survived. In the early part of the 20th century the large forces employed by late 19th-century composers were still regarded as a natural, if not a necessary, medium for expression. The composition of such works was encouraged by the apparent absence of any serious economic obstacle. As a result there were grandiose works for chorus and orchestra like the eighth symphony by Gustav Mahler (1860–1911) and the *Gurre-lieder* by Arnold Schoenberg (1874–1951). Purely orchestral works were on a similar scale and opera followed suit. The idioms of romantic music were also kept alive by a passionate style of writing that clothed a diatonic framework with a generous use of chromaticism. The leading exponent of this style in England was Sir Edward Elgar (1857–1934). In a sense it was an international style, but it had many local variants. Sometimes those variants hindered appreciation in other countries; but many of them charmed by a mildly exotic flavour or by exploiting idioms that appealed directly to ordinary men and women. The characteristically Slav melancholy of Sergei Rachmaninoff (1873–1943) conquered the world as decisively as the Italian operas of Giacomo Puccini (1858–1924). The public for such music was even larger than it had been in the late 19th century; and although the growing popularity of music did not necessarily ensure a critical attitude it did mean a widespread familiarity not only with the classics but also with works by contemporary composers. Although broadcasting did not exist and the phonograph was in its infancy, music lovers educated themselves by listening.

The chromaticism of Wagner's later operas—particularly *Parsifal*—reached a point where tonality, as hitherto understood, was in danger of becoming obscure. A kind of shifting modulation tended to take the place of the harmonic relationships that had previously served to determine a key. This tendency was not everywhere pushed to its final conclusion. The music of Mahler, Strauss and Elgar is firmly grounded in diatonic tonality; but other composers were not so ready to keep one foot on traditional territory. The most striking development was impressionism, associated particularly with the name of Claude Debussy (1862–1918), who as a young man was strongly influenced by Wagner. The term "impressionism" is used by analogy with painting, but the analogy is not exact. Impressionist music does not necessarily avoid direct statement, but it does seek to portray moods or experiences by shifting harmonies that affect the listener not so much by their relevance to each other as by the impression they make individually. Although this use of harmony is a rejection of traditional tonality, it did not, in Debussy's hands, involve the abandonment of diatonic melody. The whole-tone scale,

Ex. 47



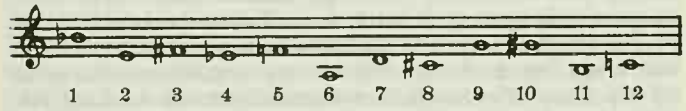
or

Ex. 48

which occurs frequently in his work, is in a sense the negation of chromaticism. Debussy was also attracted, like other French composers of his time, by the modal tonality of medieval music; he also found inspiration in the oriental music he heard at the Paris exhibition of 1889. There were many influences at work here, but they merged into one of the most individual styles of the early 20th century; *e.g.*, in the deliberate undertones of the opera *Pelléas et Mélisande*.

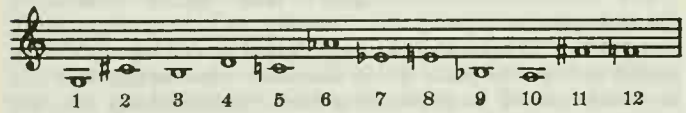
In Austria the main stream of romanticism was not diverted into other channels. The growing disintegration of tonality is most apparent in the early work of Schoenberg, who eventually solved the problem of finding a coherent harmonic structure by adopting a new system of composition. Since existing scales, whether diatonic, chromatic, pentatonic or whole tone, were no longer valid, he chose for each composition a series of notes that formed the basic pattern of the work. Since there are 12 notes in the octave, before it repeats itself, this method has become known as the 12-note system. The system assumes equal temperament, so that any note can be replaced by its enharmonic equivalent; *e.g.*, F♯ can be represented by G♭. The original series can be inverted, *i.e.*, the intervals go down instead of up and vice versa, or reversed, starting with the final note; and the reversed (or retrograde) series can also be inverted. This means that there are in fact four series, intimately linked together. Devices of this kind were often used by earlier composers but only as material for independent melodic lines. In the 12-note system the notes of the series also provide the harmony, since they can be used in combination as well as in succession. The principle may be illustrated from Schoenberg's *Variations for Orchestra*, op. 31 (1927–28). The basic series (B) is as follows:

Ex. 49



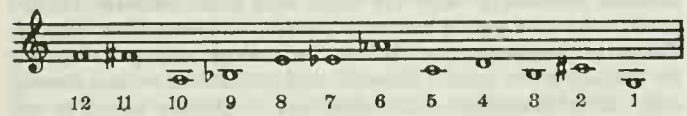

Transposed down a minor third and inverted (I) this gives:

Ex. 50



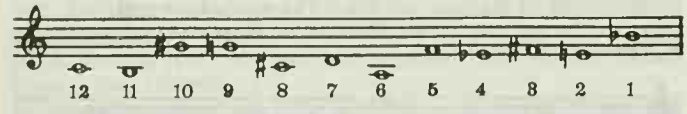

The retrograde form of this inversion (RI) is:

Ex. 51



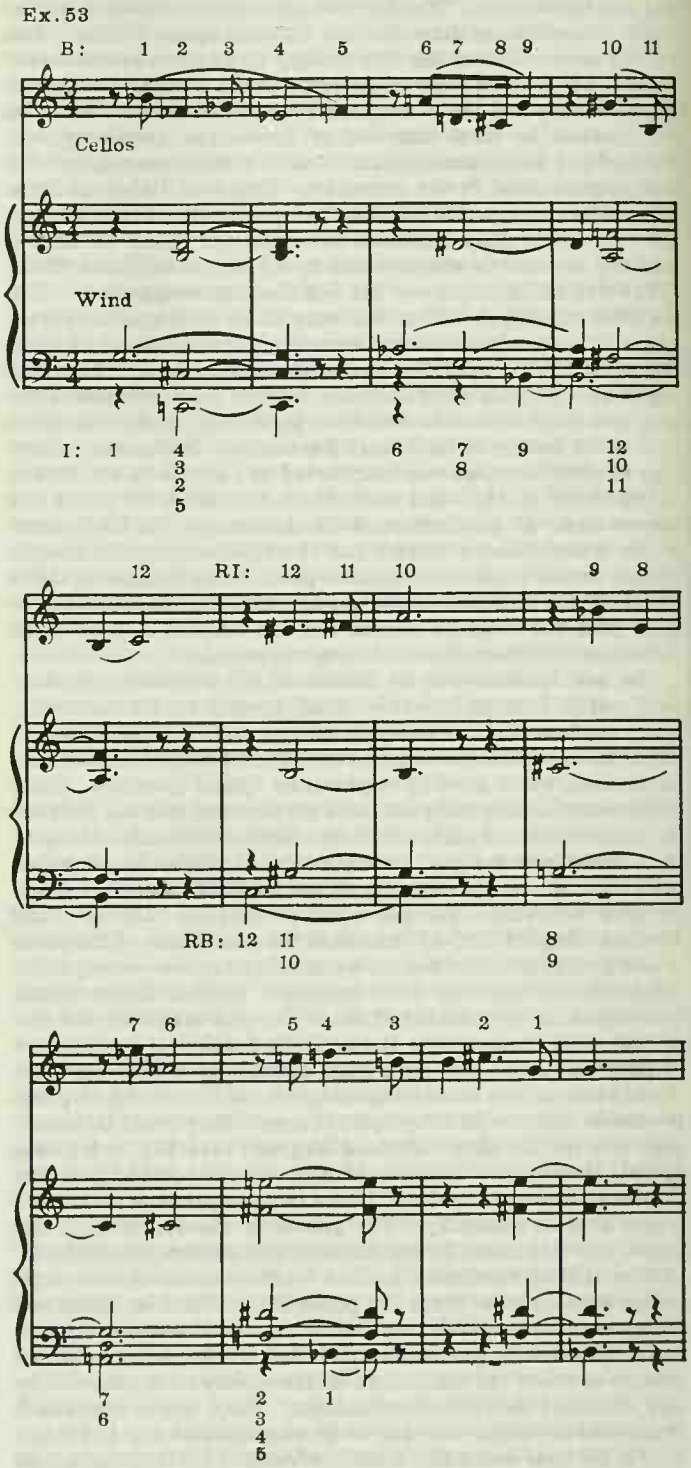

The retrograde form of the basic series (RB) is:

Ex. 52




In the statement of the theme the cellos first play the basic series (F♭ standing for E♮, G♭ for F♯ and so on) while the accompaniment is made up of the notes of the transposed inversion. In the following seven bars the cellos play the retrograde form of the inversion, accompanied by harmonies made up from the retrograde form of the basic series. (Intermittent chords for the harp are omitted, since they merely double the wind):

Ex. 53




The remainder of the theme continues with similar combinations.

The system is less rigid than it sounds, and in fact it was used by Schoenberg himself, and even more by his pupil Alban Berg (1885–1935), with a good deal of freedom. It does not deprive the composer of the power of choice, since he not only chooses the series but can use the individual notes in any octave, transpose the whole series at will and decide for himself at any moment whether the notes are to have a purely melodic function or to be associated in harmony. Though the listener may very well be unaware of the structural principle employed, he will, if the composer is expert, be conscious of an inner logic, and this is what

the 12-note system seeks to provide as a substitute for the older practice of fixed harmonic relationships. (*See* DODECAPHONY.) Since Schoenberg began as a romantic it is only natural that his music in the new style should have strong romantic associations, in spite of the apparent change of idiom; and this is confirmed by some of the music written toward the end of his life, in which he reverted to the neoromantic harmony of his youth. It was, rather, Anton von Webern (1883–1945) who marked a new point of departure by stripping music to its bare bones, employing in the process a transference from one instrument to another that recalls the method of the pointillist painters. All these composers, however novel their procedures, remained faithful to the traditional division of the octave. Experiments made by other composers in dividing the semitone into two or three smaller intervals (and even more minute subdivisions) proved unfruitful.

New methods of harmony were accompanied by a further exploration of instrumental resources, not so much by the invention of new instruments as by exploiting all the possibilities of the old. Devices such as flutter-tonguing on flutes, the muting of brass instruments, the use of string harmonics and generally the employment of instruments at the extremes of their compass were no longer introduced as incidental effects but became part of the basic material of orchestration. In the process there developed a purely instrumental style of melody that was encouraged by the method of selecting intervals from the 12-note series and switching them from one octave to another. Inevitably this melodic style had its effect on the composition of vocal music. The old tradition of solo song had been maintained by Mahler and Strauss, but the more progressive composers demanded wider intervals from singers and developed the habit of writing melodic lines that were anything but vocal in the older sense of the word. Nor was this practice confined to solo song. Singers of choral music also found that they had to develop a new technique that would enable them to pitch accurately notes that followed one another in no obvious sequence.

Folk song was not susceptible to a neoromantic treatment. Though purely melodic in origin, except in countries like Hungary and Russia where there existed a traditional popular polyphony, it contained within itself the seeds of an appropriate harmony. For that reason the borrowing of folk material and its imitation by composers was a form of reaction against the prevalent lushness of late romantic harmony, particularly in countries that had hitherto shown little interest in traditional melodies. In Spain national idioms provided a stimulus for Manuel de Falla (1876–1946), and in England Ralph Vaughan Williams (1872–1958) found in folk song an answer to some of the problems of developing an individual style. In both cases the idioms of folk song were not merely borrowed but absorbed into the composer's invention; and in both cases this absorption was combined with the use of characteristic harmony that was independent of folk song but not alien to it. The result was a reaction against romantic harmony; this, far from leading to a dead end, had fruitful consequences. It was only in the hands of composers of less imagination that folk song proved a sterile influence.

Another form of reaction was a renewed interest in baroque music, particularly in the work of Bach. The rediscovery of Bach in the 19th century had led to the widespread performance of his music, but it was not until the 20th century that composers other than organists seriously applied themselves to imitating his methods, if not his style. In the work of Ferruccio Busoni (1866–1924) such imitation did not involve a radical break with tradition, though Busoni himself was keenly interested in new harmonic experiments. It was rather the younger composers of the 1920s, notably Paul Hindemith (1895–1963), who regarded polyphony as an end in itself—an end that justified any kind of harmonic clashes between the melodic lines. This type of polyphony was christened "linear counterpoint"—an unnecessary term because all counterpoint consists in the combination of independent lines. A better description was "neoclassicism," since it indicated a desire to return to the perfection of form Busoni admired so much in Bach and Mozart. Something of this perfection appears in the work of Gabriel Fauré (1845–1924), who began as an admirer of the German romantics but in later years refined his style more and more until it acquired an austere clarity; clarity is evident also in the work of his pupil, Maurice Ravel (1875–1937).

Hindemith was not merely concerned with "art for art's sake." He always believed that art should be communication and for that reason wrote a great deal of music intended for amateurs. The term *Gebrauchsmusik* (literally "music for use") was coined to describe works of this kind. Since they were an integral part of the neoclassical movement they deliberately avoided the facile sentimentality that had previously characterized a good deal of music written for amateurs—particularly music for children. In consequence they often seemed dry and uninviting to those who were used to an older tradition; but they served a useful purpose in bridging the gulf between contemporary music and the world of education. They may also have contributed to a simplification of Hindemith's style, which became more firmly rooted in tonality, though with a far wider scheme of harmonic relationships than would have been accepted by 19th-century composers.

Allied to this movement for establishing a closer link between the public and contemporary music was the acceptance of jazz as material for artistic development. Jazz originated as a form of dance music among the Negroes of New Orleans, where it developed as a by-product of the spirituals sung by converts who had come to America as slaves. It was taken up by white musicians and rapidly spread over the civilized world, winning popularity by its use of lively syncopation and the opportunities it offered for improvisation. "Ragtime"—an early form of jazz—made sporadic appearances in serious compositions in the early part of the 20th century, but the heyday of jazz as the basis for large-scale works was between World Wars I and II in works such as the ballet *La Création du monde* by Darius Milhaud (b. 1892), the piano concerto by Aaron Copland (b. 1900), *The Rio Grande* for piano, chorus and orchestra by Constant Lambert (1905–51), and the operas *Johnny spielt auf* by Ernst Křenek (b. 1900) and *Porgy and Bess* by George Gershwin (1898–1937). The movement to bridge two worlds had not, however, any lasting success, in spite of later experiments in combining jazz band and orchestra. (*See* JAZZ.)

Throughout this period there were composers who remained largely aloof from current tendencies, such as Carl Nielsen (1865–1931) in Denmark, Jean Sibelius (1865–1957) in Finland and Ildebrando Pizzetti (b. 1880) in Italy. Sibelius' style was influenced in his youth by the Russians but it developed rapidly into a language that is more personal than national. Exhibiting on the one hand an austere solemnity and on the other a Mediterranean exuberance, he proved that classical methods of construction, as developed by Beethoven, were still valid for the 20th century and could be knit into an even tauter coherence. In spite of this, his influence on other composers was slight, perhaps because his style and idiom are so closely linked. In addition to composers who may be called, without reproach, traditional in their outlook, there are others who have either sampled a variety of styles or have shown that eclecticism is not a bar to originality. Examples of this type are Béla Bartók (1881–1945), Igor Stravinsky (b. 1882) and Benjamin Britten (b. 1913). Bartók's music is the product of a variety of influences. He was an untiring collector of folk songs not only in his native Hungary but also in other eastern European countries, and both the rhythms and the melodic intervals of folk song powerfully affected his style. In particular, he found a way of using these melodic intervals as the component parts of his harmony and this encouraged him to use chord clusters of many notes in which dissonance was strongly marked. This was a different development from the progressive use of unresolved dissonance, which in the hands of other composers was the logical consequence of Wagner's harmony; it was influenced rather by Debussy's use of chords as composite structures existing in their own right. Bartók, however, was more than an impressionist: his admiration for Bach and Beethoven impelled him toward a unity of form and material that was inspired by the spirit but did not imitate the methods of those composers. And however complex the harmony became, it did not depart from a basically diatonic foundation. The dissonance is not a new lan-

guage: it is rather an individual plant growing out of the soil of the old.

Stravinsky first became generally known as a composer of ballets for Diaghilev. In these works he rapidly grew away from a style modeled on that of the older Russian composers to a form of expression that was direct, personal and uncompromising. In the course of his long career he showed the capacity to mimic the superficial characteristics of almost any type of music. There are elements of popular music-making in *L'Histoire du soldat* and *Les Noces*, the *Symphony of Psalms* has some of the antique austerity of Russian chant, the ballet *Apollon Musagète* casts more than one backward glance at Tchaikovsky, *Oedipus Rex* has many of the characteristics of baroque oratorio, and *The Rake's Progress* goes through the motions of 18th-century opera. For this reason it has often been asserted that Stravinsky's style was a pastiche. The truth is rather that he assimilated a great deal of music by other composers and used what appealed to him as a stimulus to his own invention. The result is a series of original creations in which everything is governed by the composer's acute ear for sound; hence the harmony falls into no conveniently labeled system but may range from acute dissonance to the simplest diatonic sequences. In later years Stravinsky turned his attention to 12-note music, but the works he wrote in this style are as completely his own as any of those in which earlier influences can be detected.

Britten's methods are rather different. His acceptance of outside influences has the air of being unconscious, and his methods do not vary, as Stravinsky's do, from one work to another. His gifts lie not so much in any outstanding melodic invention nor in the capacity for large-scale construction as in the power of evoking, often by the simplest means, whatever mood or background is appropriate to a particular purpose. This is not impressionism, since the musical material is nearly always clear-cut and definite: it is rather the subtle use of sound patterns to establish an immediate contact with the listener. Britten's harmony often achieves its effect not by experiments in new combinations of sounds but by finding new associations for familiar chords.

In the 20th century opera became even more popular than it had been in the 19th, but the public showed a relatively mild interest in contemporary examples. The undoubted appeal of works like Berg's *Wozzeck* and Britten's *Peter Grimes* was small compared with the enduring success of older compositions. Only Strauss and Puccini in the 20th century were able to maintain an unchallenged position in the theatre, not only in Europe and the United States but throughout the entire world. It has been said with some truth that Puccini's *Turandot* (produced posthumously in 1926) was the last opera to achieve enduring popularity. This, however, did not prevent composers from experimenting with a variety of idioms. Where they were unsuccessful the reason lay partly in a lack of the stage experience that earlier composers acquired in the normal course of a professional career and partly in the tendency, mentioned above, to write an instrumental type of melody for voices. Since personality in drama can only be made vivid by the voice, though the orchestra can contribute a whole world of associations, the absence of a genuine vocal line in so many mid-20th-century operas was a serious obstacle to appreciation This obstacle did not exist in ballet, which, if it did not maintain the almost delirious popularity it enjoyed in the days of Diaghilev, still provided plenty of opportunities for composers to match new ideas in choreography with original music. The sound film opened a further channel, but the fact that film music is subsidiary to action encouraged composers whose chief gift was a facile technique. As long as this was applied to the strict purpose of providing background music, no harm was done; but the transference of this style of music to the concert room sometimes had disastrous results.

A disturbing feature in the world of music that was unknown before World War I was the interference of the state on ideological grounds. In Nazi Germany not only was music by Jewish composers banned: condemnation was also applied to any works suspected of what was vaguely called "Bolshevism"—a term that in this connection meant any music of a markedly progressive character. Similarly in Soviet Russia there was serious opposition to "formalism," which appears to have meant much the same as Bolshevism had to the Nazis. The result of these attitudes was partly the emigration of many composers to other countries and partly the composition of "acceptable" works by those who preferred to submit to the regime. This kind of music was generally based on simple diatonic melody and harmony that was suitable—at least in theory—for simple people. It sometimes achieved a popular directness of approach, sometimes resulted in mere banality—even in the works of such gifted and experienced composers as Sergei Prokofiev (1891–1953) and Dimitri Shostakovich (b. 1906).

The development of the electrical reproduction of music—in phonograph recording and on the radio—led to an exploration of the possibility of creating new works by electronic means. By generating frequencies corresponding to the vibrations of notes and converting them into sound the engineer can produce any tone quality at any pitch and by using several different bands can combine these sounds in an unlimited variety of ways. (*See* ELECTRONIC MUSICAL INSTRUMENTS.) Experiments conducted by composers included works built up entirely of electrically manufactured sounds and others in which these sounds are combined with living instruments or voices. In general, the effectiveness of such music varies in inverse proportion to the resemblance the electronic sounds bear to recognizable instruments. It follows from the method employed that there is no question of one performance differing from another. The work is created in a permanent form and once it has been recorded does not admit of any other interpretation. Opposed to this rigidity is the practice of writing works for actual instruments or voices which offer the performers a considerable degree of licence in choosing what they shall perform and how they shall perform it. Music of this kind may give them the opportunity of selecting from the printed page whatever happens to appeal to them or of combining different sections in whatever way they please. Whereas in electronic music the performer has no choice, since there is no performer, in music of this kind the composer abandons his right of choice and leaves it to the performer to make the ultimate decision. This is an extension to its furthest limits of the principle of improvisation as practised in the baroque period and in modern jazz. Music of this kind is in a sense indeterminate. At the same time composers also carried further the basic principles of 12-note music by choosing not only a series of notes as the foundation for a composition but also a series of rhythms and a series of dynamics. Such music is anything but indeterminate; and it often results in a complexity so advanced that the ear is incapable of appreciating the details. The intention behind such works is, as was so often the case in the past, to find a strictly logical basis for musical construction. The problem all composers have to face is that of finding a means of expression that is both intellectually and emotionally satisfying.

*See* also references under "Music" in the Index.

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**MUSIC, PRIMITIVE.** The concept of primitive music is understood in this survey to refer to vocal and instrumental sounds produced in primitive societies. Its meaning cannot be precise because usage of the words "primitive" and "music" has undergone changes. This reflects the evolution of new interests and attitudes among western observers and in illiterate societies in relation to these sounds. Anthropologists have come to suspect the term primitive of being too ambiguous and to avoid it because of its pejorative associations. Western musicians doubt whether their concept of music, which refers to the music of artists, can legitimately be applied to the sound making of so-called primitives. The impasse has been overcome to some extent by the art historians. They think of primitive music as a process and speak of premusical sounds, organized for rhythmization of work and ritual, for stimulation and perhaps for magical purposes, and of a long premusical period in which "the elementary *materials* of music became established" (S. K. Langer).

**Recordings; Origins of Music.**—Interest in primitive music began in Europe with the discovery of new routes to other continents. Explorers occasionally mentioned music of indigenous peoples. In 1615 Michael Praetorius could assume sufficient interest among his readers to include 30 illustrations of African, American and Asian musical instruments in his famous *Syntagma musicum* with remarkably clear detail, though not all his examples were primitive. Yet, the study of primitive music received little support until Walter Fewkes recorded songs of North American Indians on phonograph cylinders in 1889. Two years later B. I. Gilman was able to demonstrate the existence of a new field of musical studies in his "Zuni melodies," which were based on these recordings.

Collections grew with improved communications and more efficient apparatus, and recordings are now available from almost every country. Yet, sooner or later, primitive music will be extinct as a living tradition, largely because modern conditions break down the isolation which had been its main protection, and the recordings will be the only way by which it can be heard.

Primitive music was found to be more diverse and complex than the lexicographic meanings of the word primitive suggest, and this is not surprising. Sound enters most activities of humans and other animals. Gibbon monkeys use stereotyped vocalizations that produce characteristic reactions in their fellows and expression is given to "aggressive or defensive behaviour" (C. R. Carpenter). W. Köhler noted that chimpanzees formed a circle, decked themselves out with twigs and leaves and made rhythmic noises by stamping on the ground. But man's acoustic utterance is invested with yet another quality: the super-natural. According to students of primitive religion the super-natural took different forms at different stages of prehistory, but whatever the form, it is acted out and danced out. The elementary materials of music were thus nurtured and became established.

To speculate on the place of primitive music within the super-natural is not the same as speculating on the origin of music itself. The following have at one time or another been held responsible for the genesis of music: competition in courting; imitation of bird calls; rhythms demanded by working procedures; the lulling of an infant; the release of passion; patterns of speech, or more specifically, a primeval tonal communication that gave rise to both language and music; and calling from a distance, which requires an essentially musical treatment in order that the voice may carry. The comparative merits of these theories are discussed by J. Kunst in *Ethnomusicology* (1959).

**The Super-Natural.**—It is, of course, unreasonable to expect that the birth of music could be witnessed as the division of cells can be seen under a microscope. But with regard to the super-natural in music making among primitive societies, field work has produced ample evidence of its effects. A revealing example is the music of the Dogon (*q.v.*) tribe of west Africa. The Dogon see their environment in the light of a dualistic order of the universe which is transmitted and sanctioned in myths of creation. This is acted out in Dogon music in several ways; a song will either have a binary or ternary rhythm according to the significance of the song in a female or a male context. The onion harvest is accompanied by female rhythms because the crop grows in the womb of the earth, but the ritually important millet requires work songs in a male ternary beat. The two notes of a pair of drums are interpreted as being female for the higher note and male for the lower note. The four strings of the harp-lute are divided into pairs, one male and one female. Because the craft of weaving is important in the myth of creation the harp-lute is likened to a loom and the strings are strung like the threads on a loom. Dogon believe that a wrong note on this instrument confuses the spirits, and play such a note to prevent evil. The tempo of their songs is sometimes accelerated toward the end, even in a work song where change of tempo might run counter to the even rhythm demanded by the work; acceleration adds spiritual vitality, as does the raising of the pitch in tuning the harp-lute. Extensive song cycles are performed at funerals and marriages which require sequences of different chants to match the stages of the ritual (G. Calame-Griaule and B. Calame).

**Artistic Form.**—The Dogon examples illustrate what Marcel Griaule, the anthropologist and student of Dogon culture meant when he said "certain types of art are directed toward a spiritual rather than a human audience" (K. M. Trowell). That this approach does not occur everywhere at the same level of intensity is clearly demonstrated by comparison between two practices of superficial resemblance: both the xylophone of the Soga (*q.v.*) of east Africa and the lithophone of the Maa of south Vietnam are sprinkled with the blood of a sacrificial animal. With the Soga this has become a perfunctory gesture which has no connection with the entertainment that follows and it is almost forgotten that the offering is for the spirit of the tree from which the keys are carved. With the Maa the sole purpose of the playing of the instrument is said to be its "feasting on the meat" (G. Condominas and J. Boulbet). These examples illustrate an evolutionary trend in primitive music away from the vital spiritual level toward empty convention, a trend that eventually leads to the awareness of artistic form and the end of the premusical period.

**The Rise of Musical Instruments.**—It is no accident that vocal elements dominate in theories on the origin of music; vocal sounds are universal. Instrumental sounds in music are said to be absent among the inhabitants of the interior of Ceylon and are notably limited among many nomadic tribes, as for instance those of the Horn of Africa.

At the crudest level, among the inhabitants of Tierra del Fuego in South America no instruments are known that are especially designed for sound. "Instead they blow into the windpipe of a newly killed duck or at their death dances they pound the earth with pairs of thick, long poles or drum on a rigid rolled piece of hide. Men bellow into the hollow of their hands placed against the earth, knock sticks and branches against the frame of the festival hut for rhythm or simply beat the floor of the hut with bare fists" (E. M. Hornbostel).

An interesting attempt has been made to distinguish different levels of achievement by arranging musical instruments in accordance with their diffusion throughout the world. This was based on the assumption that diffusion progressed from a few important

centres, like ripples spreading in water. The earliest types of instrument traveled farthest and survived here and there on their way toward the periphery, while they may have become extinct near the centre. Instruments of similar range of diffusion were taken to be nearer in age and more closely related in origin even though they did not necessarily belong to the same culture (E. M. Hornbostel). This scheme, put forward by Curt Sachs in 1929, retained its usefulness as a working hypothesis even though the ethnological theory from which it derived was severely criticized.

The acoustic devices in these early instruments are manifold. The lowest (Paleolithic) levels show man stamping, shaking, rubbing, scraping and blowing, armed with common objects turned to musical purpose *ad hoc*, and later employing rattles, bull-roarers and flutes without finger holes. The subsequent prehistoric levels add to these the slit drum, stamping tubes, flutes with finger holes, trumpets and the earliest stringed instruments, including the musical bow (*see* MUSICAL INSTRUMENTS).

With the invention of the bow, man succeeded in concentrating and controlling energy. To a 20th-century person it may be plausible that this must have been for shooting an arrow; to Neolithic man it may have been equally plausible to use the energy of the bow for communicating with the super-natural by making sounds. A prehistoric cave painting at Les Trois Frères in France shows the bow thus used in ritual (H. Breuil).

**Melody and Pitch.**—With flutes and strings on which to experiment, man had the opportunity of observing the harmonic series and, if he so wished, of making the overtones the focal points for his casual musical conventions. Possibly he did; according to P. Kirby the Kalahari Bushmen have adopted a pentatonic mode based on the partials which they discovered in the strings of their shooting bows. They also mastered another musical trick: by stopping and unstopping the end of an open flute, access is obtained at will to the harmonic series of either open and stopped pipes in the same instrument and, by selecting from the pitch material thus offered to the player, a pentatonic scale can be constructed. Kirby observed both the string and this particular flute technique in action.

Yet it would be rash to conclude that such five-note patterns, developed in this way, decisively influenced primitive music. In primitive melody a stressed note, vocal or instrumental, stands out in contrast to an unstressed note. They make pairs of light and heavy (or light and dark) sounds which are indistinguishable from bitonal melody. The addition of a middle register makes tritonal tunes possible, and the repetition of either pattern (in sequences on different levels of pitch) accounts for even wider forms. Their intervals may be narrow steps or wide jumps, or, where more than one interval is involved, a combination of both (W. Wiora). None of these forms depends on the experience which the Bushmen applied to strings and flutes, an experience which may be no more than the rationalization of earlier practices, stimulated perhaps by contact with civilizations which were not primitive. Primitive melody need not have recourse to the pentatonic mode of the acoustician or even develop a concept of scale.

Western theory has been greatly influenced by speculation about the intrinsic excellence of the simple frequency ratios in the octave, fifth and fourth. In primitive music such intervals are far from universal; where they do occur they are difficult to identify. It would be unwarranted to treat them as if they were, by virtue of these frequency ratios, better fitted for survival.

**Polyphonic Forms.**—Neither the harmonic series nor the simple frequency ratios were needed to account for the rise of primitive polyphony. The same song may be sung by different persons at the same time but through vocal incompetence or sheer exuberance their renderings will differ widely. Their concerted action might be governed by the pattern of their social purpose or by the participation of groups of different status. From Australia A. P. Elkin reported the simultaneous performance of two songs intended to be different when people gathered in two groups divided according to moiety (*see* DUAL ORGANIZATION). The oldest forms of polyphony are the simultaneous execution of variants of the same tune, singing in parallel lines (which may or may not give the impression of unison), the canon (*q.v.*) and the drone (M. Schneider).

Yet polyphony is not universal. Three main regions have been distinguished: first, Polynesia, Melanesia, Indonesia, further India and the Philippines; second, the region stretching from the southern Caucasus to Europe; third, Africa south of a line between Mombasa and Freetown (M. Schneider).

**Rhythm.**—As to rhythm primitive music scholars generally agree that its wealth is unlimited but that only later cultures tend to use definite metrical schemes (M. Schneider). Others find primitive rhythm mostly asymmetrical (G. Herzog). It is difficult to isolate rhythm from other elementary materials of music. "Rhythmic manifestation without melody" is achieved only by "fairly complex cultures," and "the simplest styles, like those of the Vedda, the Modoc and Klamath of California, and the Fuegians have no solo drums or other solo percussive music" (B. Nettl, *Music in Primitive Culture*, Harvard University Press, 1956).

Thus the difficulty is understandable in identifying any survivals of rhythm from the lowest levels of the premusical period. Western civilization has a striking example of such survival in its children's rhymes. They are built to an underlying scheme of eight values, arranged in four pairs of two quavers, each pair read in $\frac{2}{8}$ time. Widely differing structures in many languages have been found to adapt their individual features to this scheme. The children's rhymes of Europe correspond to examples of adult singing among the Kabyle, Tuareg, the Negroes of Senegal, Dahomey and the Sudan, and the indigenous peoples of Formosa (C. Brailoiu).

The polyrhythmic forms that A. M. Jones observed in African drumming contrast strongly with the simplicity and wide distribution of the eight values of the children's rhythms (*see* AFRICAN MUSIC). They are constructed on the principle of simultaneous performance of different rhythms with their own method of cohesion. They may well be of more recent origin than other less complex patterns but so little is known of the growth of rhythm that even speculation must cease. It is tempting to correlate them with the practice of repeating the same part with different phrasing which is also found in Africa (D. R. Rycroft).

**Ethnomusicology.**—Primitive music forms part of a new branch of study called ethnomusicology. In Anglo-Saxon countries it is the task of the anthropological and ethnological sciences rather than a matter for music historians and musicians. The development of electronic devices and of new techniques for analysis is likely to give greater insight into primitive music than the musician, conditioned to hear in his own tradition, could ever hope to achieve.

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**MUSIC, TEACHING OF.** The study of music falls into four interrelated categories: (1) music as a branch of philosophy,

mathematics or physics; (2) music in relation to its historical and sociological background; (3) the theory of composition; and (4) the techniques of vocal or instrumental performance.

In Europe, from the middle ages, music was part of the curriculum of many religious institutions, universities and schools. Practical music training was also given by individual masters who often were well-known composers or instrumentalists, by teachers within the guild systems and, later, by the conservatories.

Methods of teaching differed according to the requirements of the age, the country or the individual. In musical cultures where composition was inseparable from improvisation, as in classical Indian music, or where the musical repertory was only very gradually added to, as in folk traditions or in plainsong in the early middle ages, music was usually taught orally, the pupil serving a period of apprenticeship. Where such an oral tradition existed the function of the master was to demonstrate and that of the pupil was to imitate. In the absence of notation the details of performance, such as pitch and duration of notes, tempo, dynamics and colour, were considered an integral part of music, and differences of interpretation—that is, style—tended to be national or regional rather than individual.

**The Middle Ages.**—In the early middle ages there was a clear distinction between the *musicus*, with his philosophical and mathematical approach to music, and the cantor, who was occupied primarily with the performance of the liturgical chant. Later, through the change in teaching methods due to the dissemination of the use of the hexachord (*q.v.*) and the developments of notation, there arose a further differentiation between the *cantor per usum*, the purely practical musician, and the *cantor per artem*, who had a measure of theoretical and scientific knowledge.

The earliest record of the science and practice of music taught at a monastery dates from the 6th century. Practical instruction was given at the *schola cantorum* of Pope Gregory the Great in Rome and in the many similar institutions throughout Europe devoted to the study and performance of liturgical chant. These schools were concerned primarily with the training of men and boys for the service of the church. The singers were taught intervals by the use of the monochord; the chant was memorized, and in rehearsal and performance the leader would use his hand to remind the singers of the rise and fall of the melody.

By the 10th century a change in teaching methods is apparent from the emphasis placed on practical teaching in the works of Odo, abbot of Cluny, and Guido of Arezzo (*q.v.*). Guido is traditionally associated with the invention both of the solmization syllables of the hexachord and of the musical stave, developments that were indicative of a movement away from the earlier, largely oral tradition. In his writings Guido takes pains to stress the practical application of his methods. He makes it clear that his chief concern was with the performance of music: "I have simplified my treatment for the sake of the young, in this not following Boëthius whose treatment is useful to philosophers but not to singers."

From the beginning of the 11th century many of the monastic schools and the newer grammar schools gave only the minimum instruction in notation needed to perform the music for the church. It was left to the cathedral schools to provide a more thoroughgoing theoretical as well as practical training, often as a preliminary to further study at the universities.

From about the 12th century speculative music theory took its place in the medieval universities within the conventional framework of the seven liberal arts. Music was studied in its relation to ethics, astronomy, mathematics and the symbolism of numbers, and the nature of sound was held to reflect the nature of the universe. In music, as in philosophy, the ideas of classical antiquity were reconciled with, and revitalized by, the doctrines of Christianity. These concepts in their Christian form were set forth in the writings of the Roman mathematician and philosopher Boëthius (b. *c.* 480), whose *De Institutione musica* held much the same authority for the medieval music theorists as the works of Aristotle held for medieval philosophers.

From the 13th century the changing styles in the rhythmic organization of music were accompanied by corresponding developments in musical notation (*q.v.*). By the end of the 14th century these musical and notational developments had reached a high degree of complexity and the differences between the old and the new and between French and Italian forms of notation are dealt with in the contemporary music treatises. Among the important treatises of the 14th century are *Speculum musicae*, attributed to Jacques de Liège (*c.* 1270–*c.* 1330), which formed the basis of most university music teaching until the end of the 16th century; *Ars novae musicae* by Jean de Muris (*c.* 1290–*c.* 1351), who was famous as a mathematician, astronomer and astrologer as well as a musician; and *Ars nova* (*q.v.*) by the poet, composer and music theorist Philippe de Vitry (1291–1361).

In the middle ages the teaching of secular music was largely the province of the jongleurs. The jongleurs were expected to be proficient on several instruments and, like the later minstrels' guilds, they jealously guarded their professional skill and indeed their repertory; newcomers were admitted to the secrets of their craft only after a term of apprenticeship (*see* MINSTREL). No account of their teaching method remains. A handful of 13th- and 14th-century dance tunes has survived; these are characteristically instrumental in style and point to a basically improvisatory tradition of performance. Scraps of information about secular music are to be found in the writings of the theorists; there are occasional, often vague or unreliable, accounts of musical performance in the literary works of the time; and there are many, sometimes inaccurate and often idealized, paintings of singers and instrumentalists. From such meagre records this important aspect of medieval musical life can now be only fragmentarily reconstructed.

**The Renaissance.**—From the beginning of the 14th century a break with the formalism of the middle ages is apparent in the rhythmically elaborate polyphony and political texts of the motets of Philippe de Vitry, in the sophisticated settings of the fixed verse forms by Guillaume de Machaut and in the smooth harmonies and expressive vocal lines of the works of Francesco Landini and his Italian contemporaries. A new formal framework was created that was capable of containing a more personal expression than had hitherto been possible. And, as the composer became an increasingly important figure, music teaching took a new direction.

By the 15th century the earlier custom of performing sacred polyphonic music with a group of skilled soloists had given way to the practice of employing more than one voice to a part. With the resulting augmentation of choirs, the cathedrals and court chapels became the usual training ground for musicians.

Many composers taught privately a select number of pupils or were employed to teach the children of noble or wealthy families. Some accounts of their teaching methods survive. With the exception of the more specialized instrumental skills, music continued to be taught through the medium of singing. The subjects included notation; vocal technique, including ornamentation; vocal improvisation on a *cantus firmus;* and composition.

During the 16th century two conservatories were established in Naples and these were followed by others in Venice and other Italian cities. Like the choir schools of the middle ages, these renaissance conservatories were charitable institutions in origin. Their pupils were orphans or illegitimate children and musical training played a considerable part in the curriculum. (*See* CONSERVATORY, MUSICAL.)

Following the invention of printing, music treatises and instruction books appeared in increasing numbers. Most renaissance contributors to music theory were practical musicians, often distinguished composers. In addition to dealing with the techniques of composition, writers such as Giuseppe Zarlino (1517–90) also were concerned with the application of the mathematics of musical temperament to the practical needs of tuning keyboard instruments and fretting viols and lutes. Nicola Vincentino (d. 1572) attempted to reconcile classical Greek music theory with renaissance practice, and other writers sought to define the nature, function and technique of musical instruments. Works such as Thomas Morley's rather conservative *A Plaine and Easie Introduction to Practicall Musicke* (1597), in the form of a dialogue between the master and two pupils, were intended as instruction books for the amateur. Morley, like most of the other writers of instruction

books at the time, stresses (in order not to seem to be putting his fellow musicians out of work) the advisability of studying also with a good teacher.

The public performance of instrumental music continued to be almost entirely the province of fraternities of musicians employed by the courts or the municipal authorities. Unlike the medieval jongleurs, these guild members tended to specialize in one instrument, and during the 15th and 16th centuries family names of musicians include the Italians Tromboncino and Pifaro and the German-Jewish Hackbrett, all deriving from the names of instruments.

Some instruments, however, such as the keyboard instruments and the lute, were played by most serious musicians, and famous performers drew pupils from all over Europe and so spread their music and methods of performance. Girolamo Frescobaldi (1583–1643), through his pupils J. J. Froberger and F. Tunder, transmitted from Rome to Germany his skill both as an organist and composer; similarly, J. P. Sweelinck (1562–1621), the great Netherlands organist and composer, himself a pupil of Zarlino, handed on to his pupils traditions of organ playing and writing that were to culminate in the work of J. S. Bach.

Among the earliest surviving examples of a systematized method of instrumental instruction are the two *fundamenta organisandi* in the Buxheim organ book, a German manuscript of the late 15th century. These *fundamenta,* one of which is attributed to the German organist and composer Conrad Paumann (*c.* 1410–73), are instructions, in the form of musical examples, for keyboard technique and improvisation. Each *fundamentum* is arranged in sections in order of key; each section is comprised of notated examples of three-part keyboard improvisations on *cantus firmi* of varying character and length and of a keyboard prelude in an improvisatory style. The remainder of the manuscript consists of florid keyboard arrangements of sacred and secular vocal works as well as several *basse danse* settings.

Sebastian Virdung's *Musica getutscht* (1511) was the first of a succession of printed instrumental instruction books intended for the amateur musician. This form of "tutor," which took commercial advantage of whatever instrument was currently popular, persisted until the 20th century. Some of these early instruction books, however, such as Silvestro di Ganassi's *Regola Rubertina* (1542), on viol playing, were serious attempts to explain instrumental practice and technique; others, like their modern counterparts, merely consisted of selections of popular pieces and contained a preliminary chapter or two on the rudiments of music and instrumental technique as encouragement to the innocent amateur. Ganassi's *La Fontegara* (1535), which contains instructions for playing the recorder, was the first of many books on improvised instrumental ornamentation; his division of the musical examples into two sections—(1) the ornamenting of intervals and (2) the ornamenting of conventional cadences—was followed by most authors of similar works published during the 17th and 18th centuries. (*See* also ORNAMENTATION.)

**The 17th to the 20th Century.**—In the 17th century in Italy a great school of violin playing was established in which the most notable representative was Arcangelo Corelli. In Padua in 1728, G. Tartini established a school that, because of the wide variety of nationalities represented among its students, became known as the "school of nations" and Tartini himself became known as the "master of the nations." Perhaps of more lasting influence was the violin school founded in Turin by G. B. Somis (1686–1763), who had studied under Corelli and Vivaldi; he in turn handed on traditions of playing that passed from pupil to pupil down to Joseph Joachim in the 19th century and from him to players of the 20th century. Another famous violinist of the 18th century was F. Geminiani, also a pupil of Corelli. He settled in 1714 in London, where he established a great reputation both as performer and teacher. In his *The Art of Playing on the Violin* (1731) he laid down rules for holding the violin and the bow and for the general management of the left hand; in all essentials these rules represent modern practice. In this work Geminiani anticipated the famous *Violinschule* (1756) of Leopold Mozart, which in numerous editions and translations was for a long time the standard "method" for the violin. These "methods" were among the large number of textbooks on instrumental playing that appeared in the 18th century. Other notable 18th-century works were the *Versuch einer Anweisung, die Flöte traversière zu spielen* (1752) by J. J. Quantz, Frederick the Great's court composer and flute teacher; François Couperin's *L'Art de toucher le clavecin* (1717), dealing with harpsichord fingering, ornamentation and expression; and, most famous of all, C. P. E. Bach's *Versuch über die wahre Art das Klavier zu spielen* (1753–62).

C. P. E. Bach is sometimes regarded as the father of modern keyboard playing. Certainly his book as well as his compositions had considerable influence. Clementi, Cramer, Field and Chopin are all said to have favoured his principles. Beethoven recommended the young Czerny to study C. P. E. Bach, yet Czerny's method, as it later developed, aimed at the equalization of all the fingers, in direct opposition to Bach's views, which in fingering and phrasing recognized the differences in the length and strength of individual fingers. From Czerny the succession passed to T. Leschetizky, one of the most distinguished teachers of modern times.

In Italy in the early 17th century the practice of the thorough bass led to a new harmonic conception and later to the teaching of harmony at the keyboard. Rameau's *Traité de l'harmonie* (1722) was one of the most important theoretical works of the classical era. In this and other writings Rameau sought to derive not only individual chords but also laws of harmonic progression from certain acoustical phenomena. Later theorists questioned the validity of the scientific basis of his system of harmony; yet Rameau's notion of the fundamental bass, a bass not necessarily coinciding with the actual bass of a given chordal progression but supplying the fundamental notes, or the "roots" of its constituent chords, together with the closely allied theory of chordal inversion, profoundly influenced the teaching of harmony until the 20th century. (*See* also HARMONY.)

Before the beginning of the 19th century there was no well-defined barrier between performance and composition: the pieces in the 15th-century *fundamenta* would have served for beginners' exercises as well as for models in three-part contrapuntal technique. In the same way, J. S. Bach's writings often served a double purpose, *i.e.,* as practice material and as models for composition. His *Orgelbüchlein* claims that "a beginner at the organ is given instruction in developing a chorale in many divers ways, and at the same time in acquiring facility in the study of the pedal." The same applies to the "Inventions," in which keyboard players are shown not only how "to play clearly in two voices, but also to deal correctly with three obbligato parts." The art of playing from a figured bass was an important feature in Bach's teaching of his composition pupils, and it is worth noting that Bach's second son, Carl Philipp Emanuel, devoted to this skill the whole of the second part of his book mentioned above. It is a pity that this close association between performance and composition was to a large extent lost in much contemporary teaching. Books on composition continued to appear in large numbers and of varying merit, though few have descended to the level of the 18th-century manual described as "A tabular system whereby any person without the least knowledge of music may compose ten thousand menuets in the most pleasing and correct manner."

The beginning of the 19th century marked a more scientific approach to the teaching of music; this approach was exemplified by the work of such teachers as Manuel Garcia (1805–1906) in singing and of Tobias Matthay (1858–1945), some of whose ideas on pianoforte playing showed affinity with the basic tenets of C. P. E. Bach. Many other schools and systems were established both for voice production and instrumental playing. The establishment in 1795 of the Paris conservatoire introduced a democratic form of music teaching, *i.e.,* one that was subsidized by the state and available to students of talent who were admitted following a competitive examination. Most of the later schools of music in both Europe and the U.S. more or less followed the French model. As a result a much more systematized and in many ways a more rigid form of teaching prevailed, often producing great technical proficiency though it sometimes tended to stifle the more imaginative aspects of musical talent, particularly the creative talent for com-

position. This came about chiefly because, at the time when the musical language was changing rapidly as a result of the innovations of Beethoven, Berlioz and other 19th-century masters, the craft of composition was persistently taught with the aid of academic treatises on harmony and counterpoint. It is significant that in France very few of the holders of the Grand Prix de Rome for music, the highest musical academic award in that country, achieved distinction as composers; and the same academic spirit tended to deaden music teaching in other countries.

At the same time the widespread use of the term musicology to describe the scientific study of music is indicative of the growth of more intensive research work and the broader dissemination of knowledge in the fields of music history and theory. The development of mechanical and electronic reproduction of music through such devices as the phonograph and radio threatened for a short time to lead to a decline in instrumental teaching among amateur musicians. On the other hand, it stimulated a demand for a new form of teaching in music appreciation courses aimed at the cultivation of a more enlightened attitude to music on the part of listeners. The teaching of musical appreciation also played a part in those schools in whose curriculum music, or at any rate class singing and the teaching of sight reading through the tonic sol-fa (*q.v.*) method, had first found a place in the 19th century. The subsequent establishment of music as a school subject for public examination led to a flood of textbooks on harmony and counterpoint, music history, ear training and the like, and to a type of teaching that, as in the academic schools of music, was often mechanical or mathematical rather than musical. At the same time there were developments in teaching music to children. Here the work of E. Jaques-Dalcroze (1865–1950) and his system of eurhythmics, which co-ordinates rhythm with bodily movement, and of Carl Orff (b. 1895), emphasizing creative musicianship through movement and improvisation, are outstanding. With the wider dissemination of music after World War II a new situation arose. Was the new musical public, largely the creation of the radio, going to be content merely to remain on the periphery of music, avidly listening but grasping only a fraction of the music's significance? Or was musical education, of perhaps another kind of education, about to meet the demands of the new inquiring public? The most encouraging aspect of music teaching after World War II was the growing realization that only in active participation in music is any real knowledge and understanding of the subject possible.

(R. E. Wo.; X.)

**MUSICAL ARRANGEMENT.** Music is conceived for instruments or voices; in modern times the composer usually specifies whether his work is intended for vocal or instrumental performance. It is often desirable to perform works by resources other than those for which they were originally written, *e.g.*, an orchestral work on the piano, and the music thus adapted from the original is called an arrangement.

Musical arrangements fall into three categories: (1) Transcriptions of a piece of music for another medium. The arrangement for cello and piano of Fauré's song "Après un rêve" is an example. This category also includes songs that are transposed; *e.g.*, those written in a higher or lower key for a singer's convenience. (2) Adaptations for another medium, such as piano duet arrangements of orchestral works, in which the music is required to be rewritten in order to comply both with the technical limitations and with the character of the new medium. Adaptations of this kind are comparable to translations in literature. (3) The paraphrase or fantasia, in which a composer's work, or themes from it, is used as the basis for a freely conceived original composition. The fantasias by Liszt on themes from 19th-century operas come into this category, as do the Stravinsky ballets *Pulcinella*, on themes of G. B. Pergolesi, and *Le Baiser de la fée* (*The Fairy's Kiss*), on themes of Tchaikovsky. This category includes the form of variations.

**The Middle Ages and the Renaissance.**—A large proportion of the surviving keyboard music from the period *c.* 1320–*c.* 1600 consists of characteristically instrumental transcriptions of polyphonic works. Most 14th- and 15th-century keyboard transcriptions are of three-part works originally intended for solo voice and two accompanying instruments. In these arrangements the original vocal line is usually elaborated with florid ornamentation, the tenor (the principal supporting voice) is preserved more or less intact and, in 15th-century arrangements, the contratenor (a filling-in part) may be (1) omitted altogether, (2) occasionally drawn upon to enrich the harmony or (3) rewritten to suit the taste of the arranger or the character of the instrument.

From the late 15th century to the early 17th century the frottola, polyphonic motet, chanson and madrigal were the principal sources for vocal and instrumental arrangement as well as for paraphrase in such forms as the parody Mass. The chansons in particular were adapted in many ways: as lute songs, the voice taking the upper part while the lower parts, often with added instrumental figuration, were played on the lute; as keyboard or lute solos; as viol solos, the viol, accompanied by a keyboard instrument, playing written or improvised divisions on the vocal bass; or as dances for instrumental ensembles (*see* DANCE FORMS IN MUSIC: *Renaissance Forms*). In many arrangements the original material provided a basis for an entire reworking that amounted virtually to a new composition.

As the ornamentation, often very elaborate, of many 16th-century styles of arrangement had a tendency to obscure the original melodic line, adaptations were usually made of works with a strong harmonic structure or of works in which the melody was well known (*see* also ORNAMENTATION). An example is John Dowland's "Lachrimae" pavan. This was conceived as a lute solo; it was later adapted by the composer and published as the lute song "Flow My Tears" in his *Seconde Booke of Songs or Ayres* (1600); four years later it reappeared as the pavan "Lachrimae antiquae" in his collection of dances for five viols and lute. Arrangements of "Lachrimae" by other composers of the time include settings for solo virginal, solo recorder, three lutes and, in Thomas Morley's *Consort Lessons* (1599), an instrumental sextet consisting of treble viol, flute, bass viol, lute, cittern and bandora.

Popular tunes also appeared in many forms of arrangement. These arrangements include settings for lute in which the melody is supplied with a simple harmonization; extended sets of divisions or variations for solo lute or for harpsichord; settings for a vocal or instrumental ensemble; instrumental fantasias where the melody is used as a *cantus firmus* (*q.v.*); *quodlibets*, in which several popular tunes, either in their entirety or in fragments, are combined contrapuntally to form a new composition; *e.g.*, "O rosa bella" in the 15th-century German *Glogauer Liederbuch* where John Dunstable's superius is accompanied by a vocal tenor and contratenor comprised of fragments of German songs.

**The 18th and 19th Centuries.**—In the 18th century J. S. Bach freely arranged the violin concertos of Vivaldi for harpsichord or organ and sometimes transposed them; *e.g.*, the concerto by Vivaldi for four violins in B minor transposed into A minor and arranged for four harpsichords. In arrangements that Bach made of his own works, such as his two violin concertos arranged for harpsichord, he not only transposes but boldly alters the figuration to suit the new medium, adds contrapuntal parts and generally remodels the work according to the character of the instrument. Other examples are Bach's prelude to his solo violin sonata in E major, which he arranged for organ and orchestral accompaniment, and the fugue from the solo violin sonata in G arranged for organ. The chorale preludes for organ were settings in the form of arrangements of pre-existent tunes.

Arrangements of this kind are in a sense creative since the texture of the work is fundamentally recast. This applies to the arrangement made by Beethoven of his Second Symphony for piano trio, demanding a chamber-music instead of an orchestral texture. Other examples illustrate aspects of a composer's technique. Mendelssohn's arrangement of his *Midsummer Night's Dream* music for piano duet reveals a knowledge of the keyboard's expressive resources, particularly in regard to runs, repeated notes and figurations, calculated not to imitate orchestral effects but to suggest their counterpart at the keyboard. Brahms' arrangement for two pianos of his Piano Quintet in F minor is another boldly conceived adaptation, amounting almost to a new work.

In the 19th century the piano was the instrument with which

orchestral, choral or operatic works could be brought to the home in much the same way music was popularized in the 20th century by the phonograph. Arrangements were accordingly made for piano solo or piano duet of all works likely to survive an initial hearing. Inevitably, some of the detail in scoring was sacrificed but arrangements made by other composers or conductors often brought a new light to bear on the original score. Hans von Bülow's arrangement for piano duet of Wagner's *Meistersinger* overture and Liszt's arrangement for piano solo of Beethoven's nine symphonies serve to underline the qualities of craftsmanship in these works while they are at the same time thoroughly pianistic. Frequently the character of the arranger predominates, as in the numerous virtuoso fantasias and paraphrases made by Liszt of 19th-century works.

**The 20th Century.**—At the beginning of the 20th century, sentimental arrangements of themes from well-known classical and romantic works were made for commercial purposes. In jazz and other forms of 20th-century dance music there frequently was no authentic version. Freely made arrangements automatically followed the publication of a tune. Many 20th-century composers made arrangements of both contemporary and older works, sometimes, as in the orchestral arrangements made by Respighi of works by Bach, arousing controversy in regard to conflicting styles. On the other hand, a movement respecting authenticity developed toward the middle of the 20th century when scholars published performing versions of works from the middle ages to the baroque. In these editions attempts were made to reconstruct the original style of performance by providing tempo indications, suggestions for instrumentation and ornamentation and by providing realizations of thorough bass. With the development of the folk song movement at the beginning of the 20th century arrangements of many kinds were made of folk music, both for the concert hall and for popular use.

**MUSICAL BOX,** or music box, a mechanical musical instrument in which the notes are produced by the vibration of steel teeth cut in a comb or flat plate of steel, reinforced by the harmonics generated in the solid steel back of the comb. The teeth are acted upon by the revolution of a brass cylinder studded with projecting pins, which, as they move round, raise and release the teeth at intervals according to the nature of the music. The revolving motion of the cylinder is effected by a spring and clockwork and the rate is governed by a fly regulator. The mechanism of the musical box is said to have been invented by Aristide Janvier in 1776.

**MUSICAL COMEDY.** Until the end of the 19th century, the term musical comedy was one of many used to describe any stage piece of a comic nature to which music was either integral or incidental. By the second part of the 20th century, the term defined a particular form of dramatic and musical entertainment which had virtually taken the lead in modern theatre forms. Within the loose usage of the previous century, an *opera buffa* such as Mozart's *Le Nozze di Figaro* could be called a musical comedy; at the opposite extreme, the term was also applied to the popular U.S. farces staged by Edward Harrigan and Tony Hart in the late 19th and early 20th century, on the strength of their interpolated songs and ballads. A specific application of the term to a genre of stage piece in which popular songs, dances and production ensembles are festooned upon a farcical plot was first made in the early 1890s by George Edwardes, manager of the Gaiety theatre in London, who called his production of *A Gaiety Girl* musical comedy to distinguish it from his previous burlesques. These musical comedies were brought from the Gaiety to the United States, where they formed the basis for the entertainment that has since persisted.

Musical comedy, as it had been known in 20th-century U.S. and English theatres, differs from comic opera and operettas in that it adheres to a more vernacular style in its music, dances, lyrics and dialogues. It differs from variety or vaudeville—to which it is indebted for many of its elements of song, dance and humour—in its possession of a plot, however minimal, and also as a rule in the elaborateness of its physical production. It differs from the revue largely in its use of a plot; the mainstays of that medium —satire, parody and topical thrusts—are also used in musical comedy. U.S. musical comedy, as it came into being just before the beginning of the 20th century, developed through a fusion of the elements of six earlier types of musical entertainment—extravaganza, pantomime, variety, burlesque, farce-comedy (in the special sense the term acquired in the 1870s) and European comic opera. The extravaganza (in France, the *féerie*) was originally an imaginative spectacle leaning upon the devices of ballet; *The Black Crook* by Charles M. Barres (1866) was a celebrated example in the United States.

After French romantic ballet dropped out of favour, almost any spectacular piece using elaborate machinery for the production of illusions was called extravaganza. Pantomime, still popular in England, was a short-lived importation in the U.S., disappearing in the 1870s. Variety served as a proving ground for performers who later graduated into musical comedy; many songs and dance routines (including those from blackface minstrel shows) became the stock in trade of musical comedy.

Burlesque, still true to its name, was taken to the United States in 1868 by Lydia Thompson of London and was given a homely U.S. showing by Edward E. Rice in *Evangeline* (1874). Among the distinguishing marks of burlesque in the 19th century were its girls in tights, playing so-called male roles, its comedians with baggy pants and red noses and its coarse humour. Farce-comedy derived from the work of the Roman comic dramatist Plautus, with its metric recitations accompanied by the flute (*tibia*), became in the middle of the 1870s a vernacular form of entertainment popular in England. The Vokes family of England and an American troupe called Salsbury's Troubadours introduced the notion of hanging variety specialties upon a slender thread of plot. These shows stood in contrast to English and Viennese comic opera and Offenbach's French *opéra bouffe,* which at best constituted a more aristocratic form produced by better craftsmen.

Borrowing from all these sources and adding a native drive and ingenuity, U.S. musical comedy began to develop. In the second decade of the 20th century, ballroom dancing and the ragtime of Irving Berlin moved musical comedy out of the world of imaginary Balkan principalities into the present. As the impact of the new continental inventions in staging, led by Max Reinhardt and Josef Urban, invaded the theatre, the artistic level of musical comedy rose considerably.

In the depression years of the 1930s, political satire per se appeared; *Of Thee I Sing* by George S. Kaufman, Morrie Ryskind and Ira and George Gershwin became the first piece of this kind to win the Pulitzer prize (1931). In the late 1930s and early 1940s such choreographers as George Balanchine and Agnes De Mille won for the dance a serious participation in the storytelling of the musical comedy form. Music and the lyric theatre took on more importance; the combined efforts of score, scenery, ballet, costumes and play were taken seriously.

From a series of "intimate" musical comedies initiated by Jerome Kern, Guy Bolton and P. G. Wodehouse with *Very Good, Eddie* (at the Princess theatre in New York in 1915), the musical theatre gradually took on believable plot construction and characterization which grew into such dramatically superior works as *Lady in the Dark* by Moss Hart and Kurt Weill (1941) and *South Pacific* by Richard Rodgers and Oscar Hammerstein II (1949). As the musical field was enriched by such serious and even tragic "musical plays" as Gian Carlo Menotti's *The Consul* (1950) and *The Saint of Bleecker Street* (1954), a change took place in more popular entertainment. The use of plays by such dramatic authors as Eugene O'Neill, Sidney Coe Howard and George Bernard Shaw became great popular successes in musical comedy form, as *New Girl in Town* by George Abbott and Bob Merrill (1954), *Most Happy Fella* by Frank Loesser (1955) and *My Fair Lady* by Alan Jay Lerner and Frederick Loewe (1956). (R. N. Le.)

**MUSICAL FORM,** a term used in musical theory meaning the intelligible shape of a musical composition, the genre to which it belongs, and also the principles of musical construction. The forms of music are determined by the dance, as in medieval dance forms and the ballet; by social and religious associations, as in the opera and the Mass; by literary and dramatic associations, as in

the song and incidental music; and by purely aesthetic considerations, as in the abstract forms of the sonata and the symphony.

These underlying origins of musical forms naturally overlap and the evolution of the forms is largely a reflection of the changing ideas in the many different spheres in which music flourishes. From a technical viewpoint the composer is concerned not only with the framework of formal conventions but also with the nature of his musical texture. Hence the term musical form has acquired a plural meaning. In the 18th and 19th centuries, when the principles of tonal harmony were firmly established, forms were relatively stable. But as a result of the disintegration of tonal harmony in the 20th century, theorists began to interpret the older forms afresh and became increasingly concerned with the rival claims of form and content. One school of thought maintained that in the abstract forms of the classical and romantic eras the conventions of design derive from elements of repetition, variation and contrast inherent in all forms of musical discourse. Another school, inspired by the theories of Gestalt psychology, tended to see the form of an abstract musical work as a phenomenon complete in itself, conceived like the span of a melody; that is to say, as a whole greater than the sum of its component parts. Other theorists discovered underlying affinities between apparently contrasted elements of melody, harmony and rhythm.

The basic form elements of repetition, variation and contrast are used in many ways. The repetition of a musical idea may be melodic, harmonic or rhythmic, or it may be achieved by a combination of these means. Variation may take the form of an embroidery of an idea or the extension of it as a development. Contrast can be achieved by changes of harmony or, in instrumentation, of tone colours. In the highly developed forms of the symphony and the opera these elements are not always distinguishable even though here, as in the more rudimentary forms, musical construction follows six basic principles. They are: (1) Binary form, consisting in its simplest aspects of a piece in two sections, the first modulating from the tonic to the dominant, the second returning to the tonic. The dance movements in the works of Bach and Handel come into this category, as do some of the piano pieces of the 19th century. (2) Ternary form, in which two contrasted sections are followed by a repeat of the first section (A B A). (3) Compound binary form, in which the first section, based on two contrasted ideas or subjects, is followed by a second section modulating through related keys to the basic tonic. This is known as sonata form and is illustrated in many of the first movements of Beethoven's piano sonatas. (4) Rondo (*q.v.*) form, in which an idea is contrasted with, and at the same time harmonically united to, several successive ideas or episodes in the form A B A C A D. This form was used by Bach and persisted throughout the 19th century. (5) Variation form, an early instrumental form in which a theme is repeated with ornamentations. In the works of Beethoven, Brahms and Schoenberg the variations assume great harmonic and contrapuntal complexity. (6) Fugue (*q.v.*), in which several independent parts are interwoven contrapuntally.

Forms may also be classified according to whether they are built on (1) the repetitive principle, like the binary, ternary and variation forms; (2) the continuation principle, which includes the fugue and some *cantus firmus* forms; and (3) compound forms, which are works consisting of several sections or movements such as the sonata, the oratorio and the opera.

The literary and pictorial influences in the 19th century and those of radio and television in the 20th century led to a breakup of the earlier forms, which had been based on the key relationships of tonal harmony. Improvisatory elements, a concern with primitive rhythms and the use, in Wagner's operas, of the *Leitmotiv* all tended to disturb the properties of these earlier forms. With the development of twelve-note or serial music (*see* DODECAPHONY) the older forms, particularly the variation form, were revived, and the neoclassical school, led by Stravinsky, similarly reinstated formal features from earlier periods, particularly those of the 18th century sonata. In the middle of the 20th century, motion-picture mood music, *musique concrète* and electronic music were bound, like the music of earlier periods, to experiment again with elements of repetition and contrast. In later serial and post-serial music, where the performer is required to co-operate with the composer by improvising or by choosing one of several alternative versions of a section, the principle of chance was introduced.

BIBLIOGRAPHY.—R. O. Morris, *The Structure of Music* (1940); G. Abraham, *Design in Music* (1949); H. Leichtentritt, *Musical Form* (1951); H. Federhofer, *Beiträge zur musikalischen Gestaltanalyse* (1950); A. Schaeffner, "Forme," in *Encyclopédie de la musique*, vol. 2, ed. by F. Michel (1959).

**MUSICAL INSTRUMENTS,** a general term used to designate instruments used for producing sound. The sound produced is generally that of musical notes with definite pitch. Each note (though there are exceptions, such as the pure tone of single frequency produced by a tuning fork and the primary tones of electronic musical instruments) normally consists of a complex of harmonic frequencies or overtones, varying in their number and relative strength according to the type of instrument and the intensity with which it is sounded. The sound is analyzed by the ear and so recognized as a musical note having the tone quality characteristic of the instrument in question. By attentive listening it is often possible to distinguish several of the overtones individually—especially in notes of deep pitch—while scientific examination, *e.g.*, by oscilloscope and mathematical analysis of the wave form shown thereon, makes possible a precise graphic demonstration of the "tonal spectra" of different notes throughout an instrument's range. With some musical instruments, such as bells and tuned drums, in which the sound-producing vibration is complex compared with that of the stretched string of stringed instruments and the air column of wind instruments, the pitch of a note may be less easy to perceive owing to the presence in it of inharmonic or dissonant frequencies. With others no definite pitch is perceived, the sound being that of a clash, knock or rustle of wholly dissonant constitution and employed to mark rhythms or points of musical structure. Occasionally the primary purpose of such an instrument may be nonmusical; *e.g.*, a pair of spoons, which exemplifies an improvised musical instrument. Also, the purpose of the sound of an instrument may be nonmusical in the strict sense, as when it is employed for signaling, *e.g.*, many whistles, or in ritual without musical context. Sound-producing instruments with such nonmusical purposes are so closely linked both typologically and genealogically with those used in music-making that all are included under the one conventional term, musical instruments. Their historical and ethnological study is called organology.

**Chronological Evolution of Instruments.**—The chronology of Curt Sachs (*Geist und Werden der Musikinstrumente*, 1929) is the foundation of modern study. The earliest instruments were used for marking rhythm. Initially a dancer beat his body, stamped and clapped; then a piece of wood, sometimes placed over a hollow in the ground, was used to amplify the sound of stamping, while sticks, spears or boomerangs were clashed, and strings of rattles were worn on the body to give sound to otherwise silent rhythmic movements. Familiar survivors of this stage of development in the western world include the jingle bells worn on the legs of morris dancers and the rumba claves (rhythm sticks). In the next stage, still a very early one, appeared many primitive instruments which show magic connotations, by which the sounds produced from natural substances by the hand or breath of man are used for communication with the spirit world in rites of every kind. These include seed-gourd rattles; scrapers, in which the sound is produced from a serrated or corrugated surface; the bull-roarer, a piece of wood whirled on a cord to spin and thereby produce a roaring vibration of the free air; and whistles made from bones. Excavations of Magdalenian sites in Europe (representing a final stage of Upper Paleolithic culture) have yielded archaeological examples of all the last three. Many simple instruments still keep their ritual use in European folklore, as, for example, willow whistles, horns, pottery flutes, and rattles and knockers sounded at various feasts of the year; the ratchet rattle swung at football matches may be placed on the fringe of these. Others have lost such associations and may be regarded as purely rhythmic instruments, as, for instance, the rumba maracas (gourd rattle) and guiro (scraper), or have degenerated into signaling instruments or toys.

A little later than the early rattles and flutes are the first "trumpets," as, for instance, conch shells, and hollow branches, such as the Australian dijeridoo. Their most primitive use is simply as voice disguisers in the utterance of spells and commands; the trumpet at this stage is not actually a true sound producer but a "pseudo musical instrument," like a kazoo or a megaphone. The first drums are placed by Sachs among the early Neolithic strata (though "friction drums," from which a roaring sound is produced by rubbing a stick or cord attached to the centre of the drum-skin, are later; the Spanish *zambomba* is a well-known surviving European species). At this stage, too, appear various instruments on which two or more contrasted pitches are deliberately obtained, like the "slit drum," a log partially hollowed out through a slit-like incision, the two edges of which give different pitches when struck (whereby in West Africa speech-tone patterns are reproduced and messages transmitted); kindred forms include the orchestral wood block, which gives but one sound, and the "temple blocks" (Chinese "wooden fish"), each sounding a different pitch. "Stamping tubes" are large bamboos pounded on a log and often tuned to chosen notes. Neolithic flutes, generally of cane, may give several notes, either as natural harmonics, or through finger-holes, or by being combined as Panpipes.

By this stage primitive stringed instruments had appeared, notably the widespread "musical bow," which may be either an ordinary hunting bow or one specially constructed; among its playing techniques, one is to hold one end of the bow to the mouth and, by altering the mouth cavity so that it acts as a selective resonator, to make melodies from the string's natural harmonics, tapping the string with a stick. The same acoustic principle is employed in playing the Jew's harp, widely distributed as a primitive instrument with a vibrating tongue of bamboo, though in Europe of metal; the melody of the mouth-resonated harmonics has to be listened for above the noisier droning of the deep-pitched fundamental frequency. In another instrument of Neolithic cultures, a slither of bark is separated from a bamboo stem except at the ends, and raised from the stem by bridges to provide a "string"; several such canes may be placed beside each other, or several "strings" may be cut in one thick bamboo, *e.g.*, the *valiha* of Madagascar, making various types of primitive zither. Generally, the greater the tuneful and tunable possibilities of a primitive instrument, the smaller are its ritualistic connotations, and primitive stringed instruments, also xylophones (which occur first among higher Neolithic cultures) and the African metal-tongued *sansa*, are played mainly for their music in recreation and entertainment rather than at rituals.

The native civilizations of America developed no stringed instruments, relying upon rattles, drums, flutes and trumpets (notably conches). In the ancient civilizations of the middle east, on the other hand, stringed instruments had risen very early to that leading position in music which they have since maintained in high civilization. Most modern authorities postulate the musical bow as progenitor of the arcuate (bow-shaped) harp (*c.* 3000 B.C.) and long-necked lute (*c.* 2000 B.C.). The middle east also knew clappers, sistra (metal rattles), drums, flutes (mainly pastoral), aulos (reed pipe) and cymbals and metal trumpets. Many of these are mentioned in the Old Testament, though some of their names in the Authorized (King James) Version are misleading: the "harp" was actually a lyre and the "psaltery" was a harp. Just before the Christian era, the organ, the first keyboard instrument, was invented, it is believed, in Alexandria. At the other end of the old world, ancient China, provided with drums, many other percussion instruments and flutes, developed its first stringed instruments from the primitive zither; the Japanese koto is their best-known modern descendant. Among wind instruments, China evolved the free-reed mouth organ, a parent of the harmonica (*q.v.*). In early medieval Europe a notable development, possibly from central Asia, was the fiddle, allowing the production of a sustained sound on a stringed instrument by bowing.

For details of ancient and modern western instruments, *see* ORCHESTRA; PERCUSSION INSTRUMENTS; STRINGED MUSICAL INSTRUMENTS; WIND INSTRUMENTS; ELECTRONIC MUSICAL INSTRUMENTS; and articles on individual instruments. *See* also AFRICAN MUSIC; CHINESE MUSIC; JAPANESE MUSIC.

TABLE I.—*Stages in the Acoustic Chain of Events*

| Instrument | A | B | C | D |
|---|---|---|---|---|
| Gong | Arm movement | Impact of stick | Vibration of *metal* | — |
| Violin | Arm movement | Impulses from resined horse-hair bow | Vibration of *string* | Resonation by air contained in body of instrument |
| Clarinet | Breath stream | Impulses from pressure changes at vibrating reed | Vibration of *air column* | — |

**Classification of Instruments.**—Musical instruments do not fall naturally into any single comprehensive taxonomic scheme, and their many physical cross-relationships make it very difficult to devise a useful classification consistently based upon straightforward criteria. Yet some scheme is required, and for the broad study of instruments (from over the entire world and back into prehistory) the familiar grouping of strings, wind and percussion has been superseded by a scheme introduced by V. C. Mahillon in 1888 (though Indian music had long observed its essence) by which instruments are grouped primarily according to the nature

TABLE II.—*Classification of Certain Instruments*

| Method | Wood or other organic material | Metal or other inorganic material |
|---|---|---|
| **I. Idiophones** | | |
| Struck | Percussion boards, xylophone | Triangle, glockenspiel, vibraphone, celesta |
| | Stamping tubes, slit drum | Tubular bells, gongs, steel drums, bells |
| Struck together | Rhythm sticks, castanets | Cymbals |
| Shaken | Rattles | Jingle bells, sistrum |
| Scraped | Guiro, ratchet rattle | Washboard |
| Rubbed | New Ireland "rubbed wood" | Glass harmonica |
| Plucked | Primitive versions of the Jew's harp | Jew's harp, African *sansa*, musical box |
| **II. Membranophones** | | |
| Struck | Drums: *bowl drums*—pottery drums, timpani; *tubular drums*—side, bass, tabor, bongos; *frame drums*—tambourines | |
| | "Roller" (a leather cylinder, China) | |
| Shaken | Rattle-drum (Tibet) | |
| Rubbed | Friction drums | |
| Plucked | Indian *gobi-yantra* drone | |
| **III. Chordophones** | | |
| Ground harps (rattan rope) | Beaten | |
| Musical bows | Plucked, beaten, or, in Hottentot *gura*, blown | |
| Zithers (strings run from end to end of resonator) | *Open-string:* plucked—psaltery, harpsichord; beaten—dulcimer, pianoforte; wind-blown—aeolian harp | |
| | *Stopped-string:* plucked—Austrian zither, mountain dulcimer; bowed—bowed zither. | |
| Lyres (strings run over resonator and along "neck" where they may be stopped) | Plucked—ancient and African lyres; bowed—Welsh crowd | |
| Lutes (strings run over resonator and along "neck" where they may be stopped) | Plucked—lute, guitar, cittern; bowed—violin, viol, tromba marina; bowed by wheel—hurdy-gurdy | |
| Harps (strings leave resonator at angle in plane vertical to soundboard) | Plucked—*arcuate or angular frame:* ancient and non-western harps; *triangular frame:* western harps; *with neck and bridge:* African harp-lute | |
| **IV. Aerophones** | | |
| Flutes (no mechanical vibrator) | *Artificial air-slit:* (tubular) whistles, flageolets, recorder; (globular) bird whistles, ocarina | |
| | *Lip-formed air-slit:* (tubular) side-blown—transverse flutes; end-blown—*kaval*, Panpipes, notched flute; (globular) gourd flutes | |
| Trumpets (vibrating lips, coupled to air column) | Conch, animal horn, tusk, wood (alpenhorn): end-blown or side-blown; with finger holes—cornet, serpent | |
| | Metal: *mainly cylindrical bore*—trumpet (natural, keyed, valved), trombone (slide, valved); *narrow-taper bore*—French horn, posthorn, cornet; *wide-taper bore*—bugle, ophicleide (keyed), *Flügelhorn*, alto and tenor horns, tubas (valved) | |
| Reed instruments (vibrating reed coupled to air column) | *Cylindrical bore:* (single reed) reed pipes, clarinet; (double reed) aulos, crumhorn, rackett; (free reed) free-reed pipe of southeast Asia | |
| | *Taper bore:* (single reed) saxophone, tarogato; (double reed) shawm, oboe, bassoon | |
| Free aerophones | *Without reed*—bull-roaret, siren; *band-reed*—grass squeakers; *free reed*—bark or fish scale placed in mouth, mouth organs, accordion, toy trumpets | |

of the material which is regarded as producing the sound in the first instance. Hence percussion instruments are divided into (I) idiophones, in which sound is produced from hard substances not previously stretched in any way (bells, cymbals, xylophones, etc.); and (II) membranophones, producing sound from a stretched skin (drums). Stringed instruments are termed (III) chordophones. Wind instruments come under (IV) aerophones, and it will be noted that the definition does not specify blowing; it requires that the sound be regarded as being produced in the first place from a vibrating mass of air. (A fifth group, electrophones, may be appended to include instruments in which sound is produced electronically.) In the main groups, the acoustic chain of events, as seen by the scheme, may be illustrated by a few examples, as is shown in Table I.

It must be stressed that the only object in thus equating the events which take place in such entirely different acoustical systems as these is to establish a basis for classification. Even so, there are a number of "borderline" cases, especially between idiophones and aerophones, *e.g.*, the free-reed instruments, and the plucked reeds (Jew's harp, musical box, *sansa*), and authorities still disagree about where these should be placed in the scheme. A. Schaeffner's discussion of such cases is of special value (see *Bibliography*). For defining subdivisions within the main groups, the sound-generating actions are referred to (*see* columns A, B, Table I), except that with stringed instruments this leads to so distorted a picture in terms of musical practice and history that arrangement according to structure is preferable. The examples cited in Table II are chosen from past and present western music, except for certain primitive types and unique oriental types.

*See* also references under "Musical Instruments" in the Index.

BIBLIOGRAPHY.—F. W. Galpin, *Old English Instruments of Music* (1910); Karl Geiringer, *Musical Instruments* (1943); Curt Sachs, *The History of Musical Instruments* (1940), which contains a full bibliography for further reference. Concerning classification *see* E. von Hornbostel and C. Sachs, "Systematik der Musik instrumente," in *Z. Ethn.*, xlvi, p. 553 (a full expansion of Mahillon's scheme) (1914); André Schaeffner, *Origine des instruments de musique*, p. 371, also especially p. 225 ff. (1936); Jaap Kunst, *Ethnomusicology*, 3rd ed., p. 55 (a review of the whole subject) (1959). (A. C. BA.)

**MUSICAL NOTATION,** a system of written symbols used to record musical sound. A notational system should, ideally, convey the relationship in duration and pitch of musical sounds that are successive and of those that are simultaneous. The system should also convey the speed, dynamic force and quality of the sounds. In practice, even the most sophisticated notations only approach exactitude in conveying the pitch and relative duration of the intended sounds.

The history of the notation of western music is an evolution toward a system enabling the composer to give clear written instructions of his intentions. Notation did not simply evolve from the crude and inadequate to the refined and accurate but adapted itself to stylistic requirements at one period or another and also to the division of responsibility between composer and performer.

**Definitions of Notation.**—*Note.* A note is a written symbol indicating the pitch and, usually, the duration of a musical sound. This word is sometimes incorrectly used in referring to the finger holes or the key mechanisms of certain instruments. In England the actual sounds produced in singing and playing are usually called notes, giving the word an additional meaning. In the U.S. the word "tone" is sometimes used for this purpose.

*Staff (or stave).* The staff consists of horizontal, parallel lines, five in number, that represent the tones (steps) and semitones (half steps) of the musical scale.

*Clef.* The clef is a sign placed at the beginning of a staff to define the pitch and, in conjunction with the key signature, the order of the tones and semitones that are represented by the lines and spaces of the staff.

*Key signature.* Certain combinations of signs for sharp (♯) or flat (♭) notes placed at the beginning of the staff after the clef are called key signatures. They define the order of tones and semitones on the staff and thus indicate the key of the music.

*Time signature.* After the key signature the staff carries a time signature that indicates the metre of a piece of music by means of a fraction; *e.g.*, $\frac{4}{4}$, which shows that the music is measured in groups of four notes and that the notes are crotchets (quarter notes).

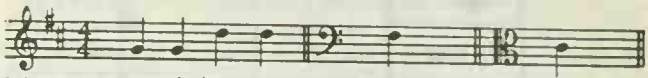

Fig. 1 (A) (B) (C)

Fig. 1(A) shows the G clef (treble clef) with the signature for the key of D major and the time signature, followed by two crotchets on the note G and two on D; fig. 1(B) gives the F clef (bass clef) with a note showing the position of F; fig. 1(C) shows the C clef with a note showing the position of C.

**The Development of Notation.**—*Origins.*—The ancient Greeks used systems of notation founded on letters of the Phoenician and Ionic alphabets. It is from Jewish liturgical recitation signs and Greek grammatical accents, however, that the whole notational system of European music first sprang. These accents gradually came into use for the melodies of Christian liturgical chants, serving as mnemonic aids to a tradition that was handed down orally in the manner of folk music. From early times, however, the church required that the authentic melodies and manner of performance be taught and preserved, and although embellishment and improvisation were introduced their use was discouraged. The need thus arose for more accurate notation.

*Neumes.*—The ancient accents / \ ^ v changed their shapes in the early Christian centuries to / • ⌒ ⌣. The last two of these indicate pairs of notes. These neumes were placed above the words and gave no precise indication of duration or pitch. They were expressive aids to the memories of singers well trained in the singing of traditional liturgical chants.

These simple neumes were gradually altered in shape, increased in number, arranged in height to convey approximate pitch relationship, and then arranged on staff lines with clefs to indicate real pitch relationships. These developments took place between the 8th and the 12th centuries. The square forms of the neumes had become fixed by 1200, and various compound neumes (ligatures) of two or more notes had developed:

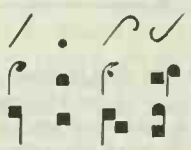

Fig. 2

*The 13th and 14th Centuries.*—During the two centuries from about 1190 to 1390, notation changed and developed more rapidly than in any other period before or since. The following is a brief summary of these developments:

*c.* 1190–*c.* 1225. The square-shaped neumes, joined in numerous ligatures of two, four and even five notes, were organized in a system of rhythmic modes in which the temporal values were controlled by set patterns of long and short notes.

*c.* 1225–*c.* 1280. The system of rhythmic modes gave way as two distinct temporal values were adopted in notation as the old virga ⌉ and punctum ■ became the *longa* and *brevis* respectively. About the middle of the 13th century the old diamond-shaped punctum ◆ became adopted as the *semibrevis*. At this time the ligatures took on precise values (they had been variable under the modal system) and thus the rigid rhythmic patterns of modal notation disintegrated with a musical style that was freer and yet more accurately notated. Franco of Cologne (11th or 12th century) was the great theorist on whose writings modern scholars greatly depend. Petrus de Cruce (fl. *c.* 1280) introduced larger groups of semibreves (*e.g.*, five and seven); these are typical of late 13th-century motets.

*Table of Names and Shapes for the Commonly Used Note Values From the 13th Century Onward*

| Old terminology / PERIOD | Long | Breve | Semibreve | Minim | Semiminim | Fusa | Semifusa |
|---|---|---|---|---|---|---|---|
| *c.* 1225 – *c.* 1300 | | | | | | | |
| *c.* 1300 – *c.* 1430 | | | | | | | rare |
| *c.* 1430 – *c.* 1600 | | | | | | | |
| *c.* 1600 to the 20th century | | gradually disused | | | | | |
| Modern terminology | not used | Breve (rarely used) | Semibreve or whole note | Minim or half note | Crotchet or quarter note | Quaver or eighth note | Semiquaver or sixteenth note |
| RESTS | | | | | | | |
| Late medieval and Renaissance | or | | | | | | |
| Modern | not used | | | | or | | |

*c.* 1300–*c.* 1400. In the first quarter of the 14th century, Philippe de Vitry (1291–1361), in his treatise *Ars Nova* (*q.v.*), laid the foundations of a notational system that is basically that of the modern system. In brief, the 14th century saw the recognition of duple time as equal in status to triple time and the appearance of shorter note values ( minima, semiminima, fusa and semifusa); with the introduction of the shorter notes the longer note values gradually began to fall into disuse.

A system of time signatures developed to define and govern the number of shorter notes that were to be performed in the time of a longer value. Thus the sign ◯ defined the division of the breve ■ into three semibreves (◯ ■ = ◆◆◆) and the sign ( defined duple division ((  ■ = ◆◆). This system, in its essentials, prevailed until 1600. It is known as mensural (or proportional) notation. It became complex but very precise, as befitted music that was highly sophisticated and sometimes, as in the 14th century, mannered in its rhythms to an extraordinary degree. Time signatures and special notational devices multiplied. Their description falls, perforce, beyond the scope of this article.

*The 15th and 16th Centuries.*—Soon after 1400 the appearance of notation underwent an important alteration when it changed from what is called black full notation to white void notation. Thus the breve ■ became 𝌜, the semibreve ◆ became ◇ and the minim became . The semiminim (the modern crotchet, or quarter note) remained black but took the appearance of the old black minim . The old black full notation remained in use here and there well into the 15th century, and it is found in some English manuscripts as late as 1500.

During the 15th century musical style lost many of the mannered complexities of the preceding century, and in the time of Josquin Després (*c.* 1440–1521) a further radical simplification of musical style took place. Notation reflects the style of the music it represents and thus, particularly from about 1450 and progressively from that time, notation became simpler, and many of the complications of the mensural system disappeared; and about 1500 many of the time signatures, *e.g.*, ◯ ⌀ ⊙ (·, became obsolescent as the ternary division of breve and semibreve fell into disuse.

At the bottom of the table are given the signs defining lengths of rests; *i.e.*, silent pauses within a continuing piece of music. In the case of the rest for the value of a long, it should be noted that when the stroke covers two spaces the rest equals two breves; when it covers three spaces it equals three breves. In the early mensural notation the other rests were treated usually in the same way as actual note values, *e.g.*, the rest sign for the value of a breve could also have the value of two or three semibreves according to the context.

*The 17th to 20th Centuries.*—To compress into a few words the

notational usages from 1600 to modern times may seem disproportionate, but the note shapes and the principles governing their use did not change to any appreciable degree in that period. Some important developments, however, must be noted:

1. The use of bar lines became standard practice and score arrangement of music for more than one instrument or voice replaced the old use of unbarred separate parts. (*See* SCORE.)

2. Time signatures ceased to indicate the various ways in which the breve and semibreve could be divided into two, three or more notes of a lower value. They now became fractions indicating the number of a particular value contained in one bar (measure).

3. A very large number of abbreviations, signs and written terms were introduced to indicate expression, manner of performance, degrees of intensity, etc. (*See* EXPRESSION, MUSICAL.) In addition, many signs came into use, in the 17th and 18th centuries in particular, to indicate ornaments.

4. Whereas the old mensural notation presupposed a basic tempo (called *integor valor*) that could be varied only by changes of time signature, modern notation and time signatures have been used so freely that tempo is made clear only by written directions and metronome marks.

In conclusion, it must be said that if oral tradition, and in music this also means aural, were to be completely broken, no notation could convey the authentic manner of performance. Debased or almost completely lost traditions make it difficult to revive old music with any certainty of real authenticity. This is not, however, to deny the value of research or the aesthetic value of modern performances of old music. *See* also HEXACHORD; PLAINSONG; RHYTHM; TIME; TONIC SOL-FA; and references under "Musical Notation" in the Index.

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**MUSICAL SOCIETIES AND INSTITUTIONS. Medieval and Renaissance Societies.**—Societies in Europe formed to promote the performance of music consisted originally of performers with common secular or religious ideals. Among the most ancient associations for the performance of secular music were the Welsh Eisteddfod (*q.v.*), the French guilds of troubadours of about the 11th century (which organized competitions called the Puy) and the German guilds of Meistersinger (*q.v.*) which flourished from the 14th to the 16th centuries. Medieval associations for the performance of sacred music were the Compagnia de Gonfalone (Rome, 1264) and the Confrérie de la Passion (Paris, 1402). In the Renaissance, academies were founded in Italy and later in France for the encouragement of music and poetry. The principal Italian academies associated with music were in Florence, founded by Lorenzo the Magnificent in 1480, Venice (Accademia Pellegrina, 1550) and Bologna (Accademia dei Filomusi, 1615).

The Camerata (Florence, 1594) led to the production in 1597 of O. Rinuccini's *Dafne*, a music drama on the lines of Greek tragedy with music by J. Peri and J. Corsi, and to the establishment in Italy of opera (*q.v.*). The chief French institutions of this kind were the Académie de poésie et de musique, founded by J. A. de Baïf in 1570, associated with secular music, and the Académie de Musique (1671), associated with opera. In London opera was promoted by the Royal Academy of Music (1720), not to be confused with the institution of this name founded in 1822.

**Early Concert Societies.**—In the 17th and 18th centuries the institution of the Collegium Musicum, deriving from an earlier institution, the Convivia Musica, was associated with universities in Germany and Switzerland. Its purpose was to organize public concerts (*see* CONCERT). The Collegium Musicum at Prague dates from before 1616, and the Gesellschaft auf dem Musiksaal was founded at Zürich in 1613. G. P. Telemann was associated with the Collegium Musicum at Hamburg at the beginning of the 18th century, and other towns where there were such institutions were Halle, Berlin and Leipzig. Early concert societies in London were the Academy of Ancient Music (1710), the Castle society (1724), the Catch club (1761), the Anacreontic society (1766), the Concerts of Ancient Music (1776, later known as the King's concerts), the Professional concerts (1783) and the Caecilia society (1785). The Edinburgh Musical society was founded about 1725.

In Paris the most important 18th-century concert-giving society was Le Concert Spirituel founded by A. D. Philidor in 1725 for the performance of sacred works, later enlarging its scope to include secular works. Its rival, the Concerts des amateurs, was founded in 1770. In Vienna the Tonkünstler Societät (1771, renamed in 1862 the Haydn Verein) was the main concert organization. Developing the activities of the Collegium Musicum, the Gewandhauskonzerte were started at Leipzig in 1781. Choral music was fostered at Berlin by the foundation of the Singakademie (1791). Other concert societies were founded at Copenhagen (1744), Bergen (1765), Stockholm (1771) and at Åbo, Finland (1790). In the United States the St. Cecilia society was founded at Charleston, S.C. (1762), and the Musical society at Stoughton, Mass. (1786).

**19th-Century Concert Societies.**—The Museums Gesellschaft was founded at Frankfurt in 1808, the Musikakademie in Munich (1811) and the Philharmonische Gesellschaft in Berlin (1826). The Gesellschaft der Musikfreunde was founded in Vienna in 1812 and led to the establishment there of the conservatory in 1821. The Singakademie was founded in Vienna in 1858.

In Paris the main concert organizations were the Société des Concerts du Conservatoire (1828), the Société Sainte-Cécile (1849), the Société Philharmonique founded by Berlioz (1850) and the Société des jeunes artistes du Conservatoire (1851). In London the Philharmonic society (1813, from 1912 the Royal Philharmonic society) was the principal concert organization, followed by the New Philharmonic society (1852) and the Halle society in Manchester (1857). The amateur choirs that sprang up in England brought the formation of the Sacred Harmonic society (1832), the Choral Harmonists' society (1833), the Royal Choral society (1871) and the Bach choir (1875). In Italy the Società Musicale Romana and the Società Orchestrale Romana (both 1874) were followed by the Società dei Concerti (Turin, 1877).

In the United States the Handel and Haydn society (Boston, 1815) gave early performances of choral music. In instrumental music the Philharmonic Society of New York (1842) was the leading institution. The Oratorio Society of New York was founded in 1873, and the New York Symphony society in 1878. Other concert societies were formed at Stockholm (1820), Amsterdam (1829), Copenhagen (1836), Prague (1862), Brussels (1865), Oslo (1871) and St. Petersburg (1873). In Australia the Royal Sydney Philharmonic society was founded in 1850. Many of these societies, which greatly developed with the wider interest in instrumental music, flourished into the 20th century, and similar societies were established in provincial towns.

**Schools and Academies.**—With the growth of concert music, schools, hitherto private or ecclesiastical institutions, were established for the public in the principal centres. In London the Royal Academy of Music was founded in 1822, the Trinity College of Music in 1872, the National Training School of Music in 1873 (becoming in 1883 the Royal College of Music) and the Guildhall School of Music in 1880. The Royal Irish Academy of Music was founded in 1848 and the Royal Scottish Academy of Music in 1885. The Metropolitan College of Music was founded in New York (1887, becoming in 1900 the American Institute of Applied Music). The Canadian Academy of Music was founded in Toronto in 1911. Taking the name conservatory from the French school founded in Paris (1795), the Boston Conservatory of Music was founded in 1867 and the Elder Conservatory in Adelaide, Austr., in 1898. (*See* also CONSERVATORY, MUSICAL.)

**Historical Societies.**—About the middle of the 19th century scholars began to publish editions of earlier composers and societies were formed to study and perform the work of particular composers. In England the Handel society was formed in 1843, the Bach society in 1849, and the Purcell society in 1876. In Germany the Mozartstiftung was founded at Frankfurt in 1838, becoming in 1951 the Deutsche Mozart Gesellschaft. The Bach Gesellschaft was founded in 1850, the Handel Gesellschaft in 1856, and other societies in Germany and Austria were formed to study the works

of Wagner (1883), Beethoven (1889) and Brahms (1904). The Société Frederic Chopin was formed in Paris (1911) and the Beethoven association in New York (1918).

**National and International Societies.**—The rise of musical nationalism about the middle of the 19th century led to societies that promoted the performance of national music such as the Russian Music society (St. Petersburg, 1859), the Société Nationale de Musique (Paris, 1871), followed by the Société Independante (1909), the British Music society (1918) and the Society for the Publication of American Music (1919). Later, international societies were formed to deal with scientific, economic, social and religious problems connected with music. The main international societies devoted to musicological research were the Internationale Musikgesellschaft (Leipzig, 1899) and the Internationale Gesellschaft für Musikwissenschaft (Basel, 1927). In 1926 the Confédération Internationale d'auteurs et compositeurs was established in Paris to protect authors' and composers' copyrights. The Performing Right society in England and the American Society of Composers, Authors and Publishers (ASCAP) in the U.S. are among the many national organizations affiliated to it. The International Society for Contemporary Music was founded in 1922, the Société Internationale des amis de la musique française (1928), the International Folk Music council in 1947 and the International Council for Music, organized by UNESCO, in 1949. The Fédération Internationale des Jeunesses Musicales (1947) co-ordinated the activities of educational concerts, and an international society for music education was founded in Brussels (1953). The Association internationale des Bibliothèques musicales (1951) began the publication of an international index of source materials. An international society for the promotion of Catholic church music was founded at Frankfurt in 1929.

**20th-Century Societies.**—The mechanical reproduction of music by phonograph and radio, as well as educational and aesthetic matters, were among the main concerns in the first half of the 20th century of both amateur and professional bodies. Among 20th-century societies devoted to the wider diffusion of music in England were the National Federation of Gramophone societies (1936), the Committee for the Promotion of New Music (1943), the Exploratory Concert society (1947) and the National Federation of Music societies (1935), founded with the support of the professional musicians' organization, the Incorporated Society of Musicians (1882). Interest in older music was encouraged by the Plainsong and Medieval Music society (1888), the Chamber Music association (1934), the Society of Recorder Players (1937), the Renaissance society (1944) and the Viola da Gamba society (1948). The English Folk Dance society (1911, becoming in 1932 the English Folk Dance and Song society), the Society for the Advancement of Musical Education (1935), the Workers' Music association (1936) and the Society of Young Musicians (1936) were devoted to the broad popularization of music. Musicological research was published by the Royal Musical association (1874) and research on old instruments was promoted by the Galpin society (1946).

In the U.S. the Society of Friends of Music (1913) sponsored performances of lesser-known works, and the League of Composers (1923) the interests of contemporary music. Chamber music was encouraged by the American Society of Ancient Instruments (1927), the Chamber Music Society of America (1933), the New Friends of Music (1936) and the Haydn society (1949). The National Music council (1940) was concerned with both professional and cultural aspects of musical life. The Music Library association was founded in 1931 and the American Musicological society in 1934.

In Argentina, 20th-century music was encouraged by the Grupo Renovación (1929) and chamber music by the Sociedad Argentina de Musica da Camera. Cultural movements were promoted in Brazil by the Academia Brasileira de Musica (1945) and U.S. and Latin-American musical interests by the Instituto Interamericano de Musica (Montevideo, 1932).

In Canada the Federation of Canadian Music festivals organized widespread activities, and the Composers, Authors and Publishers Association of Canada gave awards and scholarships to composers. The Canadian Music council (1949) promoted a broad interest in musical affairs. In Australia contemporary music was fostered by the Guild of Australian Composers (1935), chamber music by the Musica Viva society (1946) and professional interests by the National Council of Music associations (1932). The Elizabethan Theatre trust (1954) promoted opera throughout Australia.

(E. Lr.)

**MUSICAL TERMS.** The vast number of terms employed to describe the composition and execution of music may be divided into three principal categories: (1) those concerned with directions to the performer on matters of tempo, dynamics and expression; (2) those connected with technical aspects of composition; and (3) those describing musical forms and instruments. Composers began to provide terms of expression in the 16th century, when indications of dynamics (*tocca pian piano*) are found in the lute manuscript of V. Capirola (*c.* 1517) and of tempi in the vihuela music of L. Milan (1536). Indications of tempi found in English viol music of the 17th century include the term "drag," indicating a slowing of the tempo. Early in the 17th century indications of echo effects occur in vocal and instrumental music, notably in Claudio Monteverdi's opera *Orfeo* (1607), and various expression marks are found in other Italian works. Italian printed music soon became widely known in other countries and many of the expression marks found in them were used outside Italy and later became commonly accepted throughout the musical world.

The practice of using certain Italian terms for names of pieces is believed to have derived from the use of the names of dance forms, *e.g.*, pavane, sarabande, minuet and waltz, which, when placed at the head of a piece, also indicated the character and the tempo in which these pieces were to be played. An extension of this practice was the use of Italian adverbs for the names of pieces. If a piece was to be played quickly it was called an allegro; if slowly a largo or an adagio.

French and German terms of expression were used in place of Italian terms to some extent in the 18th and 19th centuries, notably by Couperin, Beethoven and Wagner, whose more precise directions for expression required the use of their native languages. Yet most of the Italian names and directions remained in common usage even by the revolutionary schools of music of the 20th century. Sometimes, however, the use of Italian was abused and terms were rendered meaningless; *e.g.*, by the prefixing of *più* (more) to *andante* (walking pace), presumed to mean more slowly.

Terms connected with the technique of composition, like the names of musical forms and instruments, are extremely numerous. Descriptions of most of them are to be found in *Grove's Dictionary of Music and Musicians*, 5th ed., edited by E. Blom (1954), and Percy Schole's *The Oxford Companion to Music* (1955). A larger selection appears in a more specialized work, *The Student's Dictionary of Musical Terms*, compiled by A. J. Greenish (1953), which lists English and foreign terms and expressions with their meanings, and also a selection of English terms and words with their equivalents in Italian, German and French. Tom S. Wotton's *Dictionary of Foreign Musical Terms* (1907) is a larger work particularly useful for the names of orchestral instruments. *See* also Expression, Musical.

**MUSIC FESTIVAL,** a term usually applied to a series of concert or opera performances inspired by a unifying theme. Music festivals may be devoted to religious music (of different denominations); national music (British, Latin American, Soviet, etc.); a particular genre (chamber music, choral music, jazz); modern music (as the annual festivals of the International Society for Contemporary Music); or the works of a prominent composer performed in an appropriate setting (*e.g.*, Handel in England, Mozart at Salzburg, Wagner at Bayreuth). They may also take the form of a competition, either for performers or composers.

**Historical and Modern Festivals.**—Series of religious services associated with a particular feast early established the idea of the music festival in the church.

*Great Britain.*—In its modern sense the term "festival" was first used in England. The Festival of the Sons of the Clergy,

originally an annual charity sermon, was first given at St. Paul's Cathedral, London, in 1655; it took on a musical character in 1698. The Three Choirs festival was established in 1724 (an earlier form existed in 1715) and was so called because it was held annually in rotation at the cathedral cities of Gloucester, Worcester and Hereford. This festival continued to flourish in the second half of the 20th century. Harp festivals took place in Ireland toward the end of the 18th century, among them the Belfast festival of 1792.

Festivals of secular music in England came into being in the 18th century. The first festival devoted to Handel was given in 1784 at Westminster abbey, where the composer is buried. The tradition of the English Handel festivals, which developed a history of demanding increasingly larger numbers of performers, dates from the London festival of his works given in 1857. The triennial Handel festivals were inaugurated at the Crystal Palace, London, in 1859. In 1923 the festival orchestra and chorus numbered 4,000. These festivals were given regularly until 1936, when the Crystal Palace was destroyed by fire.

The Birmingham festival, which was founded in 1768 and became a triennial event in 1796, at the outset was also devoted to Handel's music; in the 19th century its scope was extended to works by other composers. Mendelssohn conducted at the Birmingham festival in 1837, and Sibelius in 1912; it was held regularly until the outbreak of World War I. The Norwich festival, inaugurated in 1770, was held at infrequent intervals until 1824, when it became a triennial event. The music festival in Leeds was established in 1858 on the occasion of the opening of the town hall by Queen Victoria. It became a triennial event in 1874 and was continued in the second half of the 20th century. The Sheffield festival took place triennially from 1896 to 1911. Other festivals were held at Chester (1772–1900), Manchester (1777–1836), Liverpool (1784–1875), York (1791–1835), Edinburgh (intermittently between 1815 and 1913) and Cardiff (1892–1910). Numerous festivals were held at Oxford and Cambridge. A festival devoted to old music was founded by Arnold Dolmetsch at Haslemere, Surrey, in 1925. Among the London festivals were those devoted to the works of J. S. Bach (held between 1895 and 1926), Sir Edward Elgar (1904) and Frederick Delius (1929).

Most of the festivals established after World War II are held during the summer or early autumn. The most important is the Edinburgh International Festival of Music and Drama. Inaugurated in 1947, it presents performances by opera companies and symphony orchestras from abroad. Among other British events are the Glyndebourne festival, founded in 1934 and devoted at first to the operas of Mozart but later enlarging its repertory to include 19th- and 20th-century operas; the Cheltenham festival, organized in 1945 and devoted to contemporary music, first of Britain and later of other countries; the London Musical festival, started in 1947; the Oxford Musical festival (1948); the Bath assembly, later the Bath festival (1948); the Aldeburgh festival, formed by Benjamin Britten and others in 1948 and primarily presenting new music by British composers; the Coventry festival (1958; in 1962 the Coventry Cathedral festival was given to mark the consecration of the new cathedral); and the York Mystery Plays and Festival of the Arts (1951).

*The United States and Latin America.*—Music festivals in the U.S. followed the British pattern. The Handel and Haydn society was founded in Boston in 1815 and inaugurated triennial music festivals there in 1868. Among the large-scale festivals of the 19th century were the two Peace Jubilee festivals given in Boston in the summers of 1869 and 1872 at which 20,000 voices and an orchestra of 1,000 players took part, supplemented by artillery firing, chiming of bells and other effects. In conjunction with the 1876 Philadelphia exposition that marked the centenary of the Declaration of Independence, a festival was held in Philadelphia under the direction of Theodore Thomas; it included a "Grand Centennial Inaugural March" written for the occasion by Richard Wagner. Theodore Thomas also conducted the music festival program of the World's Columbian exposition in Chicago in 1893.

Among other regular U.S. events were the Worcester, Mass., festival (begun 1858); Oberlin, O., Spring festival (1860); Biennial May festival of Cincinnati, O. (1873); Ann Arbor, Mich., May festival (1893); Bethlehem, Pa., Bach festival (1900); Evanston, Ill., North Shore festival (1908); Westchester County, N.Y., festival (1925); and Aspen, Colo., festival (1949).

Annual chamber music festivals established by Elizabeth Sprague Coolidge in 1918 at Pittsfield, Mass., were transferred in 1925 to the Library of Congress, Washington, D.C.; their main object is to encourage the composition of chamber music by the performance of specially commissioned works. The annual Eastman School Festivals of American Music were inaugurated in 1925 at Rochester, N.Y., by their director, Howard Hanson. In 1937 Serge Koussevitzky and the Boston Symphony orchestra instituted the summer Berkshire festival at Tanglewood, near Lenox, Mass., which became one of the most important American musical institutions. The New York World's fair of 1939 presented works of composers from many countries. On another level a wide appeal was made by the annual Newport, R.I., jazz festival, established in 1954.

Works by Latin-American and U.S. composers were performed at the festivals of American music in Caracas, Venez., in 1954 and 1957, and at the two inter-American music festivals organized by the Pan American union in Washington, D.C., in 1958 and 1961. The Casals festivals in Puerto Rico were opened in 1957 under the direction of Pablo Casals.

*Continental European Festivals.*—One of the earliest music festivals in Germany was a series of concerts, *Abendmusiken* ("Evening Music"), first given in 1673 at Lübeck by Dietrich Buxtehude. Numerous festivals were given annually in German cities during the 19th century. The best known were the Lower Rhenish festivals (1817–1922). The *Tonkünstlerfeste*, organized by the *Allgemeiner deutscher Musikverein* in Leipzig in 1859, continued until 1940. The Bayreuth festivals were inaugurated by Richard Wagner in 1876 to present his music dramas in an opera house built for their production. After being suspended in 1945, the Bayreuth festivals were resumed in 1951 under the direction of Wagner's grandsons.

In Salzburg, Mozart's birthplace, the first Mozart festival was given in 1877. In later years the scope of the festival was extended to include modern works. The Salzburg festival was reorganized in 1946 and became an annual summer event.

The bicentenary of J. S. Bach's death in 1950 was commemorated by Bach festivals in many countries; and the bicentenary of Mozart's birth in 1956 was similarly celebrated. In 1959 festivals marked the 150th anniversaries of the death of Haydn and of the birth of Mendelssohn. In 1963 festivals of Wagner's and Verdi's operas were held to mark the 150th anniversaries of their births.

During the 20th century, music festivals were established in many European cities, university towns and small communities. Prominent French festivals, both established in 1948, are those at Aix-en-Provence and Besançon. In Italy the International Festival of Contemporary Music in Venice was started in 1930 as a biennial event. It was given annually from 1936, although it retained the name "La Biennale." In Florence the Maggio Musicale Fiorentino was held for the first time in May, 1933. The annual Festival of Two Worlds, organized by Gian Carlo Menotti, was first given in Spoleto, Italy, in 1958. The Holland festival was inaugurated in 1938, and numerous music festivals were held in the Scandinavian countries. The annual Sibelius festivals in Helsinki, Finland, are devoted chiefly to his music but also include works by other Finnish composers. Among the opera festivals in Europe, the most important is the one held at Munich; it was established in 1901 and is devoted mainly to works of Mozart, Wagner and Richard Strauss.

The Festival of Britain (1951) presented historical concerts of English music from the 14th to the 20th centuries and several specially commissioned works. The Brussels World's fair of 1958 introduced works by modern composers of many nations. In the U.S.S.R. festivals of Soviet music are presented in November each year on the anniversary of the Bolshevik Revolution; the programs include works by composers from several republics of the Soviet Union.

The International Society for Contemporary Music promotes performances of modern works of a novel nature. The society was founded in Salzburg, Aus., in 1922, and its festivals were held thereafter (except in 1940 and 1943–45) each summer in various cities in Europe and the U.S. The Chamber Music festival of Donaueschingen, Ger., founded in 1921, was discontinued in 1933 but resumed in 1950, enlarging its scope to include orchestral and choral music. Adventurous modern works, including electronic music, are heard at the Darmstadt, Ger., summer festivals of new music, founded in 1946.

*Other International Festivals.*—An annual series of international festivals of contemporary music was inaugurated at Warsaw, Pol., in 1956. The opening international festival of music, drama and art at Osaka, Jap., was held in the spring of 1958. Festivals of international as well as national music have been presented periodically in several Latin-American countries. Festivals of modern music have been initiated in Israel and Portugal.

**Competition Festivals.**—Contests of artistic skill in which music plays a part have a remote origin. Musical competitions were a feature of the Pythian games at Delphi in the 6th century B.C. The Eisteddfod (*q.v.*) in Wales was the earliest form of musical contest in Britain. In the 12th century the troubadours held musical competitions, the *Puys,* at Puy Notre Dame, near Saumur in France. The song contest organized by the Minnesinger at Wartburg in Germany dates from the 13th century.

*Great Britain and Ireland.*—In England in the 18th century local singing competitions were organized by groups of singers at taverns. In the 19th century, when railway travel encouraged contact between amateur musicians, singing and band competitions became popular and were adjudicated by prominent figures. Singing contests were held at Manchester (1855), Liverpool (1874), Sheffield (1881), London (1882) and other cities. In 1905 the Association of Competition Festivals was formed; in 1921 it amalgamated with the British Federation of Music Festivals. The national musical competition of Ireland, the Feis Ceoil, was established in Dublin in 1897.

In the 19th century the brass band movement was a product of the industrial society in the north of England. Contests of brass band music frequently took place in Britain, the earliest of which was held at Belle Vue Gardens, Manchester, in 1853. Competitions between brass bands continued to flourish in the 20th century, and in the London contest of 1930 nearly 200 brass bands took part. (*See* BAND.)

*The United States.*—In the U.S. a musical competition was held at Dorchester, Mass., in 1790 between singers from Dorchester and Stoughton. Later this amateur activity was encouraged among students. At the beginning of the 20th century competitions between bands, choruses and orchestras at schools and colleges began to be organized on a wide scale. In 1931 more than 1,000 bands and 700 orchestras took part in nationwide contests between student organizations.

*International Competition Festivals.*—In the 20th century a new form of international competition was organized to promote the careers of young professional performers. Competition festivals of this kind include the Chopin competition for pianists in Warsaw, begun in 1927; the Queen Elizabeth of Belgium prize competition for young violinists and pianists, established in Brussels in 1937; and the quadrennial Tchaikovsky competition in Moscow, inaugurated in 1958, for pianists, violinists and cellists. The Georges Enesco Competition festivals, held biennially, were inaugurated in Bucharest in 1958.

*See* Percy A. Scholes, "Competitions in Music," *The Oxford Companion to Music* (1955). New festivals are listed in the *Britannica Book of the Year.* (N. Sy.)

**MUSIC HALL AND VARIETY** are related forms of popular entertainment which stem from the taproom concerts given in city taverns in England during the 18th and 19th centuries. Sadler's Wells was typical of the many refreshment houses enlivened by song and dance. Gradually a stage was provided for paid singers, the most popular being comic, and the audience was seated at tables; liquor sales paid the expenses.

To discourage these entertainments, parliament passed an act (1751) which required every such pleasure haunt to obtain a magistrate's licence, but the measure had the contrary effect: the larger taverns lived up to their new dignity by employing musicians and scenery and the smaller did without the licence by forming harmonic clubs. Profits from the licensed premises led to the building of variety theatres of increasing size and glitter with elaborate scenic effects. In the early 19th century the unlicensed "musick" houses evaded the licensing laws by changing into "burletta" houses; *i.e.,* theatres where plays had to include by law a certain number of songs (*see* BURLESQUE). "Saloon" then became the name for any place of popular entertainment, while "music hall" meant a concert hall and "variety" was an evening of mixed plays.

In Victorian times the rapid increase of urban populations intensified the demand for song. Publicans adapted the adjoining building to their premises as the music hall, thus giving it the significance it has had ever since. The first was reputedly at the Canterbury Arms, Lambeth, where Charles Morton, the publican known as the "father of the halls," liked the music to be operatic and the comedians to wear smart clothes; the doorway survived a bomb of World War II and displayed its date of 1852 with an inscription referring to the act of 1751. At the same time Sam Collins, a chimney sweep who appeared as an Irish singer, founded Collins's music hall by Islington green. The humour of the halls concentrated on the hardships of life and caricatured weddings, funerals, seaside holidays, large families, wash day and other trials; yet, space was found in the protracted programs for ballads of domestic tragedy and patriotic heroism. Some outstanding performers were Marie Lloyd, Dan Leno, Vesta Tilley, Harry Champion, G. H. Chirgwin, Eugene Stratton, "Little Tich" (Harry Relph) and George (later Sir George) Robey.

There was a change in 1891 when Albert Chevalier, an actor from a fashionable theatre, broke away from taproom humour to express a side of street life at the Pavilion which gave him the name of the "costers' laureate"; he also became known for his songs of courtship and one of old age, "My Old Dutch." The idyllic strain persisted until Harry Lauder sang as a Highland lover with a hint of poetry. Will Fyffe, apart from his famous "I Belong to Glasgow," sang of the sea, moors and mountains.

When the sale of liquor during performances was no longer permitted, the comedians still dominated the halls but had a diminishing place among the many amusements which kept variety true to its name. As the 20th century advanced, the music halls were dwarfed by palaces of variety on an even larger scale than the Empire and the Alhambra. Just as Sadler's Wells had advertised, 100 years earlier, the spectacle of real water and pony races, so the Hippodrome now displayed aquatic dramas and the Coliseum representations of the Derby and chariot races in ancient Rome. None of these lasted long, but other ambitious plans kept variety prosperous after the real music hall had been killed by the competition of the cheap cinema.

Such celebrities as Sarah Bernhardt, Sir George Alexander and Sir Herbert Tree put on one-act plays or the last acts of plays; such musicians as Pietro Mascagni and Sir Henry Wood gave performances with their orchestras; Diaghilev and his ballet, at the height of its fame, appeared in 1918 at the Coliseum in a bill which included comedians and jugglers.

Yet the excitement caused by actors or dancers never exceeded the enthusiasm aroused by the popular singers of the 1920s who showed how this fame had been intensified by the phonograph. Nora Bayes, who was the first to make this trend noticeable, received a welcome when she appeared at the Palladium such as a diva of grand opera might have envied. Sophie Tucker was her successor, but Gracie Fields, fresh from a touring revue called "Mr. Tower of London," proved that Lancashire could produce a favourite equal to those of New York. Also in the 1920s the craze for dance music was started by Paul Whiteman's band; it was continued by more than 12 others, headed by those of Jack Hylton and Jack Payne.

The advent of "talking films" caused variety theatres throughout the United Kingdom to be turned into cinemas. Among the schemes invented to keep comedians employed were a mixture of

films and songs called cine-variety and attempts to keep theatres open from noon to midnight with nonstop variety. These were short-lived, with the exception of the Windmill theatre near Piccadilly Circus, London, which remained open throughout World War II and afterwards. The most remarkable experiment in entertainment during the 1930s and 1940s was the creation of the Crazy Gang (Bud Flanagan, Nervo and Knox, Naughton and Gold) who, at the Palladium and later at the Victoria Palace, restored elementary humour to favour.

The influence of radio was of fluctuating importance to music hall and variety: broadcast programs of "turns" were difficult because few comedians could survive the continual strain of composing new material. Audiences once preferred old favourites in song; television set the pace for frequent change.

Oddities of the licensing laws in Great Britain permit cabaret to be performed before an audience who are seated at tables and who consume food and strong drink which cannot be served in the auditorium of a theatre. Consequently the old music hall of Gatti's-under-the-Arches, at Charing Cross, London, run on Victorian music hall lines, became a club and the Hippodrome, while retaining its stage for revue, became a restaurant. In Europe "cabaret" often means a music hall while "music hall" usually means variety. *See* also VAUDEVILLE.

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**MUSIC IN ANCIENT CIVILIZATIONS.** The world's ancient civilizations fall approximately into seven regions, each of which has, despite internal differences and interconnections, certain distinctive musical traits. These regions are: (1) Egypt (Old, Middle and New kingdoms); (2) west Asia (Sumerian, Babylonian, Hebrew, Hittite, Phoenician, Iranian, Arabian); (3) Europe (Minoan, Hellenic, Etruscan, Latin, Orthodox Christian, Celtic Christian, pre-Christian Scandinavian); (4) India (Indo-Sumerian; Hindu); (5) northeast Asia (Chinese to the end of the Sung dynasty, A.D. 1297, Korean, Japanese); (6) southeast Asia (Khmer, Indo-Javanese); and (7) Central America and the Andes (Mayan, Aztec, Inca).

**Ancient Attitudes Toward Music.**—High civilization has always brought with it an elevated concept of music as an art. This art has, for its raw materials, drawn upon a background of folk and tribal music, but the molding influence of ideas has been paramount. All early civilizations saw their ideal music as an image of cosmic order and its practice in temple ritual and court ceremonial as a means of helping to maintain or reflect universal harmony. From such a philosophy stem the age-old concepts of the efficacy of numerical proportions in musical sound; the ethos (magical effect) of particular modes; the music of the spheres; and the musical foundation of the state. Such ideas, steadfastly maintained throughout the ages, made for very conservative traditions of music whose fundamental patterns changed little over long periods of time and in certain cases persisted far into historical times.

**Ancient Theories.**—Alongside its music philosophy, to which it was related through a symbolism of numbers, each of the seven regions had a distinctive theory of music. The Mesopotamian, Egyptian and Central American music theories are unfortunately no longer extant, although some features are open to inference, and southeast Asian theory is as yet little known. Extensive material survives, however, from northeast Asia (Chinese, Japanese), India, west Asia (Arabian, Persian) and ancient Greece, which passed on so much to medieval Europe. The several known theories indicate distinct preferences for different aspects of the musical language. The Chinese (Chou dynasty, *c.* 1122–256 B.C.) and the Pythagorean Greeks, for instance, divided sound geometrically (the former constructing a cycle of fifths); and on this basis the Chinese rationalized their principal or five-note scale (a scale known also in Central America) and the Pythagoreans their seven-note scale. India (taking the octave as the starting point) and west Asia and early Europe (taking the fourth) considered sound harmonically, in accordance with the divisions of a stretched string and, in the main, favoured a seven-note scale. The people of southeast Asia appear to have tended toward the principle of division by roots, and the systems of equal temperament that this implies, in both five-note and seven-note forms.

**Ancient Forms.**—Since the ancients made no use of harmony in the modern sense, their music sought a fine balance of melody, rhythm and timbre. But in modern times the tracing of authentic ancient melody presents many problems. Traditions that, like those of China, claim a fabulous antiquity for certain surviving tunes have, in scientific method, to be treated with the greatest reserve; for the earliest actual surviving Chinese notation is as late as the T'ang dynasty (A.D. 618–906). True, some very ancient notations are still extant: *e.g.*, some chironomic signs on Egyptian tombs (Old kingdom), a single hymn on a Sumerian tablet (*c.* 800 B.C.), fewer than 20 late Greek fragments (none earlier than the 2nd century B.C.) and a few signs in the Dead Sea scrolls having all the appearance of a musical notation. But most of the transcriptions are controversial. In fact, scholars, since they are not able to hear the actual music of antiquity, were long confined to speculating about it, until A. Z. Idelsohn (1882–1938) indicated a new possibility. This scholar proved the essential identity of various versions of Jewish chant surviving in different communities that had lived in isolation since Solomon's temple fell to Nebuchadrezzar in 586 B.C., and he further demonstrated a link with Christian Gregorian chant. Indeed, in the second half of the 20th century the growing use of the comparative method, and the harvests gathered by the tape recorder, brought a new perspective to the study of archaic survivals.

Ancient poetry also provides important clues, since ancient melody was usually designed to heighten the expression of words. Sanskrit poetry has always been metrical (patterns of long and short feet), and its metres underlie India's system of measures in music. The psalms sung in Solomon's temple, on the other hand, had a freely accentual basis, the poetic lines having a fixed number of stress accents and varying number of syllables. This poetry, approximating to prose, thus called for melody patterns that could be freely varied in length and stress. Chinese poetry, again different, is syllabic, its line comprising a chosen number of monosyllables whose meaning depends upon their tonal organization. The linguistic and poetic unit, the monosyllable without metre or dynamic accent, found its musical counterpart in the single note and, although the result was naturally rather static as regards rhythm, the resulting tonal relationships encouraged the development of melody in song. Ancient Greek poetry combined both tonal and metrical elements and preserved a close relationship between music and words; and though dating only from the 2nd century B.C., the First Delphic hymn, a poem in the cretic metre, is beautifully matched by a melody in 5/8 time.

The verse structures of the ancient Egyptians, Babylonians and Hebrews lent themselves to antiphonal singing, a pattern found in Christian psalm singing in modern times. Their flexible nature called for an adaptable musical unit like the oriental melody type —a musical idea with special melodic and rhythmic contours. Such, it seems, were the Sumerian *sir* and Greek *nomos*, and the melody types of the Babylonians and Hebrews; the Indian *raga*, Persian *dastgah* and Arabic *maqam* provide living examples. While these systems show many differences in material and mode, they normally use segments of seven-note scales, finely graduated intervals, melisma, rhythmic variety, simple heterophony and sometimes (in India as in ancient Persia) an accompanying drone. By contrast, the far east, demanding greater tonal clarity in speech, has always preferred larger intervals, five-note scales, some modulation and a "square" rhythmic framework; the clarity was offset, however, by a complex system of polyphony, which was prevalent there much earlier than in Europe. From what can be inferred of the music of Central America, it is likely to have had affinities with the music of the far east, rather than that of Persia, the Arab countries or India.

Whereas the solo voice was favoured above instruments in India and west Asia, choral singing has seemed natural to Europe ever since its great popularity in ancient Greece and Crete. Solo instrumental performances have, on the other hand, always graced

China and Japan, while the combination of large numbers of instruments in concert is characteristic of China and even more, perhaps, of the countries of southeast Asia, especially Indonesia.

**Ancient Musical Instruments.**—The knowledge of ancient instruments comes from literary and pictorial records and from archaeological finds. Certain instruments of Stone Age origin are shared by many civilizations, especially percussion (rattles, rasps, stampers, xylophone, Jew's harp, primitive drums) and wind instruments (bullroarer, primitive flutes, ribbon reeds, shell trumpets). The instruments of the Maya and Aztec cultures, which emerged direct from primitive societies, add little to this list, though the Incas knew the panpipe as well.

Stringed instruments, notably few in Stone Age societies (musical bow, ground harp, ground zither), emerge with the dawn of civilization, especially in Egypt and west Asia (from the 3rd millennium): arched harp, angle harp, lyre, long lute, short lute and, in Phoenicia and China (about 1100 B.C.), the zither. The ancients did not, however, know the use of the bow on the string; their techniques embraced plucking, rubbing and numerous other methods.

Important early wind instruments include the shawm (west Asia), double reed-pipe (Egyptian Old kingdom), reed mouth organ (Chinese Chou dynasty and southeast Asia) and, perhaps rather later, the cross flute (Etruria, China and India).

Among percussion instruments drums assumed many new forms and became important particularly in India, while the bell was known early in China (early Chou dynasty), the cymbals in Egypt, India and the Holy Land, and later the gong on the borders of Burma and Tibet. Stone chimes and bell chimes originated in China (Chou dynasty) and struck bamboo instruments were elaborated in southeast Asia.

Most modern instruments have ancestors in ancient civilizations, and it was becoming apparent in the mid-20th century just how much western musical tradition owes to the civilizations that have gone before. *See* also BYZANTINE MUSIC; CHINESE MUSIC; GREEK MUSIC (ANCIENT); INDIAN MUSIC; JAPANESE MUSIC; ORIENTAL MUSIC; MUSICAL INSTRUMENTS; PERCUSSION INSTRUMENTS; WIND INSTRUMENTS.

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**MUSICOLOGY,** the name given to the scientific study of music in all its aspects. The term, first used in English in the first quarter of the 20th century, derives from *musicologie,* introduced into French shortly before 1914. The French term was taken from the German *Musikwissenschaft,* used for the first time by F. Chrysander in 1863. A much earlier example, however, of the use of a similar term, *musurgia,* is found in the Latin title of a work by Athanasius Kircher, *Musurgia universalis* (1650).

Musicology inevitably covers a wide and heterogeneous area of research and is concerned with the study not only of European and oriental art music but also of all folk music. The scope of musicology may be summarized as covering the study of (*a*) the modern, (*b*) the historical and (*c*) the developmental aspects of: (1) performance (including the voice, musical instruments, tone quality and its analysis, the effect of acoustical surroundings and performing styles); (2) the style of the music itself; (3) theory (of intervals, temperament and composition); (4) notation and pitch; (5) the lives of composers, performers and instrument makers; and (6) the place of music in the life of the community.

**History and Development.**—The beginnings of European musicology are found in the works of the theorists of Greek antiquity (*see* GREEK MUSIC [ANCIENT]). These writers were concerned principally with speculative philosophy and with moral and aesthetic concepts of music. The numerical theories of the Greeks were preserved by later Arab and Christian theorists and their classification of the modes survived, though in a corrupted form, in medieval Europe (*see* MODES, MUSICAL).

The innovations of Guido of Arezzo (*c.* 990–1050), which included the use of the hexachord (*q.v.*) and the development of musical notation, brought about a radical change in the methods of music teaching, and subsequent theorists became increasingly concerned with the dissemination of the principles of notation and the more practical elements of music theory.

The Renaissance gave rise to the publication of a considerable number of works dealing with the aesthetics, theory and practice of music. Detailed drawings and descriptions of the construction of musical instruments begin with the manuscript treatise of Arnault de Zwolle (*c.* 1440) and, in his *De inventione et usu musicae,* Johannes Tinctoris gives an account of instruments and their function. The first printed book on music, Sebastian Virdung's *Musica getutscht* (1511), contains, as well as woodcuts of instruments, some indications of instrumental practice and technique.

In the 17th century musicians began to apply scientific principles to recording the details of contemporary vocal and instrumental practice, as well as the exact measurement of instruments. Toward the end of the century a new interest in the music of the past resulted in a certain musical antiquarianism, a gathering of facts as curiosities as well as for their historical interest.

Histories of European music first appeared in the 18th century. They include G. B. Martini's *Storia della musica* (1757–81), left uncompleted, and Antonio Eximeno's *Dell'origine e delle regole della musica* (1774), which opposes the theory that music should be composed according to rules. By maintaining that sensibility is the basis of musical theory Eximeno established himself as a practical musicologist, laying foundations for the later romantic developments in music. Important English histories of music of the 18th century are Charles Burney's *General History of Music* (1776–89) and Sir John Hawkins' *General History of the Science and Practice of Music* (1776).

Modern musicology, with its practical as well as its historical approach to the music of the past, may be said to have started about the middle of the 19th century when such pioneers as Samuel Wesley and Mendelssohn inaugurated a wide-scale interest in the performance of the music of earlier composers. The 19th century also saw the publication of the *Gesellschaft* editions of Handel and Bach, backed by the new musicological scholarship. After the turn of the century the research of such scholars as Johannes Wolf resulted in the study of medieval systems of notation and in the transcription and publication of the works of many medieval and Renaissance masters.

The new sciences of psychology and ethnology exerted an influence on musicology. The German scholars A. W. Ambros, Guido Adler, F. Chrysander, P. Spitta and H. Riemann added greatly to the historical and theoretical knowledge of music, and Adler, in his *Methode der Musikgeschichte* (1919), presented a practical system of historical procedure dealing with musical paleography, instruments, aesthetics, pedagogics and comparative studies connected with folklore and ethnography. The main contributions in French to this domain of thought were F. J. Fétis' *Histoire générale de la musique* (1869–76) and A. Lavignac's *Encyclopédie de la musique* (begun 1913).

In the 19th century the study of the relationship between the life and the work of a composer began to assume a new importance; the subsequent steady stream of biographies provided, in many cases, an increased insight into the music itself.

Ethnomusicology, *i.e.,* the investigation of the music of ancient or non-European civilizations, developed greatly as a science in the 20th century, but it had taken its rise in the 18th century with Jean Amiot's *Mémoire sur la musique des Chinois* (1779), followed by works on ancient Egyptian and other oriental music by G. A. Villoteau. Ethnomusicology is divided into two categories: (1) that connected with the invention and growth of instruments (organology) and (2) that concerned with the investigation of musical civilizations maintained by oral traditions. Curt Sachs was the pioneer in research on instruments, notably in his *Geist und Werden der Musikinstrumente* (1929), while in the realm of

aesthetics John Ellis' *On the Musical Scales of Various Nations* (1885) was followed by Carl Stumpf's *Die Anfänge der Musik* (1911).

Toward the middle of the 20th century musicology became part of the curriculum of many U.S. and European universities, and the subject then covered such wide and varied fields of research that not only musicologists but also their many societies and journals showed an ever-increasing specialization.

**Significance.**—The results of musicological scholarship have an importance for the layman as well as for the performer and composer. Transcription of early notations and research into performing practices can widen musical experience. Analyses of the physical nature of sound and the means of its production may be directly connected with the manufacture of instruments and also with the acoustical properties of concert halls and opera houses. The sense of hearing and its relation to the phenomenon of music has a bearing on musical education. Other physiological matters, such as the use of muscles or methods of breathing, may help to clarify problems in the performance of music, both instrumental and vocal. Studies in aesthetics and the philosophy of music, primarily belonging to music criticism, also bring a fresh view to the works of philosophers who have dealt with music, from Pythagoras to Herbert Spencer. Investigations into musical theory may reveal new territories to composers.

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**MUSIL, ROBERT,** EDLER VON (1880–1942), German writer renowned for his unfinished *Der Mann ohne Eigenschaften*, one of the most significant novels of the 20th century. Born at Klagenfurt, Nov. 6, 1880, he studied engineering and philosophy and obtained a doctoral degree for his work on Ernst Mach (1908). After working in the Austrian war office he went to Berlin in 1922 where he lived as an independent writer. From 1933 to 1938 he lived in Vienna, then in Geneva, where he died April 15, 1942.

*Der Mann ohne Eigenschaften* was published in three volumes (1930, 1933, 1943); a more complete version came out in 1952, the last part, however, was an unscholarly compilation from unpublished papers. There is an English translation, *The Man Without Qualities* (1953–60). This monumental novel is an ironic analysis of the ills of the age, an unmasking of false attitudes of mind and an attempt to apply scientific precision of thought to social and spiritual experiences; Musil also explores a way of life for his hero who seeks to live without pretense. His style is translucent and often resembles a scientific mode of writing, but leaves room for expression of emotion. His method of presentation shows the influence of Marcel Proust and James Joyce.

Other works include *Die Verirrungen des Zögling Törless* (1906; Eng. trans. *Young Törless*, 1955), a novel; *Der Schwärmer* (1921) and *Vinzenz oder die Freundin bedeutender Männer* (1924), dramas; and *Drei Frauen* (1924), prose tales. (H. S. R.)

**MUSK,** a type of odour that is derived commercially from the male musk deer (*q.v.*). Musklike odours are found in other animals and in several plants. Musk obtained from the deer is employed in high-grade perfumes because of its fine odour characteristics and its ability to remain in evidence for long periods of time. In addition it has some ability to act as a fixative. Chemical compounds that produce musk odour have been synthesized and also are used in perfumes. In India and other parts of the far east, musk has been used traditionally for its supposed aphrodisiac, stimulant and antispasmodic effects.

Musk from the male musk deer is derived from the musk pods contained in a pouch between the anus and sex organs. The pods weigh about one ounce, depending on the age and condition of the animal. After the deer is killed, the pods are removed with the musk intact and then dried. When musk is fresh it is a brown, unctuous semiliquid with a strong odour. It dries to a grainy powder that is 50%–75% soluble in water and 10%–15% soluble in alcohol. The odorous principle of musk is muskone ($CH_3C_{15}H_{27}O$), or 3-methyl-1-cyclopentadecanone, a 15-carbon ring compound with a ketone structure. Muskone, which makes up between 0.5% and 2% of the grain, has a dark purple colour and a bitter taste. Other natural constituents of musk are cholesterol, fat, wax, albumins and ammonia.

Dried musk pods are supplied in four commercial grades. They are, in decreasing order of quality: Tongking, or Tonkin (grades I, II and III; from the old Tongking area of Vietnam), Yünnan (from Assam), Saoko Setchouen (from India or Nepal) and Kabardine (from Russia).

Natural musk is generally prepared for use in perfumes by making a tincture of 3% grain in pure alcohol; this solution, after being allowed to stand for several months, imparts character, strength and tenacity to the perfume. Musk is one of the most penetrating and most persistent odour used in perfumery. Because of its cost, it is generally employed only in the highest grades of perfume.

Animals other than the male musk deer that produce musklike odours include the rat, duck, shrew, beetle, ox, alligator, goat, civet cat, rock badger and zebra. Musk and musklike secretions appear to serve several functions in animals; *e.g.*, in defining territorial boundaries, in providing recognition and in serving as a sexual attractant in mating.

In plants, musklike odours are given off by the seeds of the angelica (*Angelica archangelica*) and of the abelmosk (*Hibiscus moschatus*), also called the ambrette or musk seed. Other less important plant sources are the musk mallow (*Malva moschata*), musk rose (*Rosa moschata*), musk thistle (*Carduus nutans*) and musk orchis (*Herminium monorchis*).

At least six different structural classes of chemical compounds are known to possess the odour of musk. They are the macrocyclic, benzene, nitro, steroid, indan and tetrahydronaphthalene (Tetralin) types. Members of all classes, including muskone, have been synthesized. Examples are synthetic cyclopentadecanone and pentadecanolide, a 16-member lactone. Examples of synthetic nitro musks are musk ketone, musk xylene and musk ambrette. The fixative properties of chemicals possessing musklike odours have, for some reason, been exaggerated in the past. As is true with all polar compounds, the musk compounds have, by physical attraction, some power to reduce the vapour pressure of other chemicals.

*See* M. G. J. Beets, "Structure and Odour," *Molecular Structure and Organoleptic Quality*, monograph no. 1, Society of Chemical Industry (1957). (JK. P.)

**MUSK DEER** (KASTURA or KABARGA), a small deer (*Moschus moschiferus*), about 20 in. high at the shoulder, that lives in mountainous regions from east Siberia and Korea through China and Tibet to the Himalayas. It is divided into about six subspecies. The musk deer has no antlers; it has greatly developed and functional lateral hoofs and, unlike other deer, has a gall bladder. As in the muntjac, the upper canine teeth of the males are long, slender, sharp-pointed tusks that project downward out of the mouth. The ears are large and the tail rudimentary. The grayish-brown hair is long, coarse, and brittle.

Musk deer are captured, usually in snares, for the strongly odorous musk (*q.v.*), which is produced by a gland in the sheath of the male sexual organ. The gland (or musk pod) and its contained secretion measure 2 or 3 in. in diameter and 1 in. in thickness and weigh, when dried, about one ounce.

PAUL POPPER LTD.
HEAD OF A MUSK DEER (MOSCHUS MOSCHIFERUS) SHOWING TUSKS

Musk deer are solitary and nocturnal; they feed on moss, grass and leaves in thickets of birch, juniper and rhododendron at great altitudes. Pairing is said to occur in January, and the single, occasionally twin, young are said to be born in June after a gestation period of five to six months. *See* also DEER. (L. H. M.)

**MUSKEGON,** a city of western Michigan, U.S., a port of

entry and seat of Muskegon county, is on Muskegon lake and Lake Michigan, 38 mi. N.W. by W. of Grand Rapids. The largest port on the eastern shore of Lake Michigan, with an excellent land-locked harbour protected by a breakwater, it is served by all-year car-ferry and steamship lines to Milwaukee. In 1960 the population of the city was 46,485 and of the Muskegon-Muskegon Heights standard metropolitan statistical area (Muskegon county) 149,943. (For comparative population figures for the two cities, which adjoin each other, *see* table in MICHIGAN: *Population.*)

The city benefited greatly from gifts of Charles H. Hackley (1837–1905), lumberman–philanthropist, totaling about $8,500,000 and consisting of a $2,000,000 endowment to the public schools; buildings, equipment and endowments of a manual training school, public library, art gallery, stadium and hospital; and a public square with numerous statues. The city also has a public junior commercial college opened in 1926 and a historical museum.

A trading post was established on the site of the city in 1812 by Jean François Recollet and the first sawmill was erected in 1837. The town was laid out in 1849, incorporated as a village in 1861 and as a city in 1869. In 1920 the city adopted a council-manager form of government. The name is derived from the Ottawa *Mus-Kee-Go* and the Chippewa *Mas-Ki-Ki-Gon*, both of which mean "river-with-marshes." The lumber industry reached its peak in 1887, with a cut of 700,000,000 bd.ft. The population then was about 24,000 but with the depletion of the forests it dwindled. Renewed prosperity began about 1900 when the city's wealthy citizens financed new manufacturing. With more than 200 manufacturing establishments, Muskegon's principal products are automotive, military and aircraft engines, piston rings and other automobile parts, office furniture and equipment, refrigerators, bowling and billiard equipment, gray iron, steel, brass and aluminum castings, boats, electric cranes and hoists, and wire products. Points of interest include an old Indian burial ground and the grave of the abolitionist Jonathan Walker, immortalized in Whittier's poem "The Branded Hand." (E. K. W.)

**MUSKELLUNGE** (MUSKIE): *see* PIKE.

**MUSKET,** a term generally applied to all smoothbore infantry small arms before the universal adoption of rifled firearms about the middle of the 19th century. The original musket evolved during the third quarter of the 16th century in the Spanish army, then the foremost military system of Europe. Following the wars between Spain and France in Italy, the trend toward solidarity in infantry tactics led to the demand for a heavier firearm than the arquebus (*q.v.*). A solution was found in a weapon that was in effect an enlarged arquebus, since the matchlock firing principle remained unchanged.

The musket, like the arquebus, was loaded by pouring coarse powder down the barrel, then ramming home a lead ball and a wad of rag. A pull of the trigger brought the serpentine, with its length of burning slow match, into contact with the fine powder in a pan that the musketeer uncovered by hand. The resulting flash of the powder in the pan passed through the touchhole and discharged the piece. Not much accuracy could be expected of the musket. Reloading was such a complicated process that two soldiers were assigned to the clumsy weapon. The adoption of a portable iron fork, serving as a rest, made it possible to bring into the field a firearm 5½ ft. in length, weighing 20 lb. and firing a ball as heavy as 2 oz. with an effective range from 150 to 200 yd.

Musketeers and pikemen—the "shot and pike" of the 16th century—were drawn up in a phalangial formation, many ranks in depth, for the purpose of mutual protection. Reloading was such a slow process that the musketeers of the front rank retired to the rear for that function and gradually moved forward until their turn came to fire again.

Improvements in the musket during the Thirty Years' War made it possible to reduce the weight and discard the iron fork. Late in the 17th century the matchlock was replaced by the flintlock, known in France as the fusil. But the term musketry survived into the 20th century on occasion to denote infantry fire with rifles. *See* also SMALL ARMS, MILITARY. (LN. MS.)

**MUSKMELON** (*Cucumis melo*), a frost-tender annual trailing vine of the gourd family (Curcurbitaceae), grown for its edible fruits. The muskmelon originated in Iran and the Transcaucasia. Northern Pakistan, Kashmir and Afghanistan constitute a secondary centre of development. The ancient Egyptians probably grew it and the ancient Greeks and Romans definitely did. It was introduced into China about the beginning of the Christian era. It is now grown in the warmer parts of the temperate zones and less humid parts of the tropics. In the cooler parts of the temperate zones it can be grown only under glass.

The leaves are three to five inches across, coarse, hairy to rough, nearly round to slightly heart shaped, three to seven angled with angles rounded, and with margins wavy. Its flowers are yellow, five-lobed, wheel shaped, about one inch across; they occur at the nodes, usually singly, on short peduncles. Generally the plant bears male flowers and female flowers; some plants bear male and bisexual or perfect flowers. The male flowers, which appear first, are easily distinguished by the absence of the small undeveloped fruit subtending the corolla. Fruits are very diverse, ranging in weight from two to nine pounds; in shape from slightly oblate through globular to oval and long tapered; in surface features from regular to broadly sutured to wrinkled, and from smooth to heavily netted; in flesh colour from pale green to orange; in odour and flavour from very slightly to strongly musky. Harvest time is from 85 to 125 days after planting.

J. HORACE MCFARLAND CO.
MUSKMELON (CUCUMIS MELO)

Cantaloupe is sometimes loosely used in referring to the fruit of any variety of muskmelon; it properly applies, in the United States, only to small (two to four pound), round to oval, heavily netted, highly perishable varieties. All varieties of muskmelon belong to the same species and intercross freely. When grown for production of seed for planting, varieties must be separated by a quarter of a mile or more; they are insect pollinated. Contrary to popular belief, the proximity of squash or pumpkin vines has no effect on the flavour of muskmelons, and muskmelons will not cross with cucumber, squash, pumpkin or watermelon. As muskmelons of the highly perishable type approach maturity a separation layer develops where the stem joins the fruit. When a crack is visible completely around the stem at this point the fruit has its maximum sugar content and is ready for harvest. At this "full slip" stage slight pressure will remove the stem cleanly, leaving no broken tissue of stem or fruit. Muskmelons of the "winter" or long-keeping type such as honeydew, Persian and casaba do not develop this separation layer until after they are ripe, so are harvested by cutting the stems. Proper harvest stage of the winter type is detected by rind colour, which must be judged according to variety. After harvest, muskmelons will become softer but not noticeably sweeter.

Muskmelons grow well on many kinds of soil but they need high fertility and ample soil moisture. Usually seeds are planted directly in the field or garden; sometimes plants are started under protection and transplanted to the field after danger of frost is past. Early field plantings may be protected by paper covers over the plants, and by windbreaks of brush and paper. Plants usually are spaced about two feet apart in rows five to six feet apart or in "hills" five by five feet apart. (V. R. B.; X.)

**MUSKOGEAN INDIANS.** This group constituted one of the larger speech stocks of native North America, and was typical of and dominant in the southeastern area of aboriginal culture, comprising the region from the Gulf of Mexico to Tennessee, and from the Carolinas to Louisiana. The Muskogean family comprised a series of divisions: (1) Apalachee; (2) Hitchiti, Apalachicola, etc.; (3) Alabama, Koasati, etc.; (4) Choctaw, Chickasaw, Mobile, Pensacola, etc.; (5) Tuskegee; (6) Cusabo, Yamasee and other tribes of the Georgia coast; (7) Miskogee proper. The latter formed the bulk of what was later the Creek confederacy, in which the Hitchiti and other groups were included. The Natchez

and Taensa of the lower Mississippi seem to be a remote Muskogean offshoot; the Calusa and other south Floridian tribes may be. Since the middle of the 18th century the historically important tribes have been the Choctaw, Chickasaw and Creek, plus a branch of the latter, the Seminole. With the non-Muskogean Cherokee, these make up the Five Civilized Tribes (*q.v.*) which for three-quarters of a century, until 1906, maintained quasi-autonomous governments in Indian territory (Oklahoma), where they had removed under the pressure of U.S. settlement.

Ethnographically the Muskogean or Southeastern culture province included, besides the groups listed, the Chitimacha and Tunica of the lower Mississippi, the Iroquoian Cherokee, the Timucua of central Florida and, in the lower region of Georgia and Carolina, the Yuchi, the Algonkian Shawnee and various eastern Siouan tribes. All these groups were agricultural, planting maize, pumpkins, beans, cane-millet, tobacco, sometimes Jerusalem artichokes, and sunflowers. They gathered hickory nuts and wild fruits, hunted deer and, in the west, bison, and stored nut oil and bear fat. The settlements were straggling; the "town" contained a square, on which were public and religious buildings; "villages" were often outlying. The towns were autonomous and essentially constituted tribes. They united into confederacies, directed by councils; such confederacies might break up and recombine. The most successful, like those of the Creek and Choctaw, grew in population during the colonial period, largely through absorption of smaller or scattered groups. The tribes were divided into matrilineal, totemic clans; chieftainship and office were hereditary, probably in the lineage within the clan. The Natchez and some other groups had superimposed a peculiar class or caste system. Chiefs in these cases were carried in litters, enthroned on raised seats or in arbours, and accompanied in death by sacrificial followers. All the tribes were warlike and in chronic but shifting embroilment with others. They took scalps and slowly tortured prisoners to death in a frame or tied to a post in the town square. Often there was a distinction between civil and military chiefs; the towns entitled to offices of one or the other kind in a confederacy were known as peace and war, that is, white or red.

Economic life was undeveloped as compared with the fairly well-organized sociopolitical institutions. Houses were of logs or poles, wattled, chinked or plastered with mud, with roofs of thatch. Bark or thatch houses were also built. Exposed settlements were palisaded, or log forts were erected. Pottery was unpainted, basketry of cane splints; simple weaving was done in bark fibres and bison hair, but the principal clothing besides mantles was breech clouts for men and apron skirts for women. Many tribes practised head deformation. There was little property, almost no treasure, and limited trade before the coming of the whites. Ritual was also simple; the most important ceremony was the busk or green-corn festival, a first-fruits and new-fire rite. Purification by emetics was a common religious observance. There was little that could be called art. Most tribes had a migration legend.

The Muskogean-Southeastern culture extended with variations north into the Ohio valley to the prehistoric moundbuilders, and northeast to the tribes of Iroquois lineage; it was represented in pallid form among many of the Algonkian groups as far as New England and the Great Lakes. The total Muskogean population was about 50,000. At the time of discovery, there may have been 7,000 Creeks (increased to 20,000 by 1832), 3,500 Chickasaw, 15,000 Choctaw, 5,000 Apalachee, perhaps 5,000 Mobile. The first three of these tribes survive in increased numbers, but much mixed with whites and Negroes.

*See* also INDIAN, NORTH AMERICAN; CENTRAL AND NORTH AMERICAN LANGUAGES; and articles on such individual tribes as APALACHEE; CHOCTAW; CHICKASAW; CREEK; NATCHEZ.

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**MUSKOGEE,** a city of eastern Oklahoma, U.S., 50 mi. S.E. by E. of Tulsa, is situated near the confluence of the Verdigris, Grand and Arkansas rivers; the seat of Muskogee county. Incorporated in 1898, the city adopted a council-manager form of government in 1920. In Muskogee are located the U.S. Indian agency for the Five Civilized Tribes, regional offices and a hospital of the U.S. Veterans administration, the Oklahoma School for the Blind and the Oklahoma Free State fair. A municipal junior college was founded in 1920. Bacone (Junior) college (Baptist) in nearby Bacone was founded in 1880 primarily for the education of American Indians; students come there from more than 20 states and from as many as 45 different tribes.

Founded in 1872 as a townsite on the first railroad built into Indian territory and named for the Muskogee (Creek) Indians, Muskogee soon became the administrative centre for the Five Civilized Tribes. The Commission to the Five Civilized Tribes, which dissolved tribal landholdings in preparation for Oklahoma statehood, maintained headquarters there. Originally the city served an agricultural and oil region but in modern times the economy was diversified, including the processing and manufacturing of rocket and missile fuel, rare metals, glass products, clothing, steel and iron, boxes, canned goods, meat and milk products and tire repair materials.

For comparative population figures *see* table in OKLAHOMA: *Population.* (J. D. Mo.)

**MUSK OX,** a shaggy-haired arctic American ruminant (*Ovibos moschatus*) of the cattle family (Bovidae; *q.v.*). It is not a true ox (subfamily Bovinae) but belongs rather to the goat-sheep subfamily (Caprinae), and in general appearance resembles somewhat a very hairy domestic bull. It is closely related to the takin (*q.v.*) of Asia. The musky odour from which it takes its name does not come from a special gland as in so many other musk-producing mammals.

The bull musk ox stands about five feet at the shoulder; the cow is somewhat smaller. Horns, present in both sexes, are borne on a large almost "neckless" head. In old males the sometimes two-foot-long horns meet by broad bases at the mid-line of the brow and proceed laterally, dip downward at the sides of the head and then curve upward. Females and young have smaller horns with a space between the bases. The striking external feature of this animal is the coat of long, dark brown hair, reaching nearly to the feet, concealing the short tail and nearly covering the small ears. Shorter hair covers the face, and is shortest on the space between the nostrils and upper lip. Underneath the shaggy coat is a thick wool, shed in summer. The legs are stout and short with hoofs that are rounded in varying degrees, depending on the subspecies.

W. SUSCHITZKY

MUSK OX (OVIBOS MOSCHATUS)

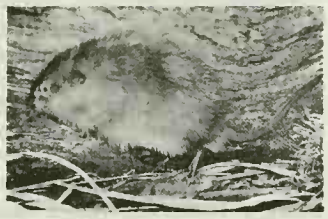
Musk oxen often travel in herds numbering 20 to 30 individuals. They are not aggressive animals, but when attacked the band forms a circle, the larger oxen presenting a formidable front of horns on the outer rim. This defense is very effective against arctic wolves and dogs. Musk oxen feed chiefly on grass, but also eat other low-growing vegetation including lichens, willows, etc. Some authorities, considering musk oxen as arctic cattle—with excellent milk production, valuable wool and good meat—are urging their domestication in suitable places. After a gestation period of 9 months the female gives birth to one young in late May or early June.

In the Pleistocene epoch (about 1,000,000 years ago) musk oxen were circumpolar in distribution, inhabiting Siberia, Germany, France, England and even parts of the southeastern United States. Today they are confined to arctic America, from about latitude 64 to the Arctic ocean and from a short distance east of the Mackenzie river delta to Greenland, including some of the arctic islands of Canada. Since the advent of firearms in the Arctic, the range of musk oxen is thought to be even further restricted. In

1929 a group of musk oxen was shipped from Greenland to Fairbanks, Alaska; this herd, now living on Nunivak Island in the Bering sea, was intended to be used to restock arctic Alaska.

*See* also V. H. Cahalane, *Mammals of North America* (1947). (O. J. M.)

**MUSKRAT** (Musquash), a large ratlike semiaquatic rodent (*Ondatra zibethicus*) of the family Cricetidae, subfamily Microtinae. The subfamily also includes the voles, meadow mice and lemmings. Muskrats occur over almost all of North America excluding the treeless tundra. They have been introduced in Europe and are becoming widespread there. The muskrat measures about 12 in. long and has an almost naked, scaly, laterally compressed tail somewhat shorter than the compact and heavy body. The eyes are small and the rounded ears project barely beyond the fur. The five-toed hind feet, partially webbed and fringed with stiff bristles, are an aid in swimming. The body is dark brown or somewhat paler; the feet are usually black. A dense, soft underfur is heavily overlaid with long, glossy, stiff guard hairs. Because of their availability, beauty and durability, muskrat pelts are a basic commodity of the fur industry. The yield in North America exceeds in value that of any other fur. The musky secretion that gives the animal its name issues from musk sacs. Muskrats live in poorly constructed reed and rush mounds, or lodges, in marshes, shallow lakes and streams. The lodge, in a bank or on a reed and mud island, is entered through an underwater opening. Food consists of a wide variety of sedges, reeds, roots—mostly of aquatic plants—and occasional freshwater mussels, crayfish, salamanders and fish. Feeding customarily takes place at special feeding sites, usually a flat rock or island of cut reeds. One to 11 young are produced once or twice a year, depending on the locality. (K. R. Kn.)



JOHN N. GERARD

MUSKRAT (ONDATRA ZIBETHICUS)

**MUSK SHREW,** the common name for small insectivores of the genus *Crocidura,* characterized by a powerful, musky odour. Because they frequent human habitations—in Africa and the warmer parts of Europe and Asia—they are often called house shrews. Their habits are like those of other shrews; they are voracious, sometimes vicious, alternately extremely active, and completely inactive in frequent and swift succession. *See* also Shrew.

**MUSLIM IBN AL-HAJJAJ** (full name, Muslim ibn al-Hajjaj abu'l Husain al-Qushairi al-Naisaburi) (*c.* A.D. 820–875), Arabian scholar, was one of the chief authorities on the apostolic tradition, the *Hadith* (*q.v.*), in which accounts of the sayings and deeds of the prophet Mohammed were collected. He was born *c.* 820 at Naisabur, northeast Persia, and died in 875 at Nasrabad near Naisabur. He traveled widely, and his great work, the *Sahih* ("The Genuine"), is said to have been compiled from about 300,000 traditions collected throughout the middle east. It has been unanimously acclaimed as authoritative and is generally ranked next to al-Bukhari's work. He was careful to give a full account of the *isnads* (links in the chain of transmission) for each tradition and to record textual variations. Muslim defended al-Bukhari's contention that the words of the Koran were the creation of an inspired prophet and not a transcript of eternal divine law. (F'U. R.)

**MUSLIN,** a plain-woven cotton fabric made in various weights from very sheer to coarse, heavy sheetings.

The better qualities are fine and smooth in texture, woven from evenly spun warps and wefts. They are given a soft finish, bleached or piece dyed and sometimes patterned in the loom or printed. The coarser varieties are often of irregular yarns and textures, bleached, unbleached or piece-dyed and generally sized in the finishing. Varieties of muslin are known under such names as book, mull, swiss, sheeting, etc.

The name is derived from the city of Mosul in Mesopotamia (Iraq), where the material was first made. Early Indian muslins were handwoven of extremely fine handspun yarns and were very costly. They were imported into Europe in the 17th century and later manufactured in Paisley and Glasgow in Scotland and in many of the English factories. (M. Da.)

**MUSSATO, ALBERTINO** (1261–1329), Italian writer, outstanding both as a poet and as a historiographer of the *Trecento,* was born at Padua in 1261, became a public notary and served his city on many diplomatic missions. In 1315, after his return from Verona, where he had been held a captive by Cangrande della Scala, he was crowned poet. His hostility to Marsilio da Carrara made him leave Padua in 1325, and he died in exile at Chioggia on May 31, 1329.

Mussato's Latin poems and, in particular, his tragedy *Ecerinis* (modeled on Seneca's tragedies, on which moreover he wrote an *Evidentia tragediarum Senecae*) are remarkable documents of the nascent Italian humanism. At the same time the *Ecerinis,* a veiled attack on Cangrande's despotic rule, shows Mussato's political views. His *De gestis Henrici VII Caesaris,* or *Historia Augusta,* and his *De gestis Italicorum post Henricum VII* are among the most important sources for the history of Italy in the early 14th century. Mussato continued these works with *Ludovicus Bavarus* and *De traditione Patavii ad Canem Grandem,* the latter a detailed and violently critical account of Padua's surrender to Cangrande in 1328 and the establishment of despotism in that city.

Mussato's historical works are printed in L. A. Muratori's *Scriptores rerum Italicarum,* vol. x (1730), apart from seven books of the *De gestis Italicorum,* which were published by L. Padrin in *Monumenti storici pubblicati dalla R. Deputazione veneta di storia patria,* 3rd series, vol. iii (1903). The *Ecerinis* is edited by L. Padrin (1900).

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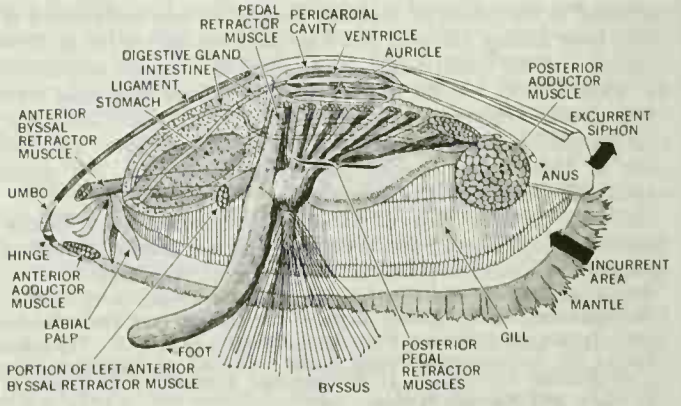
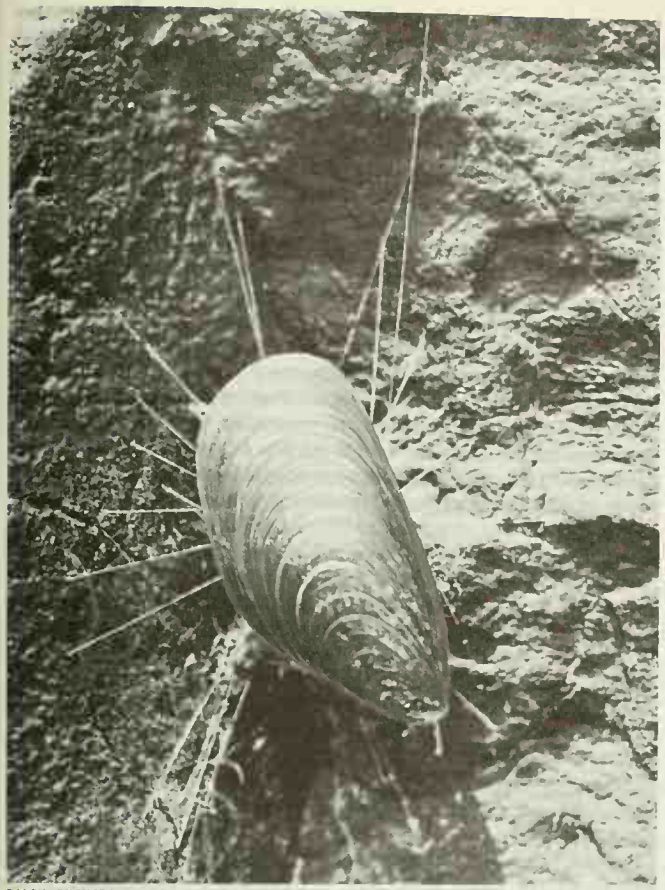
**MUSSEL,** the common name for a variety of bivalve mollusks belonging to the marine family Mytilidae and the freshwater superfamily Unionacea.

**Marine.**—The family Mytilidae is worldwide in distribution, occurring in a variety of habitats and ranging from well above the low-tide line to moderate depths. It is an ancient group, known from the Paleozoic era, and includes many genera, the best known of which are: *Mytilus* (true mussels), *Volsella* or *Modiolus* (horse mussels), *Brachidontes* (ribbed mussels) and *Lithophaga* (date or boring mussels). Although the many species in this large family vary greatly in shape, all are characterized by inequilateral valves that articulate close to the anterior end. They are usually wedge-shaped or elongate oval; they may be smooth or ribbed and often have a hairy covering, or periostracum. The foot, which is small for the size of the shell, is long, narrow and capable of considerable extension. Mussels, other than the date mussels, live




ANATOMY OF MYTILUS SHOWING THE MORE IMPORTANT ORGANS AND THEIR RELATIONSHIPS. (THE SHELL, MANTLE AND GILLS OF ONE SIDE HAVE BEEN REMOVED AND MUSCLES HAVE BEEN CUT)



RALPH BUCHSBAUM

COMMON EDIBLE MUSSEL (MYTILUS EDULIS): FINE BYSSUS THREADS, WHICH SECURE MUSSEL TO ROCK, EXTEND IN ALL DIRECTIONS

attached to the surface of rocks and pilings or, if living in muddy or sandy areas, attached to shells and stones embedded in the mud. The byssus, a holdfast device by which the shell is attached, is composed of numerous fine but tough threads produced by a gland in the foot. The threads act as "guy ropes" in effectively securing the mussel against the buffeting of the sea.

Mussels, like most other bivalves, feed on microscopic plants and animals in the water carried into the mantle cavity; the food is collected by means of cilia and mucus on the gills and labial palps. The sexes are separate, and the sex of a specimen can usually be determined by the colour of the gonads. In the edible mussel (*Mytilus edulis*), called also blue mussel for the colour of its shells, the testes are light orange-pink, the ovaries a deep maroon. The eggs and sperm are shed into the water, where fertilization takes place. Development is rapid: in three days the typical bivalve veliger larva is formed, and after one and a half weeks of free-swimming life, metamorphosis to the adult form takes place. However, the young mussel may remain pelagic for a month or more, staying afloat by means of a bubble of gas held between the valves or hanging by a byssus thread from the surface film of water. This ability to remain pelagic is probably an important factor in the wide distribution of *Mytilus*.

Many species of the *Mytilidae* are used for food, the most important being *M. edulis*, which occurs in the intertidal zone on the shores of Europe and eastern North America, living in areas where there is a good flow of clear water. As they can tolerate a rather wide range of salinity, they are often abundant in estuaries. Since earliest times this species has been an important item of food in Europe, particularly in France, where they have been under cultivation for centuries. More than 140,000,000 lb. (shell weight) of mussels are consumed as food in France each year, about 30,000,000 lb. in Great Britain, and lesser amounts in the Netherlands, Germany, Spain and Portugal. The Netherlands, however, harvests about 150,000,000 lb., two-thirds of which are exported, the remainder being used as duck food and as fertilizer.

Although edible mussels are very common on the coasts of New England and eastern Canada, they are not generally eaten, despite efforts to popularize them. Mussels are a tasty food, providing riboflavin, vitamin A, iron, copper, calcium, phosphorus and other minerals. They may be eaten raw, steamed or made into a stew, and are one of the cheapest and best sources of food in the world. It has been estimated that an acre in the best mussel areas will produce 10,000 lb. of flesh a year, while an acre of the best cattle land will produce only about 150 lb. of beef. Furthermore, mussels are easy to harvest. Occurring intertidally or in rather shallow water, they can usually be gathered with a clam rake or, if in deeper water, with dredges like those used in other shell fisheries.

On the west coast of North America both the California mussel (*M. californianus*) and the blue mussel, which had been introduced there, are eaten to some extent; both are extensively used as fish bait. In Japan the *igai* (*M. crassitesta*) is used as food only in the neighbourhood of the Inland sea.

A number of species of bivalves may cause paralytic shellfish poisoning, but species of the Mytilidae are among those most often implicated. At varying seasons of the year, depending on the locality, the mussels and clams of the intertidal area may feed on species of plankton organisms known as dinoflagellates (namely *Gonyaulax* or closely related genera). When man ingests mussels that have been feeding on poisonous plankters, he experiences nausea, numbness and paralysis of the tongue, lips and limbs; if poisoning is severe, other organs may be involved. There is a great range of susceptibility to the poison, but generally, except in the most serious cases, the effects disappear within a few hours or days. In the United States, fishery officers place signs on the mussel beds to warn collectors when there is danger of poisoning.

Species of the genera *Mytilus* and *Modiolus* may cause severe fouling of ships and buoys, or plugging of intake tunnels, pipes and conduits supplying sea water on ships or for cooling systems of condensers used in seaside industrial plants.

Mussels are preyed upon by a wide variety of animals, including starfish, bottom-feeding fishes (such as flounder) and carnivorous gastropods such as *Thais*, *Buccinum* and *Polinices*. Free-swimming embryo mussels are an important element in the plankton and are fed upon by a multitude of plankton-feeders.

**Freshwater.**—The freshwater mussels, also known as naiads, najaides or unios, belong to the superfamilies Unionacea and Mutelacea. The Unionacea, containing the families Unionidae, Hyriidae and Margaritiferidae, is characterized by larvae called glochidia (singular, glochidium) parasitic in the gills of fish; the group is worldwide in distribution. The Mutelacea comprises two families: the African Mutelidae, which have a parasitic larval stage called a haustorium, and the South American Mycetopodidae, which have a larval stage called a lasidium.

The largest family of freshwater mussels is the Unionidae, which comprises about 85 genera and perhaps 750 species and subspecies. They are found in lakes, ponds and streams throughout most of the world, with the greatest number of forms occurring in the central and southern United States. Southeastern Asia is also rich in species. The genera that constitute this family vary greatly in shape, size, sculpture, weight and hinge types; however, they are all characterized by pearly, or nacreous, shells, equal muscle scars, a well-marked pallial line (indicating the attachment of the fleshy mantle), short siphons and a well-developed plowing, or burrowing, foot.

The embryology of the Unionidae and Mutelidae is unique among the mollusks in that the young of most species are for a time parasitic on fish. The sexes are separate, and fertilization is internal. During the early developmental stages the young are held in the gills of the female mussel. Shortly after the embryo shell has developed, the young are extruded into the water and become attached to and embedded in the gills and fins of a variety of fish.

In the United States, freshwater mussels have been important in the manufacture of buttons. Mussels were an important item

of food to the American Indians, and today the flesh of naiads used in the pearl-button trade is used as food for hogs and chickens.

*See* BIVALVE; MOLLUSK.

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**MUSSELBURGH,** a small burgh of Midlothian, Scot., 6 mi. E. of Edinburgh. Pop. (1961) 17,273. The burgh, which lies on the south shore of the Firth of Forth, is intersected by the Esk and embraces the village of Fisherrow on the left bank of the river. There is a fine beach. The "burgh" in Musselburgh means "bank." While preserving most of the ancient features of its High street, the town has become a suburb of Edinburgh. Loretto school (1829) is near the site of the chapel of Our Lady of Loretto, which was founded in 1534 by Thomas Duthie, a hermit from Mt. Sinai, and was the favourite shrine of Mary of Guise. The 1st earl of Hertford destroyed it in 1544, and after it was rebuilt the Reformers demolished it again, some of its stones being used in erecting the tolbooth (1590). At Carberry hill Mary surrendered to the lords of the congregation in 1567, the spot being still known as Queen Mary's mount. Pinkie house is a Jacobean mansion with a fine fountain, formerly a seat of the abbot of Dunfermline, but transformed in 1613 by Lord Seton; the painted gallery, with an elaborate ceiling, was used as a hospital after the battle of Pinkie (1 mi. southeast) in 1547, and Prince Charles Edward slept in the house after the battle of Prestonpans (1745). Near the tolbooth stands the market cross. A 16th-century stone bridge crosses the Esk, and Roman remains have been found near it. Foundations of a 2nd-century Roman fort, similar to those along the Antonine wall, as well as other Roman remains have been found at Inveresk. The chief bridge, which carries the high road from Edinburgh to Berwick, was built by John Rennie in 1807.

The principal industries include the making of wire ropes, paper, twine and nets; there is also brewing and market gardening. Fishery is confined to Fisherrow where there is a harbour. Golf has for long been played on the links where race meetings are held in the autumn. "The Riding of the Marches of the Commonty" is a July festival celebrated every 21 years. In September is an annual event called the "Fisherman's walk."

**MUSSET, (LOUIS CHARLES) ALFRED DE** (1810–1857), French poet, playwright and novelist and one of the leading figures in the French Romantic movement, was born in Paris on Dec. 11, 1810, into a family with longstanding literary associations. After a brilliant scholastic career at the Lycée Henri IV, he briefly considered law and medicine as a career, dabbled in painting, and finally turned to literature. This last choice was due to the influence of the *Cénacle* which gathered at Victor Hugo's house in the Rue Notre-Dame-des-Champs (*see* HUGO, VICTOR MARIE), and to which he had been introduced by a school friend, Paul Foucher, Hugo's brother-in-law; it also owed something to Sainte-Beuve, who after hearing some of his poems, described him as "a child of genius." At the same time he became a *"dandy,"* one of the elegant Parisian imitators of Beau Brummell, and embarked on a life of hectic sexual and alcoholic dissipation which seriously undermined his health.

In 1830 he published his first collection of poems, *Contes d'Espagne et d'Italie*, which were fashionably romantic in their passionate themes, exotic settings and unorthodox versification, but at the same time disturbingly flippant in tone. "Ballade à la lune," for example, with its comparison of the moon to the dot over an *"i,"* foreshadowed Jules Laforgue's ironic moon-pieces of the 1880s, while "Mardoche" combined a humorous story of unhappy love with gibes at Hugo and his followers. He made his detachment from the new romantic movement more obvious that same year in the poem *Les Secrètes Pensées de Rafaël, gentilhomme français,* in which he praised the French classical writers at the expense of the foreign masters whom the romantics most admired; and in 1831, in *La Revue Fantastique,* he implicitly condemned Hugo's and Lamartine's political aspirations with the statement that a poet should never take part in politics.

Meanwhile, in Dec. 1830, his one-act play *La Nuit vénitienne* (published in the same month in *La Revue des Deux Mondes*) had failed at the Odéon, and this turned him against the stage: most of the plays written after this were intended to be read rather than acted, and many first appeared in *La Revue des Deux Mondes*. In 1833 he published *Un Spectacle dans un fauteuil,* a collection of plays, dramatic poems and *proverbes dramatiques* (reviving a form popular in the 18th century, of plays written to illustrate the truth of particular proverbs), which contained a verse drama entitled *La Coupe et les lèvres*, the first of his *proverbes;* and a delicate verse-comedy, *A quoi rêvent les jeunes filles;* as well as a poem called *Namouna,* which treated the central Musset theme of the purity of love in a life of debauchery.

Other works first published in 1833–34 were the prose plays *André del Sarto* (performed 1848), *Fantasio* (performed 1866) and *Les Caprices de Marianne* (performed 1851), all included in series II of *Un Spectacle dans un fauteuil* (2 vol., 1834); and a long poem, *Rolla,* in which a depraved hero is saved by love. This is what Musset hoped would be his own fate when he met George Sand (*q.v.*), in the summer of 1833, and set off with her on a journey to Italy (Dec. 12). In Venice, however (where they arrived in Jan. 1834), he became seriously ill, and Sand fell in love with Pietro Pagello, the young doctor she had called in to treat him. Musset returned to Paris alone, followed in August by Sand and Pagello, and after a succession of separations and reconciliations, the lovers finally parted in March 1835. The rights and wrongs of the affair have been endlessly discussed, notably by Sand herself in *Elle et Lui* and by Musset's brother Paul in *Lui et Elle* (both 1859), but whatever the truth of the matter, the liaison undoubtedly resulted in some of Musset's finest works.

These include the famous *Nuits* (1835–37), four lyrics (the *Nuits de mai, de décembre, d'août, d'octobre*), dialogues between the poet and his muse, or his *alter ego,* dwelling on his sufferings as a result of his disappointment in love, in which George Sand plays the leading, though not the only, feminine role; the *Lettre à Lamartine* (1836), which insists that love is the supreme source of great art; the autobiographical novel, *Confession d'un enfant du siècle* (1836), in which Musset extols their love, acquits Sand of blame for the failure of their liaison and incidentally paints a perceptive portrait of his own generation in the grip of the *mal du siècle;* and finally the poem *Souvenir* (1841), inspired by an accidental encounter (Feb. 1841) with Sand at the Théâtre-Italien. This, after recalling the lyrical setting of their early love in the forest of Fontainebleau, describes their unexpected meeting and sounds a note of acceptance, ending with a declaration of the greatness of their love.

During his liaison with Sand, and with her help, Musset had written a historical tragedy, *Lorenzaccio* (1834; produced 1896); which is perhaps the most successful and certainly the most Shakespearean of all romantic dramas. *On ne badine pas avec l'amour,* which he wrote in the same year, blended comedy with tragedy in a subtle amalgam, and the comic element grew in importance in the prose plays *Le Chandelier* (1835), *Il ne faut jurer de rien* (1836) and *Il faut qu'une porte soit ouverte ou fermée* (1845), all performed in 1848. The last plays which Musset wrote, encouraged by a successful performance (Nov. 1847) at the Comédie Française of *Un Caprice* (1837), were likewise works of delicate comic invention though somewhat lacking in verve: the verse *Louison;* the prose *proverbes, On ne saurait penser à tout* (both 1849) and *Carmosine* (1850; performed 1865); and *Bettine* (published and performed, 1851).

In 1852 Musset was elected to the Académie Française, an event which seemed to mark the end of his productive life, for he wrote scarcely anything else before he died, prematurely worn out by

his excesses, on May 2, 1857, in Paris.

**Reputation and Poetic and Dramatic Powers.**—Musset's reputation as a poet has suffered as a result of his undeniable and indeed vaunted facility. Succeeding generations concerned with questions of form and significant content have tended to dismiss him as a slipshod, careless versifier who wore his heart on his sleeve and regarded poetry simply as a means of bewailing lost loves. But this is to do Musset less than justice. Although he was certainly opposed to the idea of esoteric poetry, his poems are not mere sentimental effusions; nor are they solely concerned with the subject of love. Though only one of his great lyrical poems (*L'Espoir en Dieu* of 1838) is primarily concerned with religion, in nearly all his most important poems he takes love as a pretext for moving on to wider themes, such as suffering, and artistic creation, which he treats with considerable stylistic skill. And if his verse occasionally degenerates into rhetorical bombast, it is often intensely moving in its pathos and simplicity.

Musset's plays have survived the test of time far more successfully than his poems. In the first place, they generally present a society with which he was extremely familiar, and whose grace, feeling and wit he could render with charm and realism. But above all, by writing as he did for the reader rather than the spectator, he was able to achieve a freedom and a spontaneity which the modern theatregoer finds greatly to his taste.

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**MUSSOLINI, BENITO** (1883–1945), Italian statesman, the *duce* or leader of the Fascist movement who governed the kingdom of Italy as prime minister from 1922 to 1943 but was in fact dictator from 1925, was born July 29, 1883, at Dovia, in the commune of Predappio (province of Forlì). This was a region where the anarchists had strong affiliations. His father, Alessandro Mussolini, was a blacksmith of antireligious and socialist opinions; his mother, Rosa Maltoni, was a schoolteacher; and the young Mussolini was named Benito after Benito Juarez, the Mexican revolutionary leader. At the Salesian school of Faenza he became known for his insubordinate temper. Later he qualified as a schoolteacher at 18, obtaining an appointment at an elementary school in Gualtieri (province of Reggio nell'Emilia).

**The Leftist Period.**—As a youth Mussolini was interested in the Italian revolutionary movement, which was then an oddly assorted mixture of socialist, republican, syndicalist and anarchist tendencies. Looking for a better career than teaching in elementary schools, and hoping to avoid military service, he went in 1902 to Switzerland, where he earned a precarious livelihood, sometimes by manual work, while engaging in revolutionary and atheistic propaganda. Having been expelled from various cantons, he was finally expelled from the Swiss confederation. On his return to Italy he performed his military service. Back in his native Romagna, Mussolini became an active member of the socialist movement. On one occasion he was arrested, condemned to ten days' imprisonment and put under police surveillance.

At the end of 1908 Mussolini went to Trento (then belonging to the Austrian empire) to join the staff of local Italian socialist newspapers. One of these was edited by Cesare Battisti, an Italian irredentist, who was always ready to fight the Vienna government and was hanged by the Austrians in 1916. Association with Battisti inspired Mussolini with nationalist ideas, and after publishing an irredentist article he was arrested and expelled from Austrian territory. In Trento he had become acquainted with the newest German irrationalist and pessimistic philosophy, particularly that of Nietzsche, which strengthened his conviction that violence is the fundamental element of social transformation. He also published an anticlerical novel, *Claudia Particella, l'amante del cardinale* (Eng. trans., *The Cardinal's Mistress,* 1929) as a serial in *La Vita Trentina* (1909).

In 1910 Mussolini was appointed secretary of the section in Forlì of the Italian Socialist party and edited *La lotta di classe,* a paper in which he developed the idea that "Socialism is war; and in war woe to those who have humanitarian feelings." Far from having much interest in orthodox Marxism, he sympathized with the revolutionary theories of two Frenchmen: the insurrectionist Auguste Blanqui and the syndicalist Georges Sorel.

When Giovanni Giolitti's government decided on the military occupation of Tripolitania (*see* ITALO-TURKISH WAR), Mussolini was among the more vehement opponents. He said that Italy needed class war, not imperialistic wars, and that the aim of the Socialists could not be a vast Italy but should be an Italy "cultivated, rich and free." On Sept. 25–27, 1911, having led the workers of Forlì in a movement of resistance to war, he was arrested and sentenced to five months' imprisonment. At the next congress of the Socialist party in Reggio nell'Emilia (1912), the left wing won a majority, the reformist leaders Leonida Bissolati-Bergamaschi and Ivanoe Bonomi were expelled and Mussolini's position as a leader of the majority was recognized. On Dec. 1, 1912, he was made editor of *Avanti,* the official organ of the party. His closest collaborator was then the Russian revolutionary, Angelica Balabanov. Under Mussolini's editorship the circulation of *Avanti* rose. His vigorous editorials, written in a synthetic, hammering style, and his support of the "Red week" of June 1914 in the Marche and in Romagna won him considerable popularity. In *Avanti* he stated that the Italian nation needed a "bath of blood," after which the revolutionaries would be able to take power. Meanwhile he published another anticlerical book, *Giovanni Huss—il veridico* (1913).

It was during this period that Mussolini met Rachele Guidi, who later became his wife. Of humble origin and possessing a good deal of common sense, Rachele Mussolini led a retired life. She bore her husband six children, of whom the best-known was Edda, the eldest daughter, who married Galeazzo Ciano.

**World War I.**—When World War I broke out, Mussolini advocated at first a policy of absolute neutrality. In *Avanti* he threatened the government with a proletarian rising if Italy intervened on the side of Austria and Germany, the powers to which the Italian government was bound by an alliance. After seeing many of his syndicalist friends take the democratic interventionist side, he began to hesitate. The able diplomacy of the French ambassador Camille Barrère and the intermediary activity of his French Socialist friend Marcel Cachin (later a leader of the French Communist party) decided Mussolini to range himself on the side of France and Great Britain.

Mussolini was obliged to leave the editorship of *Avanti.* On Oct. 20, 1914, the Socialist congress at Milan refused to accept his justification that war would promote social revolution in Italy, and Mussolini was expelled from the Socialist party. On Nov. 14, 1914, first appeared Mussolini's new daily paper *Il Popolo d'Italia,* a Socialist daily, in which he now advocated Italy's entry into the war. He explained that if Italy would help the western democratic powers win the war, "more liberty would exist in Europe and the proletariat would have better opportunities to develop its class capacities." War also meant violence and bloodshed; it meant an opportunity for revolution and for achieving personal power.

A few Socialists followed Mussolini to *Il Popolo d'Italia.* Together with them and several young republican interventionists, Mussolini founded the *Fasci d'Azione Rivoluzionaria,* which made strong war propaganda. For his violent speaking, Mussolini was arrested in April 1915. A few days later he was slightly wounded in a duel with the pacifist Socialist leader Claudio Treves. Italy declared war against Austria in May 1915; and in September Mussolini was called up. He served as a private in the Bersaglieri. On Feb. 23, 1917, while training, he was wounded by the explosion of a hand grenade. He spent many months in the hospital and on recovery returned to the editorship of *Il Popolo d'Italia.* Here he engaged in an active campaign against the Socialist party, which continued to advocate pacifism.

**Fascism.**—Thanks to the help of rich people who feared a

Bolshevik revolution and of ex-servicemen dissatisfied with peace conditions, Mussolini was able to found on March 23, 1919, at Milan, a new political movement, the Fasci di Combattimento, with a policy of national socialism. The program, adopted on Mussolini's suggestion, asked for a constituent assembly, the abolition of the senate and the recognition of workers' and technicians' control in the factories. In foreign policy, Mussolini said that the League of Nations could be accepted only on condition that the claims of poor nations (like Italy) against the wealthy ones should be taken into consideration.

At first Mussolini tried to acquire the sympathies of the trade unions and to remove them from the influence of the Socialist party. He was not successful. He had already failed to secure election to parliament as a Socialist in 1913. At the elections of 1919 he stood as a Fascist candidate for Milan and secured only a few votes. Meanwhile, Gabriele d'Annunzio occupied Fiume. Mussolini supported him in *Il Popolo d'Italia* and in public meetings. "D'Annunzio," he said on Aug. 5, 1920, "is the only man who has dared to revolt against the plutocracy of Versailles." But when, in Dec. 1920, Giolitti settled the question of Fiume by military force, Mussolini had no possibility of actively supporting D'Annunzio. The moment had not yet arrived for a direct attack against Italy's liberal regime, and Mussolini was still trying not to make too many enemies.

**The Conquest of Power.**—The social upheaval caused by the war and by the problems of the postwar period reached its most dramatic moment in Italy in autumn 1920, with the seizure of some factories in northern Italy by metallurgical workers. Mussolini at first supported the movement. He tried to get in touch with its leaders and offered a common front of direct action against the industrialists, the government and the extremist or Bolshevik wing of the workers' movement. His offer was rejected. Largely as a result of the wise policy of the government and in exchange for small concessions, the workers surrendered the control of the factories to the owners. There had never been any serious danger in this revolutionary socialist movement, but the panic caused by the threat remained, and Mussolini decided to exploit the prevalent fear and desire for revenge in order to overthrow the liberal parliamentarian regime. The *Fasci* received ample funds from many people, chiefly industrialists and landowners. Armed squads (*squadre d'azione*) were organized to destroy the political and economic organizations of the Socialists, whose capacity to resist was hampered by their own divisions. Giolitti tolerated the actions of Mussolini's followers, believing that it was good policy to let the Fascists quell the Socialist revolutionary threat; and his successor, Ivanoe Bonomi, seems even to have encouraged or at least allowed the armed forces to support the Fascists. Various Italian liberal groups and the Catholic democratic party (who were, after the Socialists, the most important political element in Italy at that time) observed a neutrality favourable to the Fascists.

From the end of 1920 on, the Fascist squads attacked and destroyed the organizations of the Socialists, the Communists, the Republicans, etc. Hundreds of people were killed. The organization grew with success. On May 15, 1921, Mussolini and 35 other Fascists were elected to parliament, but only because the liberal leader, Giolitti, included them among the candidates of the government coalition. In Nov. 1921 at the congress of Rome, Fascism was organized into a Partito Nazionale Fascista. Mussolini was already known to his followers as *il duce* (the leader). In Aug. 1922 the trade union council, the Socialist party and the railwaymen's union tried to stem the tide by declaring a general strike. The strike was broken by the Fascist armed squads. To secure support of the army and important conservative groups Mussolini renounced his former republican convictions, as he was also tactfully modifying his socialism and his anticlericalism. A Fascist convention at Naples on Oct. 24, 1922, provided the pretext for the concentration of armed squads. Mussolini went from Naples to Milan and left the direction of the "march on Rome" to a quadrumvirate of his closest friends (Italo Balbo, Michele Bianchi, Emilio De Bono and C. M. De Vecchi). Practically no opposition was met from the civilian and military authorities.

The cabinet, headed by Luigi Facta, decided unwillingly to proclaim a state of emergency, but King Victor Emmanuel III refused to give his approval. Facta resigned and after a futile attempt on the part of the liberal-nationalist Antonio Salandra to form a coalition government the king entrusted to Mussolini the task of forming the new cabinet.

**The Fascist Government.**—The so-called "march on Rome" had taken place on Oct. 28, 1922. Three days later, in Rome, Mussolini formed his first cabinet, including a majority of non-Fascists in order to conceal his long-term plan to undermine and transform the whole fabric of the state. Liberals and Christian Democrats were at first pleased to join his coalition, but gradually he isolated the various parties and used them to destroy each other until Fascism had a complete monopoly of power. A convinced enemy of all democratic forms of government and particularly of the parliamentarian one, Mussolini gradually concentrated all power in his own hands. From the very beginning he personally held the ministries of the interior and foreign affairs as well as the premiership, and at one time he had seven portfolios at once. He held the army, navy and air force ministries in his own hand for nearly the whole duration of his regime, and it was always his policy to eliminate anyone who showed inclination for independence or acquired a personal popular following. On Jan. 12, 1923, he created the Fascist Grand council, whose members he appointed and which eventually stood higher in the state than the council of ministers. A month later he officially militarized the Fascist armed squads as the Milizia Volontaria per la Sicurezza Nazionale—a decision which provided him with a large private army to be played off if necessary against the regular armed forces.

The full scope of Mussolini's ambitions became clear only gradually. The murder on June 10, 1924, of a leading member of the Socialist party, Giacomo Matteotti (*q.v.*), made his position extremely difficult for a time, but the Liberals still went on supporting him, and the other parties merely took the passive step of not turning up in parliament (the "Aventine secession"). The king, after some hesitation, confirmed his support of Mussolini, and in a famous speech on Jan. 3, 1925, the latter took the initiative and established a full dictatorship. During the next two years, he introduced laws which gave him a special position as prime minister and the right to exercise—as head of the executive—legislative and judicial prerogatives. Parliament had begun in Nov. 1922 by freely giving Mussolini the full powers for which he had asked, and now he was able to alter the electoral law and make these full powers a reality. The classical division of powers was at an end. On Nov. 6, 1926, all opposition activity (politics, press, meetings) was specifically prohibited. After 25 years of a varied political career and seven years as the leader of Fascism, Mussolini now realized his dream of becoming the absolute ruler of his country. Yet another electoral law was approved in 1928. The Fascist political, syndical and cultural associations—through their leaders who were all appointed by Mussolini—were asked to present candidates among whom the Grand council chose those who were to be nominated. The electors had only the right to reject the whole list. In fact elections were held on this basis in 1929 and 1934 and gave the government a huge majority. Parliament was itself to be abolished and replaced by the Camera dei Fasci e delle Corporazioni, inaugurated on March 23, 1939.

The *corporazioni* were Mussolini's favourite innovation in the economic life of the country. He was not in any sense expert in economics, and in this as in every other field his policy was to vary empirically from one extreme to another. Starting with the idea that Fascism signified handing industries from public back to private enterprise, Mussolini ended up by trying to introduce rigid government controls. In the early 1930s he created the so-called *corporazioni* as the outward manifestation of this new trend. Sometimes there were about 20 of them, sometimes more or fewer, but in theory Italians were all fitted into one or another category of trade or profession, and the economic life of society was regulated by these professional organizations. They served as a kind of government-controlled trade union system. Free trade unions were banned, as were all other political parties and private organizations. It became the motto of Mussolini that "all must exist

inside the state, nothing outside it."

The judicial organization of Italy was changed in a similar direction. The old legal codes were abolished and new ones, inspired by Fascist principles, enforced (Mussolini, here as elsewhere, deliberately was trying to imitate Napoleon). The judicial power was deprived of its autonomy. Also the structure of the Fascist party was transformed. At first the party included important groups more loyal to other Fascist leaders than to Mussolini. Under the secretaryship of Augusto Turati and Achille Starace, the influence of various leaders was eliminated and their clientèles dissolved. The *duce* emerged as the one man in control of the party, and he surrounded himself with more or less insignificant "yes men." The police, too, became important, and the chief of police was probably the only man who could see Mussolini whenever he wished. The task of this man was not easy because the opposition went underground but never completely disappeared. A number of attempts were made on Mussolini's life; clandestine newspapers were published and there were occasional acts of sabotage. The police were not notably efficient, and they sometimes acted in a much more liberal sense than Mussolini would have liked.

**Foreign Policy.**—Mussolini had few basic principles of foreign policy except that of increasing Italy's power as a way of increasing his own. His chief difficulty was that Italy was poor in resources and military power. He had to rely on bluff and on taking advantage of the various rivalries already existing in Europe. As early as 1923 he sent a punitive expedition against the Greek island of Corfu, but pressure from the western democracies obliged him to retreat. He managed to obtain slight frontier rectifications in Africa from both France and Great Britain. By helping Ahmed Zogu to seize power in Albania, Mussolini was able to establish a virtual protectorate over that country in 1927. He managed to convince himself that, as a result of economic crises and social upheavals, the democratic powers were bound to give way to nations more ready to employ violence and war.

Three regions exercised a particular fascination over Mussolini's imperial dreams: the Mediterranean, the Balkan-Danubian area and the northeastern section of Africa. The Mediterranean he used to call *mare nostrum* ("our sea"). In order to win control over it he intervened in the Spanish civil war (1936–39), and he spoke of the annexation of Malta, Corsica, Tunis and the Balearics. He also subsidized anti-French and anti-British movements in Egypt and north Africa and publicly claimed to be the protector of Islam. In the Balkans, he supported the revisionist claims of Hungary and Bulgaria and backed the Croatian separatists in order to weaken Yugoslavia. In April 1939 he occupied Albania; and in 1941, during World War II (*see* below) he incorporated Dalmatia and other portions of Yugoslav territory. In Africa he invaded Ethiopia in Oct. 1935, defying economic sanctions imposed by the League of Nations, and in May 1936 he was able to name Victor Emmanuel emperor of Ethiopia.

From 1936 onward, Mussolini was forced ever closer to Nazi Germany, reluctant though he was to share his power with anyone else. In Sept. 1937 he visited Germany and came to the conclusion that Italy had better throw in its lot with Hitler. In March 1938 he was obliged to accept the annexation of Austria by Germany, despite his own previous attempts to establish an Italian protectorate over Austria. Hitler visited Italy in May 1938, and the two dictators agreed on an aggressive policy. In July Mussolini surprised his associates by following Germany in introducing racial laws against the Jews. In September, at the Munich conference, he helped Hitler to achieve a diplomatic success and the practical annexation of Czechoslovakia. In Jan. 1939 Neville Chamberlain, the British prime minister, came to Rome in the hope of persuading the *duce* to steer a more neutral course, but Mussolini could not see that Italy had far more to gain from holding the balance between the two major power groups of Europe than from joining one of them. In May 1939 an aggressive military alliance was signed between Italy and Germany, and from this moment onward Mussolini had very little freedom of action.

**World War II.**—At the beginning of World War II on Sept. 1, 1939, Mussolini proclaimed a policy of nonbelligerency, and this evidence that he did not dare fight was a sign of grave weakness and caused considerable shock in the Fascist party. The Germans had deliberately deceived him by telling him that there would be no war for three years, and now he found himself caught up in their aggressive policy. Only on June 10, 1940, when he thought that Germany had already won the war, did he declare war on France and Great Britain. He now took over personally the supreme command of Italy's armed forces and launched a singularly unsuccessful invasion of France. In the autumn he attacked Greece and suffered a disastrous defeat. In 1941 the entire Italian East African empire was overrun by the British, and in north Africa the Italian colonies were saved only by the arrival of the Germans under Gen. Erwin Rommel. Italy's influence in the Balkans was largely replaced by Germany's, and Mussolini had to submit while Italy itself became virtually a colony of the "Great German *Reich*."

The corruption and inefficiency of Mussolini's regime were now bringing their reward, and his failure to establish the strong state which he had preached was leading to his own eclipse. He had extolled violence for so long and had so continuously advocated war as a test of personal and national worth that Italy's involvement in the war was essentially his own personal responsibility. Italy's defeat was also his responsibility, for he was commander-in-chief and for a decade had been in charge of all preparations for war. At long last his bluff had been called and his weakness exposed. When Germany attacked the U.S.S.R. without consulting him, and when Japan attacked the United States, Mussolini had no option but to declare war similarly, thus sealing his own fate and that of his country.

Military defeat finally led to Mussolini's downfall on the night of July 24–25, 1943, when the Grand council repudiated his leadership by a vote of 19 to 7. The king at once arrested him and appointed Marshal Pietro Badoglio to take his place. But on Sept. 12 the Germans recaptured Mussolini by a brilliant parachute attack on his place of confinement at Campo Imperatore in the Abruzzi mountains. They then set up a Republican Fascist party in northern Italy, with Mussolini as its titular head. But Mussolini was now a sick and demoralized man. He rarely appeared in public to electrify his audience as he had so often done in former days from the balcony of his Palazzo Venezia in Rome, and his undeniable personal fascination had now withered away. In Jan. 1944, he had his son-in-law, Galeazzo Ciano, Emilio De Bono and some other Fascist "rebels" executed after a mock trial at Verona. Mussolini himself, together with his mistress Clara Petacci, who remained faithful to the end, was summarily shot by the Italian partisans on April 28, 1945, outside the village of Dongo, near Lake Como. Their bodies were hung, head downward, in the Piazza Loreto in Milan.

Mussolini's autobiography, written in 1911–12, was adapted for publication in the French weekly *Candide* in 1923 and for an English version in 1928 (expanded text 1939); an edition of the original, *La Mia Vita*, appeared in 1947. His collected works, in 25 volumes, were edited by E. and D. Susmel (1951–59).

*See* also ITALY: *History*; FASCISM; and references under "Mussolini, Benito" in the Index.

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**MUSSOORIE,** a municipal town and a popular hill station in Dehra Dun district of Uttar Pradesh, India. The town, situated about 6,932 ft. above sea level, lies 22 mi. N. by road of the railhead at Dehra Dun. It stands amid picturesque mountain scenery on a ridge of one of the ranges in the Lesser Himalayas. Mussoorie had, in 1961, a population of 9,849, which increases to about 20,000 in the hot season, since it is one of the chief summer resorts for residents in Delhi and the plains of Uttar Pradesh. Lying 38 mi. northwestward on the road to Simla is the cantonment of Chakrata at an elevation of 7,216 ft. The climate and surroundings make Mussoorie a suitable site for numerous residential schools. The first brewery in India was established there in 1850. The town has botanical gardens and is the summer seat of Indian government offices. (S. S. Bh.)

**MUSSORGSKY, MODEST PETROVICH** (1839–1881), the most important of the Russian nationalist composers. Born at Karevo, Pskov government, March 21, 1839, he was the son of a landowner. At 13 he was sent to the army cadet school in St. Petersburg and it was his meetings there in 1857 with M. A. Balakirev, A. S. Dargomyzhski and C. A. Cui that led to his serious application to music. In 1858 he left his regiment, having earlier in the year begun to study systematically under Balakirev. Financial difficulties caused by the liberation of the serfs obliged him to take a post in the civil service in 1863. In the meantime, in addition to composing several piano and orchestral works, he had made his first attempts in the two genres in which he was to excel—opera and song. In 1865 the death of his mother caused the first serious symptoms of dipsomania, which was to affect him increasingly.

He achieved artistic maturity in 1866 with a series of remarkable songs about ordinary people such as "Darling Savishna," "Hopak" and "The Seminarist," and an even larger and finer group appeared in the following year. In 1868 he reached the height of his conception of musical realism with the first song of the incomparable cycle *The Nursery* (published 1870) and a setting of act i of Gogol's *The Marriage*. In this year he began his masterpiece *Boris Godunov* (based on Pushkin's drama), finished at the end of the following year. In 1871, because of its rejection on account of its lack of love interest, Mussorgsky subjected it to a thorough revision, and it was eventually successfully performed at St. Petersburg, Feb. 8, 1874. In the same year *Pictures at an Exhibition* for piano, in memory of the painter Victor Hartmann, and the relatively introspective song cycle *Sunless* were written, and in 1875 he resumed work on a new historical opera, *Khovanshchina*. But in 1876 he turned to Gogol's *Sorochinsk Fair*, and henceforth he worked on both operas simultaneously without, however, completing either. The last of his major works was the cycle *Songs and Dances of Death*, finished in 1877. He died at St. Petersburg on March 28, 1881.

Mussorgsky's importance and influence on later composers is quite out of proportion to his relatively small output. Few composers were less derivative, or evolved so original and bold a style. His 65 songs, many to his own texts, describe scenes of Russian life with great vividness and insight and realistically reproduce the inflections of the spoken Russian language. His power of musical portrayal, his strong sense of characterization and the importance of the role of the chorus—all expressions of his antiromantic convictions—established *Boris Godunov* as a historical masterpiece. From the technical viewpoint his unorthodox use of tonality, his empirical harmony and his method of fusing arioso and recitative provided *Boris* with a dramatic intensity that he failed to recapture in his otherwise admirable later operas. Shortly after his death, Mussorgsky's original harmonic and instrumental style was unjustifiably criticized, and it was with the well-meaning intention of purging Mussorgsky's works of what he considered to be harmonic eccentricities and instrumental weakness that Rimski-Korsakov edited and "corrected" almost his entire output, of which his widely performed edition of *Boris Godunov* is best known. From about 1908 onward, however, after the production of Rimski-Korsakov's version of *Boris* at the Paris Opera, there was a growing demand for Mussorgsky's original versions, which began to be made available in 1928 in a collected edition edited by Paul Lamm. This edition displayed for the first time the full originality and range of his genius.

*See* M. D. Calvocoressi, *Mussorgsky* (1946); J. Leyda and S. Bertensson, *The Mussorgsky Reader* (1947). (D. M. L.-J.)

**MUSTACHE:** *see* BEARD.

**MUSTAFA I** (1591–1639), Ottoman sultan of Turkey (1617–18 and 1622–23), the son of Mohammed III, was born at Manisa in 1591. On Nov. 22, 1617, he succeeded his brother Ahmed I, whose elder son was a minor. Mustafa, being mentally ill, was deposed after three months, but he was brought again to the throne in 1622 by the janizaries, who had dethroned Osman II. Mustafa tried to rule with the guidance of his mother, helped by the army. His misrule, however, provoked a general reaction. Declared unfit for the caliphate by the *ulema*, he was forced to abdicate on Sept. 14, 1623. He died at Istanbul in 1639. *See* also TURKEY: *History*. (E. Z. K.)

**MUSTAFA II** (1664–1703), Ottoman sultan of Turkey from 1695 to 1703, the son of Mohammed IV, was born at Edirne on June 5, 1664, and succeeded his uncle Ahmed II on Feb. 6, 1695. He was determined to regain the territories lost after the Turkish defeat before Vienna in 1683. Having recovered Chios from the Venetians he led his army, in person, against the Austrians and gained some successes in the first and the second expeditions. He was defeated by them, however, at Senta (Zenta) in 1697. Azov had been taken by the Russians a year before. As a result of these defeats he was forced to sign the peace of Karlowitz (1699), by which Turkey was driven practically back to the Danube. Mustafa devoted his later years to hunting. He was held responsible for the interference of the sheikh ul-Islam, Feyzullah, in the government and a military mutiny forced him to abdicate on Aug. 23, 1703. He died at Istanbul on Dec. 31, 1703. *See* also TURKEY: *History*. (E. Z. K.)

**MUSTAFA III** (1717–1774), Ottoman sultan of Turkey from 1757 to 1774, the son of Ahmed III, was born at Istanbul on Jan. 28, 1717. When he came to the throne on Oct. 30, 1757, he had spent 40 years "in the cage," where he had studied astrology and medicine. He was superstitious and fatalistic but admitted that European assistance was necessary for the modernization of Turkey. With the help and guidance of Frederick the Great of Prussia, of his grand vizier Raghib Pasha and of a French baron, François de Tott, he restored order in Turkey's finances, reformed the artillery corps, reopened the engineering school closed by the janizaries in 1747 and established another school for navigation, on the European model. He contemplated the construction of a Suez canal. In his foreign policy, Mustafa favoured peace but fearing Catherine II's ambition, he declared war on Russia (1768). After some unimportant successes he took the title of Ghazi ("Victorious"). In 1770, realizing the inadequacy of his own resources, he made an alliance with Austria, but was unable to hold the Russian advance into Bessarabia, Moldavia and the Crimea. Mustafa died at Istanbul on Jan. 21, 1774, leaving to Abdul-Hamid I the task of finishing the war. *See* also TURKEY: *History*. (E. Z. K.)

**MUSTAFA IV** (1779–1808), Ottoman sultan of Turkey from 1807 to 1808, son of Abdul-Hamid I, was born at Istanbul on Sept. 8, 1779, and was brought to the throne in May 1807, after Selim III had been dethroned. Mustafa was a weak, fanatical man. He permitted his reactionary ministers to abolish all recently introduced reforms and to kill the reformers. When Bayraktar, the pasha of Ruschuk who supported the reforms, came to Istanbul to reinstate Selim III, Mustafa killed Selim and attempted, unsuccessfully, to kill his younger brother Mahmud, the only direct heir to the throne. Mustafa was, however, deposed by Bayraktar on July 28, 1808, and strangled at Istanbul on the following Nov. 17. *See* also TURKEY: *History*. (E. Z. K.)

**MUSTAFA KAMIL** (MUSTAFA KAMIL PASHA) (1874–1908), Egyptian nationalist leader, was born in Cairo on Aug. 14, 1874. He studied at the Cairo law school and afterward at Toulouse, where he graduated in law in 1894. His French education and associations exerted a strong influence upon his political thought. He formed a lifelong friendship with the French journalist Juliette Adam. Returning to Egypt he founded the National party which strove for Egyptian independence and for the return of the Sudan to exclusive Egyptian control. In 1900 he founded the journal *al-Liwa* followed in 1907 by English and French editions. In 1902 he brought out the quarterly *Majallat al-Liwa*. Encouraged by the khedive Abbas II he at first supported the pan-Islamic movement, subscribed to the construction of the Hejaz railway (opened in 1908) and championed the suzerainty over Egypt of Sultan Abdul-Hamid II, who made him a pasha in 1904.

The Anglo-French agreement of April 1904, by which France recognized the primacy of Britain in Egypt in return for Britain's giving France a free hand in Morocco, deprived the Egyptian nationalists of further French support in their struggle against the British occupation and convinced them that they must thenceforward rely on their own efforts. The redoubled intensity and

new direction of Mustafa Kamil's campaign estranged the khedive from the nationalist movement. Mustafa Kamil consistently opposed Lord Cromer, the British representative in Egypt, and, on Cromer's retirement in 1907, vehemently attacked his more liberal successor, Sir John Eldon Gorst. Already mortally ill, he made his last speech at the national congress on Dec. 7, 1907. He died in Cairo on Feb. 10, 1908. In addition to his numerous writings in Arabic, his works in English and French include *Le Péril anglais* (1899); *Égyptiens et Anglais* (1906); *What the National Party Wants* (1907); *Lettres égyptiennes-françaises* (correspondence with Juliette Adam, 1909). *See* also EGYPT: *History*.

BIBLIOGRAPHY.—Mustafa Kamil's brother, 'Ali Fahmi Kamil, published his life and speeches to Feb. 1900 in 9 vol. (1908–10), in Arabic. *See* also J. Adam, *L'Angleterre en Égypte* (1922); 'Abd al-Rahman al-Rafi'i, *Mustafa Kamil* (1950), in Arabic; F. Steppat, *Nationalismus und Islam bei Mustafa Kamil* (1956). (R. L. HE.)

**MUSTAFA KEMAL ATATÜRK:** *see* KEMAL ATATÜRK, MUSTAFA.

**MUSTANG,** the wild horse of the prairies of North America, the descendant of the horses imported by the Spaniards after the conquest in the 16th century (*see* also HORSE).

**MUSTARD** is a name applied to several cruciferous herbs of the genus *Brassica* (formerly *Sinapis*), whose pulverized seeds are used to make the condiment mustard and whose leaves are sometimes used as greens or pot herbs. By extension the name is also given to the family Cruciferae (*q.v.*). Both white mustard (*Brassica hirta*, formerly *Sinapis alba*) and black mustard (*B. nigra*) originated in the Mediterranean region or middle east, have been cultivated for 2,000 years or more and have spread almost throughout the temperate regions of the world. Mustard plants were mentioned frequently in biblical, Greek and Roman writings. Mustard seed was used medicinally by Hippocrates and probably earlier. Indian mustard (*B. juncea*) possibly originated in Africa, but if so, it reached Asia at an early date, where it is extensively cultivated. Wild mustard plants were biennial, but selection has developed annual strains, the only types cultivated.

Mustard is raised for the leaves, to be used as greens, and for the seeds, which yield oils and are used as a condiment. To produce greens the plants are grown during the spring or fall, for only basal leaves from fast-growing plants are suitable as pot herbs. Seeds are sown at two- to five-inch intervals in rows two feet apart, or broadcast. Seed-producing plants are grown in summer when flowering occurs early and few leaves appear. Both types of culture are practised in Asia, Europe and North America, and California, Montana and Kentucky lead in production in the United States. Black mustard is a weed in parts of Britain, in California and in some other areas. The plants may attain heights of 10 to 16 ft. Other species of *Brassica* are less aggressive weeds than the black mustard and are troublesome locally only. Mustard is used occasionally as a cover crop, for stock feed, as a green manure in orchards or prior to planting crops that grow best in mid-summer.

Mustard seeds contain a fixed oil that is present in amounts of 30% to 35% and is extracted by the cold press method. This oil is edible, but is used mainly as an illuminant, for making soap and rubber substitutes, in the manufacture of leather and woolen goods, for quenching steel plates and for other technical purposes. A second, very different oil, is obtained by grinding the seeds and treating the flour with water to cause a chemical action between an enzyme and a glucoside, producing an oil not present, as such, in the tissues of the plant. In black mustard the enzyme myrosin acts on a glucoside, sinigrin, to produce a volatile, very irritating oil, which was the mustard gas of World War I. In white mustard the same enzyme acts on a different glucoside, sinalbin, to produce a nonvolatile oil that is a powerful rubefacient, but less irritating than the oil from black mustard. In medicine, mustard plasters (*Emplastrum sinapis* in the *Pharmacopoeia of the U.S.A.*), which contain pulverized mustard seeds mixed with one to four parts of flour to control the irritating qualities, have long been used for their counterirritant properties.

Many species of Cruciferae have similar systems of enzymes and glucosides in the seeds, and to a lesser degree, in the leaves. The enzyme is destroyed by boiling, so greens made from *B. juncea* are boiled twice, the first water being discarded to reduce the "bite."

Table mustard made from the seeds of black mustard is preferred on the continent of Europe, while that made from white mustard is preferred in England. In the United States the condiment is usually made with a mixture of these two seeds, with a small quantity of *B. juncea* seed blended with the others in some grades. The sharpness of the condiment may be toned down by adding starch or flour, vinegar or wine, and certain other spices. Mustard, either dry or moist, soon loses its potency owing to oxidation unless it is hermetically sealed. When eaten it stimulates salivary secretions and peristaltic action in the stomach.

*See* A. F. Hill, *Economic Botany*, 2nd ed. (1952). (I. L. W.; X.)

**MUSTARD OILS,** a general term applied to the esters of isothiocyanic acid. The name arises from the fact that allyl isothiocyanate (also known as volatile oil of mustard) occurs in, and forms the principal component of, the oil obtained by distilling black mustard seeds (*Brassica nigra*). These seeds contain a glucoside called sinigrin that undergoes a fermentative change due to an enzyme, myrosin, also present in the seeds. Allyl isothiocyanate, $C_3H_5.N:C:S$, is a colourless liquid sparingly soluble in water and boiling at 152° C.; it has a sharp pungent odour and produces blisters on the skin, whence the efficacy of the mustard plaster as a counterirritant. It can be prepared synthetically by heating allyl bromide, allyl chloride or allyl iodide with potassium thiocyanate. The odour and taste of mustard (*q.v.*) are due to this substance.

The analogues of allyl isothiocyanate are readily prepared by reacting carbon disulfide with primary and secondary amines to produce alkyl dithiocarbamates, which on distillation with mercuric chloride yield the corresponding mustard oils. These compounds are colourless liquids with pungent irritating odours.

**MUTANABBI, AL-** (ABU AL-TAYYIB AHMAD IBN HUSAYN) (915–965), regarded by many Arab critics as the greatest Arab poet of Islamic times, was born at Kufa of poor and obscure parentage. He gave early signs of poetic talent and became a professional poet. This meant that he had to attach himself to a succession of rich patrons willing to support him in return for poems extolling their merits. His debut was made among the *bourgeoisie* and minor officials of Syria and Palestine. His career was interrupted by a curious incident of which little is known in detail: in 932 he joined a heretical revolutionary movement staged by a section of the nomad tribes of the Syrian desert and is alleged to have declared himself as the "prophet" of the movement. It was from this that he gained the cognomen of al-Mutanabbi, "the claimant to prophethood." The revolt failed, and he spent two years in prison, thereafter resuming his profession. The peak of his career was reached when, in 948, he attached himself to the brilliant and versatile Hamdanid prince of northern Syria, Sayf-al-Dawlah. For the first time, al-Mutanabbi had a patron whom he could admire. But the association lasted only nine years, and the latter part of it was clouded with intrigues and jealousies, which culminated in al-Mutanabbi's leaving Syria for Egypt, then under the rule of a rival princely family, the Ikhshidids. The ruler, however, was a puppet and actual power rested in the hands of the Negro eunuch Kafur, to whom al-Mutanabbi attached himself. Such patronage was wounding to his pride, and he soon transferred himself to the protection of Abu Shuja' Fatik, another prominent member of the Ikhshidid court. The latter died in 961, and the poet's position was then one of extreme danger; he had bitterly offended Kafur, both by deserting his patronage and by writing scurrilous satirical poems against him, and was forced to flee secretly. He returned to Iraq and after four years of wandering in an unsuccessful search for another patron was killed by bandits during a journey.

Ancient Arabic poetry had been characterized both by a rich and varied vocabulary and by a freshness and spontaneity resulting from an intimate acquaintance with the Bedouin environment with which the poems dealt. In the urban civilization which grew up in the 8th century, poets who clung to the ancient models were forced either to replace this freshness by literary artifice or to retain spontaneity by writing on intimate and personal themes in a

simple, everyday language. Abu Tammam and al-Buhturi (*qq.v.*), belonged to the former school and al-Mutanabbi followed them. Hence his poetry is ornately rhetorical; yet he handles this "Augustan" style with consummate skill and artistry, and greatly influenced Arabic poetry until the 19th century. His collected poems (edited by 'Abd-al-Wahhab with introduction and notes, 1944) are mainly panegyric, but contain some occasional odes (*e.g.*, laments and satires) of high quality.

*See* R. Blachère, *Un poète arabe du IV^e siècle de l'Hégire, Abou-Tayyib al-Motannabi* (1935). (A. F. L. B.)

**MUTATION** is a process by which the hereditary constitution of a cell is altered; ultimately it results in a genetically changed organism or population of cells. Thus, a heritable change to albinism may appear in an individual of an inbred colony of black rats, or a heritable change to a new seed colour in a true-breeding variety of beans. In bacteria, mutation may result in the emergence of strains that are resistant to antibiotics by which the original strain was killed.

BY COURTESY OF THE BROOKHAVEN NATIONAL LABORATORY

DARK-COLOURED FLOWERS OF A VARIEGATED TOBACCO HYBRID (NICOTIANA) SHOWING DIFFERENT SIZES OF WHITE MUTANT SECTORS

The term "mutation" was coined by Hugo de Vries, one of the rediscoverers of Mendel's work. He applied this term to the sudden appearance of striking changes in the evening primrose (*Oenothera lamarckiana*). The term has been retained, although it is now known that the changes observed by De Vries were not mutations in the present sense but were caused by chromosomal processes peculiar to *Oenothera*. More important is the fact that mutations in the modern conception, far from always having striking effects, are responsible for all the slight changes that play a major role in evolution. (*See* EVOLUTION, ORGANIC; GENETICS; HEREDITY; VARIATION.)

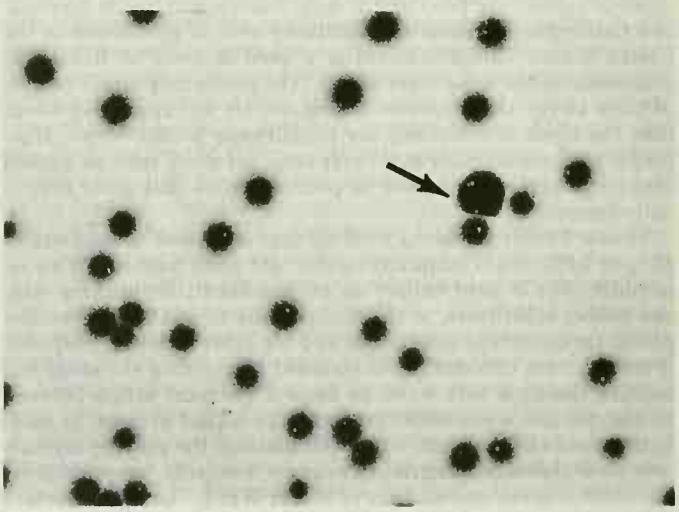
**The Nature of Mutation.**—Heritable differences between extranuclear cell constituents, such as plastids or mitochondria, may have arisen through mutational processes; but little is known about this, and the present article deals only with mutations that occur within the cell nucleus. These take place in the genes, which, according to the present view, consist of deoxyribonucleic acid (DNA) or rarely of ribonucleic acid (RNA). In the chromosomes of all but the most primitive organisms DNA is combined with protein. DNA is a long molecule with a backbone of two sugar phosphate chains to which are attached sequences formed of two purine bases (adenine and guanine) and two pyrimidine bases (thymine and cytosine). The base sequences in the two chains of DNA are complementary to each other, adenine always being paired with thymine and guanine with cytosine. These base pairs are the smallest elements of the genetical code, and their sequence spells the information for the inherited biochemical functions of a cell as well as for the formation of identical genes at each chromosome replication. Mutations arise from substitutions of one base for another or from changes in the sequence of bases. They may also be due to structural changes affecting the chromosomes; *e.g.*, to loss of a small chromosome piece or to an exchange of pieces between chromosomes. There is no recovery from mutation except for the very rare chance of a reverse mutation to the original gene or chromosome structure. Mutated genes, like their normal predecessors, form replicas of themselves before every nuclear division. (*See* GENE; NUCLEIC ACIDS.)

In haploid cells, which contain only one set of chromosomes, mutation immediately yields a mutant type. Thus one mutated yeast cell can grow into a mutant culture that, for example, can ferment a sugar that the original strain could not ferment. In cells with several haploid nuclei (many microorganisms) or in diploid cells that contain two chromosome sets (most higher organisms), recessive mutations, *i.e.*, mutations to genes whose effects are suppressed by nonmutated partner genes, remain hidden until one of the various mechanisms of hereditary transmission has produced a cell with only mutated partner genes.

In higher organisms one distinguishes between germinal mutation in reproductive cells and somatic mutation in other cells. Somatic mutations give rise to mutant sectors and form the basis of most bud sports, such as a branch with white currants on a red currant bush. Germinal mutations have no effect on the individual in which they occur but may become manifest in subsequent generations. The gametes (mature germ cells) are haploid, but diploidy is restored at fertilization by fusion of two gametes. A dominant mutation in either gamete gives rise to mutant offspring; a recessive mutation does so only when the other gamete happens to contain the same mutated gene. For rare mutations this is unlikely and a recessive mutation may remain hidden for many generations. A special case is formed by sex-linked mutations. These, even if recessive, are always capable of expression in the sex with only one X chromosome—the male in mammals and man. Thus, a sex-linked mutation to, say, hemophilia expresses itself in the first male who receives the mutated gene through a gamete.

**Spontaneous Mutations.**—In nature, mutations occur spontaneously and unpredictably in single cells out of large populations (1 in 100,000 to 1 in 10,000,000) of, for example, bacteria or spermatozoa. Such a frequency seems to indicate that spontaneous mutations are exceedingly rare events in a slow-breeding species such as man. This is true only when individual genes are considered. A set of human chromosomes contains at least 10,000 genes, and if each of these mutates at a rate of 1 in 100,000, 1 out of every 10 spermatozoa or ova will carry a newly mutated gene. Since a child may receive a mutated gene from either parent, approximately every fifth child will be born with a newly mutated gene. (This is only a rough estimate, but it is not likely to be too high.) This does not mean that every fifth child will show some visible abnormality; the majority of mutations either are recessive or have very slight effects that are likely to be taken for normal variations in development.

The origin of spontaneous mutations is imperfectly understood. Only a fraction of them are caused by cosmic or natural mineral radiation; the remainder are probably due to chemical processes in the nucleus or to temperature oscillations very close to a gene.

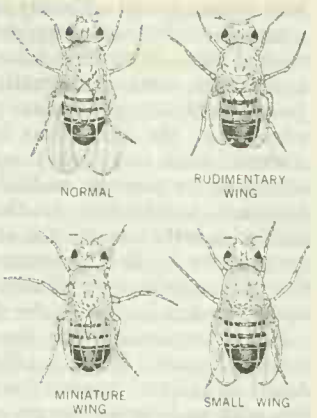


BY COURTESY OF SEYMOUR BENZER

A SPONTANEOUS MUTATIONAL EVENT IN A BACTERIAL VIRUS, OR BACTERIOPHAGE. THE WHITE BACKGROUND IS A COVERING OF BACTERIAL CELLS (ESCHERICHIA COLI) ON A SURFACE OF NUTRIENT AGAR. THE DARK FUZZY-EDGED PLAQUES ARE AREAS CLEARED OF BACTERIA BY THE LYTIC ACTION OF THE BACTERIAL VIRUS T4. ONE PLAQUE (CENTRE RIGHT), LARGER AND WITH A SHARP EDGE, IS THE RESULT OF A MUTATION AFFECTING THAT PARTICULAR VIRUS PARTICLE

**Radiation-Induced Mutations.**—The first to produce mutations by artificial means was H. J. Muller (1927), who exposed fruit flies (*Drosophila*) to X-rays and analyzed their progeny by

ingenious methods that allowed quantitative assessment of mutation frequencies. Since then many physical and chemical agents have been shown to be mutagenic (causing mutations). The physical ones include all ionizing radiations, ultraviolet light and, in cells sensitized by certain dyes, visible light. Radioactive phosphorus has been claimed to produce mutations not only through emitted radiation but through incorporation into the chromosomes followed by atomic transmutation.




FROM HANSON AND WINKLEMAN, "JOURNAL OF HEREDITY," 20:262, 1929

MUTATIONS IN DROSOPHILA RESULTING FROM RADIUM IRRADIATION

The frequency of X-ray induced mutations increases linearly with dose. This has been interpreted to mean that every mutation is the result of a single ionization or ion cluster that occurs inside a gene or very close to it. This "target theory" has recently been modified to include indirect radiation effects mediated by water radicals, organic radicals and peroxides. While leaving the theory essentially unaltered, these modifications have helped to explain the influence of physiological and environmental conditions such as cell stage, temperature, humidity and, foremost, oxygen, which is a powerful enhancer of X-ray mutagenesis. Other chemicals, *e.g.*, certain respiratory inhibitors, may enhance X-ray mutagenesis through effects on oxidative metabolism. Alternatively, they may influence short-lived repair processes that intervene between the initial effect of the radiation and the emergence of a mutated gene or a chromosome break. Some chemicals reduce the frequencies of X-ray induced mutations or chromosome breaks.

The production of structural changes can be modified at two stages: that of chromosome breakage and that of reunion of broken ends. Repair processes may be responsible for the fact that in certain cells, *e.g.*, mouse spermatogonia, low-intensity radiation produces fewer mutations than high-intensity radiation. Neither indirect radiation effects nor possible repair mechanisms alter the linear dose-effect curve for X-ray induced mutations and chromosome breaks; this has been shown for doses from several thousand to 8 r (roentgen units of radiation) and most probably holds also for the lowest possible doses. There is thus no threshold to the mutagenic effects of ionizing radiation, a fact vital in estimates of genetical radiation damage.

Ultraviolet light appears to induce mutations by a series of steps that may be interfered with by, *e.g.*, visible light or inhibition of protein synthesis, either of which greatly reduces mutation frequency. In microorganisms mutations have been produced by exposure of the plating medium to ultraviolet radiation; the energy carriers were peroxides of amino acids.

**Mutagenic Chemicals.**—Chemical substances that induce mutation occur in widely divergent chemical groups and range from simple compounds such as formaldehyde to complex ones such as alkaloids. The chemical basis of their action on the genetic material is known for very few. Peroxides form a link with radiation mutagenesis. Nitrous acid deaminates; *i.e.*, removes the amino group ($NH_2$) from purine and pyrimidine bases. Purines such as caffeine (which has produced mutations in bacteria and fungi but not in mice) may act through their influence on nucleic acid metabolism. Analogues of the naturally occurring bases in DNA, *e.g.*, 5-bromouracil or 2-aminopurine, are thought to produce mutations by first being incorporated in place of a normal base; at one of the following replications of DNA this may lead to substitution of one of the two normal purines or pyrimidines by the other; *e.g.*, of adenine by guanine. The alkylating agents (*e.g.*, mustard gas, epoxides, ethylene imines) remove purines from nucleic acid in chemical tests and may do so when producing mutations. Their mutagenic ability is strongly correlated with carcinostatic action (probably through chromosome breakage) and with carcinogenesis (which supports the mutation theory of cancer; *see* CANCER RESEARCH: *The Study of the Causes of Cancer: Mechanisms of Carcinogenesis*). In bacteriophage, acridines are thought to disturb gene replication by inserting themselves between the bases of DNA. Many chemical mutagens tend to produce delayed mutations in the descendants of treated chromosomes. Some select specific chromosome regions, genes or sites within genes for their action.

Chemical mutagens have become a tool for "decoding" the information in DNA. In bacteriophage, analysis of the frequencies with which certain chemicals produce mutations in opposite directions—from normal to mutant gene and back to normal—has been used to allot specific base pairs to certain mutational sites, and results obtained with acridines have been taken to mean that the genetic code consists of triplets of bases, to be read in a fixed direction from a given starting point. In tobacco mosaic virus the chemically predicted changes in the bases of ribonucleic acid (RNA) after treatment with nitrous acid have been correlated with changes in the amino acids of the mutant proteins; this has led to the allotment of base triplets to amino acids. All this, though still largely hypothetical, is fairly self-consistent and agrees with conclusions reached quite differently.

**Significance of Mutation.**—Natural selection has used mutations for building up well-integrated organisms. New mutations are likely to upset this balance and are therefore mostly harmful or lethal. Harmful genes are eliminated from a population by the failure of carriers to reproduce. Over a long period harmful genes do as much damage as fully lethal ones, for while a lethal gene kills the first individual in which it becomes active, a harmful gene may be carried through a series of more or less severely affected individuals before it finally kills one of them. Beneficial mutations are so rare that they can be utilized economically only in species with very high reproductive rates. Thus, better strains of *Penicillium* and other industrial fungi, and of agricultural plants, have been raised from artificially produced mutants. Since this was done at the expense of discarding thousands of inferior mutants, the method is obviously not suitable for farm animals.

Nor can it be expected that an increase in mutation frequency, as a result of exposure to ionizing radiation from X-ray machines, artificial atomic disintegration and radioactive isotopes, can have any but harmful effects on the hereditary constitution of the human race. To what extent chemicals used in industry and included in foods, drugs, cosmetics and other manufactured products are mutagenic cannot be definitely determined on the available evidence. Only the most drastic mutagens, such as ionizing radiation and mustard gas, can be assumed to act on all organisms; for other mutagens, even tentative conclusions on man will have to be drawn from experiments with mammals. *See* GENETICS, HUMAN; RADIATION: BIOLOGICAL EFFECTS; *see* also references under "Mutation" in the Index.

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(C. AU.)

**MU'TAZILITES** (MU'TAZILA), a crucial political and religious group of early Islamic history. Their origin lies in the controversies over leadership of the Muslim community after the murder of the third caliph, Othman, in 656. The best explanation of their name, "those who separate or stand apart," is probably found in their stand respecting Othman and his opponents. They would accord complete blame or approval to neither side but took a middle position, thus separating themselves from both disputing parties. Later, the Mu'tazila were among those working to overthrow the Omayyad rulers of the Arab kingdom in favour of the Abbasids. Since all these disputes over leadership concerned a religious community, they had a strong religious flavour and were conducted in theological terms. Under the caliph al-Ma'mun and his successors Mu'tazila doctrines were for a time the official theology of the empire.

The religious significance of the Mu'tazila lies in their effect upon the development of Muslim theology. The Mu'tazila were

among the first Muslims to use the categories and methods of Greek philosophy in expounding their faith. To refute them, their orthodox opponents adopted the same concepts, and thus the framework of Muslim scholastic theology came into being.

The Mu'tazila are sometimes called the "people of unity and justice." They upheld the unity of God against both Manichaean dualism and the crude anthropomorphism of Muslim traditionists, and affirmed God's justice by denying that he created evil or predestined men's actions. They aroused orthodox indignation with their doctrine that the Koran was created and not coeternal with God. In general their purpose was to expound and defend an adequate concept of God against numerous theological distortions. Though they have been maligned as free thinkers and heretics, their intention was only to guard the strict truth of Islamic faith. Among important Mu'tazila thinkers were Wasil ibn 'Ata,' Al-Nazzam, 'Amr ibn 'Ubayd and Abu-l-Hudhayl. The latter may be considered the founder of the Mu'tazila dogmatic system.

See *Shorter Encyclopaedia of Islam,* pp. 421–427, with bibliography (1953). (C. J. A.)

**MUTILATIONS AND DEFORMATIONS** are permanent or semipermanent modifications of the living human body. Mutilation implies a technique which breaks the skin (or removes hair, nails or part or all of a tooth), whereas deformation refers to changes in shape; techniques of both kinds frequently are combined in intentional modifications. The methods used, either singly or in combination, are: incision; perforation; complete or partial removal; cautery; abrasion; adhesion; insertion of foreign bodies or materials; compression; distention; diversion; enlargement; and staining.

**Reasons for Mutilation and Deformation.**—Motives for such changes are exceedingly varied. Some arise from accidental injuries. Others are the unintended results of such customs or habits as the use of footwear (also customary absence of footwear) that tends to alter foot conformation permanently; types of infant swaddling and cradling that unintentionally permanently modify skull shape; some postures such as the deep squat habitual in most of Asia and Oceania which develops facets where the long bones meet in the knees; and such occupational effects as the bowed legs of the habitual horse rider or the overdeveloped right shoulder muscles and twisted posture (from crutching hides) among old-fashioned European tanners. Intentional modifications are very frequently performed for magical and medical purposes, but cosmetic (aesthetic) motives such as those underlying much modern plastic surgery (*q.v.*) are perhaps the most common; the variability of the results in different cultures is an excellent indication of the relativity of ideals of beauty. Other motives are concerned with religion (sacrifice, ascetic mortification), magical protection, mourning, the indication of status or rank or group membership (*e.g.,* tribal marks, initiation mutilations), bravado and punishment. Intentional mutilations and deformations are widespread; intentional plus unintentional ones, even excluding the results of accidents, probably occur in all human cultures.

**Types of Modification.**—The usual and most useful classification of mutilations and deformations refers to the parts of the body affected. In cross-cultural perspective the most commonly modified are various parts of the head and the genitalia; this is also the case among modern Euramerican peoples. The following discussion includes the best-known types, but is not exhaustive either as to distinctive types or to their geographic and temporal distributions.

*Whole Body.*—Among several African peoples (Efik, Ganda, Nyoro [*qq.v.*] and others) girls were secluded at puberty for several months and fattened with special diets. Women in near eastern harems were also artificially fattened for aesthetic reasons.

*Skin.*—Artificial skin marking is of two basic types: tattooing (*q.v.*) and cicatrization. In the former, colour is introduced under the skin; in the latter, raised scars (keloids) are produced, usually in decorative patterns. Cicatrization is most frequently customary among darker-skinned peoples (where tattooing would not be so obvious); it has been practised in much of Africa, among Australian and Tasmanian aborigines, and in many Melanesian and New Guinea groups. Usually an incision is made and an irritating substance is introduced to delay healing and produce a more marked scar. Sometimes scars have been produced by burning, as in Timor, northern Australia and among the Seminole Indians (*see* BRANDING). Cicatrization also occurs sporadically elsewhere; *e.g.,* the facial scars intentionally produced in German students' duels (*see* DUEL) and light scars from chest and limb scratching for magical, medical and disciplinary purposes among Indians of southeastern North America. Another form of skin mutilation is the introduction of objects under the skin: diamonds smuggled by South African miners; jewelry concealed under the skin of chest or neck by Yünnanese travelers; various magical protective amulets inserted under the skin by some Burmese.

*Hair.*—Depilation of the face and body is especially typical of less-hairy races. Many if not most Mongoloid men (including American Indians) remove their scant beards by frequent depilation with such devices as tweezers or a pair of shells or coins. Modern chemical and other depilation for aesthetic reasons is of course mutilation. In Euramerican and other cultures continual parting of the hair in the same place is a type of deformation insofar as it diverts the growth pattern of the hair of the head.

*Cranium.*—Cephalic deformation is the best-documented form of deformation or mutilation, largely because archaeological skeletal remains clearly show its presence. Tabular deformations are produced by constant pressure of small boards or other flattened surfaces against the infant's head, and annular deformations are produced by a constricting band; each kind is subdivided according to the resulting head shapes, which are often strikingly different from the normal. Cranial deformation is known from all continents except Australia, and from Oceania. It is rather rare in Africa south of the Sahara, and apparently absent from south India, northern North America (except the North Pacific coast), and most of northern Eurasia (except Kamchatka and Scandinavia). The practice survived into the 20th century in France, Indonesia, Melanesia, North Africa and probably elsewhere.

*Nose.*—For the insertion of decorative objects, perforation of the septum, or one or each of the nasal alae (or both procedures combined), is widespread among South American Indians, Melanesians and inhabitants of India and Africa; it is sporadic elsewhere (*e.g.,* Polynesians, North American Indians). The nose was cut off as a punishment for adultery among Indians of central and southern Mexico. In modern plastic surgery the nose is mutilated for aesthetic reasons.

*Lips.*—Perforation of the lower lip (or less often the upper) for insertion of a decorative plug or other ornament is widespread in Africa and among lowland South American Indians, and was formerly common among Indians of the northwest North American coast and the Eskimo. The most striking instance is that of the women of the Sara tribe of central Africa (commonly known as Ubangi after the name erroneously applied in P. T. Barnum's publicity), whose lips are slit and then stretched by saucer-shaped plugs averaging about four inches in diameter in the upper lip and seven inches in the lower, and sometimes reaching nine or ten inches in the lower. Men of the Botocudo tribe of Brazil wear a similar disk about four inches in diameter in the lower lip. Perforations in the cheeks for insertion of ornaments are much rarer.

*Teeth.*—Dental mutilations take the form of removal, usually of one or more incisors (ancient Peru, most Australian aborigines, some groups in Africa, Melanesia and elsewhere); pointing in various patterns by chipping (Africa) or filing (ancient Mexico and Central America); filing of the surface, sometimes into relief designs (Indonesia); incrustation with precious stones or metal (southeast Asia, India, ancient Mexico and Ecuador); insertion of a peg between the teeth (India); and blackening (south India, hill peoples in Burma, some Malaysian groups). Modern Euramerican dentistry in filling, capping, replacing and straightening teeth provides other examples.

*Tongue.*—Ancient Aztec and Maya Indians drew a cord of thorns through the tongue as a form of sacrifice; some Australian tribes draw blood from gashes under the tongue at initiation rites; removal of the tongue as punishment is known from historic cultures (Europe, Africa).

*Eyes.*—The ancient Maya Indians considered cross-eye beautiful and induced the condition by hanging an object between a baby's eyes. In Japan in the 1950s a fad for a Caucasoid appearance led some women to undergo a simple operation to remove the internal epicanthic fold. Blinding as punishment is known from historic cultures.

*Ears.*—Perforation of the earlobe for insertion of an ornament is exceedingly widespread. Sometimes the hole is gradually stretched to carry a larger ornament or to yield a greatly distended pendant margin (Malaysia, Melanesia, Tonga, Easter Island, Palau, India and among many American Indian and African tribes). More rarely ornaments are inserted in holes along the auricular margin (eastern North American Indians and some African and tropical South American groups). Ears were mutilated or removed as punishment for adultery by the Mixtec (Mexico) and many North American tribes.

*Neck.*—The Padaung women of Burma are famous for necks stretched by a coiled brass neck ring to a length of about 15 inches, with about four thoracic vertebrae pulled up into the neck.

*Trunk.*—Well into the 19th century European women's tight corsets caused permanent and often deleterious deformations of the rib cage and internal organs.

*Breasts.*—The shape of the breasts has sometimes been customarily altered for aesthetic reasons by compression (*e.g.*, Caucasus, 16th–17th century Spain) or distention (*e.g.*, Payagua of Paraguay). Mutilations are also known: removal of the right breast by the Amazons of classical legend, removal of both nipples or both breasts for religious reasons by the Skoptsi (a Russian Christian sect), amputation of the breasts as punishment under Hammurabi's Code.

*Genitalia.*—The best-known and most widespread genital mutilation is circumcision (*q.v.*). Subincision (opening the urethra along the inferior surface of the penis, for a varying distance between the urinary meatus and the scrotum) is a common practice at puberty initiations among Australian aborigines, and is recorded as a therapeutic measure among Fijians, Tongans and Amazonian Indians. Customary unilateral castration (monorchy) is known for central Algeria, among the Beja (Egypt), Sidama (Ethiopia), Bushmen and Hottentot (south Africa), some Australian aborigines and on Ponape Island (Micronesia). Bilateral castration was common to produce eunuchs for Muslim harem attendants; for several centuries (until prohibited by Pope Leo XIII) to produce male sopranos or contraltos for ecclesiastical chants in the Roman Church (*see* CASTRATO); for religious reasons among Russian Skoptsi; and as practised on slaves, royal servants or priests in several ancient Mediterranean lands and Mesopotamia, in Byzantium and in China. Bilateral castration is mentioned as punishment for adultery among the Azande (central Africa), Babylonians, ancient Egyptians, ancient Chinese and elsewhere. Among the Toradja and Sadang (Celebes) and some Dayak groups (Borneo) many or most adult men wore a penis pin, knobbed on each end and averaging about an inch and a half long, in a permanent perforation through the glans, to increase pleasure in their sexual partners. The Alfur (Celebes) inserted pebbles under the skin of the glans for the same purpose. Female mutilations include excision (of part or all of the clitoris—clitoridectomy, female circumcision—and sometimes also of the labia, mons, or both) in much of Africa, ancient Egypt, India, Malaysia and Australia, and among the Russian Skoptsi; incision (of the external genitalia, without removal of any part) among the Totonac (Mexico) and tropical South American Indians; infibulation (induced adhesion of the labia minora, leaving only a small orifice, to prevent sexual intercourse until the orifice is reopened by incision) in east Africa and among some Arabs; dilatation (of the vaginal orifice, often with incision) among some Australian aborigines; elongation of the labia (*tablier*), recorded for south Africa (and doubtfully elsewhere in Africa) and the Caroline Islands (on Truk combined with suspension of rattling objects from perforations in the distended labia minora); and artificial defloration (among Australian aborigines and elsewhere).

*Limbs.*—Constriction of the arms or legs by tight bands may cause permanent enlargement of the unconstricted area. The custom occurs among several east African and tropical South American peoples, and also sporadically in Nigeria, southeast Asia and Melanesia.

*Feet.*—From the T'ang dynasty until 1911 many Chinese women had their feet tightly bound in early childhood, forming the famous "golden lily" feet, much reduced in size and deformed to match the aesthetic ideal. A similar but much less severe deformation is mentioned for the Kutchin Indians (Alaska).

*Digits.*—Amputation of a phalanx or whole finger, usually as a form of sacrifice or in demonstration of mourning, was common among North American Indians, Australian aborigines, Bushmen and Hottentots, Nicobarese, Tongans, Fijians, and some groups in New Guinea, South America and elsewhere. Outlines of hands missing digits or parts of digits found among European Paleolithic cave paintings may indicate the presence of a similar custom at that period. Amputation of the toes is less common, but occurred in Fijian mourning.

*See* also SCALPING; FLAGELLATION; EUNUCH.

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**MUTINY,** a state of affairs involving the defiance of or attack upon recognized authority by subordinates, but not involving an attack on the political power of the state. More specifically, the word "mutiny" refers to any overt act of defiance or attack upon military (including naval) authority by two or more persons subject to such authority. Occasionally, the word is used to describe other and nonmilitary instances of defiance of or attack upon authority. One example of this latter meaning is the case of mutiny on board ocean-going merchant ships; another is that of slaves rising against their masters in a state where slave owning is recognized by law and custom. It will be observed that the words "revolt" and "rebellion," which also involve defiance of or attack upon recognized authority, have a much more general and civilian connotation; furthermore, their objects are generally political. The aim of a rebellion is to subvert the government but the aim of a mutiny is generally more circumscribed.

The long history of the British armed forces provides a good example of differing and developing attitudes toward the problem of mutiny. In both the army and the navy mutiny was regarded, with the possible exception of treason, as the most serious military offense. However, the two services developed different attitudes toward it, attitudes that are clearly traceable through the different punishments inflicted on mutineers in the two services. In naval vessels the safety of the ship depends on the submission and obedience of all persons on board to the will of one man, the captain. Therefore, until very recently, it was in the power of the officer in command of a ship at sea, and especially a ship of the Royal Navy, to award the death penalty for mutiny without waiting for return to port and trial by court-martial. The Naval Discipline acts of 1864 and 1866 (27 and 28 Vict., cap. 119 and 29 and 30 Vict., cap. 109) reduced the power of a commanding officer to award serious punishments but left him the power to inflict the death penalty for this particular offense. This peculiar requirement regarding discipline aboard ships has always been widely recognized. In the 20th century, however, the rise of searching air power and of modern swift communications has made it almost impossible for a ship to be lost from contact for long periods, and this change has led to punishment for mutiny becoming the concern of the court-martial.

The treatment of mutiny in the army has been subject to quite different forces. The first Mutiny act was passed in 1689 (1 Will. and Mary, cap. 5) for the express purpose of preventing the defection of Englishmen to the service of ex-King James II. This Mutiny act made provision for the operation of Articles of War so that the two were, up to 1878, inextricably connected. Because of the fear of military domination of the state induced by Cromwell's rule and the standing armies of the later Stuarts, the Mutiny act was henceforth passed by parliament, whenever it became necessary, for yearly periods only. Originally, the act applied only

to forces stationed in the United Kingdom. Army offenses of a capital nature that were committed abroad had to be tried at home. After 1712 the act was extended to the army in Ireland and after 1718 further expanded to take in newly acquired territories overseas. It was not until 1803 that it was made applicable to British troops in foreign countries. The Mutiny act is a good example of legislation passed for a specific purpose and retained and expanded in imperfect form to include new cases as they arose. In 1878 a general revision took place that effectively amalgamated the Mutiny act and the Articles of War (Act for Punishing Mutiny and Desertion, 41 Vict., cap. 10).

Today in England mutiny is dealt with under the Queen's Regulations for the various services. The legislation is designed so that inter-service co-operation for the punishment of mutiny is possible. The death penalty is carefully reserved for a court-martial and hedged about with safeguards for the individual.

In the United States, until recent times, mutiny was defined and punishments for it were prescribed in the Articles of War (for the army and, from 1947, the air force), the Articles for the Government of the Navy (for the navy and marine corps) and the disciplinary laws of the coast guard. As the result of an act of congress dated May 5, 1950, these three authorities were superseded by the Uniform Code of Military Justice (UCMJ). This code was applicable to all branches of the armed forces and went into effect on May 31, 1951, following promulgation of the *Manual for Courts-Martial, United States, 1951.* Article 94 of the UCMJ contains the following provision:

> Any person subject to tbis code . . . who with intent to usurp or override lawful military authority refuses, in concert with any other person or persons, to obey orders or otherwise do his duty or creates any violence or disturbance is guilty of mutiny; . . . .

Article 94 also includes, as an offense, the failure to prevent, suppress or report a mutiny or sedition. The court-martial is free to award the death penalty on these enumerated offenses, although such penalty is not mandatory. Clearly, a much more positive response than is customary from civilians is expected from military and naval personnel who are faced with, caught up in, or aware of a mutinous situation, and the penalties imposed upon them are more severe.

Slave revolts, such as that aboard the American brig "Creole" in 1841, have taken place at sea, but the most notorious slave revolt in history was that led by the gladiator slave Spartacus (*q.v.*) in the Roman empire between 73 and 71 B.C. A good example of a nonmilitary revolt at sea was that of the crew of the "Discovery" against Henry Hudson (*q.v.*) in Hudson's bay in June 1611. Another explorer, La Salle, met death at the hands of his mutinous men in 1687.

**Naval Mutinies.**—Of naval mutinies the best known is clearly that which took place on board H.M.S. "Bounty" against its captain, Lieutenant William Bligh (*q.v.*), on April 28, 1789. An interesting feature of this mutiny is the contrast between the reported splenetic nature of the captain and his high qualities of leadership and command. These qualities allowed the 19 men set adrift by the mutineers to survive a sea voyage of almost 4,000 miles in a small open boat without the loss of a man. Another naval mutiny of note was that alleged to have taken place aboard the U.S.S. "Somers" while bound from Liberia for the United States between Nov. 26 and Dec. 2, 1842. Commander Alexander Slidell Mackenzie suspected his acting midshipman Philip Spencer of intended mutiny. Spencer, the son of the secretary of war, and two seamen were hanged after a summary trial at sea. But the evidence of their guilt was not conclusive and Mackenzie was himself later court-martialed. He was acquitted, however, although the verdict has often been questioned. More important naval mutinies took place at Spithead and the Nore in ships of the Royal Navy in April and May of 1797. The most noteworthy features of these mutinies was the orderly way in which the demands of the men were forced on their officers, the lack of extensive bloodshed and the declared willingness of the mutinous crews to proceed against the French should the need arise. The Spithead mutiny was settled largely through the wise counsel and the personality of Admiral Lord Howe who calmed the men in person.

**Army Mutinies.**—On Jan. 1, 1781, during the American Revolution, men of the Pennsylvania line in Washington's continental army mutinied. Bad conditions, war weariness, meagre rations and the imprecise nature of the terms of their enlistment contract were all contributing factors. The mutineers, having killed one officer and wounded others, marched to Princeton, N.J. Washington was not certain that his army could be trusted to deal with the mutiny in forthright military fashion; direct negotiations were therefore conducted between the civil authorities and the mutineers. The latter resisted British inducements to defect. The terms granted included a general amnesty, and, for large numbers of the Pennsylvanians, the right to be demobilized. On Jan. 20 some New Jersey troops also mutinied. Washington, who believed that the lenient civil agreement reached with the Pennsylvanians would occasion more disciplinary trouble, was ready to act vigorously. By Jan. 27 the mutineers were surrounded at Pompton, N.J.; they were forced to parade without arms, acknowledge their officers and pledge future good conduct. Twelve of the mutineers were selected as a firing squad to shoot two of the leaders of the mutiny. These January mutinies occurred at a most difficult period during the war and provided a good example of Washington's ability to combine common sense and firmness, under conditions of extreme pressure.

One of the most notorious, bloody and widespread of army mutinies was that which took place in India when the Indian troops serving under British officers in the army of the East India company mutinied. The first large-scale revolt took place at Meerut on May 10, 1857. It spread swiftly over central India, lasting over a year, and both Indians and Britons were guilty of unbridled savagery and atrocity as they fought one another. Many modern Indian historians refer to the mutiny as the First War of Independence, and since the antagonists were national representatives and more than the military were included, this appears to be a valid description. It is, however, not easy to prove that the revolt was planned in advance or that it had been widely concerted. Certainly it originated in an assault on military authority (*see* INDIAN MUTINY).

Probably the next most dangerous mutiny occurred in the French army on the western front in 1917. In May, June and July French army units, exhausted from the April offensives of General Nivelle, mutinied. The extent of the mutiny varied from unit to unit, but the punishments, as the local military authorities tightened their grip, were both severe and capricious. The mutiny was the direct result of the pressures of war itself; its suppression was mainly due to the good sense of the *poilus* (French soldiers) and the sanity of their general, Pétain, who realized that "ruthlessness was not the only answer."

Neither the reasons for nor the measures taken to suppress mutiny have ever been uniform. While it is true that mutineers are often men under a system of discipline pressed too far, it is also true that brutal treatment alone is seldom the sole cause of a mutiny. This was certainly the case in the British naval mutinies in 1797 when the men were much more concerned with food, pay and leave than they were with reforming the inhuman punishment code. Similarly, the Indian mutiny had historical, racial and religious rather than disciplinary causes. It is perhaps fair to say that military men tended to see the cause of mutiny in slackness of discipline and its cure in more stringent discipline. This was certainly the case in France in 1917, when officers generally failed to understand the real causes of the mutiny and wished to shoot on a grand scale to restore order. The situation was saved only by Pétain's wise restraint.

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**MUTIS, JOSE CELESTINO** (1732–1808), Spanish naturalist noted for his studies of the plants of Colombia and for his part in the early history of quinine, was born at Cadiz on April 6, 1732. He took his degree at Seville university and afterward studied medicine at Madrid, where for a time he lectured in anatomy. His preference, however, was for the study of mathematics and natural science, especially botany. He became one of the first Spanish disciples of Linnaeus. Attracted by the wide and fruitful fields of study which South America then afforded, Mutis sailed in 1760 for New Granada (Colombia).

There he occupied himself collecting and describing plants from the lowlands and from the higher Andean regions, but that he did not neglect medicine is shown by his appointment as king's physician in the viceroyship. He spent much time on sanitary problems, including the establishment of proper cemeteries, the prevention of smallpox and the reduction of malaria. He put into general use many South American herbs, the properties of which he had studied, among them ipecacuanha (ipecac), guaco and Peruvian balsam. Some of these, such as the cinnamon laurel of the Andes, he made known in Europe.

Mutis' favourite study, however, was quinine, which he investigated from every angle, from the distribution of the different species of cinchona down to experiments in the curative properties of the drug. Having been presented with some samples of bark and a drawing of the tree, he sent them to Linnaeus (1764). His *El Arcano de la quina* was published in 1793. Later studies were published in the *Papel periodico* and, after his death, by his nephew Sinforoso Mutis, who completed and arranged his notes on the subject (1828).

His work probably had much to do with making possible the colonization of malaria-infested regions. It attracted the attention of the king, who created the Royal Botanical expedition of New Granada and placed Mutis at its head. With 18 of his best students, Mutis carried out a systematic survey in which material was collected for the monumental *Flora de Bogotá ó de Nueva Granada*, which he planned in 13 folio volumes.

Only the first volumes of this intended work were arranged at his death. For the remainder he left manuscripts, notes, illustrations and sketches in such profusion that only someone knowing his schemes of arrangement could have finished the work. Among these botanical riches were 6,480 illustrations, admirable in precision and colour, which were intended for an atlas volume. This material, amounting to more than 4,000 folios of loose manuscripts, and his collection of more than 20,000 plants were sent after his death to the botanical garden at Madrid, where they are preserved.

For 18 years Mutis carried on a correspondence with Linnaeus, much of which was published in *A Selection of the Correspondence of Linnaeus* (1821). He furnished many specimens of plants which the Swedish naturalist described, including additional material from which Linnaeus' son perfected the generic description of cinchona. Linnaeus the younger named in Mutis' honour the beautiful genus *Mutisia*, of the family Compositae, comprising about 50 species of plants found in South America. Mutis died at Bogotá on Sept. 11, 1808.

**MUTISM:** *see* DEAF AND HARD OF HEARING, TRAINING AND WELFARE OF: *The 20th Century;* DEAFNESS AND IMPAIRED HEARING: *Deaf-Mutism.*

**MUTTON:** *see* LAMB AND MUTTON.

**MUTTONBIRD:** *see* SHEARWATER.

**MUTTRA:** *see* MATHURA.

**MUTUAL ECONOMIC ASSISTANCE, COUNCIL FOR,** an organization established in Jan. 1949 in Moscow, U.S.S.R., to centralize arrangements for trade, credit and technical assistance among its members, who were originally the Soviet Union, Bulgaria, Czechoslovakia, Hungary, Poland and Rumania. In Feb. 1949 Albania joined the Council for Mutual Economic Assistance (C.E.M.A., or Comecon) but ceased taking an active part in the organization at the end of 1961, following its ideological dispute with the Soviet Union. The German Democratic Republic became a member of Comecon in Sept. 1950 and the Mongolian People's Republic in June 1962. Communist China, North Korea and North Vietnam participate in Comecon as observers with associate membership. On Sept. 4, 1963, a Yugoslav official announced that Yugoslavia would shortly be granted observer status in Comecon.

The total value of exports of states with full membership in Comecon was $14,300,000,000 in 1961, or somewhat less than half the value of exports of the European Economic Community. Of these total exports, approximately one third represented exports of member states to nonmembers, another third represented exports of east European members to the Soviet Union and the remaining third consisted of exports of east European members to each other. The volume of credits granted by the Soviet Union to other members was estimated at $2,300,000,000 for the period 1956–61.

The plenary sessions of Comecon, which take place once or twice a year and are normally attended by the vice-premiers of member governments, formulate the general policy of the council and direct the work of its organs: the executive committee, the standing commissions and the secretariat. The executive committee, created in July 1962, normally meets at least once every two months and is vested with plenipotentiary powers between plenary sessions. The standing commissions, most of which were set up in 1956, number 19. They co-ordinate the economic and scientific activity of members in such spheres as finance, statistics, coal, peaceful uses of atomic energy, etc. The secretariat, located in Moscow, prepares materials for the plenary sessions and for the executive committee, conducts economic research, and circulates economic and statistical information for the benefit of member states. In the early 1960s it was headed by a Soviet secretary assisted by three deputies from eastern Europe.

From 1949 to the death of Stalin in 1953 the activities of Comecon were restricted chiefly to the registration of bilateral trade and credit agreements among member countries. This period was marked by a significant degree of autarky in the industrial development of the people's democracies. In 1954–55 Comecon co-ordinated the first systematic efforts to promote industrial specialization and reduce "parallelism" in the economies of member states. In 1956 and 1957, when most of the standing commissions began to operate, attempts were made to harmonize the long-term plans of participants, particularly for the output of mined products, whose expansion requires heavy investment outlays and a considerable lead time. In June 1962, at the behest of the Polish delegation, which had long been urging tighter co-operation within Comecon, a top-level meeting of representatives of Communist and Workers' parties of member countries was held in Moscow at which "basic principles for the international socialist division of labour" were elaborated. The declaration stressed the growth-retarding effects for individual countries and for the Soviet bloc as a whole of autarkic tendencies. It recommended that individual development plans should be co-ordinated at their draft stage when they could still be subjected to fundamental adjustments. Finally, it called for a network of multilateral payments, which would gradually replace the prevailing system of balanced bilateral accounts on planned transactions. (A 1957 agreement had provided for multilateral clearing of unanticipated surpluses and deficits arising from transactions not included in bilateral trade plans.)

The Bank for Socialist Countries, founded in 1963 under Comecon auspices, began to operate on Jan. 1, 1964. In addition to facilitating multilateral clearings, it is empowered to finance investment projects undertaken in common by two or more members.

The far-reaching economic integration envisaged in the "basic principles" soon met with opposition within the council. The Rumanian government, in particular, made manifest its intent to carry out the all-around industrialization of the Rumanian economy, including the rapid expansion of its metallurgical, chemical and machine-building industries (in opposition to the policy of

specialization in raw materials and agricultural products that is said to have been recommended by the council). On this issue, the Rumanians received ideological support from the Chinese Communists, who also advocated a relatively autarkic policy.

For a discussion of Soviet aid to countries outside the Sino-Soviet bloc, *see* FOREIGN AID PROGRAMS.

*See* Nicolas Spulber, *The Economics of Communist Eastern Europe* (1957); and Frederic L. Pryor, *The Communist Foreign Trade System* (1963). (J. M. Mo.)

**MUTUAL FUND,** an investment company that pools the funds of its numerous shareholders and invests them in securities that it selects. The advantages held out to the small investor are safety, diversification and convenience. The mutual fund is able to hold a diversified portfolio and make its investment choices on the basis of expert professional advice. In contrast to the closed-end investment company, which has a fixed capitalization and whose shares are bought and sold on the market, the mutual or open-end fund makes a continuous offering of new shares at net asset value (plus a sales charge) and stands ready to redeem its shares at net asset value determined daily by the market value of the securities it holds.

*See* INVESTMENTS: INDIVIDUAL.

**MUTUAL SECURITY PROGRAM,** the name by which U.S. foreign aid programs became officially known in 1951. The concept of U.S. economic aid to Europe exemplified by the Marshall plan (European Recovery program) was applied to non-European areas, as well as to Europe, and combined with U.S.-aided technical assistance programs and programs of mutual military defense and defense support in the Mutual Security act of Oct. 10, 1951 and succeeding mutual security acts. A Mutual Security agency (MSA) was established as the successor of the Economic Cooperation administration (ECA), which had administered the Marshall plan. In 1953 MSA was superseded by the Foreign Operations administration (FOA) and in 1955 by the International Cooperation administration (ICA). *See* FOREIGN AID PROGRAMS.

**MUWASHSHAH,** an Arabic poetical genre in strophic form (in contrast to classical Arabic poetry in which a poem has one single rhyme recurring at the end of each line); it is said to have been invented in Spain by a poet from Cabra who lived *c.* 900. The fundamental scheme is seen in the following example, and its translation:

Nasimu'l-rawdi fah (A) fa-qumu nashrabu (B)

A-la qum ya ghulam (c)
Adir ka'sa'l-mudam (c)
Mada sirfu'l-zulam (c)
Wa-kafuru'l-sabah (A) ilayna yujlabu (B)

Silu mazja'l-khumur (d)
Bi-salsali'l-thughur (d)
Fa-ma sirru'l-surur (d)
Siwa ka'sati rah (A) wa-riqin ya'dhubu (B)

The garden scents the air; (A) Awake and drink, my friend; (B)

Awaken boy, I say, (c)
And pass the cup this way; (c)
Darkness is gone, and day, (c)
Shining and camphor-fair, (A) To us doth perfume send. (B)

Come, mix the ruby sips (d)
With nectar of the lips. (d)
While time for ever slips (d)
Away, what joys are there (A) But these, before the end? (B)

The usual number of strophes is five. The rhyme scheme can be complicated by introducing internal rhymes (*e.g.*, ABCABC defdefdefABCABC, etc.). The poems are written in classical Arabic and their subjects are those of classical Arabic poetry, such as panegyric, love, wine. The second part of the last strophe (called *kharja* or *markaz*) is usually written in vernacular Arabic or in the Spanish Mozarabic dialect; it is normally put into the mouth of a girl and expresses her longing for her absent lover. These verses—the earliest examples of lyric poetry in a Romance language—make it probable that the inventors of the *muwashshah* were partly inspired by some kind of oral Romance poetry. Most of the Arabic *muwashshahs* from Spain are from the 11th and 12th centuries. From the 12th century onward the genre also spread to north Africa and the east. Jewish poets of Spain also wrote *muwashshahs* in Hebrew, with *kharjas* in Arabic and Spanish.

*See* M. Hartmann, *Das arabische Strophengedicht. I: Das Muwassah* (1897); S. M. Stern, *Les chansons mozarabes* (1953). (S. M. St.)

**MUYBRIDGE, EADWEARD** (EDWARD JAMES MUGGERIDGE) (1830–1904), English photographer and lecturer whose work in motion-picture photography stimulated invention and public interest the world over. He was born on April 9, 1830, in Kingston-upon-Thames, and emigrated to the U.S. in about 1852. After a series of photographic assignments from the U.S. government, he took up the photography of motion in 1872 and was said to have proved then that at one time during its stride a trotting horse has all four feet off the ground. After a photographic excursion to Latin America, he resumed the motion work, the results of which caused worldwide reappraisals of the conventional method of showing motion in art. Extensive lecture tours (in which he projected his motion pictures on a screen) were interrupted by two years of work at the University of Pennsylvania, in Philadelphia. The results were published in 1887 and formed a tour de force of motion photography which remains unexceeded. Muybridge returned to Kingston-upon-Thames in 1900 and died there May 8, 1904, leaving the motion-picture industry well established throughout the world.

Besides a great many separate photographs of the western U.S. —which gained him an international reputation before he took up the photography of motion—Muybridge produced the following works: *The Horse in Motion* (1878–79), *The Attitudes of Animals in Motion* (1882), *Animal Locomotion . . . Prospectus and Catalogue* (1887), *Animal Locomotion . . .*, with 781 plates (1887), *Animal Locomotion. The Muybridge Work at the University of Pennsylvania* (1888), *The Science of Animal Locomotion* (1891?), *Zoopraxography or the Science of Animal Locomotion* (1893), *Descriptive Zoopraxography* (1893), *Animals in Motion* (1899) and *The Human Figure in Motion* (1901).

(G. W. He.)

**MUZAFFARNAGAR,** a town and district in the Meerut division of Uttar Pradesh, India. The town, headquarters of the district, lies 75 mi. N.N.E. of Delhi on the Delhi-Saharanpur railway. It was founded by Khan-i-Jahan, son of Muzaffar Khan, during the reign of Shah Jahan about 1633. Pop. (1961) 87,622. There are two colleges affiliated with Agra university. The town is essentially a trade centre for wheat and sugar. Coarse woolen blankets are manufactured and exported.

MUZAFFARNAGAR DISTRICT (area 1,683 sq.mi.; pop. [1961] 1,144,921), constituted in 1826, lies south of Saharanpur district in the upper part of the Ganges-Jumna doab. Its eastern boundary is formed by the Ganges (Ganga) and the western boundary by the Jumna (Yamuna) river. A generally southward sloping plain, it is elevated in the central parts and flanked on either side by the lowlands of the Ganges and the Jumna. The central part is drained by the west Kali Nadi (river) and the Hindan stream.

The district is agricultural in character, owing its prosperity to the irrigation provided by the Eastern Jumna canal in the west and by the branches of the Ganges canal in the east. More than half of the total area is irrigated. Wheat and gram are the chief food crops while sugar cane (occupying more than a quarter of the cultivated area) is an important commercial crop. There are four large sugar mills and power stations are located at Nirgajni, Chitaura and Salwa. Other towns in the district include Kairana (pop. [1961] 26,454), Shamli (26,397), Khatauli (17,898), and Kandhla (15,990). (S. S. Bh.)

**MUZAFFARPUR,** a town and district in the Tirhut division of Bihar, India. The town, headquarters of the district and division, lies near the southern bank of the Burhi Gandak, about 36 mi. N.N.E. of Patna. Pop. (1961) 109,048. It is well laid out along two lakes and is a trade centre on the Patna-Nepal route. It is also a main rail and road junction. It contains four colleges and has become the seat of Bihar university, which is one of the divisional universities of Bihar state that came into existence in July 1960. Muzaffarpur is an important Muslim religious centre.

MUZAFFARPUR DISTRICT (area 3,018 sq.mi.; pop. [1961] 4,118,398) is a comparatively moist plain watered by the Great Gandak, Baghmati and Little Gandak rivers and their tributaries. It is dotted with mango groves and clumps of bamboo, and is closely cultivated. The principal crops are rice, barley, maize (corn), wheat, gram, tobacco, mangoes and litchi. The indigo industry, now completely extinct, has been partly replaced by sugar. The other important towns are Hajipur (pop. 34,044) and Sitamarhi (17,873).

Excavations revealed the remains of buildings of *c.* A.D. 300; hundreds of seals of the 4th or 5th century A.D. have also been found. At Kolhua, 3 mi. N.W. of Muzaffarpur town, is a pillar crowned by a lion, reputedly set up by the emperor Asoka to mark a stage of his journey to Nepal about 250 B.C. Vaisali (near Lalganj), 16 mi. S.W. of Muzaffarpur, is a noted Buddhist pilgrimage centre. (E. AH.)

**MWANZA REGION, TANGANYIKA,** established in May 1963 following a reorganization of administrative units in Tanganyika, comprises Geita, Mwanza, Kwimba and Ukerewe Island districts, which previously belonged to the former Lake region. Area 13,300 sq.mi. Pop. (1957) 836,341. It is bounded north by Lake Victoria, east and south by Shinyanga region and west by West Lake region. The gently undulating land between 3,800 and 4,500 ft. is part of the central plateau of Tanganyika warped toward the shore of Lake Victoria which has many inlets, including Speke gulf separating Mara region. Granites and metamorphosed rocks of Pre-Cambrian Age have been peneplained leaving granite torrs and hills of banded ironstone. The Moame river drains to Lake Victoria at Mwanza but 12 mi. S. of the lake a low watershed separates streams draining south to the Malagarasi river and Lake Tanganyika. Mean annual rainfall ranges from 30 to more than 40 in., the rain falling mainly during November–April. No month is completely dry near the lake, although offshore winds tend to drive storms away from the region. Soils are mostly granitic with gray and brown loams on hills and black calcareous clays in the *mbugas*—poorly drained areas south of the lake. *Brachystegia* woodland (*miombo*) and savanna are characteristic, with wide areas of derived grassland and natural grassland in the *mbugas*.

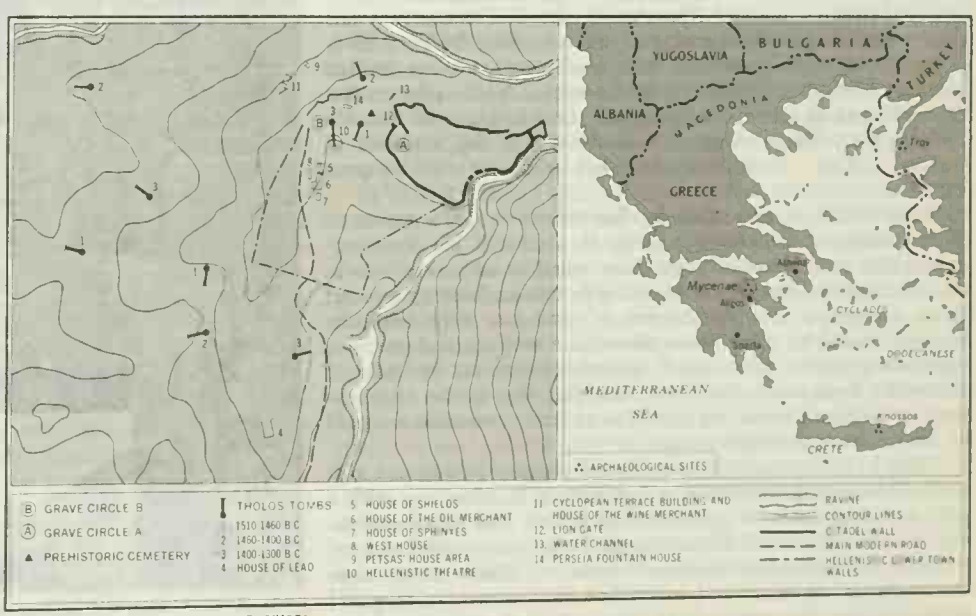
Regional headquarters are at Mwanza (pop. [1957] 19,877), a lake port with rail and road connections. The population is dense in Mwanza and Kwimba districts where the Usukumu (Sukuma) tribe are well known for their intensive mixed farming, including cattle and cotton, and for their co-operative unions. The Zinga (Zinza) tribe occupy much of Geita district, where gold mining is important. The region's main food crops are maize (corn) and millet, and there is considerable trade in livestock produce. Parts of the region are tsetse infested. (J. M. KE.)

**MWERU, LAKE** (*mweru*, Bantu for "lake"), in Africa, is bordered by Northern Rhodesia on the east and Katanga province, Republic of the Congo, on the west. It lies in the northwestern part of the Mweru-Luapula-Bangweulu plain (3,100–3,500 ft.). Its surface is about 3,010 ft. above sea level; greatest length (S.S.W.-N.N.E.) 71 mi.; average width about 28 mi.; area 1,620 sq.mi. The margins are in general flat, except on the western coast where rock cliffs rise in places 100 to 200 ft. The Luapula river enters it on the south, and the Luvua leaves it on the north, to the west of the town of Pweto. The Luvua cuts a gorge as it flows northward and northwestward to join the Lualaba (Congo). Two islands, Kilwa and Sokwe, are situated in the southern part of the lake. Lake Mweru was first visited by F. de Lacerda in 1798 and reached by David Livingstone in 1867; Sir Alfred Sharpe explored the western shore in 1890 and circumnavigated the lake in 1892. (J. H. WN.)

**MYAUNGMYA,** a town and district (area [1962] 2,835 sq.mi.) in the Irrawaddy delta of the Union of Burma. The town, capital of the district, lies 20 mi. S.E. of Bassein. As in neighbouring Pyapon, the population of the district (85,027 in 1953) expanded greatly in the early part of the 20th century as the wet alluvial lands were settled by Burmans and Karens, and the land was devoted to rice cultivation except toward the sea where tall mangrove swamp forests of *Heritiera fomes* cover large areas. Communication is mainly by water and the villages are strung out along river banks. Depopulation and abandonment of land during and after the Japanese occupation have rendered rehabilitation difficult. (L. D. S.)

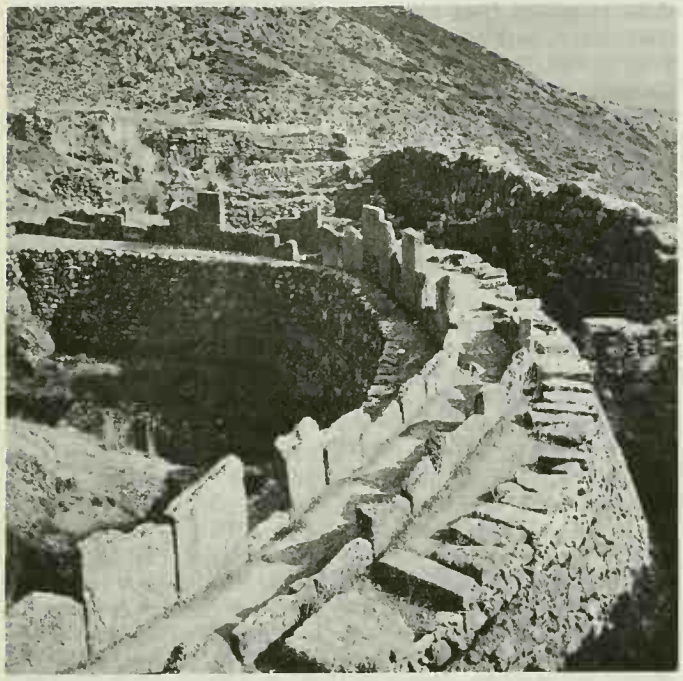
**MYCENAE,** a prehistoric Greek city in the Argolid celebrated by Homer as "broad-streeted" and "golden," the capital of Agamemnon, the Achaean king who sacked the city of Troy, set, as the poet says, "in a nook of Argos," with a natural citadel formed by the ravines between the mountains of Hagios Elias (Ayios Ilias) and Zara, and furnished with a fine perennial spring named Perseia after Perseus, the legendary founder of Mycenae. It is the chief Late Bronze Age site in mainland Greece. Systematic excavation of the site began in 1840, but the most celebrated discoveries there were those of Heinrich Schliemann (*q.v.*). For the context of Mycenae in the prehistory of the Aegean area and for explanation of the archaeological terms and chronological divisions used below *see* AEGEAN CIVILIZATION. The term "Mycenaean" is often applied to the Late Bronze Age of mainland Greece in general and of the islands except Crete.

There was a settlement at Mycenae in the Early Bronze Age, but all structures of that or of the succeeding Middle Bronze Age have, with insignificant exceptions, been swept away by later buildings. The Early Helladic (or Early Bronze Age) cemetery which must have existed in the vicinity has not been discovered. The Middle Helladic burials were in simple pit graves, cist graves or shaft graves that, except for the shaft graves dug for the royal family and Grave Circle B, contained few offerings. The latter, excavated by J. Papadimitriou from 1952 to 1954, may represent the burial ground of the first dynasty ever to establish its capital at Mycenae (long before the probable date of Perseus in the mid-14th century B.C.). Of the 24 graves in this circle only 14 were shaft graves. Grave Alpha contained the bones of three men accompanied by three bronze swords, an engraved dagger, two




ADAPTED FROM H. WACE, "MYCENAE GUIDE"

THE SITE OF MYCENAE



ENRICO MARIANI—COMO

SANDSTONE SLAB AROUND GRAVE CIRCLE A AT MYCENAE

vases of silver and two of bronze, a bracelet and a so-called "gaiter ornament" in gold. Grave Gamma was surmounted by a plain rock stele and two stele bases of which one had been cut from an older sculptured stele. The shaft contained the bones of three men and a girl. The grave goods included a gold cup, a series of bronze swords, an electrum mask of a man and a splendid amethyst seal engraved with the portrait head apparently of an Achaean prince. Epsilon had a single skeleton, a mass of crushed gold ornaments and a service of bronze vessels. Omicron, "the crystal grave," contained a magnificent rock crystal vase in the form of a duck and bronze pins with crystal heads. Nu had the remains of two warriors and their weapons (the earlier burial, of Middle Helladic date, being evidently one of a person of some importance). The central area had no graves but the southern sector contained graves Kappa 1 and 2, Lambda, Mu, Sigma and Tau. Lambda, though robbed, contained a fine sword with gold mounted scabbard, ivory pommel and possibly a baldric, and 20 stone arrowheads. The eastern sector contained graves Alpha, Rho and Upsilon, of which Rho, though robbed of its contents, was particularly interesting because of its structure; inside a Middle Helladic shaft grave had been constructed a stone vaulted chamber tomb of the type known at ancient Ugarit (modern Ras Shamra north of Latakia in Syria) and there dating from the 14th century B.C. There were no cremations nor any evidence of wooden coffins. Gems were rare but gold leaf and weapons common.

Grave Circle A, excavated by Schliemann in 1876, seems to have overlapped in date with Circle B, so that it has been suggested that two dynasties might have ruled simultaneously as in classical Sparta. But Circle A, unlike B, was enclosed by a round fence comprised of a double row of sandstone slabs with the interval roofed by other slabs and with a well-marked entrance approach from the "lion gate" (so-called from the fine pair of sculptured lions above the lintel), implying that in the 14th century B.C. probably some cult existed or at least veneration was paid to the tombs of the earlier kings.

Grave I (Schliemann's 2) contained the bones of three men with gold diadems and ornaments, a fragment of a silver cup with a gold rim, fragments of a boar's tusk helmet and other objects. Grave II (Schliemann's 5) had a single burial with a small cup and mask of gold, some Cretan imports such as a faïence vase and an ovoid rhyton or filler, and a number of weapons. Grave III (Schliemann's 3) contained the bones of three women and two children with a crown, a diadem and ornaments in gold leaf, two fine engraved gems, a bowl and ladle of alabaster, and fragments of a faïence jug with helmeted heads in relief. Grave IV (Schliemann's 4) had the bones of three men and two women. The dedications included some splendid rhytons, one in gold leaf in the form of a lion's head, another formed in a bull's head in silver with gold additions, and part of a conical rhyton in silver with an embossed representation of the siege of a coastal city by Mycenaean troops; a shrine of Minoan type in gold leaf; gold earrings and scales; a silver jug; bronze vessels; fragments of vases in faïence and silver; and a fine series of bronze swords and daggers. Grave V (Schliemann's 1) held the bones of three men; the grave goods included masks and ornaments of gold, a hexagonal wooden vessel coated with gold, a necklace of gold beads, a bronze sword with finely decorated hilt, sword daggers inlaid with Nilotic scenes, and two daggers inlaid one with griffins, the other with lilies. Grave VI, excavated by P. Stamatakis, had a single skeleton buried full length and the remains of an earlier burial, and lay outside the grave circle. The grave goods included a small cup in gold and a large one in silver, a sword, a dagger and spear points in bronze and a halberd resembling a west European form, stone sharpeners, some Middle Helladic vases and fragments of three Cycladic jugs. The latter were like those found at Knossos (*q.v.*), in the temple repositories and therefore to be dated in the first quarter of the 16th century B.C. Grave VI was the earliest of this group, the first burial perhaps to be dated about 1600 B.C., and was succeeded by Graves II, IV, V, III and I in that order. The main circuit of the citadel walls seems to have been erected about 1350–30, and its author could well have been Perseus, the legendary founder of Mycenae. But G. E. Mylonas gives reasons for dating the lion gate and the Cyclopean enclosure wall to about 1250 B.C., while all authorities after C. Tsountas agree that the northeast extension of the walls enclosing the underground cistern is the latest, and may have been built after the return of the Greeks from the sack of Troy. Steles plain, incised or sculptured were erected over the graves.

While the royal dynasty were burying their dead in shaft graves the commoners had abandoned the Middle Helladic practice of individual graves for chamber tombs with entrance passage cut in the soft grave and employed as family graves, a practice that continued for 500 years. About 1510 B.C. the royal family also began to inter their dead in family tombs in the form of tholos or "beehive" tombs with corbelled vaulting that may have been influenced

LAWRENCE CHERNEY—MONKMEYER

THE LION GATE OF THE CITADEL AT MYCENAE

by tombs in Crete or in the western Peloponnese but might also be classed as chamber tombs lined with masonry. Nine such tholos tombs are known at Mycenae, and there are others in the Argolid. The earliest group (1500–1460 B.C.) had uncut stones in the vault and no masonry in the dromos or entrance passage, with short lintels and no relieving triangle over the doorway. In the second group (1460–1400 B.C.) lintels are longer and surmounted by a relieving triangle and there is a growing use of dressed conglomerate, especially for jambs and doorways. In the third group (1400–1300 B.C.) only the earliest, the "tomb of the genii," has rubble masonry in the dromos. The others, such as the so-called "treasury of Atreus" (*c.* 1330 B.C.) and the "tomb of Clytemnestra" (*c.* 1300 B.C.), have ashlar conglomerate throughout.

All the kings of the "tholos tomb dynasty" must have lived on the acropolis, but little remains of the earlier buildings, and the existing palace must have been reconstructed in the 14th century (perhaps by Perseus himself).

From the lion gate a graded road, 12 ft. wide, leads to a ramp supported by a five-terrace wall and thence to the southwestern entrance of the palace. The latter is comprised of two main blocks, one originally covering the top of the hill but largely destroyed on the erection of the Hellenistic temple, the other occupying the lower terrace to the south banked up artificially on its western edge. The two blocks were separated by two parallel east-west corridors with storerooms opening off them. The existence of a palace shrine on the upper terrace seems implied by A. J. B. Wace's discoveries of a magnificent ivory group consisting of two goddesses and an infant god with fragments of painted tripod altars and other objects.

At the southwestern corner of the later palace the west lobby gave access to the grand staircase of 22 steps, a landing and another 17 or 18 steps culminating in a small forecourt which afforded entrance to the great court and to a square room immediately to the north of it. Here an oblong area with raised plaster border was interpreted by Wace and L. B. Holland as the base for a throne where the king sat in audience. Tsountas, however, followed by Mylonas, regarded it as a hearth and the room as a guest chamber; the throne might then have stood, as at Tiryns and Pylos, on the right of the megaron, a part that has now disappeared. Both the porch and the main hall of the megaron had floors of painted stucco with borders of gypsum slabs and with frescoes on the walls, one apparently representing a battle in front of a fortified citadel. In the centre was a round plaster hearth enclosed by four wooden columns, possibly implying the existence of a clerestory. The ten plaster layers of the hearth and four of the floor suggest that this hall was in use for a considerable time. The roof was probably flat. East of the corridor lay a series of rooms, the most interesting being known from its decoration as "the room of the curtain frescoes"; east of these was a staircase leading to the domestic quarters, of which little survives.

Within the citadel were various houses of retainers. The most imposing, "the house of the columns," rose to three stories in height. South of the grave circle lie the ruins of the "ramp house" where V. Drosinos found a gold treasure, the "south house" and the "house of Tsountas." Another building known as "the granary" from the carbonized barley, wheat and vetches found in its basement, was erected in the 13th century between the Cyclopean citadel wall and Grave Circle A and continued in use up to the destruction of the city by fire about 1100 B.C.

The Late Mycenaean period (1400–1100 B.C.) was one of great prosperity in the Peloponnese. After the destruction of Knossos, Mycenae became the dominant power in the Aegean, where its fleet must have controlled the nearer seas and colonized the Cyclades, Crete, Cyprus, the Dodecanese, northern Greece and Macedonia, western Asia Minor, Sicily and some sites in Italy. Mycenaean rather than Minoan goods are found in the markets of Egypt, Syria and Palestine. Mycenaean raiders harried the coasts of the Egyptians and the Hittites, and at a date traditionally supposed to be 1180, but by some scholars now estimated at 1250 B.C., Agamemnon and his followers sacked the great city of Troy.

In the 16th century Mycenaean art was temporarily dominated by the influences of Minoan art. Cretan artists must have emigrated to the mainland, and local varieties of all the Minoan arts arose at Mycenae. Minoan naturalism and exuberance were tempered by Greek formality and sense of balance, already visible in Middle Helladic painted wares and later to culminate in the splendid Geometric pottery of the Dipylon cemetery at Athens.

Until 1950, when P. Petsas found a fragment of a clay tablet, Mycenaean literacy was attested only by a few symbols painted on vases; but in 1952 Wace's excavation of "the house of the oil merchant" and "the house of the wine merchant" outside the walls disclosed a number of tablets in the Linear B script first identified at Knossos and later proved by Michael Ventris to have been written in an earlier form of the Greek language. These tablets were studied by E. L. Bennett, who identified the hands of six different scribes.

Mycenae was burned and destroyed perhaps by invading Dorians about 1100 B.C., but the outer city was not deserted, since graves of the Proto-Geometric and Geometric periods have been excavated by D. Evangelides and V. A. Desborough. Mycenae evidently continued to exist as a small city-state and the walls were not pulled down. Early in the 6th century B.C. a temple, from which one fine relief survives, was erected; in 480 Mycenae sent 400 men to fight against the Persians at Thermopylae, and its men were at Plataea in 479. In 470, however, its aggressive neighbour Argos, which had been neutral in the Persian war, took an ignoble revenge by besieging Mycenae and in 468 destroyed it. In the Hellenistic period Mycenae revived and a new temple was built on the crown of the acropolis; in 235 B.C. the Argive tyrant Aristippus was killed there and the city wall repaired. Nabis of Sparta carried off some of the young men about 195, and an inscription of 194 B.C. refers to their detention. A few Roman objects have been found, but when Pausanias visited the site *c.* A.D. 160 he found it in ruins.

*See* also references under "Mycenae" in the Index.

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**MYCENAEAN CIVILIZATION:** *see* AEGEAN CIVILIZATION; GREECE: *History;* MYCENAE.

**MYCETOZOA,** the term used by some biologists for the slime molds, multinucleate amoebalike organisms now considered by most biologists to be plants and accordingly placed in the plant phylum Myxomycophyta (Myxomycetes). *See* SLIME MOLDS.

**MYCOLOGY,** from the Greek meaning "a discourse on mushrooms," is the science of fungi. *See* FUNGI.

**MYCORHIZA** (MYCORRHIZA), a word used to describe several types of partnership between a fungus and the roots of a higher plant. The term mycorhiza, derived as a compound of the Greek terms for "fungus" and "root," also designates the composite organs formed by the fungus and the host plant, and has been extended to include organs in which the component of the higher plant is a rhizome (underground stem) or thallus (undifferentiated plant body) rather than a root. Such growths are common on the roots of trees and many other plants. Since the organs of the host plant are unharmed, although modified in structure, and root growth may be stimulated, these associations are considered symbiotic or mutually helpful.

The roots of land plants live in soil, competing therein for water and nutrients with a crowded population of microorganisms. This population varies greatly in density depending on the various components of which the soil is composed, and great densities of colonization occur in the immediate environs of living roots. The soil surrounding the roots is called the rhizosphere and in this re-

gion, and on the surfaces of roots themselves, populations of fungi, differing in number and kind from the general soil population, are present. Many of the organisms of the root region are specialized in nutritional requirements and have important effects on their hosts in respect to their potential to cause or inhibit disease or to affect the availability of nutrients.

Many species of land plants enter into an even closer association with certain fungi in which they form composite organs of root and fungal tissues. This phenomenon was comparatively well known, especially to foresters, when in 1885 the German botanist A. B. Frank coined the name mycorhiza for the fungus root organs of forest trees, especially oak, beech, hornbeam and other members of the Cupuliferae and certain conifers, to register his view that these constituted an organ of importance in nutrition. He put forward the hypothesis, based on observations and experiment, that in woodland conditions certain trees normally were infected by fungi that formed mycorhizae with their roots. Later he and others described analogous associations of fungi with roots and absorbing organs of many other plants and distinguished various other kinds of mycorhiza. Robert Hartig and other botanists took the view that these fungal infections were of a parasitic nature and it was not until the end of the 19th century that mycorhizal associations were accepted as a natural and healthy condition of many plants.

**Distribution.**—Mycorhizae are formed by liverworts, ferns, club mosses and conifers and by flowering plants of most families. Analogous associations, the lichens, are formed between algae and fungi. Mycorhizae are constantly formed in certain groups of seed plants (*e.g.*, orchids, heaths) and are invariably developed by saprophytic species lacking chlorophyll. Fungal infections, similar histologically to living examples of certain mycorhizae, have been observed in fossils such as the Psilophytales from the Devonian period and the Cordaitales from the Carboniferous period.

The widespread occurrence of mycorhizae in living and fossil plants and their universal presence in diverse saprophytes are arguments supporting the view that infections of this kind are of selective value to the host plants.

**Structure of Mycorhizae.**—It is still convenient to recognize two main types of mycorhizal structure and to use the descriptive names given to these by Frank. The ectotrophic types are specially characteristic of many forest trees in which the fungal mycelium completely invests the tips and younger portions of the root with a sheath of compact fungal tissue. From the sheath, hyphal branches penetrate between the cortical cells to form a network but rarely penetrate into the cells themselves. The endotrophic types of infection are more variable than the ectotrophic types and are characterized by the usual absence of a fungal sheath, although there may be in some a profuse development of extraradical mycelium. The hyphae or branching threads penetrate the cortex of the root, usually entering the cells where they form coils or branched haustoria. In the majority of endotrophic infections the hyphae at some stage disintegrate or are digested within the host cells, liberating soluble products that presumably become available to the host.

Ectotrophic mycorhizae are to a great degree uniform in structure regardless of the species of host plant. Their main variability lies in the extent of penetration of the cells of the host and in the thickness of development of the sheath. Some, in which the cells are heavily penetrated, have been called ectendotrophic mycorhizae; others, in which the fungus appears to give rise to slight parasitic symptoms, have been called pseudomycorhizae. These variations seem to be due to the species of fungus involved and to conditions of growth.

By contrast, endotrophic mycorhizae do not comprise a single natural kind of mycorhiza. That found among the orchids, some gentians and in certain liverworts, for instance, differs markedly from that of heath, although in both the fungal hyphae are septate and form coils within the cells. Again, plants belonging to many other angiosperm families such as the grass, pea and rose, to conifers such as cypress and yew and to certain groups of liverworts and ferns, form mycorhizae with fungi lacking septa (walls) in their hyphae; these hyphae form large branched haustoria and swollen vesicles in the host cells.

**Mycorhiza of Trees.**—The ectotrophic mycorhiza of forest trees is easily recognized. Each rootlet is enveloped in a sheath of fungal tissue, branches from which penetrate on the one hand into the cortex and on the other into the soil. In most species the infected roots are aggregated into racemose systems of short rootlets borne upon long mother roots of more normal appearance. These mother roots are, however, normally infected in some way, either by a network of hyphae in the cortical cells or by a superficial fungal sheath. The young short branches consequently become infected as they grow out through the cortical tissues of the mother root. The mycorhizal rootlets of pines differ from those of other trees in being forked rather than racemosely branched.

Many of the characteristic fungi of forests have been isolated into pure culture and some have been shown experimentally to form mycorhizae with trees. These belong mainly to the toadstool fungi (Hymenomycetes), of which genera such as *Boletus*, *Russula*, *Tricholoma* and *Lactarius* include many mycorhizal species. Some puffball fungi (Gasteromycetes) such as *Rhizopogon* are mycorhizal, as are a few sac fungi (Ascomycetes). By cultural experiments 50–100 species have been shown to be capable of forming mycorhizae with forest trees and these show variable specificity. For instance, *Boletus elegans* is known to form mycorhizae only with larch, whereas *Cenococcum graniforme* forms them with numerous and varied tree species.

Elias Melin and his colleagues in Sweden demonstrated that most of these mycorhizal fungi have characteristic nutritional requirements. They usually are dependent upon a supply of simple carbohydrates, vitamins and growth factors. Although in this respect there is considerable variation among them, their development on root surfaces is to some degree explicable by their nutritional characteristics. Some produce as end products of their metabolism substances with auxinlike properties that can affect the pattern of root growth and this affords a partial explanation of the characteristic form and structure of mycorhizal rootlets.

Although totally uninfected individuals of mycotrophic trees are probably never found in nature, the intensity of mycorhizal infection varies, especially in seedlings. Such variation has its explanation in the nutritional status of the host plant. Adequate or excessive supply of nutrients in the soil tends to confer resistance on the host, whereas deficiency or lack of balance in one or more nutrients predisposes the host to infection. At the same time infection occurs abundantly only on plants with excess of carbohydrates in their root systems. Hence plants grown in low light intensity or in normal light intensity with high nutrient supplies are deficient in mycorhizal development. This complex interaction of carbohydrate status and mineral nutrient status upon susceptibility of hosts to infection, which was first shown by E. Björkman, has not been fully explained. Reasons have been sought in the change in nature or quantity of substances secreted by the roots of host plants. Similarly, the effects of auxinlike secretion of mycorhizal fungi have been shown to give a partial explanation of the change of histological pattern in the cells of the host roots. Both these problems are being actively investigated by research workers.

By contrast with those on natural sites, it has been observed that plantations of exotic trees, especially conifers, in areas far removed from their normal habitat sometimes fail to produce mycorhizae when first planted. Such plantations often fail to develop normally but sometimes recover after inoculation with suitable mycorhizal fungi. In controlled experiments, where inoculation has been done with pure cultures, it was shown that mycorhizal plants grow faster, that mycorhizal root systems are able to extract nutrients more rapidly from deficient soil than uninfected systems and that they pass these nutrients on to the host plant.

In some degree the explanation of these results is to be found in the effect of mycorhizal infection upon the form of the root system, for the fungus appears to stimulate root growth and to prolong the life of the feeding roots. In addition it was shown, using nutrients with labeled isotopes, that the hyphae connecting

mycorhizae with the soil may absorb and pass substances to the host and that the sheath tissues themselves are capable of a greater rate of absorption of some nutrients than are uninfected roots. Mycorhizal roots accumulate rapidly great quantities of some nutrients into their sheath tissues and this may be translocated to the host under suitable conditions. Root systems equipped with ectotrophic mycorhizal rootlets are nutrient-absorbing organs of great efficiency that can compete with other soil inhabitants and confer a selective advantage on their host plants.

The ectotrophic mycorhizal habit, characteristic of forest dominants in the temperate regions of the northern hemisphere, is also found in southern hemisphere trees such as renantheroid eucalypts.

**Mycorhiza in Ericaceae and Related Families.**—In the northern hemisphere certain members of the family Ericaceae, *e.g.*, heath (*Erica*), ling or heather (*Calluna*) and cranberry and bilberry (*Vaccinium*), and Empetraceae, *e.g.*, crowberry (*Empetrum*), are constant features of the vegetation of acid humus soils—moorland and woodland—on which they often dominate large areas almost to the exclusion of other plants. In the southern hemisphere the heathlike Epacridaceae have a somewhat similar habit.

The mycorhiza of these plants is of the endotrophic type with certain characteristic features, in some respects showing points of resemblance with that of trees. The young roots are of small diameter and the outermost layer of cells forms a definite mycorhizal zone. In favourable soil conditions practically every cell in this layer is filled with a densely branched complex of fungal hyphae from which strands of mycelium extend outward into the soil. The growth of the mycelium on the outside of the roots is usually profuse and in *Arbutus* species may resemble the sheath of ectotrophic mycorhizae. In the cells the hyphal complexes are subject to digestion and the resulting products appear to be absorbed by the host cells.

There has been some disagreement among research workers who have investigated the mycorhiza in Ericaceae. Some described a cyclic symbiosis in which all the organs of the host plant were infected by fungal hyphae so that the seed coat became infected before seed dispersal and the seedlings became infected early in germination. Normal germination and growth failed if infection did not take place. But the evidence against this view of mycorhiza in the Ericaceae is stronger than that for it, since asymbiotic germination of many species has been brought about in sterile natural substrates and great difficulty is experienced in obtaining evidence for fungal infection of stems, leaves and floral parts.

At one time the mycorhizal fungi of Ericaceae were believed to belong to the imperfect genus *Phoma*, which may be capable of fixing atmospheric nitrogen. This is questionable since several fungi other than *Phoma* produce typical mycorhizae with many ericaceous species. Many commonly held opinions concerning the functioning of this mycorhiza probably are of doubtful validity.

Work on the *Pernettya* genus of evergreen shrubs further emphasized the similarity of the mycorhizae of Ericaceae with that of forest trees. In respect to both the factors affecting intensity of infection and the rate of salt absorption from deficient soils, similarities with ectotrophic mycorhizae are apparent.

**Mycorhiza of Orchids.**—The mycorhiza of orchids is endotrophic and the mycelium is widely distributed throughout the cortex of the root or, in rootless forms, in the chlorophyll-free tissues of the absorbing organs. Two contrasted types of cell usually are observable: "host" cells containing active hyphae and "digestion" cells in which hyphal digestion or disintegration occurs. In the former the mycelium fills the cells with skeins or "pelotons" of characteristic appearance and is believed to extract nutrients from the host. In the digestion cells the contents of the hyphae are released to the cells.

The French botanist Noël Bernard and the German botanist Hans Burgeff were responsible for important researches on orchid mycorhiza. Fungi were isolated into pure culture from the roots and shown, by back inoculation into sterile seedlings, to be capable of mycorhiza formation. Many of these fungi belong to the imperfect genus *Rhizoctonia*, of which some species are known to be dangerous parasites and others weak root-inhabiting parasites. *Rhizoctonia solani* is a parasite of many plants but also forms mycorhiza with at least one orchid. Certain mycorhizal *Rhizoctonia* species, including *R. solani*, are capable of forming clublike basidiomycete fructifications in some conditions and may be referred to the genus *Corticium*. Basidiomycetes in perfect state such as species of *Fomes*, *Xerotus* and *Armillaria* form mycorhiza with saprophytic orchids. The majority of these fungi have the ability to utilize as carbon sources many resistant substances of soil and plant material; many utilize cellulose and some lignin also. In this respect the fungi of orchid mycorhiza are contrasted with those of ectotrophic mycorhiza.

The minute seeds of orchids usually do not germinate in natural substrates unless they become infected by appropriate fungi. They may, as L. Knudson first showed, be stimulated to germination in aseptic culture if given appropriate conditions. Research upon the conditions required for aseptic germination indicates that the provision of soluble carbohydrate is all that is needed in some cases, but more often the seed is unable to synthesize some essentials. For instance, many orchid seeds require nicotinic acid or nicotinamide (precursor of the enzyme cocarboxylase) before germination proceeds.

After germination, the tiny orchid seedling grows saprophytically, usually for a period of years, before producing organs above ground. Hence, even those species that become self-supporting in respect to carbon compounds as adults are saprophytic and dependent on fungal activity in youth. The mechanism whereby the fungi of orchids improve the supply of carbon compounds to their hosts is not fully understood. It is, however, probable that the hyphae in the substrate absorb carbonaceous substances and conduct them into the host where they are released by both direct secretion and digestion.

Mycorhizal infection similar to that of orchids is found in many other plants, including some of the gentian family and some liverworts, including *Cryptothallus*, the only saprophytic member of the group.

**Mycorhiza of Common Crop Plants.**—By far the commonest type of mycorhiza is that in which the fungi concerned belong to the algalike fungi (class Phycomycetes) with aseptate hyphae. In these endotrophic mycorhizae the main hyphae may either grow between the cells of the cortex of the host or be completely intercellular. In both cases specialized lateral branches of small diameter are formed that ramify in the cells to form complex haustorial organs called arbuscules. In addition the main hyphae may also form large swellings or vesicles in or between the cells. In many cases the fungal hyphae are also present in the soil on or around the roots and the extraradical vesicules may be formed. In spite of the presence of profuse mycelium in the soil around many of these mycorhizae great difficulty has been experienced in culturing the fungi and so in learning anything of their physiological properties.

The roots of plants infected with vesicular-arbuscular mycorhiza are often little modified in form or structure. Indeed the majority of common angiosperm crop plants, *e.g.*, Gramineae (grasses and cereals) and Leguminosae (clover, peas, beans, etc.) are infected in this way as also are Rosaceae (roses, apples, pears, peaches, strawberry, etc.). Among the conifers this form of mycorhiza is common in all families except Pinaceae, so that many forest dominants, *e.g.*, cypresses, redwoods, yew, etc., are infected. Many ferns, club mosses and liverworts also have this mycorhiza.

As yet there is no conclusive evidence that mycorhizal infection of this type has any marked effect on the growth of the host plant. Experiments have been impeded because of the difficulty of isolating the fungi into pure culture. On the one hand it was shown that a species of *Endogone* can produce mycorhizae of this type with many Rosaceae. On the other hand the phycomycetous parasite *Pythium ultimum* was isolated from mycorhizae of wild garlic and is said to be capable of forming mycorhizae with various plants when back inoculated. These lines of investigation may lead to fuller understanding of the commonest type of mycorhiza.

*See* also FUNGI: *Nutrition and Functions;* SYMBIOSIS.

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**MYERS, FREDERIC WILLIAM HENRY** (1843–1901), English writer and one of the founders of the Society for Psychical Research, was born at Keswick, Cumberland, on Feb. 6, 1843. He was educated at Cheltenham and Trinity college, Cambridge, where he was appointed fellow and classical lecturer in 1865. Though remaining in Cambridge, in 1872 he gave up teaching to become school inspector. Of his poems *St. Paul* (1867) is best known, though more successful work is perhaps found in his collection *The Renewal of Youth* (1882). He wrote an illuminating book on Wordsworth (1881) and, in *Essays, Classical and Modern* (1883), a fine essay on Virgil which represents the matured enthusiasm of a student and a disciple to whom the exquisite artificiality and refined culture of Virgil's method were profoundly congenial. His later life, however, was increasingly devoted to the work of the Society for Psychical Research, which, together with Henry Sidgwick, Richard Hodgson and others, he founded in 1882. The society's aim was to collect evidence of psychical phenomena and to undertake scientifically controlled experiments. Myers' later writings were largely devoted to this sphere. His *Human Personality and its Survival of Bodily Death* (1903) was described by William James as "the first attempt to consider the phenomena of hallucination, hypnotism, automatism, double personality and mediumship, as connected parts of one whole subject." His other works include *Phantasms of the Living* (1886) and *Science and a Future Life* (1893). He died at Rome on Jan. 17, 1901. (M. Kl.)

**MYINGYAN,** a district in the heart of the dry zone of the Union of Burma, in the Mandalay division. Area 3,078 sq.mi. Pop. (1964 est.) 83,000. The central ridge of Burma, the Pegu Yoma, dies out near the border of Myingyan, and the district consists mainly of low undulating country, but along the Irrawaddy river, which forms the northwest boundary, terraces afford gravel-capped plateaus, especially one about 100 ft. above river level. Alterations of course have afforded some fine river bluffs and on one stand the ruins of the famous old capital Pagan (*q.v.*) with hundreds of pagodas, undoubtedly the richest storehouse of Burmese archaeological and historical treasures still only partly explored. In the heart of the district, rising to 4,985 ft. (or about 4,000 ft. from the surrounding plain), is the extinct volcano of Popa (Popadaung), the walls and slopes of whose breached crater, partly wooded and partly grassed, are the home of the dreaded hamadryad or king cobra, as well as of a wealth of flowers akin to those of temperate lands. The dry-zone agriculture resembles that of the neighbouring districts of Meiktila or Magwe (*q.v.*) and cotton is grown for export. The north end of the Singu-Chauk oilfield lies in the extreme southwest corner of the district. Myingyan town (40,000), district headquarters, is a river port and the terminus of a branch line taking off from the main Rangoon–Mandalay line at Thazi junction. (L. D. S.)

**MYITKYINA,** a town and district (area 22,317 sq.mi.; pop. [1964 est.] 18,000) in the Kachin state of the Union of Burma, formerly in Burma proper. The town (pop. 14,000) lies on the banks of the Irrawaddy river about 25 mi. below the confluence of its two headstreams, whence it is navigable for more than 1,000 mi. to the sea. It is also the terminus of the main railway from Rangoon. Northward the old mule track leads to Puta-o (150 mi.) and so to the Tibetan frontier. Along the railway are agricultural villages but most of Myitkyina is hilly and forested. The district lies north of Burma's dry belt and has a rainfall of 40–80 in. There are large areas of reserved forest with an output of teak and other timbers. (L. D. S.)

**MYLIUS-ERICHSEN, LUDVIG** (1872–1907), Danish journalist and explorer of Greenland, was born at Viborg, Jutland, on Jan. 15, 1872. He led two notable expeditions to Greenland in 1902–04 and 1906–08; the first yielded much valuable information on the polar Eskimo of the northwest, and the second important data on the geography of the northeast coast. He died in Nov. 1907, with two companions, while returning from a sledge journey to Independence fjord. (P. A. B. G.)

**MYLONITE,** in petrology, a rock which has been crushed and ground down by earth movement and at the same time rendered compact by pressure. Mylonites are fine grained, sometimes even flinty in appearance, and often banded in parallel fashion with stripes of varying composition. The great majority are quartzose rocks, such as quartzite and quartz-schist; but mylonitic structure may be developed in almost any type of rock. Gneisses of various kinds, hornblende-schists, chlorite-schists and limestones are not infrequently found in belts of mylonitic rock. The process of crushing by which mylonites are formed is known also as "granulitization" and "cataclasis," and mylonites are often described as granulites, though the two terms are not strictly equivalent in all their applications.

Mylonites occur in regions where there have been intense earth movements. Thrust planes and great reversed faults are often bounded by rocks which have all been crushed to fine slabby mylonites that split readily along planes parallel to the direction in which movement has taken place. These "crush belts" may be only a few feet or several hundred yards broad. The movements have probably taken place slowly without great rise of temperature, and hence the rocks have not recrystallized to any extent.

**MYMENSINGH,** a municipality and district in the Dacca division of East Pakistan. The town, formerly known as Nasirabad, lies on an old channel of the Brahmaputra, 70 mi. N. of Dacca, with which it is connected by a line of the isolated metre-gauge system of the Pakistan Eastern railway. Pop. (1961) 53,256. It was once noted for the manufacture of glass bangles. There is one college affiliated to Dacca university, and the East Pakistan Agricultural university was established at Mymensingh in 1961.

Mymensingh District, the largest in East Pakistan, lies in the north of Dacca division and east of the Jamuna, the main channel of the Brahmaputra. Area 6,361 sq.mi.; pop. (1961) 7,018,906. It is mostly an open plain covered with recent alluvium. In the east the district is intersected by extensive marshes and *haors* (*bhils;* depressed stagnant-water pools). They are submerged under water during the rainy season and form grazing ground during the cold season. With a large area consisting of the old alluvium the general elevation of the country west of the old Brahmaputra is higher. It is partly covered with red ferruginous clay and contains a great part of Madhupur jungle. The district has the highest acreage under rice, jute, sugar cane, tobacco, and mustard and pulses. More than 20% of the total produce of jute in East Pakistan comes from this district. Rainfall is heavy, the mean annual rainfall at Mymensingh town being 91.48 in. There are 15 colleges in the district affiliated to Dacca university. The well-known painter Zainul Abedin comes from Kishoreganj *tehsil*. The Provincial Administration commission (1960) recommended that the district should be split up into three districts—Mymensingh, Quaidabad and Nasirabad. (K. S. Ad.)

**MYNA** (Mynah), the name given to several species of starlings of India and Malaysia, the best known of which is the talking, or wattled, myna, *Gracula* (or *Eulabes*) *religiosa*. This is a glossy black bird, about a foot or more in length, with white patches on the wing quills, a thick orange bill, short yellow legs and variable yellow wattles under the eye and on the nape. It has some popularity as a talking cage bird, both in southeastern Asia and in the west. *See* also Bird. (A. L. Rd.)

**MYOGLOBIN** is an intracellular heme-containing protein found in both invertebrates and vertebrates. In vertebrates it occurs exclusively in red muscle and is the pigment responsible for the red colour. There is a close chemical similarity between myoglobin and hemoglobin, the red pigment of vertebrate blood. Like hemoglobin, myoglobin combines reversibly with oxygen. It is thought that myoglobin functions by storing molecular oxygen for use by the working muscle. In invertebrates the function is not clear but it appears to be similar to that in vertebrates.

At the low oxygen tension of venous blood, myoglobin combines with oxygen more readily than does hemoglobin; this favours the transfer of oxygen from blood to the muscle cells, where oxygen is consumed by the chemical reactions that provide energy for the exercising muscle. The combination of oxygen with myoglobin occurs in such a way that the ratio of the concentration of oxygenated myoglobin, or oxymyoglobin, to unoxygenated myoglobin is equal to a constant times the oxygen pressure. This simple relationship follows from the fact that there is one beme group in each molecule of myoglobin, and all the heme groups are alike but act independently.

In hemoglobin, there are four heme groups per molecule, and the heme groups within a molecule interact and differ in their affinity for oxygen, so that the combination of hemoglobin with oxygen is more complex than the combination of myoglobin with oxygen. For this reason, it is possible for the two heme proteins to have very different affinities for oxygen at low oxygen pressure but similar affinities for oxygen at high oxygen pressure.

Myoglobin has been obtained in pure crystalline form from many sources. It has a molecular weight of 16,000, about one-fourth that of hemoglobin. Though the heme portion of all myoglobins is the same, the globular protein portions vary considerably from species to species.

Myoglobin has been of great importance in the elucidation of protein structure. The complete amino acid sequence of sperm whale myoglobin is known. In 1962 the Nobel prize in chemistry was awarded jointly to John C. Kendrew and Max F. Perutz for their work on the structure of myoglobin and hemoglobin, respectively. Kendrew's work, utilizing the technique of X-ray diffraction, permitted construction of a three-dimensional model of crystalline sperm whale myoglobin.

*See* J. C. Kendrew, "Myoglobin and the Structure of Proteins," *Science,* vol. 139, no. 3561, pp. 1259–66 (March 29, 1963). (A. Dor.)

**MYRA** (mod. Demre in the *il* of Antalya, Turkey), one of the most important towns of ancient Lycia (*q.v.*), situated a short distance inland between the Myrus and Andriacus rivers, not far from modern Finike. No excavations have taken place at Myra, and its early history is unknown. St. Paul touched at Myra on his last journey westward, and boarded "a ship of Alexandria sailing for Italy." In the 4th century, St. Nicholas (*q.v.*) was its bishop. Theodosius II made Myra the Byzantine capital of Lycia, and as such it was besieged and taken by Harun al-Rashid in 808. The town seems to have decayed shortly afterward. The western scarp of the acropolis has been sculptured into a very large number of rock-cut sepulchres, imitating wooden houses and shrines, with pillared façades and reliefs. Some have Lycian inscriptions, pediment reliefs, or large-scale relief friezes, and one of them has a rock-cut porch with reliefs in their original colours. All of these date from the 5th to the 3rd centuries B.C. The theatre, one of the largest and finest in Asia Minor, lies at the foot of this cliff and is partly excavated out of it, partly built. There are also extensive ruins of the port of Myra, containing churches, baths and a great grain store, inscribed with Hadrian's name. They lie along the course of the Andriacus river toward the estuary. (F. J. Tr.)

**MYRDAL, (KARL) GUNNAR** (1898– ), Swedish economist and public official noted for his influential study of the Negro in the United States, was born in Gustaf parish, Swed., Dec. 6, 1898. He studied law at the University of Stockholm, graduating in 1923, and four years later received a doctor's degree from the same university. During the next few years he taught economics, traveled abroad, and engaged in research and writing. He married Alva Reimer in 1924 and with her prepared a study of Sweden's decreasing population that was published in 1934. The preceding year he had been appointed professor of economics at the University of Stockholm, a post he held until 1950. In 1938 he was selected by the Carnegie corporation to direct a comprehensive study of the Negro in the United States. His two-volume report, published in 1944 as *An American Dilemma: the Negro Problem and Modern Democracy,* contained a wealth of sociological, legal and anthropological data and emphasized the great gap between the nation's ideals and practices.

Myrdal served as a representative of the Social Democratic party in the upper house of the Swedish *riksdag* on two occasions, 1936–38 and 1944–45, and was a cabinet minister, 1945–47. For the next ten years he served as executive secretary of the UN Economic Commission for Europe. In 1960 he accepted appointment to a new professorship of international economics at the University of Stockholm. Alva Myrdal meanwhile had served as director of the Department of Social Sciences of the UN Educational, Scientific and Cultural organization (1951–55) and headed a Swedish diplomatic mission to India in 1955.

Among Myrdal's published works, in addition to that noted above, are *Monetary Equilibrium* (1939), *An International Economy: Problems and Prospects* (1956) and *Beyond the Welfare State* (1960).

**MYRIAPODA,** an obsolete term in use for a large group of many-legged, air-breathing arthropods, formerly regarded as a single class but now separated into four well-defined classes: Chilopoda, or centipedes (*q.v.*); Diplopoda, or millipedes (*q.v.*); Symphyla (*q.v.*); and Pauropoda (*q.v.*). *See* also Arthropoda.

**MYRICA,** a genus of the wax myrtle or sweet gale family (Myricaceae), containing about 40 species of shrubs or trees widely distributed throughout the world. Well-known representatives are the sweet fern (*q.v.*), sweet gale (*q.v.*) or bog myrtle, wax myrtle (*q.v.*) and bayberry. (J. M. Bl.)

**MYRISTICACEAE,** the nutmeg (*q.v.*) family, comprising 15 genera and 260 species, all tropical and especially numerous in Asia. They are trees or shrubs with evergreen leaves.

**MYRIVELES, STRATES** (Stratis Mirivilis) (1892– ), Greek novelist, whose best-known work is his "war trilogy": the *Zoe en Tapho* ("Life in the Tomb"; 1930); the *Daskala me ta Chrysa Matia* ("The Teacher With the Golden Eyes"; 1932); and the *Panagia Gorgona* ("The Mermaid Virgin"; 1955). Born in Lesbos in 1892, he first appeared as a writer in 1915 with a book of short stories, *To Kokkino Biblio* ("The Scarlet Book"), but it was in 1932 that he captured the public imagination, with his *Zoe en Tapho.* This is a series of war impressions from the Macedonian front, where the author fought in World War I. It was followed by the *Daskala me ta Chrysa Matia,* in many respects a maturer novel, which starts with the Asia Minor campaign of 1921–22 and continues in the island of Lesbos. The *Panagia Gorgona* tells of the life of a group of Greek refugees from Asia Minor who settled in Lesbos.

Myriveles also wrote several shorter novels and short stories; a lively travel book on Greece, *Apo ten Hellada* (1954); and a few poems and prose poems. His style is forceful and he has a fine mastery of language. Occasionally, however, the dialect and the lyrical elements in his prose are excessive. He is at his best in descriptions of natural scenery. (Ce. A. T.)

**MYRMIDONS,** in Homer, the inhabitants of Phthiotis in Thessaly of ancient Greece. According to post-Homeric legends their original home was Aegina, from which they crossed over to Thessaly with Peleus, but the converse view is now more generally accepted. Their name is derived from a supposed ancestor, son of Zeus and Eurymedusa, who was wooed by the god in the form of an ant; or from the repeopling of Aegina (when all its inhabitants had died of the plague) with ants changed into men by Zeus at the prayer of Aeacus, king of the island. As the fierce and devoted followers of Achilles, their name came to be used in modern times to mean subordinates who carry out orders implacably.

**MYROBALAN,** the name given to several different economically useful shrubs or trees of warm regions. Two species of *Terminalia* are called myrobalan, including the tropical or Indian almond of the family Combretaceae; their unripe, astringent fruits, the myrobalans of commerce, are a source of tannin. The emblic or myrobalan (*Phyllanthus emblic*) of the spurge family (Euphorbiaceae; *q.v.*) yields fleshy, globular fruit, about an inch across, that are made into preserves in tropical Asia. The myrobalan plum or cherry plum (*Prunus cerasifera*), although producing edible fruit, is valued more as a grafting stock and as an ornamental (*see* also Plum).

**MYRRH,** an agreeably aromatic but bitter-tasting resinous substance obtained from certain small thorny trees that belong to the genus *Commiphora,* of the incense-tree family (Burseraceae).

The name is derived from the Arabic *murr* meaning "bitter." The myrrh of present-day commerce comes from *C. myrrha* of Somaliland; in former times, Arabian myrrh, from *C. molmol,* shared commercial importance with Somali myrrh. Myrrh was highly esteemed in the ancient near east and Mediterranean regions, as evidenced by its being chosen by the Magi as a gift for the young child Jesus. It was used in costly incenses, cosmetics, perfumes, in medicines and for embalming. In medieval Europe myrrh was regarded as rare and precious but in present-day commerce the resin is of trifling value. An estimated 20,000 lb., valued at perhaps $5,000, are imported yearly into the United States. An essential oil distilled from myrrh is a constituent of certain heavy perfumes. Medicinally, myrrh possesses slight antiseptic, astringent, stomachic and carminative properties; tincture of myrrh has been used for relief of sore gums and mouth.

Myrrh trees, found on parched rocky hills, grow 4 to 20 ft. tall. The trunk, disproportionately short and thick, can attain a diameter of one foot; pale orange-brown bark on young trunks and branches may peel off to expose the pale green new bark beneath. The tree is in leaf and flower for only a short time, beginning usually in late August or early September. The leaves, borne in small tufts at the end of twigs, have three leaflets; the two side leaflets are small and inconspicuous. The white to light green flowers, about three-eighths inch long, occur singly or in small clusters among the leaves. The bark contains numerous resin ducts, from which, when the bark splits naturally or is cut in tapping, exudes a

BY COURTESY OF JOHN E. STEPHAN

LUMPS OF MYRRH RESIN, THE HARDENED EXUDATE OF COMMIPHORA TREES

yellowish fluid, the myrrh. Upon exposure to the air, the resin hardens slowly into globules and irregular lumps of varying size called "tears." The tears are collected from the trees during the dry summer months and in winter they are brought, commonly in goatskin bags, to the coast for export. Myrrh appears in commerce as yellowish-, reddish- or grayish-brown pieces. Myrrh is an oleoresinous gum: it contains 25%–45% of resin, 3%–8% of essential oil and 40%–60% of gum.

*See* G. W. Van Beek, "Frankincense and Myrrh," in *The Biblical Archaeologist,* vol. xxiii, no. 3, pp. 70–95 (1960). (J. W. Tr.)

**MYRTACEAE,** the myrtle or eucalyptus family of shrubs and trees. There are about 80 genera and approximately 3,000 species distributed widely throughout the tropics; the major centres of abundance in species and numbers are Australia and tropical America. All members of the family have evergreen leaves, usually rather leathery and with oil glands.

The family is of considerable economic importance in many parts of the world. The eucalyptus (*q.v.*) trees of Australia provide timber and oil of eucalyptus. Other products of world importance, primarily from the American tropics, include edible fruits

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SCARLET FLOWERING GUM (EUCALYPTUS FICIFOLIA)

of the guavas (*q.v.; Psidium*), rose apple (*Eugenia jambos*), Surinam cherry (*E. uniflora*), and feijoa (*q.v.; Feijoa sellowiana*); spices such as allspice (*q.v.;* the unripe berry of *Pimenta officinalis*) and clove (*q.v.;* dried flower buds of *Eugenia caryophyllata*); oil of bay rum (*Pimenta racemosa*).

Among the many members useful as ornamental plants, and introduced widely in warmer areas, are: bottle-brushes (*q.v.; Callistemon* and *Melaleuca*), Australian tea tree (*Leptospermum*), Brisbane box (*Tristania*), and common myrtle.

**MYRTLE,** common name for *Myrtus,* a genus of evergreen shrubs typifying the myrtle family (Myrtaceae), and especially the highly aromatic *Myrtus communis,* held by the ancients as sacred to Venus and used as an emblem of love. The plant is generally less than ten feet high with opposite, simple, rather thick and lustrous leaves, plentifully supplied with minute oil-bearing glands, upon which the foliage depends for its fragrance. The solitary flowers are white or pink, fragrant, about three-quarters of an inch wide, borne on short stalks in the leaf axils. The fruit is a purplish-black, many-seeded berry. The volatile oil found in most parts of the plant, known as myrtol, was once used as an internal antiseptic. Myrtle flowers, leaves and berries have been used in perfumery and as a condiment.

The common myrtle is native throughout the Mediterranean region and western Asia and is cultivated in southern England and the warmer parts of the United States, but it is not frost hardy. It is also widely grown in the cool greenhouse as the foliage is in much demand for decoration. Variegated, yellow-fruited and white-fruited varieties are also cultivated for ornament. While *M. communis* is the most commonly grown species of over 100 known in the genus *Myrtus,* the Chilean guava (*M. ugni*), with edible fruit, and *M. bullata,* a New Zealand shrub, are both grown.

JOHN H. GERARD

COMMON MYRTLE (MYRTUS COMMUNIS)

Other plants known as myrtle are wax myrtle (*q.v.;* genus *Myrica*); hog myrtle or sweet gale (*q.v.*); crape myrtle (*Lagerstroemia* species); sand myrtle (genus *Leiophyllum,* especially, *L. buxifolium*); gum-myrtle (*Angophora* species); downy myrtle (*Rhodomyrtus tomentosa*); and Oregon myrtle, the California laurel (*Umbellularia californica*). The creeping or running myrtle is the periwinkle (*q.v.; Vinca minor*). (N. Tr.)

**MYSIA,** an ancient district of northwestern Asia Minor, bounded by Lydia on the south, Phrygia on the southeast and east,

Bithynia on the northeast, the Propontis (Sea of Marmara) and the Aegean sea on the north and west. Its precise limits are difficult to assign; its frontier with Phrygia was vague and fluctuating, while in the northwest the Troad is sometimes regarded as part of Mysia, sometimes not. It is a mountainous country with a fairly high rainfall, and in antiquity was covered to a large extent with marsh and forest. The Mysians of the interior were late in adopting city organization, but the coasts were studded with Greek cities, including Adramyttium (Edremit) on the Aegean, Cyzicus (*q.v.*) on the Propontis and, inland, Pergamum (*q.v.*).

Ancient writers agree in describing the Mysians (Gr. *Musoi*) as a distinct people, though no action of theirs as an independent nation is recorded. They shared access to the temple of Carian Zeus at Labraunda on the grounds of kinship with the Carians and Lydians, but the geographer Strabo maintained they came originally from Thrace (*see* BITHYNIA; PHRYGIA) and were related to the Moesi (also *Musoi* in Greek) south of the Danube. Strabo stated that their language was a mixture of Lydian and Phrygian; the one doubtful fragment discovered in 1926 is inconclusive. The Mysians appear in the list of Trojan allies in Homer's *Iliad*. Together with all the neighbouring nations, they were subjugated by Croesus of Lydia and after his fall (*c.* 540 B.C.) were part of the Persian empire until its overthrow by Alexander the Great. Mysia was a Seleucid possession until the defeat of Antiochus III (190/189 B.C.), after which it was transferred by the Romans to Eumenes II of Pergamum. After the defeat of the Pergamene pretender Aristonicus (129 B.C.) it became part of the Roman province of Asia. To judge from the primitive armour ascribed to them by Herodotus, the Mysians originally had a simple culture, but they were later completely sophisticated by Greek influence. They were widely employed as mercenaries during the Hellenistic period.

**MYSORE,** a constituent state of the Republic of India, coinciding, after the State Reorganization act of 1956, approximately with the area within which Kanarese, or Kannada, is spoken. It has an area of 74,210 sq.mi. The state stretches from the west coast between the former Portuguese territory of Goa and the state of Kerala, across the Western Ghats to embrace a large section of the high southern part of the great Indian plateau. It is bounded north by Maharashtra, northeast and east by Andhra Pradesh and southeast by Madras. Before the independence of India in 1947 Mysore was a prosperous and progressive princely state ruled by a maharaja. The dynastic capital was Mysore city and the state administrative capital was Bangalore. Its area was 29,458 sq.mi. and population (1941) 7,329,140. Successive changes followed India's independence. The small British-Indian province of Coorg was absorbed in a greater Mysore and parts of Bellary district were transferred from Madras to Mysore in Oct. 1953. But the really great expansion came in 1956 when the transfer of districts of southern Bombay gave Mysore an outlet to the sea, and the addition of a large western part of the former Hyderabad state served to unite the Kanarese-speaking people. The modern state includes the old Mysore but is greatly extended; the old capital Bangalore (*q.v.*), though now excentrally placed and ill-served by communications with the western districts of the state, remains its capital; the maharaja became the governor of the state.

**Physical Features.**—That part of the state lying along the west coast has a very heavy rainfall from the southwest monsoon and is a northern continuation of the Malabar coast (*q.v.*). Coastal sand dunes give place inland to small alluvial plains with coconut-fringed lagoons, and then eastward the land rises sharply to the forested slopes of the Western Ghats. Numerous swift streams flow directly from the crest of the Ghats and include the Sharavati river with Gersoppa falls (*q.v.*). The coast is difficult of access except by sea. From the Ghats the land drops gently eastward and the greater part of the state lies on the rolling surface of the plateau. Near the Ghats rainfall is heavy and there are dense forests, but eastward rainfall quickly diminishes and monsoon forests give place to scrub forests and scrubland. Broad, open valley plains become more extensive as lower ground is reached eastward and the hilly forested country, called the *malnad*, of the west gives place to the more open plain country, known as *maidan*, of the east. The southern part of the plateau—the old state of Mysore proper—lies mainly in the basin of the Cauvery (Kaveri); the larger northern area is in the Krishna (Kistna) basin and an important tributary of the main stream of the Krishna is the Tungabhadra (*q.v.*). From early times the small streams have been dammed by earth banks to form tanks from which irrigation water was led; later came much larger dams or anicuts from which canals controlled large areas, *e.g.*, the masonry dam on the Cauvery near Mysore city. The old state was a notable pioneer in hydro-electric power development. This has been followed by many large works, notably the Tungabhadra and Sharavati Valley projects. (L. D. S.)

**History.**—Mysore was a relatively unimportant town which gave its name to the state in the 17th century when the *wadiyars* (*wodeyars;* "rulers") of Mysore came to power. The history of Mysore deals mainly with the state as it was before its expansion in 1953 and 1956 (*see* above), for no dynasty succeeded in ruling all Karnatak (Kanara); *i.e.*, the region occupied by Kanarese-speaking peoples. Its prehistory, insofar as it is known, is related in the article DECCAN.

After Asoka Maurya's time, the principal dynasties ruling in the area of Mysore were the Kadambas of Banavasi; the Western Gangas (3rd to 11th centuries A.D.; *see* GANGAS, WESTERN); the Banas, and other feudatories of the Pallava dynasty. The rich lands of the upper Tungabhadra region and the land between that river and the Krishna were taken from the Kadambas in the 6th century by a central Karnatak family, the Chalukyas (*see* CHALUKYA). Their efforts and those of their competitors, the Rashtrakuta (*q.v.*) dynasty, to unite the plateau and exploit the softer lands in the coastal plains enriched Mysore but led to reprisals. The reprisals of the Tamils have left traces in the archaeology and population of eastern and extreme southern Mysore.

After Malik Kafur, general of 'Ala' ud-Din Khalji, sultan of Delhi, had forced the submission of Ballala III Hoysala (*see* HOYSALA) in 1310–11, Mysore gradually came under the sway of the state of Vijayanagar (*q.v.*). After 1565 Muslim rule north of the Tungabhadra was undisturbed and Mysore remained as successor to the fading Vijayanagar empire. The *wadiyar* of Mysore seized Srirangapatnam (Seringapatam) in 1610, acquired more territory and displaced the imperial family. Under Chikkadevaraja Wadiyar (1673–1704) Mysore was prosperous and well ruled. Later, however, maladministration at home and interference in wars of succession in the plains (*c.* 1751) led to the usurpation by the military adventurer Haidar Ali (*q.v.*). His invasions of Malabar and the Carnatic plains led, after the Mysore Wars, to the death of his colourful and energetic son Tipu Sahib (*q.v.*) at Srirangapatnam and the conquest of Mysore by the British (1799), the cessation of war with the Marathas and Hyderabad, and the reinstatement of a child *wadiyar* as subsidiary ally of the East India company. After a period of tutelage to the credit of both parties, the dynasty received back responsibility for administration in 1881 (Bangalore "civil and military station" remaining in British hands). In 1913 a treaty between the government of India and Mysore signalized the paramount power's confidence in the competence and loyalty of Mysore. A happy relationship existed between the dynasty and the people. Sri Jayachamaraja Wadiyar, *rajpramukh* of Mysore upon its peaceful accession to India in 1947, remained the state's governor under the reorganization in 1953 and 1956. Educationally and socially advanced, the state is rapidly undertaking industrialization.

**Religion and Literature.**—Buddhism has left few traces in Mysore, but Jainism flourishes, particularly at Sravana-Belgola and in the coastal districts. Its decline as compared with Shivaism, particularly with the indigenous Lingayatism and Vishnuism, especially in the Ramanuja-Sri-Vishnu sect, dates from about the 12th century. Kanarese literature (from the 9th century onward) expanded with each of these faiths, and Sanskrit and Kanarese poetry were cultivated at all prosperous periods. (J. D. M. D.)

**Population, Administration and Social Conditions.**—Mysore state had a population of 23,586,722 in 1961, which showed an increase of 22% since 1951. The population of the cities and of the major towns according to the 1961 census is as follows:

Bangalore, the capital, 905,134; Mysore 253,865; Hubli 171,326; Kolar Gold Fields 146,811; Mangalore 142,669; Belgaum 127,885; Gulbarga 97,069; Bellary 85,673; Dharwar 77,163; Bijapur 78,854; Davangere 78,124; Raichur 63,329; Shimoga 63,764.

Kanarese (*q.v.*) is the language of administration and is spoken by about 60% of the people, other languages being Telugu (15%), Tamil and Hindi (each 7%). Kodagu, the language of the Coorg people, is a dialect of old Kanarese. The population is mainly Hindu, with some Muslims, Jains and Christians. More than two-thirds of the latter are Roman Catholics.

The state, which has a bicameral legislature, is divided into 19 districts grouped in 4 administrative divisions: Bangalore, Kolar, Bellary, Chitaldrug and Tumkur (Bangalore division); Mysore, Mandya, Hassan, Chikmagalur, Shimoga, South Kanara and Coorg (Mysore division); Belgaum, Dharwar, Bijapur and North Kanara (Belgaum division); Gulbarga, Bidar and Raichur (Gulbarga division). There are 288 towns and 25,880 inhabited villages in the state.

According to the 1961 census Mysore, with more than 25% of the population literate, was one of the educationally advanced states of India. There are about 30,000 schools and educational institutions, including two universities (Mysore, and Karnatak in Dharwar), nearly half of which are managed by the government, and the remainder by local boards and private bodies. Compulsory free primary education is provided in about 4,370 towns and villages.

By the mid-1960s there were about 900 hospitals and dispensaries and a number of health centres in urban and rural areas. The Employees' State Insurance scheme covers sickness, maternity and employment injury risks, and provides free medical treatment to 48,000 factory workers and their families in Bangalore. Welfare plans run by the government for tribal and backward classes include provision of houses, cash subsidy for purchase of agricultural implements, scholarships, community centres and cultural and recreational facilities. The State Social Welfare board also provides educational, cultural and welfare facilities for women and children through more than 400 rural centres. (S. Ch.; S. B. L. N.)

**The Economy.**—The forests of the *malnad* produce various timbers, bamboo and minor products. The bulk of the world's sandalwood comes from the Mysore forests; oil processed from it at Mysore city is a leading state export. Agriculture is the main occupation of three-quarters of the population, with rice, mainly irrigated, occupying a third of the land under food crops, the second biggest crop being millets. Other leading crops are peanuts, other oilseeds, cotton, sugar cane and tobacco. Nearly two-thirds of India's coffee is grown in southern Mysore and there is a considerable production of tea in the higher hills adjoining the Nilgiris of Madras state. There is a little rubber in the western regions, and fruits such as bananas and oranges are widely grown. The second five-year plan (1956–61) aimed especially at increasing irrigation and intensifying agricultural production. Reddish soils are the rule, but not all are suitable for irrigation. In places the pre-Cambrian rocks of Mysore are highly mineralized; manganese ore, iron ores, mica and chromite are obtained in small quantities. Kolar Gold Fields (*q.v.*) in the east of the state have long been India's chief source of gold. In the years between World Wars I and II production was between 300,000 and 400,000 fine ounces; by the 1960s about half these amounts were obtained from the chief mines, now nationalized, in workings up to 9,000 ft. deep.

With its varied natural resources and abundance of hydroelectric power (Sharavati project, near Jog, being the largest), the state is well equipped for development of modern industry. Bangalore manufactures machine tools, aircraft, electrical materials, telephones and electronic equipment; the Mysore iron and steel works are at Bhadravati; the Tungabhadra irrigation works favour developments farther north. Other industries include the making of cement, paper and sugar. Both Mysore city and Bangalore have old established silk industries.

Bangalore has long been a focus of railways and is now served by an international airport and good roads, especially to Madras, the north (Hyderabad), northwest (Bombay) and westward through Mysore city and Mercara to the west coast at Mangalore. Main centres in the heart and north of the state include Davangere, Bellary, Hubli, Belgaum, Bijapur and Gulbarga.

*See* also references under "Mysore" in the Index. (L. D. S.)

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**MYSORE,** a city and district of Mysore state, India. The city, the state capital during the Wadiyar (Wodeyar) dynasty and now the district headquarters, lies 250 mi. W.S.W. of Madras and 86 mi. S.W. of Bangalore by rail. Pop. (1961) 253,865. It is situated on an undulating plateau at an altitude of 2,525 ft. northwest of the Chamundi hill and halfway between the Cauvery (Kaveri) and the Kabini rivers. Rain-filled shallow depressions (tanks) surround the city.

Mysore, though large and industrial, has wide streets and many parks, and a reputation of being the "garden city" of India. The fort area comprises the maharaja's palace (1897), Curzon park, the Silver Jubilee clock tower (1927), Gandhi square and the two maharajas' statues. The former British residency (government house) built in 1805, the Victoria Silver Jubilee institute (now known as the Oriental library), university buildings (Crawford hall), law courts and the public offices are located near Gordon park to the west of the city. The statue of Sir John James Gordon, who was tutor of Maharaja Chamarajendra and in 1878 became chief commissioner of Mysore, stands at the entrance to the public offices. The summer palace, Lalitha Mahal, the pleasure palace, zoological gardens, Mary Holdsworth hospital (a memorial to the Wesleyan missionary) and the three kumaris' mansions are the other main buildings. Krishnaraj Sagar, a reservoir (50 sq.mi.) with a dam across the Cauvery, lies 11 mi. N.W. Below the dam are the beautiful terraced Brindavan gardens, with cascades and fountains, which are floodlit at night.

The city is a centre of learning and the seat of Mysore university, established in 1916. The Maharaja's college offers graduate and postgraduate courses in languages and the humanities. There are affiliated colleges of medicine, law, engineering and teachers' training besides a college for women.

Mysore is an important manufacturing and trading city, with textile (cotton and silk), rice and oil mills, sandalwood oil and chemical factories, and tanneries. Cotton-weaving, tobacco- and coffee-processing and the making of *bidis* (local cigarettes) are the principal cottage industries. There is a market near the railway station for agricultural products from adjacent rural areas.

The town of Mysore was known as Mahishmati and is mentioned in the epic *Mahabharata.* In the Mauryan reign (3rd century B.C.) its site was occupied by a village known as Purigere, which became Mahishapura, and is referred to as Mysore. It ceased to be the administrative capital from 1610 to 1799 and again from 1831 to 1881, when it was superseded by Bangalore (*q.v.*).

Mysore District (area 4,617 sq.mi.; pop. [1961] 1,671,399) is drained by the Cauvery and its tributaries. The Nanjangud and Chamarajnagar talukas have large tracts of black soil devoted to cotton production. The southwest of the district abounds in wild animals and has semi-*malnad* characteristics (*see* Mysore: *Physical Geography*). Bandipur is a famous wild-elephant trapping region and is a tourist centre. The open country (*maidan*) produces both wet and dry crops; the district exports rice, millets and oilseeds to the neighbouring Madras state in the south.

At Srirangapatnam (Seringapatam), 10 mi. N. of Mysore city, are the mausoleums of Tipu Sahib and Haidar Ali. (G. K. Gh.)

**MYSTERY.** In classical antiquity the word mystery (Gr. *mysterion*), or mysteries, for the plural was more generally used in this sense, denoted a religious rite about which one kept the mouth or eyes closed; *i.e.,* a rite which was not to be revealed to the uninitiated. This article deals only with such ancient rites; for the medieval mysteries *see* Drama: *Medieval Drama.* Much of what follows is necessarily conjecture, as the evidence is fragmentary and debatable.

**The Rites.**—The secrets of the rites were apparently well kept, so that there is but vague and doubtful information as to what went on. Theon of Smyrna (2nd century A.D.) professes to give an outline of the procedure by way of illustrating the stages by which one becomes a philosopher, and says there are five.

1. Purification is preliminary and there is nothing distinctive about it (*see* LUSTRATION), but Theon seems to include in it the preparatory address that warned off those who were ineligible by reason of "impure hands or unintelligible speech"; *i.e.*, labouring under pollution—such as that of homicide—not yet purged by the proper ritual, or unable to understand the language used, which presumably was Greek. Aristophanes parodies this in *The Frogs*, and Lucian states in his life of Alexander of Abonuteichos that the latter began his initiatory rites with a proclamation bidding all Christians and Epicureans begone. This again is not peculiar to mysteries: Callimachus in his *Hymn to Apollo* bids anyone who is a sinner depart because Apollo is visiting his temple, but Apollo is not a god of mysteries.

2. The conferring of the rite constitutes the initiation proper.

3. The highest degree of initiation (called *epopteia*) follows.

4. Then the initiate is garlanded, and this confers upon him the power to initiate others.

5. A state of blessedness results.

There is no reason to suppose that Theon had any particular mysteries in mind, certainly not those of Eleusis, except in a very general way, for the fourth stage definitely cannot apply to them. His initiate may initiate others "if he gets the position of hierophant or *daduchos*" ("torchbearer"), but at Eleusis these priesthoods were reserved for members of two ancient priestly families and no other initiate could be appointed to them. The fifth stage is the statement of a sentiment expressed in one form or another from the Homeric hymn to Demeter onward and throws no light on what happened during the initiation.

**Classical Mysteries.**—By far the most famous are those of Eleusis, so much so that when an Attic author speaks of "the mysteries" without qualification it is regularly these that he means. There is very little information concerning what was actually done, and scholars evolved all manner of fantastic theories which were later rejected by modern researchers, beginning with C. A. Lobeck (1781–1860). However, excavations, inscriptions and careful sifting of the literary testimonies have given a fairly clear outline of the procedure. The date was Boedromion 13–22 or 23, and this is doubly significant. The days of the actual initiations were the 21st and 22nd, that is to say they fell during the wane of the moon, which is one of the appropriate times for chthonian rites. Demeter and her daughter Kore are chthonian deities, the embodiments of the old and new grain; while the god that with the goddess makes up the pair of Eleusinian deities is Pluto, not as god of the dead but as the giver of wealth, which, in its earliest form among men above the food-gathering stage, is the fruits of the earth.

More important than this, Boedromion is a month of late summer or early autumn, about August–September of the Julian year. At that time Greek fields are at their most desolate and barren looking, for the harvest has long been gathered, the weather is hot and dry and the autumn sowing has not yet started. The grain has been stored away in underground receptacles, so Kore, the corn-maiden, is literally underground and has been so for roughly a third of the year. When the autumn plowing and sowing are done, the fields soon become green again and remain so almost all the winter until late spring or early summer, when the grain ripens.

All this fits admirably with the myth as told in the Homeric hymn to Demeter, the date of which can hardly be later than *c.* 600 B.C. (*see* HOMERIC HYMNS). This tells how Hades (Aïdoneus, Pluto) wanted a wife and how, with the connivance of Zeus, he carried off Persephone (Kore), daughter of Demeter (or Deo). Demeter, who searched for her, was told by Hecate and Helios what had happened, and in her disconsolate wanderings she came in disguise to the house of Celeus, king of Eleusis, where she was received. Acting as nurse to his child, she planned to make the baby immortal by burning away the mortal part of his body and anointing him with ambrosia, but was prevented by the interference of Metanira, his mother. Demeter then revealed herself, to the great awe of the Eleusinians, who built her a temple. Meanwhile the earth had produced no grain and Demeter had refused to be reconciled to the other gods, so Hades was bidden to send Persephone back. This he did, but because she had eaten a pomegranate seed while in the underworld she could not be completely released, and a compromise was reached by which she spent one-third of the year with her husband, the rest with her mother. Satisfied with this, Demeter caused grain to grow again and taught the Eleusinians her rites; whoever receives them is blessed above other mortals when he dies.

It is plain that this myth embodies a blend of the etiological myth of an ancient agricultural rite with a story of the god of the dead and his wife. The former is at least predominantly Greek; the latter contains the obviously non-Greek name Persephone, whose widely varying forms (Phersephassa, Pherrephatta, etc.) show how hard Hellenic mouths found it to pronounce. Such confusions between what may be called the upper and lower chthonians (*i.e.*, between those who give the fruits of the earth and those who govern or inhabit the world of the dead) are fairly common and characteristic of Greek belief.

There is sufficient reason to suppose that the agricultural rite is very old. Not only is the name Eleusis non-Hellenic and so presumably belonging to the language of the pre-Greek population, but there is good archaeological evidence of a Mycenaean settlement on the spot, and more especially on the very site, occupied in historical times by the sacred buildings and therefore, it may reasonably be supposed, sacred from time immemorial. It may even be that the "two deities" or the "god and goddess" of classical terminology descend from a pair, perhaps always nameless, of pre-Hellenic date, identified by the Greeks with their own Demeter (if she was indeed a purely Greek goddess, a somewhat doubtful point) and her daughter, the maiden (*kore*). As to the ritual of the mysteries, if the information given by Hippolytus is trustworthy (*see* below), the divine child is an outstanding feature of a still older stratum of religion, the cults of the Minoan age, radiating out from Crete.

A question frequently asked in connection with this and other mysteries is why they were kept secret at all. An obvious suggestion, several times made, is that being pre-Hellenic they were looked upon with disfavour by the invading Greeks and perhaps even persecuted. But anything like cogent evidence for this is lacking. The Greeks were polytheists from the earliest-known times, and polytheism tolerates foreign gods, including those of an invaded country. A people which held Athena in high regard and made the great goddess of Argos the sister and consort of their own chief god are not likely to have been harsh to a beneficent deity who, if properly worshiped, made the Eleusinian fields bear good crops. It seems much more probable that either the Eleusinians themselves were jealous of their traditional approach to their goddesses and did not wish strangers to become acquainted with the approved ritual, or that possibly they held certain members of their own people to be unworthy for the time being of participation. Comparable, perhaps, is the completeness with which the initiation rites of boys in certain primitive communities are guarded from the women and the younger boys (*see* PASSAGE RITES), and a trace of this may have lingered until comparatively late at Eleusis and so become traditional. However, the curious fact remains that according to Diodorus Siculus similar rites were performed quite openly in Crete. It is much to be regretted that no description of those rites is known.

A good deal of the ceremonial was open even in the Eleusinian ritual, at least in historical times when Eleusis had been taken over by Athens. The mysteries were free to everyone not disqualified in the ways mentioned above, at first to all Greeks (perhaps the circle of those admissible was gradually extended), later to Roman citizens also, and it is not to be forgotten that to many educated Romans the Greek language was almost as familiar as Latin. There were some preliminary arrangements when the *epheboi* (youths undergoing their two years of military training and employed in light duties) went to Eleusis on Boedromion 13 and

brought back certain holy objects, arriving at the temple of the deities of Eleusis on the 14th. Apart from this, the first day of the ceremonial proper, Boedromion 15, was known as the Gathering, the next day as *halade mystai* ("initiants to the sea"), when there was a ritual bath in the great cleanser of all human evils. Then followed a gap of two days, filled, after the reception of Asclepius (Aesculapius) (*q.v.*) in Athens, by ceremonies in his honour, which have nothing to do with Eleusis.

On the 19th came the famous procession to Eleusis along the Sacred way. It was made on foot; at one point a bridge had to be passed and certain ritual jests were made there. On the way the cry *Iakch' o Iakche* was raised which, whatever it may originally have meant, was interpreted as an invocation of a god called Iakchos. This name, presumably because it sounded not unlike Bacchus, was taken to be a title of Dionysus, who in fact seems not to have had any real connection with the mysteries till the 4th century B.C. However, the identification found its way into Athenian cult, for at the Lenaea, which is undoubtedly a festival of Dionysus, the *daduchos* (presumably the Eleusinian official; *see* below) cried "Invoke the god!" and the people answered "Semele's son, Iakchos, giver of wealth!" In the evening of the 19th—and therefore, by Greek reckoning, which began the day at sunset, on the 20th—the procession reached Eleusis and the mysteries proper began by torchlight.

These were under the immediate control of Eleusinian officials, chosen from certain families. The chief was the *hierophantes* ("displayer of holy things"), who was always one of the Eumolpidai, a house tracing its ancestry to mythical times. Next to him came the *daduchos* ("torchbearer"), who was one of the family known as Kerykes, or heralds, until they died out and were replaced by an Athenian clan, the Lykomidai, who also claimed very long descent. These were, so to speak, the chief of the officiating clergy. General control was exercised in historical times—but obviously not while Eleusis was still independent—by the archon basileus (*see* ARCHON). As to what the rites included, there are only hints, mostly from very late authors who, oftener than not, were Christians and therefore hostile. But one thing is certain: no secret doctrine was taught, for there was none to teach. Greek religion, more especially in its older forms, had neither creed nor dogma, and the fancies of older scholars who did not realize this are wholly without foundation either in direct evidence or in general probability. Apart from these negative considerations, there is a most valuable piece of positive evidence in a fragment of a lost dialogue by Aristotle, *On Prayer*. In this the philosopher gives it as his opinion that those undergoing initiation "have to learn nothing, but to experience something and be in a certain condition." He does not specifically mention Eleusis, but there can be little doubt that these, the most famous of all mysteries and well known to one who spent much of his life at Athens, were in his thoughts. The saying is easy to interpret in the light of the mental state of any pious member of one of the older Christian churches at any of its great ceremonies. He is presumably already acquainted with the dogmas concerning, for instance, the resurrection, and so is taught nothing by the Easter ritual, but this does not prevent his being greatly moved and edified by it.

Lucian provides a key to the proceedings when he speaks of "one of the initiates speaking out and dancing out the secrets of the two deities," and other late authors have the corresponding phrase, "to dance out the mysteries," meaning to reveal what should not be revealed. There was, then, a sacral dance which, like most performances of that kind, was meaningful and so may well have been a kind of ballet hinting at, if not actually displaying, the central features of the myth, whatever else it may have signified. There is a further hint in Tertullian, who, in the course of one of his attacks on pagan deities, asks indignantly *"cur rapitur sacerdos Cereris, si non tale Ceres passa est?"* ("why is the priestess of Demeter carried off, if something of the sort did not happen to Demeter?"). He is probably confusing mother and daughter, but it is not improbable that the priestess took part in the sacred ballet and represented Persephone. Since everyone knew the myth it may have been impious merely to reveal that it was acted in the hall of initiation.

There are a few other hints, not necessarily to be taken at their face value, since it is by no means always certain that they really refer to Eleusis or, if they do, that they are not willfully distorted or based on insufficient knowledge. One of the best is the confirmation by Clement of Alexandria of what has just been said: "Deo and Kore have ere now become a mystical play, and Eleusis holds the torch to their wandering, abduction and grief." More interesting, if true, are two statements of Hippolytus. One is that "the hierophant himself, not castrated like Attis but made impotent by hemlock and having utterly renounced fleshly generation, at night in Eleusis, while celebrating the great and unspeakable mysteries, cries aloud saying, 'Our Lady Brimo has brought forth a holy child Brimos.'" The context does not encourage great confidence in his testimony, for it occurs in the middle of a long diatribe against the Naassenian heretics and is largely concerned with Phrygian, not Attic, rites, but vase paintings associate the Eleusinian deities with a child, probably Plutus, and a holy or divine child is a characteristic figure of Minoan-Mycenaean religion. If the hierophant indeed used artificial means to lessen his own virility, that at least is hardly a procedure of early days but does suggest that part of the sacral performance was a marriage rite, in which he perhaps played the part of Pluto, though direct confirmation of this is quite lacking. Hippolytus again says that "the Athenians" displayed a reaped stalk of corn as their *teleiotaton epoptikon mysterion,* and although the meaning of *teleiotaton mysterion* is certain ("the most perfect mystery"), that of *epoptikon* is doubtful. It is possible that the phrase refers to part of a second ceremony, the *epopteia,* which an initiate might later undergo if he chose, and this in itself is credible. The cornstalk would be a sign that Persephone, although she had departed, would return and that she neither dies nor quits her worshipers forever; this would be a perfectly acceptable climax to a rite originally agrarian and perhaps as much magical as religious. In any case, the religious ballet or drama was a simple affair, for the *telesterion* (*see* ELEUSIS), which has been thoroughly excavated, shows no signs of having any elaborate apparatus for stage effects or illusions. Doubtless the flickering light of the torches, however, would lend a certain weirdness to the performance.

There is some evidence that the part played by the initiands (*i.e.*, those to be initiated) was not entirely passive. Clement of Alexandria quotes what he calls a *synthema,* apparently a sort of password or sign of mutual recognition used in connection with the mysteries: "I have fasted, I have drunk the *kykeon,* I have taken from the chest; having wrought [*ergasamenos;* Lobeck suggested *engeusamenos*], I put back into the basket and from the basket into the chest." The *kykeon* was a drink composed of water, meal and pennyroyal, said to have refreshed Demeter on her arrival at Eleusis after she had refused wine (often tabu in chthonian rites). What it was that the initiand took from the chest, how he "wrought" with it (or, on Lobeck's reading, what it was that he "tasted"), why he put it into a basket and thence into the chest again are matters on which there is no information, and there is little use in guessing. But clearly there were certain ritual actions which he had to perform at the time of the mysteries: the fasting was part of the preliminary purification, like the sea bathing, and is a not uncommon feature of various kinds of ritual, while both the chest and the basket are typical and familiar receptacles for sacred objects used in the rites of Demeter and not to be exposed to the general gaze, and they are not confined to Eleusis. Naturally, the obscure language is intentional; such a formula would prove whether a stranger was an initiate or not, without telling a third person anything he should not hear.

Although there cannot originally have been any doctrinal discourse by the hierophant or anyone else, that official did undoubtedly say something to the initiands. This is implied by Galen, for instance, who speaks of the attention paid to "things said" as well as things done, and there is an epigram on a hierophant who "poured forth a delightsome voice." Similarly the story by the rhetorician Sopatros (5th century A.D.), for what it is worth, tells of the man who dreamed that he had been initiated and on waking was anxious to hear the voice of the hierophant. But what he said is not known; possibly he explained the meaning of some of the

ritual. Neither is it known whether he followed any traditional text or was at liberty to improvise as he chose. Generally speaking, elaborate liturgical texts do not appear to have been used in classical Greece; therefore the latter possibility is more likely and, if this was so, the hierophant's speech may have gradually developed into a philosophical discourse in accordance with current speculations. But nothing proves this. Of other spoken parts of the ritual only one scrap is known, again from late sources but fairly certain. Hippolytus speaks of "the great and unspeakable Eleusinian mystery, *kye, kye* ['rain, conceive']", as simple a prayer formula as could be imagined, the first word addressed to the sky, the second to the earth. In addition, there was no doubt some singing (the invariable accompaniment of dancing) instanced by the ancient name of the Eumolpidai, the clan of Eumolpus; *i.e.*, of the "good singer." One further indication regarding the ritual hints that in later times some of the outward show was modernized, though it is hardly likely that the important parts of the ceremony (the canon, so to say, of the Eleusinian mass) were changed at all. This is the statement of Porphyry, preserved by Eusebius of Caesarea, that "the hierophant is costumed in the likeness of the Creator, the *daduchos* in that of the Sun, the sacrificial priest [*ho epi bomo*] in that of the Moon and the sacred herald [*hierokeryx*] in that of Hermes." If this is not simply Porphyry's fancy (and he is a fanciful writer, overfond of reading Neoplatonism into everything), it certainly denotes a change, for the original rite had nothing whatever to do with astral worship, cosmogony or Hermes.

A feature of the Athenian interest in what was, to begin with, a purely Eleusinian custom is the ceremony of the "child from the [civic] hearth." This was the annual choice by lot of an Athenian boy of good family to be initiated. Porphyry again says that he "placates Deity in the room of all the initiands, by performing accurately what is commanded," and this shows that quite young candidates were accepted.

It remains to ask if anything corresponding to Theon's fourth and fifth essentials of initiation is to be found at Eleusis. The garlands may be assumed, for they were regularly worn during religious ceremonies, but they had no special ceremonial, so far as is known, and no extraordinary significance. The beatitude of the initiates is an idea at least as old as the Homeric hymn, and a long series of testimonies of later date might be compiled. To explain this it is not necessary to assume any close communion with the Eleusinian deities resulting from the ritual. It seems to have been universally assumed that to be initiated meant winning the favour of whatever deities presided over the initiation. An occasional mark of divine favour was to make the favourite in some sense immortal, by transporting him to Elysium or otherwise, and so exempt him from the dreary lot of the ordinary dead in the Homeric and later underworld. This would be particularly easy to suppose in the case of chthonian deities owing to the frequent confusion between "upper" and "lower" chthonians, and not least with reference to Demeter, for an attested euphemism for the dead is "Demeter's people." Exactly how the favour was to be shown and how the initiate was to fare in the next world would be left to the initiate himself to determine in accordance with whatever ideas, philosophical or other, he might accept. Some idea of how the average Athenian of the late 5th century B.C. conceived this may be gathered from Aristophanes' *The Frogs*.

An Athenian intrusion, not into the Eleusinian ritual itself but into its preliminaries, was the requirement that an initiand must first have been initiated in what were known as the Little Mysteries (those of Eleusis being the Great). These were celebrated at Agra in the spring month of Anthesterion, probably in honour of Demeter, whose temple stood there on the banks of the little river Ilissus. Nothing is known of the ritual, except that apparently the water of the Ilissus was used for purifications and that the candidates wore cloaks which they must never change until they wore out. That these, too, were agricultural rites is fairly clear from the season: the young crops would by that time be showing well above ground.

**Hellenistic and Roman Times.**—The great increase in a demand for a personal religion (*i.e.*, for gods who were interested in the individual as such and not merely, or chiefly, as a citizen of a given community) was partly caused by the collapse of the city-state as a real political power and its replacement by comparatively large kingdoms. Mysteries were one of the obvious ways of meeting this demand. It is probable that Eleusis, to begin with, had carried with it no more than an assurance that its deities would continue to give the community the civilized sustenance on which it depended for its continued existence, and that the hope of individual favours was a secondary growth; but in the new mysteries which sprang up on every hand there can be little doubt that, even if they were managed by communities (as those of Andania; *see* below), their intent from the first was to secure for each initiate the favour of the gods concerned.

*Orphism.*—During this later period there seems to have been a certain revival of that religious movement or group of movements known as Orphism. This appears in the time of Plato to have degenerated into a parasitic dependence on such well-to-do persons as could have their fears worked upon or their desires excited by unscrupulous suppliers of charms and rites, until they were willing to pay good prices for ceremonials which were alleged to ensure their happiness after death or to harm their enemies in this life. Whether anything which could be properly called mysteries were celebrated by the more respectable representatives of Orphism there is no way of knowing, but certainly some believers in that or a similar doctrine used books describing the journey of the soul after death and the means by which it might attain happiness. Extracts from such writings, inscribed on gold leaf, have been found in various places and are of various dates, and they deal with a thirsty and apparently long journey of the soul until it arrives at a place where there is a spring on the left-hand side (perhaps Lethe), which it must not approach. There is another, presumably on the right, which flows from the "lake of memory," and the soul is to address the guardians of it, claiming heavenly descent, complaining of thirst and asking to be given of the water. It is then kindly answered and assured of divinity. This suggests, but does not in itself prove, the existence of some previous Orphic rite of initiation which was a survival of Pythagoreanism in some popular form. Knowledge of the complete poem from which these tablets seem to be somewhat corrupt extracts might make it possible to judge more accurately.

*Andania.*—The most famous Hellenistic mysteries are those of the Messenian town of Andania, of which there is fortunately both literary and inscriptional evidence. Pausanias gives what may be considered the official account of their origin—that they were founded in the heroic age by Lykos, son of Pandion, king of Attica—and also has a story that Epiteles, commander of an Argive force serving with Epaminondas of Thebes against the Spartans, dreamed that a man of imposing appearance, "most like a hierophant," bade him dig in a certain place, and when he did so he found a jug containing a roll of tin inscribed with the directions for the rites. The mysteries were, according to Pausanias, second in majesty only to those of Eleusis. They were in honour of the "great goddesses," Demeter and Kore, and the latter had the epithet of Hagne, "the pure." The claim to an origin in mythical times need not be taken very seriously, nor the alleged circumstances of the discovery, but there is nothing to disprove that an ancient cult of Demeter and Kore, or possibly some local deities equated with them, had existed and been interrupted by the Spartan conquest of Messenia. A long inscription of 92 B.C. gives elaborate directions for the conduct of the rites, although naturally it gives no details of what went on during initiation. The ritual was performed by certain "holy ones" of both sexes who were chosen from the various tribes into which the people were divided, presumably the same number from each tribe. Supervising the whole procedure was a committee of ten persons of mature age (not less than 40 years old).

Despite the reticence concerning the ceremonial, there are some glimpses of what went on. There was a written text of directions of not inconsiderable length, for the inscription speaks of *biblia* ("volumes"), contained in a case of some sort, which are to be put into the hands of the celebrants. Initiation seems to have been open to men, women and children, bond and free, for there are detailed directions as to the costumes to be worn by all these classes

of initiands: all are to be severely plain and not of too expensive material. One exception is made, for those who are to be "costumed into the likeness of deities," from which it is a reasonable assumption that some kind of pageant or rudimentary drama was performed. There was a procession, precedence in which was strictly regulated, and the main ceremonial was preceded by sacrifices to a number of deities—Demeter, Hermes, the Great gods (perhaps the Dioscuri, who are prominent in Messenian tradition), Apollo Carneius (a god widely worshiped by Dorians) and Kore Hagne. Plainly Apollo has nothing directly to do with the mysteries, but is present perhaps as lending his beneficent patronage to Messenian cults generally. The other deities are appropriate, Hermes manifestly being included in his chthonian aspect.

*Isis.*—Other mysteries widespread in the Hellenistic and still more in the Roman period include the Egyptian rites, particularly those of Isis (*q.v.*). Although once more the reticence of a pious initiate prevents Apuleius from revealing details, a good deal can be learned from his eloquent description of Lucius' experiences in the *Golden Ass.* After preliminary instruction and a period of abstinence he was dressed in a linen garment and taken to the temple where, he says, "I trod the threshold of Proserpina and came back borne through all the elements; at midnight I saw the sun ablaze with white splendour; I came into the presence of the gods infernal and supernal and adored them face to face." The ritual lasted till dawn, when he was clothed in an elaborate costume in resemblance of the sun-god, seated on a dais and exposed to the admiring gaze of the congregation. Feasting and merrymaking followed. Clearly this implies either strong imagination on the part of the initiand during the ceremony, or an elaborate performance involving the use of some kind of apparatus for the light effects and several actors to represent the gods. The prevalence of solar cults at the time, together with the familiar idea that the initiate was brought into very close relations with the deities presiding over the rite, explains his imitation of the sun. Apuleius emphasizes the heavy expense involved, and comparable is the fact that at Andania a certain amount of revenue (*diaphora*) was handled by a board of substantial citizens. This, however, was public money, whereas in the mysteries described by Apuleius it had to be found by the initiand himself or his friends; they were private affairs comparable to the ceremonies of any modern church which is dependent for its support on the contributions of the faithful. It is noteworthy that these foreign cults, not only of Isis, but of Mithras (*see* MITHRAISM), Attis (*q.v.*) and others, took little hold on Greece proper although they were widely popular elsewhere in the Greco-Roman world. There are abundant instances of persons undergoing initiation into a number of mysteries of various deities, and the stress is often laid on the eschatological side, as sepulchral inscriptions and literary evidence testify.

One development of this was the occasional initiation of young children in order to secure their future blessedness if the high infant mortality of those days carried them off. There is a late but interesting testimony in the lament of the rhetorician Himerius for his little son Rufinus. This boy was a "child from the [civic] hearth" and also, it would seem, an initiate in some Dionysiac mystery. The bereaved father reproaches Demeter and Kore for not preserving his child and asks how he can continue to trust Dionysus. He then comforts himself by the reflection that his son now enjoys the company of the gods, especially of certain youthful figures of conventional mythology, such as Eros and Hymen, and with characteristic vanity adds that his speech will immortalize the child on earth. A kind of commentary on the whole tone of the passage is furnished by, *e.g.*, the tomb fresco reproduced and commented on by F. Cumont (see *Bibliography*): a six-year-old girl, Octavia Paulina, is shown carried off by Eros (as Persephone was carried off by Hades) and introduced by Hermes into a sort of childish Elysian fields where a number of other young spirits are playing and gathering flowers. It may be that this child was an initiate, perhaps into the Dionysiac mysteries.

*Dionysus.*—Dionysus (*q.v.*) was not originally a god of the dead but of the fertility of nature. The first traces of his activities in the underworld are to be found as early as the 6th century B.C., not, however, in Greece proper, still less in his native Thrace, but in southern Italy (Magna Graecia), which was one of the principal regions where the Orphic movement spread and was also the home of Pythagoreanism. Among the Orphic writings a poem, or poems, deals with a descent into the nether regions, and terra-cottas from Tarentum and Locri show Dionysus associated with both Demeter and Persephone. A famous inscription from Cumae, dating from the early 5th century B.C. and evidently set up originally in a cemetery, reads, *ou themis entoutha keisthai ei me ton bebachcheumenon* ("it is not lawful for any to lie here save the initiate of Bacchus"). Considering the great popularity of Dionysus (or Bacchus), the fact that his votaries were on occasion so far identified with him as to be called Bacchoi and the legend that he visited the underworld to bring back his mother, Semele, it is understandable that in time he should have been thought of as having power to help his worshipers after death. Also, the element of secrecy about his most characteristic rites, which were traditionally held in lonely places, may have contributed to the formation of mysteries in the proper sense. Be that as it may, his mysteries were among the most popular, in late times especially, and differ from those of the foreign gods already mentioned in that they were, so far as can be judged, of purely Greek or Greco-Italian origin. It must not be assumed that all late developments of his cult were concerned with the fate of man in the afterlife, however; *e.g.*, there is no proof that the notorious Bacchanalia of A.D. 186 promised their initiates a blissful immortality, although it is not impossible that they should have done so. But here and elsewhere one striking new feature is to be observed: namely, that some of the participants in the secret rites were men, whereas those taking part in the classical Dionysiac orgies were almost exclusively women. But women remained very prominent, as is shown in the famous frescoes of the Villa Item, Pompeii; however these are interpreted, they certainly contain Dionysiac elements and most of the figures are female. Another example (one of several) is to be found in the *Miles Gloriosus* of Plautus, together with an indication that the initiates in these mysteries had their passwords in the same way as those of Eleusis are alleged to have had theirs: the girl Milphidippa, ostensibly wanting to make sure that the slave Palaestrio knows of the intrigue in which she is taking part, says to him, *"cedo signum si harunc Baccharum es"* ("if you are one of our Dionysiac initiates, give the password"), and she uses the feminine form, *Baccharum,* although she is addressing a man. It is of course a joke, but founded evidently on reality.

These associations were serious, at least for the most part. It should, however, be remembered that there were others which had little religious significance, being rather the amusements of well-to-do people who added a slight touch of the supernatural to their social pleasures. To them, as indeed to most people in Roman times, Dionysus was primarily a wine-god, and therefore his worship was regarded as a good excuse for revelry and his paradise as an eternal banquet. It may be suspected that many of the Bacchic societies described by inscriptions in Greece and elsewhere were little more than dining clubs with a mildly religious flavour.

**Terminology.**—The terminology of the mysteries was so well known and the rites themselves so familiar to the multitude of initiates that it is not surprising that they provided material for metaphors and passed beyond paganism into Christian use. One example of such metaphors occurs in the essay *On the Soul* by Themistius: he speaks of the experiences of one at the point of death, who

> undergoes something like what they who are initiated into great mysteries experience . . . First come wanderings and wearisome runnings about, and journeyings through darkness, full of suspicion and without purpose, then before the rite itself all terrors, shudderings and tremblings, sweat and wonder; but after that, a marvellous light meets him, and pure places and meadows receive him, which have sounds and dances and reverend holinesses to hear and sacred sights to behold.

Incidentally, this testifies to the elaboration of the ritual of at least some mysteries by Themistius' time (4th century A.D.). An instance of how this terminology was used by the Christians can be seen in a passage from St. John Chrysostom. He tells his congregation that they must learn "the marvel of the mysteries" and proceeds to speak at some length on the Eucharist, bidding "the initiates" give attention to what he says. Clearly by

"initiates" he means the baptized, *i.e.*, those who have completed their instruction and are no longer catechumens, and this may explain how the Christian use of the word came about: the period of preparation for full membership is analogous to the preliminary ceremonies which had to be gone through before the actual initiation, at Eleusis or elsewhere. A like use, this time relating to the words of the service and not to the underlying doctrine, is to be found in St. Augustine, who speaks of the things commanded *inter sacra mysteria* ("among the sacred mysteries") and proceeds to quote from the Eucharist "*sursum corda . . . gratias agamus Domino Deo nostro . . . dignum et iustum est*" ("lift up your hearts . . . let us give thanks to our Lord God . . . it is meet and right so to do"). Thus there are Christian equivalents of both the "things done" and "things said" at pre-Christian initiations. The resemblance, however, is but partial, for the newer religion had both a theology, which grew more elaborate, and an accepted creed, neither of which was present to the pagan mysteries, and also there seems never to have been any objection to expounding its doctrines to all who cared to listen, whatever their beliefs.

*See* also APOLLO; ATTIS; DEMETER; DIONYSUS; GREAT MOTHER OF THE GODS; ISIS; MITHRAISM; ORPHEUS; and references under "Mystery" in the Index.

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**MYSTERY AND DETECTIVE STORIES.** Although the mystery story as a minor literary genre, a convenient category for book reviewers, is not old, its seeds are found in the folklore of the oldest nations: little tales, hints, anecdotes, superstitions, that are as old as recorded time. They are part of ethnology, philosophy, religion; and their long growth into a department of literary art or artifice parallels the history of man's mind.

## MYSTERY STORIES

In that history the emotion of fear always has bulked large, and the oldest and strongest of man's fears is fear of the unknown. Mystery, by definition, is that which is unknown. But tied in with fear of the unknown is the emotion of curiosity concerning it; and out of that fear and curiosity perhaps was born the mystery story. At first a tale of wonder and terror concerned largely with supernatural matters, it later became a subsidiary of romance; and in still later times, notably our own, it came to be a sort of game invented and played for intellectual relaxation and artificial excitement.

Today a mystery story is, loosely, any story containing a mystery. It may be, and frequently is, a tale of horror and terror; but it may also be a pseudoscientific fantasy (*see* SCIENCE FICTION), a tale of diplomatic intrigue, an affair of codes and ciphers and secret societies, a crime story or a dozen other things involving an enigma. In the beginning, however, it was a tale of spectres and the supernatural.

It will be noted that the detective story per se is omitted from the above list. By recent arbitrary definition, the detective story, lustiest offspring of the mystery story, is a separate and distinct division of literature, a pure form that demands individual consideration. However, it is obviously a mystery story; the separation is largely one of convenience. Other mystery stories may be divided into two groups: ghost stories and riddle stories.

**Ghost Stories, the Gothic and Beyond.**—The literature of ghosts, as already stated, is as old as time. The middle ages took over the dark heritage of antiquity and amplified it with academically formulated magic and cabalism. Perhaps the ghostly angle—complicated by devils, ghouls, ruined castles, subterranean passages and suchlike medieval claptrap—began to emerge most clearly as a department of romance in the 18th century, with what is called the Gothic tale. It was invented by a worldly Englishman, Horace Walpole, whose *Castle of Otranto* (1764) may be said to have founded the horror story as a permanent form. Among his outstanding successors were Ann Radcliffe (*The Mysteries of Udolpho,* 1794), Matthew Gregory Lewis (*The Monk,* 1796), Charles Robert Maturin (*Melmoth the Wanderer,* 1820) and the early American novelist Charles Brockden Brown (*Wieland,* 1798). Mary Godwin Shelley, the wife of the poet, took a hand in the game, with her famous novel *Frankenstein* (1818), still a classic horror story, and with it introduced the pseudoscientific note—the creation out of charnel fragments of a monster that ultimately destroyed its creator.

The influence of the Gothic tale persisted well into the 19th century in the work of such writers as J. Sheridan Le Fanu and Wilkie Collins; indeed, it is obvious in Bram Stoker's gruesome vampire tale *Dracula,* published as late as the year 1891. And pseudoscientific nightmares have not ended with H. G. Wells. Greatest of all names in the field, however, is that of Edgar Allan Poe (1809–49), who first forced the tale of mystery and horror into the artistic regions of pure literature and invented the modern short story form.

Poe's most relevant successors perhaps have been Le Fanu, a strangely neglected Irish genius, Robert Louis Stevenson, Arthur Conan Doyle, Ambrose Bierce, Arthur Machen, Algernon Blackwood, Lord Dunsany and the American *fantaisiste* H. P. Lovecraft. But any such list of masters is inevitably and unfairly incomplete—such isolated masterpieces as W. W. Jacobs' "The Monkey's Paw" have not infrequently lifted writers of a more miscellaneous genius into the front rank of mystery masters.

**Riddle Stories.**—Riddle stories too began in time out of mind, for the enjoyment of puzzles is as old as humanity itself. But there is a practical utility in puzzle solving, also, that no doubt was recognized by the ancients; regular exercise is as necessary for the brain as for the body. The riddle of Samson, propounded in the Bible (Judg. xiv, 12–18), is the most famous early example; but, although Samson has been called the father of riddles, it may be that older and better ones were even then buried in antiquity.

Among the Egyptians, puzzling was a religious rite, and the Sphinx was their goddess. Such was the esoteric religion of the Egyptians that all the priests were riddlers and their religion one vast enigma. The classic riddle of the Sphinx, however, belongs to Grecian mythology. Its date is not authenticated, but it is of antiquity, for Sophocles wrote about it in the 4th century B.C.

So much for antiquity. The riddle story came down the years as did the ghost story, and not infrequently the two overlapped. Its distinguishing feature, at the moment, is that the reader be confronted with a number of mysterious facts and situations, explanation of which is reserved until the end of the story. Unlike the pure detective story—which also, of course, is a riddle story—there may be no clues, either leading or misleading, to assist or to trick the reader. The whole operation of reading may be one of sustained wonder and abiding curiosity.

A good example of the riddle story may be one describing a search for lost treasure, in which mysterious conditions are encountered. In many such, a cipher or cryptogram is added to the tale to complicate the over-all mystery with an interior riddle that most readers find irresistibly attractive.

Poe's great short story "The Gold Bug" is a classic example of this ingenious and popular story plot. Of another kind is Kipling's short mystery "The Sending of Dana Da," a tale involving a plethora of cats visited upon a hater of cats. In the more sinister field of murder are innumerable tales of roguery involving mystery and crime but without the familiar detective interludes. Two notable—almost notorious—riddle stories of modern times offered no solution to the riddle posed and gained wide attention by their novelty—"The Lady or the Tiger" by Frank R. Stockton, and "The Mysterious Card" by Cleveland Moffett.

More nearly kin to the detective story than any of these are the spy stories, the secret service stories, the tales of international intrigue and adventure that, in our own day, have been entertainingly written and prolifically produced by such men as E. Phillips Oppenheim, John Buchan, Francis Beeding (joint pseud. of J. L. Palmer and H. A. St. G. Saunders), Valentine Williams, H. C. McNeile and William Le Queux to name only half a dozen out of

many who are typical. These stories are on the border line between adventure and bona fide detection; in certain instances—*Bulldog Drummond, Clubfoot, et al.*—they overlap the pure detective story and almost force an entrance into the more select field.

### DETECTIVE STORIES

The detective story, as a literary form, celebrated its 100th anniversary in April 1941. Pedantry asserts that its seeds are to be found in the earliest folklores, and it is true that the antecedents of the various motifs combined in the genre are as old as man's mental habits, of which they are in part the history. The puzzle motif is as old as the Prophets, and the Erinyes theme—revenge relentlessly tracking down the wicked—is anterior to literature. Alleged examples of the detective story, in this prenatal sense, have been dug from the pages of Aesop, Herodotus, Cicero, Virgil and the authors of the Apocryphal Scriptures; specimens have been found in all the literatures of the east. Best of these, perhaps, is the Apocryphal account of Daniel's superb sleuthing in the story of "Bel and the Dragon," in which the prophet is shown to have anticipated Sherlock Holmes by many centuries.

Medieval literature also yields relevant tales and legends from the writings of Boccaccio, Chaucer and others, revealing detective habits of thinking in certain fictive characters; and more pertinent examples are outstanding in the *Arabian Nights*. Most striking of modern prototypes is a famous chapter in Voltaire's *Zadig*, an 18th-century romance in which the philosopher-hero accurately describes a lost horse and dog, although he has seen neither, by pure Holmesian deduction.

Nevertheless, the detective story as we know it was born in the pages of *Graham's Magazine*, a Philadelphia journal, in April 1841, with the publication of a short story, "The Murders in the Rue Morgue," by Edgar Allan Poe. Of this story, Dorothy L. Sayers has observed that "it constitutes in itself almost a complete manual of detective theory and practice." A sequel, "The Mystery of Marie Rogêt," appeared in *Snowden's Ladies' Companion*, of New York, in the issues of Nov. and Dec. 1842 and Feb. 1843. Poe's third and last pure detective story, "The Purloined Letter," was published in a Philadelphia annual, *The Gift*, for the year 1845, in which year all three stories, with others, were brought together in a book called simply *Tales*, the most important volume in the history of the detective story. Each of the three tales celebrated an exploit of the chevalier C. Auguste Dupin, who must be called the first fictional detective, and this for a good reason: the profession of detective had only recently been invented, and until there were detectives in the world to write about, no stories about them were possible.

If anybody preceded Poe, it was François Eugène Vidocq, the reformed French thief, who established the world's first official detective bureau, at Paris in 1817, and published his *Mémoires*, in 1828–29. There is no doubt that Poe read this book and was influenced by it; but presumably—and ostensibly—Vidocq's volume was a factual record of his own experience, not a fictional detective story. And if Poe drew some of his inspiration from the French book—the background of his tales was the Paris of Vidocq's brigade de sûreté—Dupin was no Vidocq: he was Poe himself in a new role invented for the occasion, that of the perfect reasoner, the divine amateur, later to find world popularity in the epic figure of Sherlock Holmes. It may be noted, however, that Poe did not use the word detective in any of his stories: that was to come later.

With Poe's three tales of ratiocination, almost miraculously the detective story sprang into flower full blown. "The extraordinary thing," says H. Douglas Thomson, in *Masters of Mystery*, "is that at its very inception the principles and canons of detective fiction writing were brilliantly conceived, even with a touch of finality." It is not known why Poe stopped at the third story: he may have tired of his creation or, as is more likely, the public response may have been lukewarm. Two other mysteries by this author, "The Gold Bug" and "Thou Art the Man," are sometimes called detective stories, but strictly speaking they are outside the canon.

Poe was ahead of his public. Twenty years were to elapse before the infant he had laboured and then deserted was adopted; and then it was a parent from another land. The year was 1866 when Emile Gaboriau, who had been contributing stories of military and fashionable life to the Parisian newspapers, began to publish his *L'Affaire Lerouge* in *Le Pays* and woke up one morning to find himself famous. Thereafter until his death in 1873 he was a busy man, for he had invented the long detective story, and it was a spectacular success. Other detective novels flowed from his pen —*Le Dossier 113*, *Le Crime d'Orcival*, *Monsieur Lecoq*—and his detective creations, Père Tabaret and Lecoq, now stand with Dupin on the shelf of illustrious practitioners. Less clever than Dupin, they were more humorously alive and more recognizably human—Tabaret, the bibliomaniac amateur; Lecoq, the brilliant professional. With Dupin they are the forerunners, the immediate ancestry, of Sherlock Holmes.

It is possible that Gaboriau was familiar with Poe's *Tales*, in the translation of Baudelaire (1856–57), but more likely that he was directly influenced by Vidocq, whose *Mémoires* were looted by scores of French writers of the period, among them Balzac, Hugo and Dumas. These masters, however, never wrote a detective story. Gaboriau's only relevant contemporary was his successor and imitator Fortuné du Boisgobey, author of a line of sensational police romances, of which the first, *Le Forçat Colonel*, was published in 1872.

But before Gaboriau had ceased to write, the movement had crossed the channel; the next landmark in detective fiction was English. In 1868, within a year of the appearance of *L'Affaire Lerouge*, a famous book was published in London—*The Moonstone*, by Wilkie Collins.

An earlier masterpiece by Collins, *The Woman in White*, had appeared in 1860, but, although an excellent mystery, it was not a detective story. In *The Moonstone*, Collins wrote what many critics have called the greatest detective story of them all. However that may be—and the detection in the book is not exhibitional, but a device to catalyze the elaborate ingredients—it was the first full-length detective novel in English and is properly a classic. With Sergeant Cuff, the professional detective who raised roses in his unprofessional moments, says Thomson, "the paradox was born, the detective with a sensibility greater than his sense." With Sergeant Cuff also, it has been said, "character began to raise its head."

Throughout all these years Charles Dickens had been writing voluminously in England without producing a detective novel. He was, however, interested in police work and had watched the growth of England's protective system with alert appreciation of its possibilities for literature. In 1829 Sir Robert Peel had established the London metropolitan police force, with a backdoor opening on a spot called Scotland Yard; and in 1842 a detective branch had been added, with headquarters in the Yard itself. Thus the scene was set; and Charles Dickens in a sense inaugurated the long literature that followed those momentous events when, in 1853, he made his friend Inspector Field a character (Bucket) in *Bleak House*. However, *Bleak House* is not a detective novel. Suddenly, in the last year of his life, and probably under the influence of Collins, he began to write *The Mystery of Edwin Drood* but died with the novel half finished on his desk. The fragment was published in 1870 and remains to this day the most exasperating detective story in the world. Hundreds of literary detectives have tried to penetrate its mystery and none has succeeded. There can be little doubt, though, that the book is another landmark in the history of detective fiction.

In America, meanwhile, a young woman named Anna Katharine Green was getting ready to write *The Leavenworth Case*, first of a long line of melodramatic novels of crime and detection from the same hand. The book appeared in 1878 and is still its author's most famous story, although possibly not her best. It is an American classic, however, the first detective novel by an American and the first by a woman in any language. Stilted and old-fashioned as Miss Green's books now seem, her plots, says Howard Haycraft, in *Murder for Pleasure*, are "models of careful construction that can still hold their own against today's competition."

Two remarkable events occurred in 1887 to make that year

memorable in the history of the detective story. Out of Australia came a sensational thriller, *The Mystery of a Hansom Cab*, by Fergus Hume, to become the greatest commercial success in the annals of literary crime. When Hume died, in 1932, more than 500,000 copies had gone over the counter. This famous tale is scarcely readable today, but historically it is important.

That was the first event. The second was the appearance of Sherlock Holmes, still the greatest name in detective literature. His creator, Arthur Conan Doyle, was a young Scotch-Irish physician, who had been inspired by an insufficiency of patients to try his hand at writing. *A Study in Scarlet*, first of the Holmes stories, was a potboiler that brought him only £25. It appeared just before Christmas 1887, and there was no sequel until 1890, when *The Sign of Four* was written for an American magazine. Neither story set England on fire, but both were widely pirated in America, in the absence of an international copyright act. The widespread popularity of the detective dates from July 1891, when "A Scandal in Bohemia," first of the shorter *Adventures of Sherlock Holmes*, was published in the *Strand Magazine*, to be followed by 22 others over the next two years. The last 11 became the *Memoirs of Sherlock Holmes*, and in the final story Holmes was killed off by his creator, a deed of violence that shocked the world. By that time, however, the doctor's future had been assured; he had given up medicine and was—as he confessed—heartily tired of his famous puppet, who was obscuring his more important work in the historical field.

But public indignation harassed him until he was forced to bring Holmes back to life. In 1902 he yielded to supplication and published *The Hound of the Baskervilles*, a reminiscence of Sherlock Holmes; in 1905 he surrendered unconditionally in *The Return of Sherlock Holmes*, in which he resurrected the detective with great ingenuity. Three other volumes followed: *The Valley of Fear*, in 1915; *His Last Bow*, in 1917; and *The Case-Book of Sherlock Holmes*, in 1927. Sir Arthur Conan Doyle died in 1930, leaving behind him the greatest reputation in the history of detective fiction and a detective whose name bids fair to remain a permanent part of the English language.

For the inspiration that led Conan Doyle to write the tales of Sherlock Holmes we have to thank, first, his unemployment; second, his admiration for the work of Poe and Gaboriau; and, last, his happy recollection of the methods and mannerisms of his old teacher, Joseph Bell of Edinburgh, who was the living prototype of the detective. Most of the stories are told by the amiable and obtuse Doctor Watson, a fictional character almost as famous and well loved as Holmes himself. In Watson, it is fair to assume, we have a self-portrait of Conan Doyle, the impecunious Portsmouth physician, who contributed them both to the gallery of immortals. Thus, says Dorothy L. Sayers, "the ball—the original nucleus deposited by Edgar Allan Poe nearly 40 years earlier—was at last set rolling. As it went, it swelled into a vast mass—it set off others—it became a spate—a torrent—an avalanche of mystery fiction."

In England and America writers were quick to try their talents at the popular game, and for the most part the Sherlock model prevailed. Best of immediate imitations was *Martin Hewitt, Investigator* (1894), by Arthur Morrison, and its several sequels. Simultaneously, pseudoscientific detection made its appearance in the tales of L. T. Meade and her collaborators, Clifford Halifax and Robert Eustace, a series that began with *Stories From the Diary of a Doctor* in 1894. The aestheticism of the 1890s was reflected in the genre, to some extent, in M. P. Shiel's *Prince Zaleski* (1895); and Grant Allen closed the decade with three excellent volumes, of which the best was *Hilda Wade* (1900).

The 20th century opened with the Baroness Orczy's anonymous detective, *The Old Man in the Corner*, functioning brilliantly in the magazines (book publication was delayed), and between the years 1907 and 1911 three detectives of the first water appeared in book form: Dr. John Thorndyke, in R. Austin Freeman's *The Red Thumb Mark* (1907), A. E. W. Mason's Hanaud, in *At the Villa Rose* (1910), and G. K. Chesterton's Father Brown, in *The Innocence of Father Brown* (1911). Father Brown, the little English Roman Catholic priest, has been called one of the immortals, and Thorndyke is indubitably great, a scientific investigator whose science is as sound as it is fascinating. In 1913 *Trent's Last Case*, by E. C. Bentley, was hailed by critics as one of the great masterpieces of the genre. The Sherlock Holmes period may be said to have ended in England, with Ernest Bramah's *Max Carrados* (1914), a volume of notable short stories introducing the first blind detective.

The American scene in the early years of the century produced detective stories in number but only a few that were important. Still remembered is the work of Jacques Futrelle, best viewed in *The Thinking Machine* (1907), and Arthur B. Reeve, whose stories in *The Silent Bullet* (1912) introduced the long series about Craig Kennedy. More important are Mary Roberts Rinehart and, perhaps, Carolyn Wells. Mrs. Rinehart's *The Circular Staircase* (1908) was the first of several books—on the border line between detection and mystery—that helped to make her for a time the most popular of American storytellers. Miss Wells, with less talent, wrote more than 70 detective novels, most of them starring her Sherlockian creation Fleming Stone.

High spots of the period were *In the Fog* (1901), by Richard Harding Davis; *Through the Wall* (1909), by Cleveland Moffett; *The Mystery of the Boule Cabinet* (1912), by Burton E. Stevenson; and *The Achievements of Luther Trant* (1910), by William MacHarg and Edwin Balmer. In the last book the methods of the psychological laboratory were used for the first time in fictional crime detection.

America's outstanding contribution to detective fiction, after Poe's Dupin stories, was *Uncle Abner: Master of Mysteries*, by Melville Davisson Post, which was not published until 1918; but as early as 1896 Post had begun his career in crime literature. His first attempts were stories of legal chicanery, but by 1909 his tricksy lawyers had gone over to the side of law and order, and this superlative technician was moving into the field of pure detection. In the Uncle Abner stories, tales of early Virginia, he produced an American classic and added the first great American investigator to the gallery of illustrious detectives. Post's only comparable contemporary was Frederick Irving Anderson, who published just three books between 1914 and 1930 and was, in consequence, forgotten between volumes. His best-known work is *The Book of Murder* (1930).

Of the years between World Wars I and II it is difficult to write briefly. For a time the most popular writer of detective fiction in the world probably was J. S. Fletcher, whose excellent novels were given a tremendous impetus by President Wilson's publicized pleasure in *The Middle Temple Murder* (1918). Then, in 1920, another great landmark made its appearance in England: this was *The Cask*, by Freeman Wills Crofts, a book of remarkable quality that has influenced profoundly the modern detective story as a whole. "Mr. Crofts," says John Carter "combined the elaboration of Gaboriau with an integrity of method which set an altogether new standard for the many police detectives who have followed [his] Inspector French."

And the years from 1920 onward introduce, one after another, names that today are household words among readers of detective fiction: Poirot, in Agatha Christie's *Mysterious Affair at Styles* (1920); Reggie Fortune, in H. C. Bailey's *Call Mr. Fortune* (1920); Lord Peter Wimsey, in Dorothy L. Sayers' *Whose Body?* (1923); Anthony Gethryn, in Philip MacDonald's *The Rasp* (1924); Dr. Priestly, in John Rhode's *Poddington Mystery* (1925); Roger Sheringham, in Anthony Berkeley's *Layton Court Mystery* (1925); J. G. Reeder, in Edgar Wallace's *The Mind of Mr. J. G. Reeder* (1926).

Others who contributed notable volumes of detection in this period were Eden Phillpotts and A. A. Milne, authors more widely known in other fields. In *Enter Sir John* (1928) Clemence Dane and Helen Simpson created a popular actor-detective. Albert Campion, languid hero of a dozen distinguished books by Margery Allingham, although he made his first appearance in 1928, did not reach his peak until 1934.

All in all, the third decade of the century was memorable—a golden age of the detective story.

In America also, in this decade, important deeds were accom-

plished: at least four fictional detectives of stature were added to the records. Chronologically, Charlie Chan was first: a new and appealing figure in the world of fantasy, he made his bow in *The House Without a Key* (1925), by Earl Derr Biggers. Five other novels now celebrate his exploits and, aided by the motion pictures, the aphoristic little Chinese-American lives in the affection of readers more surely than many better detectives.

Philo Vance, his immediate successor, became the best American detective in the English tradition. With Vance, according to Howard Haycraft, "overnight, American crime fiction came of age." Introduced in *The Benson Murder Case* (1926), by S. S. Van Dine, his later appearances broke records for detective fiction and made him for some years the most famous fictional sleuth in the world. Van Dine, his reputed creator, was in reality Willard Huntington Wright, a well-known critic of the arts—and, like his hero, a dilettante—who brought all his imposing erudition in several fields to the task of making Vance one of the immortals of detective fiction. In spite of considerable pretentiousness and some lack of humour, it may be admitted that he succeeded.

Ellery Queen, as writer and detective, entered the field in 1929. The name is a pseudonym concealing the identities of Frederic Dannay and Manfred B. Lee; but Queen also is the central figure in the stories written under that name. Since his appearance in *The Roman Hat Mystery,* his adventures have been increasingly popular; his name is the trade-mark of a reliable brand of entertainment.

Last and most important of the four leading American writers of the period is Dashiell Hammett, ex-Pinkertonian and graduate of the pulp magazines, whose unsentimental narratives established new standards of realism in the detective story field. In five novels of startling originality, with backgrounds supplied largely by the underworld of American gangsterdom, Hammett invented what has been called the hard-boiled school of crime fiction; but he did more than that—he created a definitely American style, separate and distinct from the English pattern which had been slavishly followed by American writers for generations. As character studies alone, it is claimed, his stories approximate capitalized "Literature." His influence, however, while enormous, was not altogether good: it has been the more meretricious of Hammett's spectacular bag of tricks that have been exploited by his less talented imitators, in particular his not infrequent salaciousness. First of the Hammett novels was *Red Harvest* (1929). His masterpiece is generally believed to be *The Maltese Falcon* (1930), one of the all-time high points in its field. His most sensationally successful story, *The Thin Man* (1934), was the last of an extraordinary quintette. Summing up his short and brilliant career, critical opinion finds that no other writer of modern times has so basically changed and influenced the detective story form.

Most popular of American writers after Hammett were Erle Stanley Gardner, author of the persistent Perry Mason novels and, under the pseudonym A. A. Fair, of the deeds of Donald Lam and Bertha Cool; Rex Stout, whose fat, orchid-raising Nero Wolfe with his assistant, Archie Goodwin, seems to have become a permanent part of the new mythology; and Raymond Chandler, Hammett's most relevant successor. In England the best traditions of Holmes, Thorndyke, *et al.,* were carried on in the literate entertainments of such writers as Nicholas Blake, Michael Innes, Ngaio Marsh and Cyril Hare. A topflight practitioner hailed on both sides of the Atlantic is the Anglo-American writer John Dickson Carr (Carter Dickson).

On the continent of Europe, except in France, few detective stories of distinction were published at any time. Germany's efforts along the years have been abortive and ponderous; and examples of Scandinavian detective literature, although readable, are unexceptional and not strictly canonical. In France two writers of high importance must be noted in Gaston Leroux and Maurice Leblanc. Leroux's *Le Mystère de la chambre jaune* (1908) has been called the masterpiece of French detective fiction. In Arsène Lupin, in the same period, Leblanc created a romantic rogue, half detective, who ranks with E. W. Hornung's Raffles in popular esteem. It was not until 1930 that a writer came to stand with Gaboriau, Leroux and Leblanc; then there appeared a figure of international interest, Georges Simenon. His masterful and masterly Inspector Maigret became popular in 17 languages. Introduced to the English-speaking world in *The Crime of Inspector Maigret* (1932), he joined the immortals; in the opinion of a critic, "the greatest character in detective fiction since Sherlock Holmes." (V. STA.)

**The Boom.**—Quantitatively speaking, the detective story's climb to the world popularity it enjoys in the second half of the 20th century was slow until comparatively recent times. From its beginnings with Poe in 1841 up to and including 1920, an estimated 1,300 new titles were published in English-speaking countries; whereas from 1921 to 1940, inclusive, more than 8,000 new titles were published. It is also estimated that about 1,700 new writers of detective stories appeared in the years 1921–40, as against only 300 in the preceding 80 years. World War II brought an inevitable hiatus, which makes continued comparison difficult. Following its conclusion, however, production quickly regained prewar levels. More importantly, the postwar years witnessed two developments which increased the readership of detective stories astronomically: (1) the phenomenal rise of paper-bound books published in huge editions; and (2) the growth of book clubs. While exact statistics are unavailable, it may be safely asserted that if the prewar readership of detective stories could be numbered in the hundreds of thousands, the postwar audience might be counted in the millions.

Coincident with this broadening of its audience, the arbitrary and rather doctrinaire separation of the detective story from other forms of mystery fiction tended to disappear. By the 1950s most recognized authorities were treating detective-mystery-crime fiction as a single if multibranched genre. An interesting subspecies to emerge in the postwar years was the psychological or suspense novel, with its emphasis primarily on the why of crime as distinguished from the traditional who and how. Like the hard-boiled detective novel before it, the suspense novel, after a brief crest of popularity, tended to be absorbed back into the mainstream of mystery fiction, while influencing the more orthodox mystery novel healthily in the direction of imaginativeness and heightened awareness of human values. More generally, critics on both sides of the water noted a trend away from the story of pure detection, or so-called chess puzzle, and toward the novel of character, with a crime or detection motif.

Although the postwar years were marked by a high level of competence in mystery writing, they produced fewer recognizable titans than the preceding decades: a development not unusual in a maturing literary form. Nevertheless a few writers may be mentioned whose fame seems secure for more than the moment. In England, Josephine Tey (*The Franchise Affair, The Daughter of Time*), Raymond Postgate (*Verdict of Twelve*) and Edgar Lustgarten (*One More Unfortunate*) upheld the dignity of the British detective novel, though departing frequently from the classical formula; while Eric Ambler and Manning Coles gave new stature to the tale of intrigue and espionage. In America the period produced a number of writers whose importance rests less on scintillating solo performances than on a highly competent, continuing body of work; of these, Frances and Richard Lockridge, with their Mr. and Mrs. North narratives, may be cited as representative. In the field of the suspense story Dorothy B. Hughes and Cornell Woolrich (pseudonym, William Irish) won high standing, among many.

Two timely events considerably influenced the production of mystery fiction, especially in the U.S. In 1941 *Ellery Queen's Mystery Magazine* was established, the first quality periodical in the field; its American success was followed, after World War II, by editions published in France, Great Britain, Italy, Brazil, Australia, Japan and Mexico. Founded in 1945, Mystery Writers of America, Inc., is a professional organization dedicated to elevating the standards of mystery fiction and the economic status of its members. Boasting a membership of more than 400 active writers, and with flourishing chapters in New York, Chicago, Los Angeles and San Francisco, its annual "Edgar" awards (named, of course, for Edgar Allan Poe) are as eagerly awaited in the mystery field as the Academy of Motion Picture Arts and Sciences' "Oscars"

in the motion-picture industry. (H. Ht.)

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**MYSTERY PLAY:** *see* DRAMA: *Medieval Drama.*

**MYSTICISM,** the immediate experience of oneness with Ultimate Reality. Both those who have known mystical experience and those who have only studied it are agreed that the mystical vision is ineffable. Therefore any attempt to define it with logical precision is bound to fail. But the task of defining mysticism or even of describing it is complicated still further by what one observer has called "the current absurdities of identifying mysticism with esoteric occultism, the use of allegory and symbol, mysteriousness, pretty fancifulness, ineffectual idealism, 'seeing things,' second sight, anything 'vast, vague and sentimental.'" (Donald Attwater, *A Catholic Dictionary;* New York: The Macmillan Company; London: Cassell and Company Ltd.) Each term of the definition given requires clarification. To say that mysticism is an immediate experience is to set it apart from experiences that are mediated through historical revelation, sacraments or other normal media. When we call mysticism an experience of oneness, we mean that the relationship into which the mystic is inducted transcends the ordinary distinctions between subject and object or between I and Thou. And the term "Ultimate Reality" in the definition seeks to make clear that the mystic knows himself to be involved with no mere idea or thing but with that beyond which nothing can be known or imagined. Yet another complication in the theoretical study of mysticism is the question of its relation to the disciplined, ordered reflection upon the data of religion that we call theology. For although mysticism is often set over against theology and is said to be more authentic or more subjective or more dithyrambic, the two forms of religious thought have in fact existed side-by-side, frequently in the same man. But this is not the same as saying that a reduction of the mystical experience to its theological implications does it justice. On the contrary, the mystical theologians have been the most explicit in their insistence that no theological systematization can capture or explain the unique experience of mystical purgation, illumination and union.

## MYSTICISM IN THE WORLD RELIGIONS

The relation between mysticism and religion is susceptible of various oversimplifications. In popular, nontechnical usage, the term "mysticism" is practically identical with "religion," differing, if at all, only in its intensity: the mystic experiences profoundly what the more casual believer perceives dimly. On the other hand, many scholarly interpreters of mysticism have contrasted it sharply with conventional religion. Thus Friedrich von Hügel, whose researches penetrated deeply into mystical religion, distinguished between the historical-institutional, the intellectual-speculative and the experiential-mystical elements in religion, and described the persistent tendency in the history of religion to elevate one of these over the other two. Perhaps the most radical antithesis drawn between mysticism and faith is that expressed by the German Protestant theologian Wilhelm Herrmann: "True, outside of Christianity, mysticism will everywhere arise, as the very flower of the religious development. But a Christian is bound to declare the mystical experience of God to be a delusion" (quoted in Hügel, *The Mystical Element of Religion*, vol. ii, p. 263; J. M. Dent & Sons Ltd., London, 1961). Proceeding as it does from a rejection of all "natural theology," this antithesis fails to do justice either to the role of mysticism in Christian history or to the genius of the world religions. It also makes too facile and uncritical an identification between Christian mysticism and the mystical religion that occurs apart from the Judaeo-Christian tradition.

In the strict technical sense it is probably unwarranted to speak of mysticism in the primitive religions at all, for neither the technique nor the abstract notion of mystical religion appears among them. What does appear, however, is the experience of religious ecstasy, which bears unmistakable analogies to the transport experienced by the mystic. In the shamanism (*q.v.*) of various primitive peoples, the medicine man can carry out his social function as the healer of the people because he has the private experience of transcending his physical existence and of becoming one with the spirit world. Some forms of religious ecstasy are induced by narcotics such as hashish, but there are also specific methods of preparation by which the ecstatic brings on his rapture. The Maulawiyah dervishes who arose in the Sufi movement within Islam (*see* below) followed prescribed forms of ritual dance to achieve ecstasy; it seems likely that such "whirling dervishes" were in existence before Sufism or even before Islam. In other religious traditions, incantation, the recitation of magical formulas, the contemplation of sacred objects or the observance of special techniques of breathing can be means of reaching an ecstatic exaltation. All these means have also appeared within the history of mysticism in the "higher religions," and it is at least plausible to suppose that there is some continuity between primitive religion and mysticism in this respect as well. Difficult though it is to understand the ineffable experience of either the primitive ecstatic or the advanced mystic, the external similarities seem clear enough to justify our including the religious experience of primitive man in a discussion of mysticism in world religions. Nevertheless, the most important world religions for this discussion are Hinduism, Buddhism and Islam.

**Hinduism.**—More perhaps than any other religious system, Hinduism is naturally predisposed to mystical interpretation. The ascetic practices of Hinduism, which are more familiar to westerners than any other feature of Indian religion, are conducive to the cultivation of the "steps" through which the mystic passes. As the highest ideal of Hindu religious practice, ascetic *moksha* has received most attention not only from western students but from Hindu masters as well. To escape from the endless cycle of birth and death, the devout follower of the *ashramas* or "ways of salvation" strives to attain a disinterestedness about the process of change and of becoming and thus to transcend his mortal, physical, temporal existence. Thus the ultimate aim of Hindu religion would seem to be to make of every believer a mystic, or at least a shaman.

In fact, of course, Hinduism has been willing to come to terms with the facts of life about the varieties of religious experience and expression. At least in part Yoga (*q.v.*) represents the rise within traditional Hinduism of a special mystical technique, that of Hatha Yoga, which was intended to make possible for the select few a level of mystical insight originally predicated of the many; in this respect, Yoga is a paradigm for the relation between other religions and their mystical expression, for there, too, the mystic has put into practice what had originally been promised to all believers as at least a possibility. The techniques of Yoga were combined with traditional Hindu doctrines about the absorption of the individual soul in the All. Other forms of Hindu mysticism are more personal, relating the devotee to a particular deity of the Hindu pantheon (*e.g.*, Krishna or Shiva), while still others stress the passivity of faith as trust and surrender to the grace and power of the Ultimate Reality (so Ramanuja). Indicative of the power of Hindu mysticism is the influence it has had upon western religious thinkers such as Helena Petrovna Blavatsky (*q.v.*) and, through them, upon such widely diverse minds as Aldous Huxley and Rudolf Steiner. When sophisticated western secularists hear the word mystic, they usually think of Hinduism and Yoga.

**Buddhism.**—Not in the secular west but in the religious east, and particularly in Buddhism, is the primary locus of the influence of Hindu mysticism. For the Buddhist ideal of enlightenment and Nirvana promised deliverance from the *karma* of continuing

transmigration by obedience to the Four Noble Truths proclaimed by Gautama Buddha. Pain and pleasure, birth and death, passion and action are all transcended in the blessedness of Nirvana, which, like the mystical experience in other systems, defies definition or abstract formulation. Common to the various sects of Buddhist thought is an emphasis upon meditation and contemplation as means of moving toward Nirvana, but each of the Buddhist traditions sets its own distinctive interpretation on Nirvana. As one scholar has put it, "Nirvana was regarded by the Theravadins as the antinomy of Samsara [the phenomenal world]; the Mahayanist equated Nirvana and Samsara in void. . . . The Mantrayanist viewed the phenomenal world as the manifestation of the Cosmic Body of the Sun-Buddha" (Joseph M. Kitagawa, *Religions of the East*, pp. 186–187; The Westminster Press, Philadelphia, 1960).

Of special interest in the determination of the Buddhist version of mysticism is Zen (*q.v.*) or Ch'an Buddhism. Because of its practical emphasis and matter-of-fact language, Zen is often interpreted as the direct antithesis of the mystical strain in Buddhism, but its cultivation of *prajna* (supreme intuition) over against the partial knowledge attained through ordinary means displays its affinities for mystical thought. At the middle of the 20th century Zen attracted the curiosity of western intellectuals, who found in its combination of mysticism and common sense the sort of working philosophy of life that they missed in traditional western religion and in the traditions of Christian mysticism.

**Islam.**—Of all the forms of mysticism outside the Judaeo-Christian tradition, the one most easily recognized by westerners bas been the Sufi mysticism of Islam. Sufism (*q.v.*), like Zen Buddhism, arose in response to the practical religious needs of those for whom conventional answers were inadequate, and it caught up some of the tendencies toward mystical experience that had been indigenous in Islam from the beginning. Those tendencies were deepened by the influence of Greek ideas during the 9th, 10th and 11th centuries. As the Neoplatonism of Dionysius the Areopagite shaped the thought and language of Christian mysticism (*see* below), so it was also Neoplatonism (as represented by the so-called *Theology of Aristotle*, a paraphrase of Plotinus which was translated into Arabic in the middle of the 9th century) that fructified Muslim mysticism. The zenith of mysticism in Islam came in the thought of al-Ghazzali, whose *magnum opus, The Revival of the Religious Sciences*, sought to bridge the gulf between orthodox Muslim theology and Sufi mysticism. The mildness and moderation of al-Ghazzali's speculation are in decided contrast to the pantheistic strains in the development of Sufism among men like Ibn 'Arabi. The extremes of Ibn 'Arabi's mysticism led him to claim private revelations and to speak of the unity of all things with Allah in a manner that seemed to lose the distinction between Creator and creature in the transport of the mystical vision. Sufi mysticism, like its Christian counterpart, has often expressed itself in the metaphors of intoxication and of the love between bride and bridegroom—language that has not been easy to reconcile with the stress of the Koran upon the sovereignty and transcendence of Allah. At the same time, mysticism has made the reality of the divine more accessible to those who found the "wholly other" god of the Koran too austere and distant.

## MYSTICISM IN THE JUDAEO-CHRISTIAN TRADITION

**Jewish Mysticism.**—At first examination nothing seems further from the spirit of mysticism than the prophetic tradition of biblical religion. In the words of a scholar whose researches have investigated both, "what is important in mystical acts is that *something happens;* what is important in prophetic acts is that *something is said*" (Abraham J. Heschel, *The Prophets*, p. 364; Harper & Row Publishers, Inc., New York, 1963). Nevertheless, mysticism has flourished in the Judaeo-Christian tradition, not merely as an exotic flower from another garden but as an authentic expression of the faith of Israel and of the church. The visions of the biblical prophets and the apocalyptic imagery of postbiblical Judaism led to the Hekhalot, which described the heavenly mansions and thus laid the foundations for Jewish mysticism. The most characteristic and profound theme of mystical Judaism is the Cabala, which reached its climax in the *Sefer ha-Zohar* near the end of the 13th century. This "Book of Splendour" described the power and inner life of God and set forth the principles and commandments by means of which the true believer could regain the *devequt* ("adherence to God") that had been destroyed by the fall of man from pristine purity. Upon this zoharic wisdom subsequent Jewish mysticism has continued to build. Although the manipulation of the holy and unutterable Name of God, the Tetragrammaton, undoubtedly degenerated into magic, the Cabala also helped to produce the *Pardes* of Moses Cordovero in the 16th century and the Hasidism of the Baal Shem-Tob ("Master of the Holy Name") in the 18th. The hasidic form of Jewish mysticism had far-reaching effects upon the piety and practice of the common people, and particularly in the form it took in the thought of Martin Buber (*q.v.*) it shaped both Christian and secular thought as well. (*See* also CABALA; HASIDISM.)

**Influence of Neoplatonism.**—Not from its Jewish sources, however, but from its Greek sources has come the principal mystical impulse in Christianity. Exegetes are sharply divided on the question of whether there are mystical elements in the New Testament itself. The unmistakable parallels between mystical language and the speech of the apostle Paul ("it is no longer I who live, but Christ who lives in me") or of the Gospel of John ("I am the vine, you are the branches") had led most interpreters to claim the authority of the New Testament or at least of these two writers for a Christian mysticism. Other scholars, notably Rudolf Bultmann, argued that the emphasis of the New Testament upon the lordship of God and its conception of the historical revelation are in such complete antithesis to any mystical notions that the mystical language of the biblical writers must be seen as a rejection rather than as an adaptation of the mystical tradition.

It certainly is true that the idea of a mystical technique for the attainment of unity with God, which figures so prominently in the history of mysticism, is absent from the New Testament and alien to its spirit. Yet the attempt to explain away all the mystical phrases in Paul and John leads to an artificial and arbitrary exegesis, which trivializes some of the deepest spirituality of the Bible into an anticipation of modern existentialism. A completely antimystical reading of Paul will be hard put to account for his ideas of dying with Christ through baptism. Equally distorted is any talk about "Christian mysticism" that fails to recognize the essential qualitative distinction between the pantheistic yearning for oneness with an impersonal All and the response of faith to the life, death and resurrection of a historical person. This fundamental distinction marks all subsequent Christian mysticism, despite its obvious borrowing from Greek, especially from Neoplatonic, thought.

Both the distinction and the borrowing are evident in the earliest Christian thinkers to whom the title "mystic" applies. The affinities between heretical Gnosticism (*q.v.*) and mysticism served to caution the mystics of the church against an uncritical acceptance of pagan spirituality. When Clement of Alexandria and Origen described the stages of the spiritual ascent of the believer toward Christlike perfection, therefore, they did indeed employ Greek language about the contemplative life, but not at the expense of illumination through divine grace. Learning from the thought of Origen but bringing it even more closely into alignment with orthodox dogma, Gregory of Nyssa propounded and practised a Christian mysticism whose goal was the untrammeled vision of God, attained by the denial of lesser goods and the purification of the soul through asceticism and devotion. In the West, Augustine also found Neoplatonic language a congenial instrument for describing the return of the soul to rest in God after the estrangement of sin.

**Byzantine Mysticism.**—The various mystic strains of early Christianity were caught up and synthesized by Dionysius (*q.v.*) the Areopagite, the *nom de plume* of an unknown Christian Neoplatonist who wrote about A.D. 500. His *Mystical Theology* described the threefold path to "deification" as purification, illumination and union: the soul puts both the empirical and the rational world behind and by this "way of negation" it finds union with God and becomes, in the words of the New Testa-

ment, "a partaker of the divine nature." So imbued is the history of Christian mysticism with these ideas that, according to Anders Nygren, "an unbroken line runs from the ancient Mysteries through Plato, Plotinus, Proclus, Pseudo-Dionysius and Mediaeval mysticism down to our own time" (*Agape and Eros*, Eng. trans., p. 574; Westminster Press, Philadelphia, 1953).

Although this judgment is an exaggeration, it is nevertheless true that the history of mysticism in the Christian East was decisively shaped by the Dionysian writings, which provided a perspective for interpreting earlier strata of the tradition. Writing about a century later, John Climacus combined asceticism and mysticism in his *Ladder of Paradise* (sometimes also called *Ladder of Virtues*), which outlined 30 steps to perfection, one for each of the mysterious years of the life of Christ before his public ministry. Even more explicitly dependent on Pseudo-Dionysius than Climacus was his contemporary, Maximus the Confessor, who took over the Dionysian idea of mystical ecstasy, even though "it is not used here in the full Dionysian sense of an irrational, suprarational estrangement of the mind in the divine darkness" (Polycarp Sherwood, "Introduction" to Maximus Confessor, *The Ascetic Life* and *The Four Centuries on Charity*, p. 96; Newman Press, Westminster, Md., 1955).

The most thoroughgoing systematization of both the technique and the theory of Byzantine mysticism came in the thought of Gregory Palamas, the 14th-century mystic and theologian who defended and developed hesychasm against Barlaam of Calabria. (*See* PALAMAS, SAINT GREGORY; HESYCHASM.) The aim of mystical devotion was serenity (Gr. *hesychia*). To achieve this aim, the hesychast mystic strove for control of his bodily functions, even of his breath, until his very breathing would be one uninterrupted prayer. (Affinities between hesychasm and Yoga, while interesting, are rather superficial.) The significance of hesychasm for the history of Christian mysticism lies rather in its influence upon most of Eastern Orthodoxy, especially also Russian Orthodoxy, and in its divergence even from the Dionysian forms of the Western mystical tradition.

**Mysticism in the Medieval Western Church.**—In the Western mystical tradition the Dionysian forms of mystical experience and expression were taken over and transformed by Hugh (*q.v.*) of St. Victor and the mystical school of St. Victor, represented by Richard and Adam of St. Victor, who blended the Dionysian ideas with Augustinian thought about the contemplative life. Hugh outlined the stages of this life as *cogitatio, meditatio, contemplatio;* Richard's *Benjamin Major* and *Benjamin Minor* became standard manuals on the practice of mystical spirituality.

Another prominent element in medieval spirituality, related to the Victorine but independent in its development, is the Christ-mysticism of Bernard of Clairvaux (*see* BERNARD, SAINT). His *Sermons on the Canticle of Canticles* is perhaps the best known of the monastic expositions of this book of the Bible, on which more commentaries were composed than on any other. Here the soul ascends from penance ("kissing the feet of Christ") through imitation of Christ ("kissing his hands") to mystical rapture ("kissing his mouth"). Bernard's treatise *On Loving God* gives a theological foundation for his mystical teaching. Thus he shows that mysticism and scholasticism, which are often set into opposition with each other by later interpreters, can be compatible. Mysticism and scholasticism are combined also in the Franciscan theologian Bonaventura and in his Dominican contemporary Thomas Aquinas (*see* BONAVENTURA, SAINT; AQUINAS, SAINT THOMAS). Of special interest in the history of medieval mysticism are the visions and writings of several women: Julian of Norwich and Margery Kempe in England, Bridget of Sweden, Catherine of Siena and Catherine of Genoa in Italy.

During the later middle ages Catholic mysticism moved into several contrasting, if not indeed contradictory, directions. The most widely read book in the history of Christian mysticism, in fact the most widely circulated book in Christian history except the Bible, was *The Imitation of Christ* (*q.v.*), attributed to Thomas à Kempis. The mystical devotion of the *Imitation* is practical, nonspeculative, simple—so much so that some scholars have refused to call it mysticism at all, while others have seen it as the climax and consummation of all mysticism.

A different line of development begins with Meister Eckhart and proceeds through Johann Tauler and Heinrich Suso (*qq.v.*) to the "friends of God" (*Gottesfreunde*). Although it is inaccurate to depict Eckhart as a pantheistic opponent of the orthodox Catholic tradition, as was the fashion in the 19th century, his mysticism did involve speculations about the nature of God and his relations to the world that went beyond traditional dogma. The *Theologia Germanica*, an anonymous treatise from the late 14th century, summarized much of this German mysticism.

**The Reformation and After.**—The importance of the *Theologia Germanica* in church history stems from the circumstance that its first printed edition was prepared by Martin Luther in 1518. In the opinion of many historians, it was at least in part from this source that Luther originally drew his stress upon the passivity of the soul in its reception of grace. Nevertheless, the principal place to look for the influence of mysticism on the Reformation is not the thought of Luther or Calvin, but that of some of the Reformation radicals, of whom Kaspar von Schwenckfeld and Sebastian Franck are perhaps the most original. The attack of the Reformation upon Catholic sacramentalism enabled these mystics to break with the traditional principle of mediated revelation more drastically than medieval mystics had dared to.

The radical Reformation did not, however, exhaust the mysticism of the 16th century. In Spain, a land less affected by the Reformation than almost any other, Roman Catholicism of this period produced an exquisitely wrought and thoroughly orthodox mysticism in a figure like John of Ávila, but above all in Teresa of Ávila and in John of the Cross. Teresa attempted to identify the "prayer of quiet" and the "prayer of union" as stages between ordinary prayer and the spiritual marriage of the soul with Christ, where man's will and God's will become one. She was also influential in the mystical development of John of the Cross, who worked with her in the reformation of Spanish monasticism. Perhaps even more than the Victorine mystics of the middle ages, John of the Cross succeeded in schematizing the steps of mystical ascent, for he combined a poetic sensitivity for the nuances of mystical experience with a theological and philosophical precision shaped by a study of Thomas Aquinas. His best-known work, *The Dark Night of the Soul* (*Noche oscura*), describes the process by which the soul sheds its attachment to all things created and eventually passes through a personal experience of the cross to the incandescent union of fire with fire. (*See* JOHN, SAINT, of the Cross; THERESA, SAINT.)

The history of Roman Catholic mysticism after Teresa and John of the Cross was sometimes marred by theological controversy. As a result of their thought, there arose in Spain and then in France a form of mystical spirituality that earned the label Quietism (*q.v.*). As developed by Madame Guyon and Archbishop Fénelon (*see* GUYON, JEANNE MARIE BOUVIER DE LA MOTTE; FÉNELON, FRANÇOIS DE SALIGNAC DE LA MOTHE), Quietism taught the necessity of utter passivity and "disinterestedness" in the relation of the soul to God. Because of its potential threat to the function of the church and the sacraments as a means of grace, Quietism was condemned in 1687. But this condemnation did not inhibit the authentically Catholic mysticism we have been describing, which was a powerful factor in the religious development of men like John Henry Newman and reached a wide audience through the writings of Thomas Merton.

Nevertheless, the position of Roman Catholicism in the Counter-Reformation was not as favourable to the rise of mysticism as medieval Catholicism had been, and some of the medieval forms of mystical devotion found a more congenial place in Protestantism. Strongly medieval in its flavour was the mysticism of Johann Arndt whose *Four Books on True Christianity* was circulated all over Europe in many languages. The mystical thought of Jakob Böhme (*q.v.*) was also nourished by medieval sources, among which the speculations of Eckhart and Tauler were significant; therefore Böhme's mysticism, like theirs, was suspect among orthodox theologians. From Arndt and Böhme Protestant mysticism moved into most of the denominations and lands of the

Reformation. Johann Amos Comenius (*q.v.*), theologian and bishop of the Moravian Church, constructed a system of "pansophia," in which mystical insight was a means of going beyond the details of human knowledge to a vision of the whole. Gerhard Tersteegen (1697–1769), owed much to Roman Catholic Quietism. His mysticism is especially powerful in his hymns, which appear in the hymnbooks of most Protestant denominations.

The thought of Arndt, Böhme and Tersteegen was a major inspiration for the attack of Protestant Pietism (*q.v.*) on the intellectualism and formalism of Orthodoxy. P. J. Spener and A. H. Francke both cultivated a devotion that stood in the mystical tradition, but strove to keep it within orthodox limits. Their descendants, however, moved beyond those limits, and in the work of Count von Zinzendorf Protestant mysticism found one of its most influential formulations, which shaped the theology of Friedrich Schleiermacher as well as the religion of John Wesley. The devotional writings of English and American Puritanism, often ignored by both the defenders of the movement and its critics, qualify it for inclusion in the history of Protestant mysticism. The theological schools of Albrecht Ritschl and Karl Barth, which clashed on most issues, were agreed in their condemnation of mysticism, which was therefore under a cloud in the Protestantism of the 20th century. But its hold on popular devotion and its prominence in Protestant history assured it a continuing place despite this condemnation.

### NATURALISTIC MYSTICISM

Some of the men and movements discussed in the preceding history of Christian mysticism since the Reformation also belong to the history of secular thought. For in the area of devotion and worship, as in the area of metaphysics and ethics, modern thought has witnessed a secularization, as many men found the conventional forms and ideas of religion inadequate and turned outside the churches for satisfaction. This secular mysticism continued to study religious mysticism, especially that of the religions of the east, but it broke with organized religion. Any classification of thinkers and writers in this field will be arbitrary, but differences of emphasis do justify some attempt at taxonomy.

The history of philosophy since the middle ages includes a form of thought best characterized as cosmic mysticism. Its most brilliant exposition as a philosophical system is the religious metaphysics of Benedictus de Spinoza (*q.v.*), whose doctrine of an impersonal God and of the relation of the world to him was at the same time unorthodox dogmatically and mystical devotionally. The most brilliant exposition of this cosmic mysticism in a literary form is the work of Johann Wolfgang von Goethe (*q.v.*), who saw in Spinoza a fulfillment of many of his own religious intuitions. In a universe that often seemed to be absurd and threatening, man could find meaning by identifying himself with its structures and purposes and by cultivating attitudes of reverence and commitment. Taken as they stand, many of Goethe's statements about the universe imply pantheism, as do Spinoza's, for both thinkers rejected the traditional notions of Judaism and Christianity about the transcendence of the Creator over the creation. The development of modern scientific cosmology, with its repudiation of traditional biblical pictures of the universe and its creation, has made this cosmic mysticism attractive to many both inside and outside the churches. *Mysticism and Logic,* published by Bertrand Russell in 1929, and *The Phenomenon of Man* of the Jesuit scientist Pierre Teilhard de Chardin are at opposite ends of the pole; yet they both attempted to relate the scientific picture of the universe to the mystical quest for oneness with the Ultimate—whatever that Ultimate may be thought to be.

As the example of Goethe suggests, men of letters have meant more for the history of naturalistic mysticism than have either scientists or philosophers. So prominent have they been that the relation between mystical vision and literary inspiration has become a major issue in aesthetics. Just as this relation was so intimate in ancient Greece, in the epics of the Germanic peoples and even in the Old Testament, so the inspiration of the poet is still the chief form of mystical rapture in the thought of secularized westerners. For example, the poetry of William Blake has provided a documentation of the mystical experience outside the ordinary ecclesiastical channels. Blake's younger German contemporary, J. C. F. Hölderlin, combined the themes of Christ-mysticism with the imagery of pagan Greece in poems whose lyric beauty and profound reverence mark him as a mystic of a high order. Poets like Stéphane Mallarmé, Paul Valéry and even Edgar Allan Poe spoke of the life of man in the world in language that showed its mystical lineage even as it by-passed the religious traditions. Interpreters of mysticism such as Evelyn Underhill and Hügel, who studied it from within the framework of the religious traditions, recognized the affinities between poetic inspiration and the mystical element of religion but rejected the facile identification of the two. But even they found that their readers were better acquainted with the aesthetic than with the religious experience of the beatific vision, and therefore they were obliged to define religious mysticism in language borrowed from the world of the poet and the artist.

A special problem in the history of modern mysticism is the mystical expressions of nationalism. The very language of patriotic hymns and the use of terms like "shrine" for the sites of patriotic pilgrimages suggest that the attachment of many men in the 19th and 20th centuries to their nation partakes of the nature of religion. Not all these expressions qualify as mystical, of course, but the more rhapsodic ones certainly do. In the ideology and practice of National Socialism in Germany, the devotion to blood and earth reached heights of intensity for which only the experience of the mystics provides a satisfactory parallel. The extremes of such mystical nationalism have served as proof to many that nothing less than all of humanity is a worthy object of devotion and commitment. This universal humanitarianism has also articulated itself in the symbols of the mystical tradition. Thus mysticism has demonstrated both its durability and its adaptability, as it has survived both the end of paganism and the rise of secularism. For some it has been a way into the religious traditions, for others a way out of them. But for both it has continued to provide an immediate experience of oneness with Ultimate Reality. Their experience, in turn, provides proof of what Hügel called "the character and necessity, the limits, dangers and helpfulness of the Mystic Element of Religion" (*The Mystical Element of Religion,* vol. ii, p. 396).

*See* also references under "Mysticism" in the Index.

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**MYTH.** In the language current during the 19th century, "myth" meant anything that was opposed to "reality": the creation of Adam, the invisible man, no less than the history of the world as described by the Zulus or the Polynesians or the *Theogony* of Hesiod—these were all "myths." Like many of the other cliches of Positivism, this was of Christian and ultimately of Greek origin. For the Greeks, *mythos* meant "fable," "tale," "talk," "speech." Contrasted both with *logos* and later with *historia, mythos* finally came to denote "what cannot really exist." The earliest Milesian philosophers had criticized and rejected the Homeric myths as fictions and inventions. Xenophanes (6th–5th century B.C.) refused to believe that God moves about from place to place, as Homer told. He rejected the immorality of the gods as described by Homer and Hesiod: ". . . Homer and Hesiod say that the gods do all manner of things which man would consider disgraceful: adultery, stealing, deceiving each other" (B 11, B 12). He especially criticized the anthropomorphism of the gods: "But if cattle and horses or lions had hands, or were able to draw with their hands and do the works that man can do, horses would draw the forms of gods like horses, and cattle like cattle, and they would

make their bodies such as they each had themselves" (B 15).

In these critiques of Homeric mythology may be seen an effort to free the concept of divinity from the anthropomorphic expressions of the poets. Even a profoundly religious author like Pindar rejected the "incredible" myths (*I Olympic*, 28 ff.). When Plato (*Republic*, 378 ff.) criticized the poets for the way in which they had presented the gods, he was probably addressing an audience which was already convinced.

## STUDY AND INTERPRETATION OF MYTHS

**Allegorical Interpretations.**—The criticism of mythological traditions was almost pedantically elaborated by the Alexandrian rhetoricians. The Christian apologists patterned themselves on these authors when they in turn were called to deal with the problem of distinguishing the historical elements in the Gospels. Nevertheless, the mythology of Homer and Hesiod continued to interest the elite in all parts of the Hellenistic world. But the myths were no longer taken literally; what was now sought was their "hidden meanings" (*hyponoiai;* the term *allegoria* was used later). Theagenes of Rhegium (fl. *c.* 525) had already suggested that the names of the gods in Homer represented either the human faculties or the natural elements. But it was especially the Stoics who developed the allegorical interpretation of Homeric mythology and, in general, of all religious traditions. Chrysippus reduced the Greek gods to physical or ethical principles. In the *Quastiones Homericae* of Heraclitus (1st century A.D.), there is a whole series of allegorical interpretations. For example, when the myth says that Zeus bound Hera, the episode really signifies that the ether is the limit of the air, and so on. The allegorical method was employed by Philo to decipher and illustrate the "enigmas" of the Old Testament.

**Euhemerism.**—About the beginning of the 3rd century B.C., Euhemerus published a romance in the form of a philosophical voyage, *Sacred Writing* (*Hyera anagraphe*), the success of which was great and immediate. Ennius translated it into Latin; indeed, it was the first Greek text to be translated. Euhemerus believed that he had discovered the origin of the gods: they were ancient kings who had been deified. Here was another "rational" way to preserve the gods of Homer. They now had a "reality"; it was historical—or, more precisely, prehistorical. The myths represented the confused memory or an imaginative transfiguration of the exploits of the primitive kings.

This allegorizing in reverse had wide repercussions, undreamed of by Euhemerus and Ennius or even by Lactantius Firmianus and the other Christian apologists who, following Euhemerus, had attempted to demonstrate the humanity and hence the unreality of the Greek gods. Because of allegorical interpretation and euhemerism, the Greek gods and heroes did not sink into oblivion after the long process of "demythicization" or even after the triumph of Christianity.

**The Study of Myths in Modern Times.**—The scientific study of myth began with Karl Otfried Müller's *Prolegomena zu einer wissenschaftlichen Mythologie* (Göttingen, 1825). But it was through the numerous and brilliant works of Max Müller (*q.v.*) that the study of mythology became popular in the second half of the 19th century (cf. *Essays in Comparative Mythology*, 1856; *Contributions to the Science of Mythology*, 1897). According to Max Müller, mythology is the result of a "disease of language." The fact that an object can have many names (polyonymy) and conversely that the same name can be applied to several objects (homonymy) produced a confusion of names which resulted in the combination of several gods into one and the separation of one into many: *nomina, numina.* Moreover, the use of endings denoting grammatical gender led to the personification of the gods. According to Müller, the ancient Aryans constructed their pantheon around the sun, the dawn and the sky.

This all-embracing "solar mythology" was wittily criticized by Andrew Lang, a brilliant and learned Scottish scholar, who asserted that myths result not from any "disease of language" but from the personification of the cosmic elements, a mental process characteristic of the animistic stage of culture. In criticizing Müller's theory, Lang utilized the data of the new science of anthropology, drawing heavily upon E. B. Tylor's belief that animism was the earliest stage of religion. (Tylor had published his *Primitive Culture* in 1871, and the book almost immediately became a classic.) The interpretation of myth as the reflection of celestial phenomena, mainly the movements of the great luminaries, knew a new revival in Germany at the beginning of the 20th century. The *Mythologische Bibliothek*, founded in 1907 by E. Siecke, and the "pan-Babylonian" school (H. Winckler, A. Jeremias, E. Stucken) illustrate this new interest in comparative mythology. But now the lunar and Mesopotamian myths usurped the exalted position of Max Müller's solar and Vedic myths.

A different approach to the understanding of myths was put forward by the English anthropological school. Sir James George Frazer, Jane Harrison, Gilbert Murray and other scholars tried to explain the ancient near eastern and Greek myths in terms of ritual magic. The periodical death and resurrection of vegetation, Frazer claimed, created the figure and the myth of a dying god, of which Adonis, Attis and Osiris (*qq.v.*) are the best-known examples. A great number of scholars concluded that the rituals preceded the myths; the myth was held to be an explanation of the ritual.

The English and Scandinavian "myth and ritual school" or "patternism" elaborated the interdependence of myths and rituals. S. H. Hooke, for example, pointed out that in the ancient near east the king, representing the god, was the centre of the cultus, and as such he was responsible for the crops and for the prosperity of the cities. G. Widengren went even further: the king was responsible for the very well-being of the cosmos. This conception, Widengren claimed, later gave rise to the Iranian saviour ideology and to Jewish messianism. "Patternism" has been attacked from many sides, especially by H. Frankfort, who maintained that differences are more important than similarities and consequentially that the myth and ritual pattern is an artificial construction.

Important contributions to the understanding of myth and mythical thought have been made by many philosophers and psychologists. The new approach to myth is greatly indebted to the results of modern ethnology. The scientific study of archaic societies—*i.e.*, those societies in which mythology is, or was until recently, "living"—has revealed that myth, for the "primitive" man, means a true story and, beyond that, a story that is a most precious treasure because it is sacred, exemplary and significant. As Bronislaw Malinowski puts it:

> Studied alive, myth . . . is not an explanation in satisfaction of a scientific interest, but a narrative resurrection of a primeval reality, told in satisfaction of deep religious wants, moral cravings, social submissions, assertions, even practical requirements. Myth fulfills in primitive culture an indispensable function; it expresses, enhances, and codifies belief; it safeguards and enforces morality; it vouches for the efficiency of ritual and contains practical rules for the guidance of man. Myth is thus a vital ingredient of human civilization; it is not an idle tale, but a hard-worked active force; it is not an intellectual explanation or an artistic imagery, but a pragmatic charter of primitive faith and moral wisdom. . . . These stories . . . are to the natives a statement of a primeval, greater, and more relevant reality, by which the present life, fates, and activities of mankind are determined, the knowledge of which supplies man with the motive for ritual and moral actions, as well as with indications as to how to perform them. (*Myth in Primitive Psychology* by Bronislaw Malinowski. By permission of W. W. Norton & Company, Inc. Copyright 1926 by W. W. Norton & Company, Inc., and Copyright renewed 1954 by A. V. Malinowska.)

**Toward a Definition of Myth.**—It would be hard to define myth in a way that would be acceptable to all scholars and at the same time intelligible to nonspecialists. Myth is an extremely complex cultural reality, which can be approached and interpreted from various and complementary viewpoints. The definition that seems least inadequate because most embracing is this: Myth narrates a sacred history; it relates an event that took place in primordial time, the fabled time of the "beginnings." In other words, myth tells how, through the deeds of supernatural beings, a reality came into existence, be it the whole of reality, the cosmos, or only a fragment of reality—an island, a species of plant, a particular kind of human behaviour, an institution. Myth, then, is always an account of a "creation": it relates how something was produced, began to be. Myth tells only of that which really

happened, which manifested itself completely. The actors in myths are supernatural beings. They are known primarily by what they did in the times of the beginnings. Hence myths disclose their creative activity and reveal the sacredness (or simply the supernaturalness) of their works. In short, myths describe the various and sometimes dramatic breakthroughs of the sacred (or the supernatural) into the world. It is this sudden breakthrough of the sacred that really establishes the world and makes it what it is today. Furthermore, it is a result of the intervention of supernatural beings that man himself is what he is today, a mortal, sexed and cultural being. The myth is regarded as a sacred story and hence a "true history," because it always deals with realities. The cosmogonic myth is "true" because the existence of the world is there to prove it; the myth of the origin of death is equally true because man's mortality proves it, and so on.

Because myth relates the *gesta* of supernatural beings and the manifestation of their sacred powers, it becomes the exemplary model for all significant human activities. When the missionary and ethnologist G. Strehlow asked the Australian Arunta why they performed certain ceremonies, the answer was always, "Because the ancestors so commanded it." The Kai of New Guinea refused to change their way of living and working, and they explained: "It was thus that the Nemu [the mythical ancestors] did, and we do likewise." Asked the reason for a particular detail in a ceremony, a Navaho chanter answered, "Because the Holy People did it that way in the first place." The same justification is alleged by the Hindu theologians and ritualists: "We must do what the gods did in the beginning" (Shatapatha Brahmana, VII, 2, 1, 4); "Thus the gods did; thus men do" (Taittiriya Brahmana, I, 5, 9, 4). In summary, the foremost function of myth is to reveal the exemplary models for all human rites and all significant human activities—alimentation or marriage, work or education, art or wisdom.

**Myths and Tales.**—In societies where myth is still alive the people carefully distinguish myths—"true stories"—from fables or tales, which they call "false stories." The Pawnee differentiate "true stories" from "false stories," and include among the "true" stories in the first place all those which deal with the beginnings of the world; in these the actors are divine beings, supernatural, heavenly, or astral. Next come those tales which relate the marvellous adventures of the national hero, a youth of humble birth who became the savior of his people, freeing them from monsters, delivering them from famine and other disasters, and performing other noble and beneficent deeds. Last come the stories which have to do with the world of the medicine-men and explain how such-and-such a sorcerer got his superhuman powers, how such-and-such an association of shamans originated, and so on. The "false" stories are those which tell of the far from edifying adventures and exploits of Coyote, the prairie-wolf. Thus in the "true" stories we have to do with the holy and the supernatural, while the "false" ones on the other hand are of profane content, for Coyote is extremely popular in this and other North American mythologies in the character of a trickster, deceiver, sleight-of-hand expert and accomplished rogue. (R. Pettazoni, *Essays on the History of Religions*, pp. 11–12; E. J. Brill, Leiden, 1954.)

Similarly, the Cherokee distinguish between sacred myths (cosmogony, creation of the stars, origin of death) and profane stories, which explain, for example, certain anatomical peculiarities of animals. The same distinction is found in Africa. The Herero consider the stories that relate the beginnings of the different groups of the tribe "true" because they report facts that really took place, while the more or less humorous tales have no foundation. As for the people of Togo, they look on their origin myths as absolutely real.

This is why myths cannot be related without regard to circumstances. Among many tribes they are not recited before women and children, that is, before the uninitiated. Usually the old teachers communicate the myths to the neophytes during their isolation in the bush, and this forms part of their initiation. Whereas "false stories" can be told anywhere and at any time, myths must not be recited except during a sacred period.

The distinction made between true stories and false stories is significant. Both categories of narratives present histories—that is, relate a series of events that took place in a distant and fabulous past. Although the actors in myths are usually gods and supernatural beings, while those in tales are heroes or miraculous animals, all the actors share the common trait that they do not belong to the everyday world. Nevertheless, the people have felt that the two kinds of stories are basically different. For everything that the myths relate concerns them directly, while the tales and fables refer to events that, even when they have caused changes in the world (*cf.* the anatomical or physiological peculiarities of certain animals), have not altered the human condition as such.

Myths narrate not only the origin of the world, of animals, plants and man, but also all the primordial events in consequence of which man became what he is today—mortal, sexed, organized in a society, obliged to work in order to live and working in accordance with certain rules. If the world exists, if man exists, it is because supernatural beings exercised creative powers in the "beginning." But after the cosmogony and the creation of man other events occurred, and man as he is today is the direct result of those mythical events, he is constituted by those events. He is mortal because something happened in the mythical time. If that thing had not happened, man would not be mortal—he would have gone on existing indefinitely, like rocks; or he might have changed his skin periodically like snakes, and hence would have been able to renew his life, begin it over again indefinitely. But the myth of the origin of death narrates what happened *in illo tempore*, and, in telling the incident, explains why man is mortal.

Similarly, a certain tribe live by fishing because in mythical times a supernatural being taught their ancestors to catch and cook fish. The myth tells the story of the first fishery and, in so doing, at once reveals a superhuman act, teaches men how to perform it and, finally, explains why this particular tribe must procure their food in this way.

It would be easy to multiply examples. But those already given show why, for archaic man, myth is a matter of primary importance, while tales and fables are not. Myth teaches him the primordial "stories" that have constituted him existentially; and everything connected with his existence and his legitimate mode of existence in the cosmos concerns him directly. Moreover, what happened *ab origine* can be repeated by the power of rites. For the man of archaic societies, it is essential to know the myths. By recollecting the myths, by reenacting them, he is able to repeat what the gods, the heroes or the ancestors did *ab origine*. To know the myths is to learn the secret of the origin of things. In other words, one learns not only how things came into existence but also where to find them and how to make them reappear when they disappear. (*See* also FOLKLORE.)

**The Functions of Myth.**—Australian totemic myths usually consist in a rather monotonous narrative of peregrinations by mythical ancestors or totemic animals. They tell how, in the "dream time" (*alcheringa*)—that is, in mythical time—these supernatural beings made their appearance on earth and set out on long journeys, stopping now and then to change the landscape or to produce certain animals and plants, and finally vanished underground. But knowledge of these myths is essential for the life of the Australians. The myths teach them how to repeat the creative acts of the supernatural beings and hence how to ensure the multiplication of such-and-such an animal or plant.

These myths are told to the neophytes during their initiation; or rather, they are performed, that is, reenacted. The "story" narrated by the myth thus constitutes a "knowledge" which is esoteric not only because it is secret and is handed on during the course of an initiation but also because the "knowledge" is accompanied by a magico-religious power. For knowing the origin of an object, an animal, a plant and so on is equivalent to acquiring a magical power over them by which they can be controlled, multiplied or reproduced at will. Erland Nordenskiöld has reported some particularly suggestive examples from the Cuna Indians of Panama. According to their beliefs, the lucky hunter is the one who knows the origin of the game. And if certain animals can be tamed, it is because the magicians know the secret of their creation. Similarly, one can hold red-hot iron or grasp a poisonous snake if one knows the origin of fire and snakes.

This is a quite widespread belief, not connected with any particu-

lar type of culture. In Timor, for example, when a rice field sprouts, someone who knows the mythical traditions concerning rice goes to the spot. He spends the night there in the plantation hut, reciting the legends that explain how man came to possess rice. Reciting its origin myth compels the rice to come up as fine and thick and vigorous as it was when it first appeared.

In most cases it is not enough to know the origin myth, it must be recited; this, in a sense, is a proclamation of one's knowledge, displays it. But this is not all. He who recites or performs the origin myth is thereby steeped in the sacred atmosphere in which these miraculous events took place. The mythical time of origins is a "strong" time because it was transfigured by the active, creative presence of the supernatural beings. By reciting the myths one reconstitutes that fabulous time and hence in some way becomes contemporary with the events described, one is in the presence of the gods or heroes. As a summary formula it might be said that by "living" the myths one emerges from profane, chronological time and enters a time that is of a different quality, a "sacred" time at once primordial and indefinitely recoverable.

**Summary.**—In general it can be said that myth, as experienced by archaic societies, (1) constitutes the history of the acts of the supernaturals; (2) that this history is considered to be absolutely true (because it is concerned with realities) and sacred (because it is the work of the supernaturals); (3) that myth is always related to a "creation," it tells how something came into existence, or how a pattern of behaviour, an institution, a manner of working were established; this is why myths constitute the paradigms for all significant human acts; (4) that by knowing the myth one knows the origin of things and hence can control and manipulate them at will; this is not an external, abstract knowledge but a knowledge that one experiences ritually, either by ceremonially recounting the myth or by performing the ritual for which it is the justification; (5) that in one way or another one lives the myth, in the sense that one is seized by the sacred, exalting power of the events recollected or reenacted.

"Living" a myth, then, implies a genuinely religious experience, since it differs from the ordinary experience of everyday life. The "religiousness" of this experience is due to the fact that one reenacts fabulous, exalting, significant events, one again witnesses the creative works of the supernaturals; one ceases to exist in the everyday world and enters a transfigured, auroral world impregnated with the supernaturals' presence. What is involved is not a commemoration of mythical events but a reiteration of them. The protagonists of the myth are made present, one becomes their contemporary. This also implies that one is no longer living in chronological time but in the primordial time, the time when the event *first took place*. This is why we can use the term the "strong time" of myth; it is the prodigious, "sacred" time when something new, strong and significant was manifested. To reexperience that time, to reenact it as often as possible, to witness again the spectacle of the divine works, to meet with the supernaturals and relearn their creative lesson is the desire that runs like a pattern through all the ritual reiterations of myths. In short, myths reveal that the world, man and life have a supernatural origin and history, and that this history is significant, precious and exemplary.

## MYTHS OF THE BEGINNING AND OF THE END

**Origin Myths and Cosmogonic Myths.**—Every mythical account of the origin of anything presupposes and continues the cosmogony. From the structural point of view, origin myths can be homologized with the cosmogonic myth. The creation of the world being the preeminent instance of creation, the cosmogony becomes the exemplary model for creation of every kind. This does not mean that the origin myth imitates or copies the cosmogonic model, for no concerted or systematic reflection is involved. But every new appearance—an animal, a plant, an institution—implies the existence of a world. Every origin myth narrates and justifies a new situation—new in the sense that it did not exist from the beginning of the world. Origin myths continue and complete the cosmogonic myth; they tell how the world was changed, made richer or poorer.

This is why some origin myths begin by outlining a cosmogony. The history of the great families and dynasties of Tibet opens by rehearsing the birth of the cosmos from an egg. The Polynesian genealogical chants begin in the same way. Such ritual genealogical chants are composed by the bards when the princess is pregnant, and they are communicated to the *hula* dancers to be learned by heart. The dancers, men and women, dance and recite the chant continuously until the child is born. It is as if the embryological development of the future chief were accompanied by a recapitulation of the cosmogony, the history of the world and the history of the tribe. The gestation of a chief is the occasion for a symbolic recreation of the world. The recapitulation is at once a reminder and a ritual reactualization, through song and dance, of the essential mythical events that have taken place since the creation.

The close connection between the cosmogonic myth, the myth of the origin of sickness and its remedy, and the ritual of magical healing is clearly exemplified in, for example, the ancient near east or among the Tibetans. Sometimes a solemn recitation of the cosmogonic myth is enough to cure certain sicknesses or imperfections. As the exemplary model for all creation, the cosmogonic myth can help the patient to make a new beginning of his life. The return to origins gives the hopes of a rebirth. All this is clearly apparent from the many ritual applications of the Polynesian cosmogonic myth. According to this myth, in the beginning there were only the waters and darkness. Io, the supreme god, separated the waters by the power of thought and of his words, and created the sky and the earth. He said, "Let the waters be separated, let the heavens be formed, let the earth be!" These cosmogonic words of Io's, by virtue of which the world came into existence, are creative words, charged with sacred power. Hence men utter them when there is something to do, to create. They are repeated during the rite for making a sterile womb fecund, during the rite for curing body and mind, but also on the occasion of a death, of war and of the recitation of genealogies. A Polynesian, Hare Hongi, puts it this way:

> The words by which Io fashioned the Universe—that is to say, by which it was implanted and caused to produce a world of light—the same words are used in the ritual for implanting a child in a barren womb. The words by which Io caused light to shine in the darkness are used in rituals for cheering a gloomy and despondent heart, the feeble aged, the decrepit; for shedding light into secret places and matters, for inspiration in song-composing and in many other affairs, affecting man to despair in times of adverse war. For all such the ritual includes the words (used by Io) to overcome and dispel darkness. (E. S. C. Handy, *Polynesian Religion*, p. 11; Bulletin 34, Bishop Museum Press, Honolulu, 1927.)

This remarkable text presents direct testimony concerning the function of the cosmogonic myth in a traditional society. This myth serves as the model for every kind of creation—the procreation of a child as well as the reestablishment of a military situation in jeopardy or of a psychic equilibrium threatened by melancholy and despair.

Regard of the cosmogonic myth as the exemplary model for every creation is admirably illustrated by a custom of the Osage Indians. When a child is born among the Osage, "a man who had talked with the gods" is summoned. When he reaches the new mother's house he recites the history of the creation of the universe and the terrestrial animals to the newborn infant. Not until this has been done is the baby given the breast. Later, when it wants to drink water, the same man—or sometimes another—is called in again. Once again he recites the creation, ending with the origin of water. When the child is old enough to take solid food the "man who had talked with the gods" comes once more and again recites the creation, this time also relating the origin of grains and other foods. (Alice C. Fletcher and F. La Flesche, *The Omaha Tribe*, p. 116; Bureau of American Ethnology, 27th Annual Report, Washington, D.C., 1911.)

It would be hard to find a more eloquent example of the belief that each new birth represents a symbolic recapitulation of the cosmogony and of the tribe's mythical history. The object of this recapitulation is to introduce the newborn child ritually into the sacramental reality of the world and culture and thus to vali-

date the new existence by announcing that it conforms with the mythical paradigms. But this is not all. The newborn child is also made a witness to a series of beginnings. And one cannot "begin" anything unless one knows its origin, how it first came into being. When it "begins" to suckle or to drink water or to eat solid food, the child is ritually projected into the time of origin when milk, water and grains first appeared on earth. The idea implicit in this belief is that it is the first manifestation of a thing which is significant and valid, and not its successive epiphanies.

**Periodic Repetition of the Cosmogonic Myth.**—The Australians reenacted annually their myths of the origins of food animals and food plants. This reiteration of the creative work done in the "dream [mythical] time" by supernatural beings amounts to a ritual repetition of cosmogony. But among the Australians that cosmogony is limited to the fashioning of the territory with which they are familiar. This is their "world," and it must be periodically renewed or it may perish. The idea that the cosmos is threatened with ruin if it is not annually re-created provides the inspiration for the chief festival of the Californian Karok, Hupa and Yurok tribes. In their respective languages the ceremony is called "repair" or "fixing" of the world; in English, it is "New Year." Its purpose is to reestablish or strengthen the earth for the following year or two years. The essential part of the ceremonial consists in long pilgrimages undertaken by the priest to all the places where the "immortals" (*i.e.*, the divine beings) performed certain creative acts. During all this time the priest incarnates the immortals.

The mythico-ritual scenario of periodic renewal of the world through a symbolic repetition of the cosmogony is also found among other Californian tribes (*e.g.*, the Hill and Plains Maidu, the Eastern Pomo). This Californian scenario may be compared with the Shawnee ritual "Cabin of New Life" (which forms part of the Sun Dance; *q.v.*) and the "Big House" ceremonies of the Lenape. In both cases may be seen a cosmogonic ritual, a renewal of the world and rebirth of life.

Similar ideas are found in the religions of the ancient near east, though of course with the inevitable differences among societies in the pre- and protoagricultural stage and fully agricultural and urban societies, such as Mesopotamia and Egypt. Yet one essential fact remains. The Egyptians, the Mesopotamians, the Jews and other peoples of the ancient near east felt the need to renew the world periodically. The renewal consisted in a cult scenario the chief rite of which symbolized the reiteration of the cosmogony. In Mesopotamia the creation of the world was ritually reiterated during the New Year festival. A series of rites reenacted the fight between Marduk and Tiamat (the dragon symbolizing the primordial ocean), the victory of the god, and his cosmogonic labours. The "Poem of Creation" (*Enuma elish*) was recited in the temple. As H. Frankfort puts it, "each New Year shared something essential with the first day when the world was created and the cycle of the seasons started." (H. Frankfort, *Kingship and the Gods*, p. 319; The University of Chicago Press, 1942.) Among the Egyptians, too, the New Year symbolized the creation. (*See* also CREATION, MYTHS OF.)

**The End of the World—in the Past and the Future.**—Myths of cosmic cataclysms are extremely widespread among primitives. They tell how the world was destroyed and mankind annihilated except for a single couple or a few survivors. The myths of the flood are the most numerous and are known nearly everywhere, although extremely infrequent in Africa. (*See* FLOOD [IN RELIGION AND MYTH].) In addition to flood myths, others recount the destruction of mankind by cataclysms of cosmic proportions—earthquakes, conflagrations, falling mountains, epidemics and so forth. Clearly, this end of the world was not final; rather, it was the end of one human race, followed by the appearance of another. But the total submergence of the earth under the waters or its destruction by fire, followed by the emergence of a virgin earth, symbolize return to chaos followed by cosmogony.

In many myths the flood is connected with a ritual fault that aroused the wrath of the supreme being; sometimes it is merely the result of a divine being's wish to put an end to humanity. But if we examine the myths that announce the impending flood, we find that one of its chief causes is the sins of mankind together with the decrepitude of the world. The flood opened the way at once to a re-creation of the world and to a regeneration of humanity.

Most American Indian myths of the end imply either a cyclic theory (as among the Aztecs) or the belief that the catastrophe will be followed by a new creation, or, finally (in some parts of North America), the belief in a universal regeneration accomplished without a cataclysm. (In this process of regeneration, only sinners will perish.) According to Aztec tradition, there have already been three or four destructions of the world, and the fourth (or the fifth) is expected in the future. Each of these worlds is ruled by a "sun," whose fall or disappearance marks the end.

The belief that the catastrophe is the inevitable consequence of the "old age," or decrepitude, of the world appears to be comparatively common. According to the Cherokee, "when the world grows old and worn out, the people will die and the cords will break and let the earth sink down into the Ocean." (H. B. Alexander, *North American Mythology*, p. 60; Marshall Jones Co., Boston, 1916.) In a Maidu (California) myth Earth-Maker assures the couple he had created: "When this world becomes bad, I will make it over again; and after I make it, ye shall be born." (*Ibid.*, p. 219.) One of the chief cosmogonic myths among the Kato, an Athapaskan-speaking tribe of California, begins with the creation of a new sky to replace the old one, which seems about to fall. As Alexander remarks in connection with the cosmogonic myths of the Pacific coast, "many of the creation-stories seem to be, in fact, traditions of the re-forming of the earth after the great annihilation, although in some myths both the creation and the re-creation are described." (*Ibid.*, p. 225.)

All in all, these myths of the end of the world—implying, as they do in clearer or darker fashion, the re-creation of a new universe—express the same archaic and extremely widespread idea of the progressive degradation of a cosmos, necessitating its periodical destruction and re-creation. These myths of a final catastrophe that will at the same time be the sign announcing the imminent re-creation of the world have been the seed bed for the prophetic and millennialist movements that have developed among primitive peoples in modern times (*see* below, *Millennialist Myths and Cargo Cults*).

**The Myth of the End of the World in Oriental Religions.**—In all probability the doctrine of the destruction of the world (*pralaya*) was already known in Vedic times (*cf.* Atharva Veda, X, 8, 39–40). The universal conflagration (Ragnarök; *q.v.*), followed by a new creation, is an element in Germanic mythology. These facts seem to show that the Indo-Europeans were not unacquainted with the end-of-the-world myth. But beginning with the Brahmanas, and especially in the Puranas, the Indians sedulously developed the doctrine of the four *yugas*, the four ages of the world. The essence of this theory is the cyclical creation and destruction of the world and the belief in the "perfection of the beginnings." (*See* CHRONOLOGY: *Hindu;* HINDUISM: *Cosmology.*) As the Buddhists and the Jains hold the same views, the doctrine of the eternal creation and destruction of the universe evidently is a pan-Indian idea.

The complete cycle is terminated by a dissolution, a *pralaya*, which is repeated more intensely (*mahapralaya*, great dissolution) at the end of the thousandth cycle. According to the Mahabharata and the Puranas, the horizon will burst into flame, 7 or 12 suns will appear in the heavens and will dry up the seas and burn the earth. The *Samvartaka* (the Fire of the Cosmic Conflagration) will destroy the entire universe. Then rain will fall in floods for 12 years, and the earth will be submerged and mankind destroyed (Vishnu Purana 24, 25). Sitting on the cosmic snake Shesha on the surface of the ocean, Vishnu is sunk in yogic sleep (Vishnu Purana, VI, 4, 1–11). And then everything will begin over again—*ad infinitum*.

As to the myth of the "perfection of the beginnings," it is easily recognized in the purity, intelligence, bliss and longevity of human

life during the *krita yuga*, the first age. In the course of the following *yugas* there is a progressive deterioration in human intelligence and morality as well as in man's bodily size and longevity. Jainism expresses the perfection of the beginnings and the subsequent degeneration in extravagant terms. According to Hemacandra, in the beginning man's stature was six miles and his life lasted a *krore* (10,000,000) of *purvas* (a *purva* = 8,400,000 years). But at the end of a cycle his stature barely reaches seven cubits and his life does not last more than a hundred years. The Buddhists too dwell on the immense shortening of human life—80,000 years and even more ("immeasurable length," according to some traditions) at the beginning of the cycle and only ten years at the end of it.

The Indian doctrine of the ages of the world, that is, the eternal creation, deterioration, destruction and re-creation of the universe, is to some extent similar to the primitive conception of the annual renewal of the world, but there are important differences. In the Indian theory man plays no part whatever in the periodic re-creation of the world; basically, man does not want this eternal re-creation; his goal is escape from the cosmic cycle. Then, too, the gods themselves seem not to be actual creators; they are more the instruments through which the cosmic process is accomplished. For India there is no final end of the world properly speaking; there are only periods of varying lengths between the annihilation of one universe and the appearance of another. The "end" has no meaning except for the human condition; man can halt the process of transmigration in which he is blindly carried along.

The myth of the perfection of the beginnings is clearly documented among the Mesopotamians, the Jews and the Greeks. According to Babylonian traditions, the eight or ten antediluvian kings reigned between 10,800 and 72,000 years; in contrast the kings of the first postdiluvian dynasties reigned no more than 1,200 years. The Babylonians also knew the myth of a primordial paradise and had preserved the memory of a series (probably totaling seven) of successive destructions and re-creations of the human race. The Jews held similar ideas—the loss of the original paradise, the progressive shortening of the span of human life, the flood that annihilated humanity except for a few privileged individuals. In Egypt the myth of the "perfection of the beginnings" is not attested, but we find the legendary tradition of the fabulous longevity of the kings before Menes.

In Greece there are two different but connected traditions: (1) the theory of the ages of the world, including the myth of the perfection of the beginnings; (2) the cyclic doctrine. Hesiod is the first to describe the progressive degeneration of humanity during the five ages (*Works*, 109–201). The first, the Age of Gold under the reign of Cronus (Kronos), was a sort of paradise: men lived for a long time, never grew old, and their life was like that of the gods. The cyclic theory makes its appearance with Heraclitus, who will later greatly influence the Stoic doctrine of the eternal return. The two mythical themes—the ages of the world and the continuous cycle of creations and destructions—are already associated in Empedocles. There is no need to discuss the different forms these theories assumed in Greece, especially as the result of oriental influences. Suffice it to say that the Stoics took over from Heraclitus the idea of the end of the world by fire (*ekpyrosis*) and that Plato (*Timaeus* 22, C) already knew, as an alternative, the end by flood. These two cataclysms in a measure determined the rhythm of the Great Year (*magnus annus*). According to a lost work of Aristotle (*Protrepticus*), the two catastrophes occurred at the two solstices—the *conflagratio* at the summer solstice, the *diluvium* at the winter.

**Judaeo-Christian Apocalypses.**—Some of these apocalyptic images of the end of the world recur in the Judaeo-Christian eschatological visions. But Judaeo-Christianity makes an innovation of the first importance. The end of the world will occur only once, just as the cosmogony occurred only once. The cosmos that will reappear after the catastrophe will be the same cosmos that God created at the beginning of time, but purified, regenerated, restored to its original glory. This earthly paradise will not be destroyed again, will have no end. Time is no longer the circular time of the eternal return; it has become a linear and irreversible time. Nor is this all: the eschatology also represents the triumph of a sacred history. For the end of the world will reveal the religious value of human acts, and men will be judged by their acts. Here there is no longer any cosmic regeneration implying the accompanying regeneration of a collectivity (or of the whole human race). There is a judgment, a selection: only the chosen will live in eternal bliss. The chosen, the good, will be saved by their loyalty to a sacred history; faced by the powers and the temptations of this world, they remained true to the kingdom of heaven. (*See* also ESCHATOLOGY; APOCALYPTIC LITERATURE.)

Further in distinction from the cosmic religions, for Judaeo-Christianity the end of the world is part of the messianic mystery (*see* MESSIAH). For the Jews the coming of the Messiah will announce the end of the world and the restoration of paradise. For the Christians the end of the world will precede the second coming of Christ and the Last Judgment (*q.v.*). But for both alike the triumph of sacred history—manifested by the end of the world—in some measure implies the restoration of paradise. The prophets proclaim that the cosmos will be renewed—there will be a new heaven and a new earth. There will be an abundance of all things, as in the Garden of Eden (Amos ix, 13 ff.; Isa. xxx, 23 ff.; xxxv, 1, 2, 7; lxv, 17; lxvi, 22; Hos. ii, 18 ff.; Zech. viii, 12; Ezek. xxxiv, 14, 27; xxxvi, 9 ff., 30, 35). Wild beasts will live in peace together and "a little child shall lead them" (Isa. xi, 6). Sickness and infirmities will vanish forever; the lame will walk, the deaf hear, the blind see, and there will be no more weeping (Isa. xxx, 19; xxxv, 3 ff.; Ezek. xxxiv, 16). The new Israel will be built on Mt. Zion because paradise was set on a mountain (Isa. xxxv, 10; Ps. xlviii, 2).

For the Christians, too, the total renewal of the cosmos and the restoration of paradise are essential characteristics of the *eschaton*. In the Book of Revelation (xxi, 1–5) we read: "Then I saw a new heaven and a new earth; for the first heaven and the first earth had passed away . . . and I heard a great voice from the throne saying, . . . 'and death shall be no more, neither shall there be mourning nor crying nor pain any more. . . . Behold, I make all things new.'"

But this new creation will rise on the ruins of the first. The syndrome of the final catastrophe resembles the Indian descriptions of the destruction of the universe. There will be drought and famine, and the days will grow short. The period immediately preceding the end will be dominated by Antichrist (*q.v.*). But Christ will come and will purify the world by fire. As Ephraem Syrus expresses it: "The sea shall roar and be dried up . . . the heaven and earth shall be dissolved, and darkness and smoke shall prevail. Against the earth shall the Lord send fire, which lasting 40 days shall cleanse it from wickedness and the stains of sins." (Quoted in W. Bousset, *The Antichrist Legend*, p. 238; Eng. trans., London, 1896.) The destroying fire appears only once in the New Testament, in the Second Epistle of St. Peter (iii, 7–12). But it is an important element in the Sibylline Oracles, in Stoicism and in later Christian literature. It is probably Iranian in origin.

The reign of Antichrist is in some sense equivalent to a return to chaos. On the one hand, Antichrist is presented in the form of a dragon or demon, and this is reminiscent of the old myth of the fight between God and the dragon; the fight took place in the beginning, before the creation of the world, and it will take place again at the end. On the other hand, when Antichrist comes to be regarded as the false Messiah his reign will represent the total overthrow of social, moral and religious values—in other words, the return to chaos.

**Millennialist Myths and Cargo Cults.**—The myth of the end of the world is in the centre of the countless nativist and millennialist movements, of which the best known are the Melanesian cargo cults. These prophetic movements announce that the world is about to be destroyed and that the tribe will regain a kind of paradise: the dead will rise again and there will be neither death nor sickness. But, as in the Indo-Iranian and Judaeo-Christian eschatologies, this new creation—or recovery of paradise—will be preceded by a series of cosmic catastrophes. The earth will shake, there will be rains of fire, the mountains will crumble and fill the

valleys, the whites and the natives who have not joined the cult will be annihilated, and so on.

To give some examples, in 1923 the prophet Ronovuro, of the island of Espiritu Santo, in the New Hebrides, predicted a flood to be followed by the return of the dead in cargo ships loaded with rice and other provisions. In 1933, in the valley of Markham in New Guinea, a man named Marafi declared that the return of the dead would be preceded by a cosmic cataclysm: an earthquake would overturn everything, and then immediately a rain of kerosene flames would consume houses, gardens and all living beings. Marafi advised the construction, at the first earth tremor, of a huge house large enough to shelter entire communities. The next day it would be found that the dead had already arrived, loaded with gifts: preserved meat, tobacco, rice, clothing, lamps and guns. There would be no need for the people ever again to work in the gardens.

A myth famous in Indonesia predicts the return of the hero Mansren to inaugurate the Golden Age: the old will recover their youth, the sick will be healed, and the dead will return to earth. There will be an abundance of food, women, clothing and arms. No one will have to work or to pay taxes any longer. In some later versions of the myth, the arrival of Mansren will radically modify not only the social situation and the human mode of being but the very structure of the cosmos. Yams and potatoes will grow on trees while coconuts and other fruits will grow as roots. Fish will live on land and land animals in the sea. These are all symbolic images of a total reversal of the forms and the laws of the present world: what is below will be found above, and so on. The entire cosmos will be made anew; heaven and earth will be dissolved and a new heaven and a new earth will be created in their stead.

Most of these millennialist movements may be considered to be developments of the mythico-ritual scenario of the periodic renewal of the world. In many cases, this development was incited under the influence, direct or indirect, of Christian eschatology. The messianic figure is sometimes identified with the culture hero or the mythical ancestor whose return was awaited. Their coming is equivalent to a reinstauration of the mythical times of the origins, and hence to a re-creation of the world. (*See* Cargo Cults; Ghost Dance; Nativistic Movements.)

## OTHER TYPES OF MYTHS

The types of myths that have been discussed are directly or indirectly dependent on the cosmogonic myth. The myths of origin complete and prolong the creation myth. The myths of the end of the world, on the other hand, as well as the mythico-ritual pattern of a periodic regeneration of the universe, are structurally related to the cosmogonic myth. One can say that, in this case, eschatology repeats cosmogony. These types of myth have been stressed because of the considerable role they play in the religious life of primitive and old oriental societies. As a matter of fact, they reveal not only how the world was created but also how everything important and significant came into being. Moreover, these myths disclose how the world can be periodically regenerated and how, consequently, man can share in this universal renewal.

But there are other types of myths; they can be classified as follows: (1) myths of the gods and of other divine beings; (2) myths of the creation of man; (3) myths telling of the subsequent modifications of the world and of the human condition; (4) myths associated with celestial bodies and the life of nature; (5) myths about heroes.

A common trait of all these types of myths is that they relate events which took place after the creation of the world. Some of them may be considered myths of origin; for example, the anthropogonic myth tells how man was created; the myths of the origin of death explain why man became mortal; the solar and lunar myths recount the origin of the sun and the moon, and so on. Moreover, many of the myths relating radical modifications of the world and of man are at the same time myths of origin. Such are, for example, stories telling of the transformation of the earth at the hands of a demiurge, a culture hero, or a trickster (the origin of mountains, rivers, lakes, etc.); stories about the remoteness of heaven; myths of the origin of plants and domesticated animals from the body of a murdered divine being; etc.

All the events related in myths belong to the fabulous past. But it is possible to distinguish between a primordial epoch, corresponding to the very beginnings of the world, and the subsequent changes of that initial situation. Thus there are: (*a*) myths narrating the creation of the world and of man and describing that primeval epoch which lasted until the first change in the structure of the cosmos or in man's mode of being; (*b*) myths relating the countless dramatic modifications of the world and of man which took place from that moment until the end of the mythical time. A third group of myths is constituted by the adventures of gods, supernatural beings and heroes, which may or may not be related to these modifications and which took place either before or after them.

**Myths of High Beings and Celestial Gods.**—Among the most primitive societies (*i.e.*, those of food-gatherers or hunters) the myths of the high gods are relatively simple. The supreme being is believed to have created the world and man, but he soon abandoned his creations and withdrew into the sky. Sometimes he did not even complete the creation, and another divine being, his representative, took over the task. In some cases, his withdrawal was accompanied by a break in communications between sky and earth or by a great increase in the distance between them. In some myths the original nearness of the sky and the presence of God on earth constitute a paradisal syndrome (to which must be added man's original immortality, his friendly relations with the animals, and the absence of any need for work). The place of this more or less forgotten *deus otiosus* was taken by various divinities, all of whom are closer to man and who help him or persecute him in a more direct and constant way.

The celestial supreme being and creator recovers his religious activity only in certain pastoral cultures (especially among the Turko-Mongols) and in the monotheism of Moses, in the reform of Zoroaster and in Islam. Even when his name is still remembered—An (Anu) of the Mesopotamians, El of the Canaanites, Dyaus of the Vedic Indians, Uranus of the Greeks—the supreme being no longer plays an important role in religious life and is but little represented in mythology (sometimes he is completely absent from it; *e.g.*, Dyaus). The "passivity" of Uranus as *deus otiosus* is plastically expressed by his castration: he has become impotent and unable to take part in the affairs of the world. In Vedic India Varuna supplanted Dyaus, but he in his turn first gives way before a young warrior god, Indra, and then is completely supplanted by Vishnu and Shiva. El yields the primacy to Baal as An does to Marduk.

Except for Marduk, all these supreme gods are no longer "creative" in the active sense. They did not create the world, they only organized it and assumed the responsibility for maintaining order and fertility in it. Primarily, they are fecundators, like Zeus or Baal, who, by their hierogamies with the earth goddesses, ensure the fertility of the fields and the abundance of harvests. Marduk himself is only the creator of this world, of the universe as it exists today. Another "world"—almost unthinkable for us, because fluid, an ocean not a cosmos—existed before this one: it was the world ruled by Tiamat and her spouse, in which three generations of gods lived.

The polytheistic religions (*e.g.*, of the ancient near east, India, Greece) are characterized by rich, variegated and dramatic mythologies. Besides celestial and storm gods, important roles are played by deities of vegetation and chthonic fertility. Special mention must be made of the pathetic myths of the young gods who die murdered or by accident (Osiris, Tammuz, Attis, Adonis, etc.) and sometimes come back to life, or of a goddess who goes down to Hades (Ishtar), or of a divine maiden who is forced to descend there (Persephone). These "deaths" are creative in the sense that they bear some relation to vegetation. Around one of these violent deaths or the descent of a divinity to hell the mystery religions later grew up.

**Anthropogonic Myths.**—The myths of the creation of man represent in some respects a continuation of the cosmogony. In a great number of myths, man is created by a god from a material

substance. Thus, for example, the Yoruba of Nigeria believe that the primordial couple was fashioned out of mud by the god Obatala; the Indonesian and Melanesian myths tell how the first man was created from a stone. In Oceania, a god created man either from earth or from a figure drawn upon the ground and sprinkled with his blood. In some mythologies (*e.g.*, of southeast Asia and ancient Iran) man is believed to have been created from an animal or plant. There are also examples of androgyny of the primordial man. Either the creator separates the two sexes after his creation of the androgynous being or he draws the woman forth from the body of the man. In some cases, a god creates the first man *ex nihilo*, by an act of thought. Thus the Californian Wiyot know the following myth: Gudatrigakwitl, the high god, used neither sand nor earth to fashion man; he simply thought, and man came into being.

**Myths of Transformation.**—By far the most complex and dramatic category of myths includes those which tell of radical alterations in the structure of the world and in man's mode of being. One group of such myths is concerned with the cosmic changes which took place at a certain moment in the primordial past: the heaven, which had been very close to earth, abruptly became remote; the mountains which once had touched the sky were flattened out; the tree or the liana connecting earth and heaven was cut. This rupture between heaven and earth put an end to the paradisiac age when the gods came down and mingled with men and when men, for their part, could ascend to heaven by climbing the mountain or the tree. As a consequence of this cosmic alteration, man became mortal and sexed and he was obliged to work in order to live.

Another group of these myths is concerned with the origin of death. The most common African motif is what has been called "the message that failed." God sent the chameleon to the mythical ancestors with the message that they would be immortal, and he sent the lizard with the message that they would die. The chameleon sauntered on the way and the lizard arrived first. After she delivered her message, death entered the world. Another African motif is that of "death in a bundle": God allowed the first human beings to choose between two bundles, one of which contained life, the other death. According to a third motif, mortality is the result of man's transgressing a commandment of God.

Among the myths relating changes in the structure of the world and the condition of man, perhaps the most pathetic are those of the *dema* type. *Dema* is the term applied by the Marind-Anim of New Guinea to the primordial beings who existed in mythical times. The central myth narrates the slaying of a *dema* divinity by the *dema* men of that primeval epoch. Its general outlines are as follows. A man named Ameta found a coconut on a boar's tusk and he planted it. In a few days a coconut palm sprang from it and flowered. Ameta cut his finger and the blood dropped onto a blossom. Nine days later he found a girl-child on the blossom and after another three days she became a marriageable girl. He named her Hainuwele ("coconut branch"). During a great festival, Hainuwele stood in the middle of the dancing place and for nine days and nights she distributed gifts to the dancers. But on the ninth day the men dug a grave in the middle of the dancing place and during the dance they threw Hainuwele into it. The grave was filled in and the men danced on it. On the next morning, Ameta found the body, disinterred it and cut it into pieces, which he buried in various places, except for the arms. The buried pieces gave birth to plants previously unknown, especially to tubers, which since then have been the chief food of human beings. Ameta took Hainuwele's arms to another *dema* divinity, Satene. Satene drew a spiral with nine turns on a dancing ground and placed herself at the centre of it. From Hainuwele's arms she made a door; then she summoned the dancers. "Since you have killed," she said, "I will no longer live here. I shall leave this very day. Now you will have to come to me through this door." Those who were able to pass through it remained human beings. The others were changed into animals (pigs, birds, fish) or spirits. Satene announced that after her going men would meet her only after their death, and she vanished from the surface of the earth.

A. E. Jensen has shown the importance of this myth for an understanding of the religion and world image of the ancient planters. The murder of a *dema* divinity by the *dema*, the ancestors of present humanity, ends an epoch and opens that in which we live today. The *dema* became men, that is, sexed and mortal beings. As for the murdered *dema* divinity, she survives both in her own creations (food, plants, animals, etc.) and in the house of the dead into which she was changed, or in the "mode of being of death," which she established by her own demise. The violent death of the *dema* divinity is not only a creative death, it is also a way of being continually present in the life of men and even in their death. For by feeding on the plants and animals that sprang from her body, men actually feed on the very substance of the *dema* divinity. Hainuwele, for example, survives in the coconut, the tubers and the pigs that men eat.

**Sun-Moon Myths.**—A rich and multifarious mythology has grown up around the two great luminaries. In many cultures, the sun and the moon are considered to be the eyes of a celestial supreme being. Even more frequent is the process of "solarization" of the supreme being; *i.e.*, his transformation into a sun-god. Myths of man's descent from the sun are known among some North American Indian tribes (*e.g.*, Blackfoot, Arapaho), and they are especially prevalent in Indonesia and Melanesia. The sun is also conceived as a hero and is symbolized by an eagle or a falcon. Dynasties and military aristocracies have been traced to solar heroes (ancient Egypt, Melanesia, etc.). The well-known motif of the two antagonistic brothers is probably related to the mythical conflict between the sun and the moon. Many myths of this type have survived in the folklore of many nations. It is worth noting that, together with myths related to the animal world (lord of animals, theriomorphic guardian spirits, etc.), astral mythologies and hero myths have provided most of the world's folklore themes and motifs. Certain solar myths, for example, have survived in secularized form as folk tales or sagas long after being emptied of their religious content.

The lunar mythologies are more dramatic. The sun always remains the same; the moon, on the other hand, is a body which waxes, wanes and disappears, only to come to life again after three moonless nights. In the religion of many primitive peoples, the moon is considered to be the first man who died. But for the religious man, death does not represent an extinction but rather a change, a new kind of life. A great number of myths are related to the phases of the moon, to its death and resurrection (or rebirth); *e.g.*, myths of the land of the dead, of the adventures of the first ancestor, of the mysteries of fertility and birth, myths of initiation, of magic and sorcery, etc. Most of these myths have survived, degraded and transformed, in the world's universal folklore. In some instances, the moon-god has usurped the role of a celestial supreme being.

**The Hero.**—Extremely widespread are myths about the son of a king who is abandoned immediately after his birth because of a prophecy threatening danger to his father. Consigned to the waters, usually in a box, the child is saved by animals or shepherds and is suckled by a female animal or by a humble woman. When fully grown, he embarks on extraordinary adventures (slays monsters, overcomes death, etc.). Later he finds his parents and takes revenge on his father (or uncle); finally he is recognized and achieves rank and homage. In most of the myths of this type, the dangers and trials of the hero (encounters with monsters and demons, descents into hell, being swallowed by a marine monster, etc.) have an initiatory meaning. By overcoming all these ordeals, the young man proves that he has surpassed the human condition and henceforth he belongs to a class of semidivine beings. Many epic legends and folktales utilize and readapt the highly dramatic scenarios of a hero's initiation (*e.g.*, Siegfried, Arthur, Robin Hood, etc.).

The folklore of all nations contains a large number of myths and mythical motifs emptied of their religious values and functions but preserved for their epical or fantastic qualities. Moreover, the heroic poetry of the world's oral tradition (*see* HERO), as well as the beginnings of drama and comedy, are directly dependent upon the respective mythical traditions of the world.

For myths of various cultures, *see* CELTIC MYTHOLOGY; GER-

MANIC MYTHOLOGY AND HEROIC LEGENDS; GREEK RELIGION; ROMAN RELIGION; BABYLONIA AND ASSYRIA: *Religion;* EGYPT: *History: Ancient Religion;* VEDIC RELIGION; MYTHOLOGY, PRIMITIVE.

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A study rich in new insights into the structure and function of myths in archaic societies is H. Baumann, "Mythos in ethnologischer Sicht," in *Studium Generale,* vol. xii, pp. 1–17, 583–597 (1959). Henry A. Murray (ed.), *Myth and Mythmaking* (1960), contains 17 articles on various aspects of myth, relations between myth and folklore, myths and literature, etc. *See* also Charles H. Long, *Alpha: the Myths of Creation* (1963); M. Eliade, *Myth and Reality* (1963). (M. EE.)

**MYTHOLOGY, PRIMITIVE.** Primitive mythology is the scientific study of myths specifically among nonliterate peoples. Primitive mythology may also refer to the myths themselves as opposed to their study. A myth is defined here as a traditional sacred narrative transmitted orally from one generation to another, and in which a social or universal lack is satisfied, or in which an earlier luxury or benefit is lost (*see* MYTH). The lack is often stated early in the narrative; for example, the world was without form, without man; man was without woman, without fire or without death. Similarly, it may be related that people once had all they wanted or were free of all sickness. Often the myths are placed at a time before the present features of earth and man were established. The dramatis personae are extraordinary individuals, ranging from culture heroes to gods. Usually a number of myths in a given culture will concern the same individual, although they may not necessarily form a logically consistent system.

Many scholars (F. Boas, for example) have despaired of making a rigorous distinction between myths and folktales. Boas suggested that the question of whether a given narrative was myth or folktale should be disregarded. Folklorist S. Thompson has also voiced doubts that myth can be accurately defined and distinguished from folktale. The usual distinctions are based on such factors as the setting and the dramatis personae. According to Boas, myths are set in a time "when the world had not yet assumed its present form" and contemporary forms of human arts and customs had not yet emerged, whereas folktales are set in the modern or post-creation period. In myths, the actors are usually of divine origin; most commonly they are gods or culture heroes. In folktales, the protagonists are frequently human beings or anthropomorphic animals. Perhaps a more useful distinction can be made on the basis of function. Individuals in a given culture believe their myths to be true; thus myths function as culturally sacred precedents for present actions. In contrast, folktales are not necessarily believed, serving principally to instruct or amuse. However, since the same plot can occur in one culture as a myth and in another as a folktale, there may well be no structural generic distinction. The distinction is one of content and function rather than structure; for example, if the fulfilled need is that of an individual, *e.g.,* a hero seeks a bride, the narrative is probably a folktale. If a lack is liquidated for a community or for the world, *e.g.,* men are without fire, the narrative is probably a myth.

### THEORIES OF MYTH

Almost all of the many theories represent attempts to account for the multiple existence and apparent irrationality of myths. Mythologists have sought to explain the occurrence of essentially the same narrative, *e.g.,* the flood myth, among many unrelated peoples. One theory, predicated on the notion of the psychic unity of man or on the universality of much human experience, explains multiple existence by the principle of parallel development (polygenesis), according to which the same myth could have arisen independently many times. Others contend that each myth originated only once (monogenesis), attributing multiple existence to borrowing and diffusion. Advocates of both theories employ the comparative approach; this consists of gathering and examining a great number of versions or variants of the same myth. In addition to providing evidence suggesting the psychological unity of mankind and indicating the possible paths of myth diffusion, the comparative method is also used to suggest possible historic relationships between peoples or tribes. Presumably the more myth elements they have in common, the more likely it is that two peoples are related or that they were once in close contact. Thus, for example, the Asian origin of American Indians has in part been inferred from comparative studies of myth diffusion (G. Hatt).

Efforts to interpret irrational, magical or unnatural elements in myths have provided the greatest challenge to mythologists: for example, the meaning of the myth of human creation from clay or dust. Advocates of theories of symbolism argue that these elements merely symbolize actual human experience and are not to be understood literally. The principal difficulty is that each school of symbolism claims the one and only correct key to interpret the symbolic code. In the latter part of the 19th century, primitive myth was interpreted as primitive man's symbolic translation of such phenomena as the rising and setting of the sun (solar mythology). In the 20th century, the same irrational elements were explained by another symbolic code provided by psychoanalytic theory. According to this approach, myths with symbols and plots that may also be found in dreams are projections of individual human experiences and psychological problems. Just as psychoanalysts interpret the apparent irrationality of dreams as rationally derived, so was the irrationality of myth elucidated (*see* DREAM AND DREAMING). In marked contrast to symbolic notions is the literal approach to myth. Proponents of one of the literal theories contend that irrational myth elements are simply distortions of actual events and customs; irrational myth is thus history misremembered. Anthropologists (for example, B. Malinowski) generally have tended to lean toward such a literal approach.

Theoretical bases for the study of primitive mythology may be classified as emphasizing either origin, function or structure. The greatest effort by far has been expended in origin studies. Investigations of the psychological origins of myth are intended to discover their ultimate origin in human imagination and thought. Historical origin studies are designed to discover where and when a particular myth first arose and what its paths of subsequent diffusion were. Studies concerned with psychological origins generally have favoured a polygenetic and symbolic approach, while those dealing with historical origins have tended towards monogenetic and literal interpretations.

Mythologists interested primarily in origins have tended to study myths in a context of time and to treat them as survivals of the historical past. Often, in origin studies, hypotheses about man are used to explain myths. In contrast, mythologists concerned with the function and structure of myth tend to study myths synchronically; that is, out of the context of time. A functionalist does not study myths as survivals, but rather as functioning elements of present human culture. In functional and structural studies, hypotheses about myths are used to explain man.

Malinowski, one of the first to advocate a functional approach, suggested that myths were essentially charters for belief, serving to reinforce traditional morality, social structure and magic by linking their origins to superior beings or supernatural occurrence. However, the function of myths need not be limited to the validation of cultural traditions. Paradoxically they may also offer socially approved outlets for violating (albeit vicariously) institutionalized behaviour. Thus in a myth wherein a culture hero violates a tabu (*q.v.*) or interdiction, at least two coincident functions may be involved. The audience not only is reminded of definite canons of behaviour but may also enjoy the hero's flagrant viola-

tion of the culturally sacred and his escape from the commonly inevitable consequences.

The notion of myth as a charter for such aspects of culture as values, beliefs and social organization led to an attempt to derive value systems and ethical constructs in any given group from its mythology. Boas, in one of the most comprehensive of such studies, attempted to describe the habits and ethics of the Tsimshian (*q.v.*). He held that mythology is a reflection of the ordinary life of a people, and that the plots exhibit clearly "what is considered right and wrong." Other studies of this type include K. Spencer's analytic extraction of values and patterns of social organization from Navaho (*q.v.*) mythology, and M. Jacobs' delineation of Chinook (*q.v.*) ethics and personality on the basis of an intensive analysis of myth texts.

Myths may also be studied in terms of their structure (morphology). However, one obstacle in studying the component parts, their interrelations and their relationship to the myth as a whole, has been a lack of adequate morphological units. Nevertheless, the absence of such units has not precluded the description of structural patterns in mythology. O. Rank and the 4th Lord Raglan have each provided ample evidence of the basic pattern of many Euro-Asiatic hero myths. Rank gave a detailed account of the myth of the birth of the hero in an attempt to demonstrate the infantile origin of mythological patterns. Lord Raglan outlined a hero pattern consisting of 22 typical incidents to suggest that any life history of a traditional hero which contained these incidents was necessarily ahistorical and that myths are derived from rituals. On the complex problem of the interrelation of myth and ritual, C. Kluckhohn has made perhaps the sanest comment that available evidence fails to show that myth invariably derives from or generates ritual.

However, the structural similarity between myth and ritual has also been pointed out by C. Lévi-Strauss. He suggests that myths are structurally a series of resolved or mediated binary oppositions; *e.g.*, life and death, male and female, man and god, earth and sky. He finds the same types of opposition in his structural analyses of rituals. In postulating that the resolution of binary oppositions is a characteristic of mythical thought and that the purpose of myth is to provide a "logical model capable of overcoming a contradiction" he has clearly transcended mere morphological analysis. Moreover, since his illustrative oppositions include states (*e.g.*, life and death) and dramatis personae (*e.g.*, man and god), it is apparent that his analysis confuses myth structure and content. There is, however, no question of the value of the notion that there is a comparatively small number of recurrent structural patterns of myths in contrast to the total number of individual myth texts reported. A. B. Rooth, after analyzing 300 North American Indian creation myths, found that most of them belonged to one of only eight distinct types. Although there is a large number of worldwide myths, there are undoubtedly very few worldwide myth patterns. One such structural pattern might be described as consisting of an interdiction, the violation of the interdiction, a consequence, and a successful (or unsuccessful, depending upon the culture or individual narrator) attempt to escape the consequence.

## TYPES OF MYTH

Many myths are concerned with creation. The creation may be of the universe, the heavens, the earth and its topographical features, gods, man and other animals, plants, or cultural customs and artifacts. Myths frequently describe the establishment of the natural order which governs earth and man: the origin of the arrangement of the waters, winds, seasons, months, day and night, as well as the physical-psychological attributes of man. The origins of customs related to such important phases of the life cycle as birth, marriage and death are also the subjects of myths. To refer conveniently to specific myths, professional students of mythology utilize a shorthand system found in Thompson's monumental *Motif-Index of Folk-Literature*, six volumes (1955–1958). This also gives some information as to the approximate geographical distribution of specific myths and provides a valuable bibliography. Motif numbers given in the *Motif-Index* for the various myths discussed below are noted in parentheses.

**Creation of the World.**—In some myths a creator exists before all things (A 610) and may simply create the earth (A 830); or the world may arise from parts of the creator's body (A 614). In the widely diffused myth of the world-parents the sky father descends upon the earth mother and begets the world (A 625) or the sky and earth are joined and must be separated to permit life on earth. In one motif (from Asia and aboriginal North America) the creator on a raft in the primeval sea has animals dive for the earth stuff (A 812); in North American versions it is often the muskrat that succeeds in bringing up a bit of mud from which the earth is made. In another primitive creation myth the universe is brought forth from an egg (A 641).

**Creation of Man.**—Most of the techniques employed in myths of world creation are also used in myths of human origin. The maker may directly create man (A 1210); or humanity may originate from parts of the creator (A 1211) such as sweat, body rubbings or nails. Man may be the offspring of the creator (A 1216) or may be created from earth, clay, mud or dust (A 1241). Among peoples in Polynesia and South America, mankind originates from eggs (A 1222), from trees (A 1251) or from animals (A 1224). Specific myth types deal with man's arrival on earth; for example, he may descend from the sky (A 1231) or (in a myth common to aboriginal North and South America) he may emerge from under the ground (A 1232).

**Origin of Death.**—The same natural event may be explained by a variety of myths. Thus a number of different explanations can be found for the origin of death (A 1335). Among some African tribes it is related that death began as a result of a falsified message. Another African myth states that death originated when the people made an unwise choice, choosing a large bundle of tempting articles instead of a smaller bundle that contained everlasting life. Among the Cumberland sound (Canada) Eskimo and the Chiriguano Indians of South America, death is supposed to have originated because of threatened world overpopulation.

**Acquisition of Necessities.**—Probably the majority of primitive myths deal with the acquisition of critical necessities originally absent or not readily available. Frequently an object needed by all the community is hoarded by one individual, often a monster. The culture hero is thus forced to steal the sun (A 721.1), fire (A 1415), light (A 1411), the seasons (A 1151), water (A 1111), game animals (A 1421), plants (A 1423.0.1) and even wisdom (A 1481).

**Loss of Luxuries.**—In addition to the host of primitive myths in which a necessity is obtained for mankind, there are other myths in which an account is given of how man forfeited a previous state of surplus or a precious luxury. Often the loss results from a violation of an interdiction; for example, paradise is usually lost (A 1331) this way. Thus myths relate how food was originally obtained without effort (A 1420.4) and how the first people had everything they wished (A 1346.2.2.). By the same token, originally there was no disease (A 1337) and there were no mosquitoes (A 2034).

Whether the primitive myth explains how a desirable state was lost or how an undesirable lack was liquidated, the movement is from disequilibrium to equilibrium. A state of excess or of deficiency is the given initial disequilibrium; the myth accounts for the elimination of either state. Primitive myth explains the status quo of earth and man in terms of the archetypal past. Specifically, it tells how traditional patterns underlying the present world equilibrium represent significant departures from previous disequilibrium.

*See* also FOLKLORE; FOLKLORE (AMERICAN INDIAN).

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**MYTILENE** (modern Gr. MITILINI), chief town of the island of Lesbos (*q.v.*), Greece, and of the *nomos* (department) of Lesbos (Lesvos), which includes Lemnos and Ayios Evstratios. Pop. (1961) 25,758. The name is pre-Greek. In the middle ages it was applied to the whole island. The ancient city occupied an island or peninsula, now only a headland, on the east coast of the island where there was a Byzantine fortress (Kastro) rebuilt by the Genoese Gattilusio family who occupied the island from 1355 to 1462, and added to by the Turks. An ancient theatre on its slopes has been excavated, and there are minor Roman remains in the town. There are harbours on either side of the headland, the southern one being somewhat exposed. (J. BO.)

**MYXEDEMA,** or hypothyroidism (lack of circulating thyroid hormone) in the juvenile or adult, occurs principally in women at the age of the menopause. Hypothyroidism that is present at birth or begins in infancy is termed cretinism (*q.v.*). Myxedema was first called Gull's disease after it was described by Sir William Gull in 1873. Its symptoms vary widely in range and severity but generally include a lowered basal metabolic rate, sensitivity to cold, dryness of the skin, constipation, puffiness of the face, enlarged tongue, slow speech, lowered pulse rate, fatigue, either drowsiness or sleeplessness, poor memory, mild anemia, reduced blood circulation time, increased body weight and bulk, loss of scalp hair, and menorrhagia or occasionally amenorrhea. The cause of myxedema is unknown except when the onset follows the removal of the thyroid gland in surgery or its therapeutic destruction by radiation. The condition usually is diagnosed on the basis of the patient's appearance and history along with tests of his metabolic rate and serum levels of cholesterol and iodine. Treatment usually consists of daily administration of powdered desiccated thyroid glands of animals used as food by man but synthetic hormones may be used. Myxedematous patients treated with replacement thyroid substance can lead normal lives and expect normal length of life. *See* also THYROID GLAND, DISEASES OF: *Hypothyroidism.*

**MYXOMYCETES:** *see* SLIME MOLDS.

**MYXOMYCOPHYTA** (MYXOMYCOTA, MYXOMYCETES), a phylum or division of lower plants comprising the slime molds, amoeboid creeping fungi, which are among the most effective scavengers on the forest floor. Some biologists place these forms in the animal kingdom as the phylum Mycetozoa.

*See* SLIME MOLDS.

**MZAB** (MZABITES, MOZABITES), a Berber-speaking people who inhabit the Mzab district comprising seven oases in the south of Algeria. At the centre of the district are Ghardaïa and the holy town of Beni-Isguen, which were built by Muslims of the Ibadite sect between 1011 and 1053; the members of this sect were also known as Kharijites ("repudiators") because they repudiated the authority of Ali (*q.v.*), the son-in-law of the Prophet, and thus formed the first Islamic sect. The nucleus of the present-day Mzab is composed of families of *sharif* origin (descendants of Fatima). Unions with slaves from Sudan are not uncommon and give many of the population a rather dark complexion which, however, has no sociological importance in this patrilineal society. A puritan code of morals and purity of faith are at the root of Mzab society. No Muslim of another sect is admitted to their mosques; most of their rites, as the essential of their doctrine, are still kept secret.

The towns of the district are administered by an assembly of 12 devout scholars (*halqa*) led by a sheikh. The seven main towns are spread out over an extent of 9 km. (5.6 mi.) along the course of the Oued Mzab. Distribution of water and construction of dams to make use of floods have been carried out in a truly scientific manner. Perfected methods of cultivation have produced an immense palm grove which provides work for the populace between May and December. There are no local industries and most Mzab do business away from home, sometimes for considerable periods, but they return periodically because customary law does not allow women to leave Mzab territory and forbids men to marry foreign women. Thus the Mzab district has become the centre of a network of small retailers which spreads through the whole of Algeria. In the 1960s the Mzab numbered about 50,000.

*See* also BERBER.

*See* A. de C. Motylinski, "Notes historiques sur le Mzab," *Revue Africaine*, p. 411 (1884); A. M. Goichon, *La Vie féminine au Mzab* (1927). (J. H. SE.)

IN all known alphabets the letter N has stood in close connection with M, the particular form of one being generally reflected in the other. Semitic 𐤍 (*nun*, originally probably meaning "fish") and Greek Ν (*nu*) are its predecessors. In the inscriptions from Thera the form was consistently Ν. Other forms were Ν from Corinth and Ν in the Ionic alphabet of Abu Simbel. In the Lydian alphabet the form was 𐤍; Etruscan had sometimes the curious form Μ corresponding to its five-stroked Μ (M). The Latin forms were N and Ν.

The minuscule cursive form of the 6th century was ɳ, probably accounted for by the writing of the letter without taking the pen from the paper commencing at the top of the left-hand vertical stroke. This would cause the oblique stroke to rise from left to right instead of being downward in direction. The Carolingian

| NAME OF FORM | APPROXIMATE DATE | FORM OF LETTER |
|---|---|---|
| PHOENICIAN | 1200 B.C. | 𐤍 |
| CRETAN | 1100-900 | 𐤍 |
| THERAEAN | 700-600 | 𐤍 |
| ARCHAIC LATIN | 700-500 | Ν |
| ATTIC | 600 | 𐤍 |
| CORINTHIAN | 600 | 𐤍 |
| CHALCIDIAN | 600 | Ν |
| IONIC | 403 | Ν |
| ROMAN COLONIAL | PRECLASSICAL AND CLASSICAL TIMES | Ν |
| URBAN ROMAN | | N |
| FALISCAN | | Ν |
| OSCAN | | Ν N |
| UMBRIAN | | Ν ᴎ |
| CLASSICAL LATIN AND ONWARD | | N |

THE DEVELOPMENT OF THE LETTER "N" FROM THE PHOENICIAN THROUGH CLASSICAL LATIN TO THE PRESENT FORM

hand developed the rounded minuscule form ɳ. From this derives the modern minuscule. The sound that the letter has represented throughout its history is the dental nasal, the nasals being of all sounds the least liable to change. Before the velar consonants *k*, hard *c*, hard *g*, *q*, and *x*, however, *n* has the velar sound heard in "long" as distinguished from the dental sound heard in "lawn" (*e.g.*, in "ink," "angle," "relinquish"); but not so in "unkempt," "ingrate," where *n* ends the prior member of a compound. *See* also ALPHABET. (B. F. C. A.; J. W. P.)

**NAAS** (NÁS NA RÍOGH), the county town of County Kildare, Republic of Ireland, lies 21 mi. S.W. of Dublin by road. It is a market town and a centre for hunting and horse racing. Pop. (1961) 4,023. The nearest railway station is at Sallins, 3 mi. N., and at Naas the main Waterford-Dublin road joins the Cork-Dublin road. As its ancient name, Nás na Ríogh ("the assembly place of the kings"), indicates, Naas was, until the end of the 9th century, the residence of the kings of Leinster. The North mote, an earthen mound on the outskirts of the town, is a monument of that period. A Norman castle also partly survives. The Jigginstown castle, just west of Naas, was erected in 1632–39 during the vice-royalty of Thomas Wentworth, earl of Strafford, and was intended as a royal residence for Charles I. Near Clane, 5 mi. N. of Naas, is Clongowes Wood college, a boys' school conducted by the Jesuits. Naas is close to the Kildare horse-breeding country and 3 mi. S.E. is Punchestown racecourse, famous for its steeplechases. Near the racecourse is a remarkable monolith; another is at Longstone rath 3 mi. E. of Naas. (HU. S.)

**NABADWIP** (formerly NADIA), a town in Nadia district of West Bengal, India, lies on the right bank of the Bhagirathi river, opposite its confluence with the Jalangi, about 60 mi. N. of Calcutta. Pop. (1961) 72,861. The Bhagirathi has so shifted its course that the town is cut off from the rest of the district. It was founded in 1063 by a king of the Sena dynasty of Bengal, and is well known for its sanctity and learning, especially for its many Sanskrit schools in which Hindu social and religious law and logic are taught. Chaitanya (*q.v.*; 1486–1533), a Hindu mystic who founded a Vishnu (Vaishnava) sect, was born at Nabadwip. There is a college affiliated to Calcutta university. (S. P. C.)

**NABATAEANS,** a people of ancient Arabia whose settlements lay in the border lands between Syria and Arabia from the Euphrates to the Red sea. Their history is unknown before 312 B.C. when they were attacked by Demetrius (Poliorcetes), the son of Antigonus Monophthalmus, in their mountain fortress of Petra (*q.v.*) south of the Dead sea. This attack they resisted successfully. The expedition of Demetrius had been motivated by a wish to sever the trade routes which led from several directions through the Nabataean territory to the Red sea and Egypt and so to inflict damage upon the economy of Egypt, which was ruled by Antigonus' enemy Ptolemy. At this time Egypt was content to allow the Nabataeans a monopoly of the rich caravan trade which passed from the interior of Arabia to the coast. This monopoly, which they guarded jealously, was the source of their prosperity. Trade and agriculture were their chief concerns but some of them also practised piracy. Under Ptolemy II Philadelphus (king 285–246 B.C.) an Egyptian expedition occupied the port of Elath in the Gulf of Aqaba, and energetic attempts were made to break the Nabataean monopoly by developing commerce in the Red sea. But under the same king the conflict between Egypt and the Nabataeans gave way to a peaceful understanding.

The relations of the Nabataeans with the Seleucid kings, their neighbours on the north after the conquest of Palestine by Antiochus III, are unknown. As the Seleucid kingdom grew weaker in the 2nd century B.C. the Nabataean kingdom increased in strength and extended its frontiers to the north and east. An ex-

pansion of the kingdom to the south along the eastern coast of the Red sea also appears to have occurred about this time. In the 1st century B.C. the Nabataeans intervened against the Hasmonaean kings of Judaea. Moving northward over the country east of the Jordan they occupied Hauran and for a short period after 85 B.C. their king Aretas III made himself master of Damascus and Coele-Syria (Lebanon). On the entry of Pompey into Palestine (63 B.C.) Aretas became a Roman vassal, retaining Damascus and his other conquests. Damascus was shortly afterward lost by the Nabataeans but was restored to them by the Roman emperor Caligula (Gaius) about A.D. 40, before being reannexed by Nero.

The final period of Nabataean history was one of peaceful prosperity as allies of Rome. Their extensive dominions stretched from the outskirts of Damascus to the eastern shore of the Red sea and from the Sinai peninsula far into the Arabian desert. Hellenistic influences may be traced in the royal coinage and in the architecture at Petra, where the houses and temples cut into the red sandstone are in part well preserved. When the Roman emperor Trajan annexed the kingdom in A.D. 105–106 the more conveniently situated Bozrah (Bostra; to the east of the Jordan) was chosen in place of Petra to be the capital of the new province of Arabia then set up. *See* also EDOM; SEMITIC LANGUAGES: *Aramaic.*

*See* M. Rostovtzeff, *Caravan Cities,* Eng. trans. by D. and T. Talbot Rice, esp. ch. 1 and 2 (1932). (R. H. Si.)

**NABIGHAH, AL-** (AL-NABIGHAH AL-DHUBYANI) (fl. *c.* A.D. 600), one of the six pre-Islamic Arab poets whose works were collected before the middle of the 2nd century of Islam; his poetry is represented in the anthologies *al-Sumut* (*see* MU'ALLAQAT) and *Hamasah* (*q.v.*). After living much of his life at the court of the kings of Hira he fled for a time to the court of Ghassan because, according to legend, his poem praising the beauty of Queen Mutajarida, wife of King Nu'man of Hira, was inspired by an accidental view of her unveiled charms. Later he was pardoned and returned to Hira but after Nu'man's death withdrew to live with his own tribe, the Dhubyan. He wrote mainly eulogies and satires concerned with the strife between Arab tribes.

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**NABIS,** son of Demaratus, probably descended from an exiled branch of the Eurypontid house, ruled Sparta from 207 to 192 B.C., carrying on the revolutionary tradition of Agis IV and Cleomenes III. Ancient accounts of him consist mainly of abuse and his measures remain obscure in detail, but he certainly confiscated much property and enfranchised helots. He maintained a mercenary army, and even a fleet, based mainly on Gythium; he was friendly with Cretan cities and received honours at Delos.

In Nabis' war with the Achaean league after the peace of Phoenice (205), Philopoemen rescued Messene from him and later defeated him at Scotitas in Laconia. Nabis acquired Argos in 197 from Philip V of Macedonia, then at war with Rome, but immediately came to terms with the Roman commander T. Flamininus and retained Argos till 195. Then Flamininus, having defeated Philip and proclaimed the Greeks independent, led an allied army into Laconia and took Gythium. Flamininus' assault on Sparta miscarried, but Nabis only survived by surrendering Argos and his fleet. He tried to recover Gythium when the Romans left in 194, but was heavily defeated by Philopoemen north of Sparta, only to be rescued again by Flamininus. Eventually the Aetolians, as part of their maneuvers to bring about war between Rome and Antiochus III, murdered Nabis and temporarily occupied Sparta (192).

Overshadowed by the struggle between Rome and Macedonia, Nabis maintained his power adroitly. He cannot have been the monster Polybius depicts, and his social order survived him for a while; but Sparta's independent history ends with him.

*See* general histories of Greece; W. W. Tarn and G. T. Griffith, *Hellenistic Civilisation,* 3rd ed., ch. 1 and 3 (1952). (A. As.)

**NABLUS** (NABULUS), a town of Jordan, capital of the *liwa'* (district) of the same name, 40 mi. N. of Jerusalem. Pop. (1961) 45,658. Lying in an enclosed, fertile valley, Nablus is the second largest town in Jordan. Most of it is of modern growth, and houses and villas of the wealthy inhabitants spread up the steep hillsides to the north and south; the old part of the town, in the valley, includes the markets, mosques and some administrative buildings. The only communications are by road, connecting it with Janin, Tul Karm, the Jordan valley and Jerusalem. Nablus has always been an important political and administrative centre, though its politics have generally been against whatever government was in power. In the middle ages the inhabitants had a bad reputation for unfriendliness and treachery, but some years of settled government and closer acquaintance with foreigners has changed this attitude.

The name derives from the Roman name Neapolis; the site of its Old Testament predecessor, Shechem (*q.v.*), lies at Balatah at the eastern entrance to the valley. Near there tradition locates the site of Jacob's well and the tomb of Joseph farther north. On Mt. Gerizim (*see* GERIZIM, MOUNT) dwell the remnants of the Samaritans (*q.v.*), who built their temple there as a rival to Jerusalem; only a handful of them survive.

NABLUS LIWA', which includes the subdistricts of Nablus (pop. [1961] 174,851), Janin and Tul Karm, is devoted to grain and fruit growing. Area 969 sq.mi. Pop. (1961) 342,155. (G. W. L. H.)

**NABOB,** a corruption of the word *nawab,* the plural form of the Arabic word *naib* ("a deputy"). The word, first used in Mogul India to denote an official deputy, came to be used honorifically in the plural form and finally was used to describe the office itself. Thus the Mogul *subadar* ("governor") of Bengal became the *nawab* of Bengal. In the 18th century the corrupted form "nabob" was applied to Englishmen who had returned home from India with large fortunes and who behaved ostentatiously. The name was popularized by Samuel Foote in his play *The Nabob* (1772).

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**NABONIDUS** (Babylonian NABU-NA'ID, "reverer of Nabu") was king of Babylon from 556 to 539 B.C. The son of a noble and of Adda-Guppi', the influential high priestess of Sin at Harran, he succeeded Labashi-Marduk in June 556 B.C., after a revolt in which he is said to have participated. His rule was not popular, partly because he gave prominence to the moon-god Sin at the expense of Marduk. He devoted much energy to the restoration of Sin's temple at Harran, where many building inscriptions survive.

In his first year, Nabonidus suppressed a revolt at Hamath in Syria. There was famine and fever in Babylonia and the priests led a popular rising against him. The king made his son Belshazzar (*q.v.*) co-regent in Babylon and, with a small group of Babylonians, invaded northwest Arabia. He remained in Tema (Tayma') for 10 years, controlling a kingdom which extended south to Iatribu (Medina). The support of Egypt and Persia and the restoration of favourable conditions in Babylonia led to his return to Babylon, following a vision recorded in both the cuneiform texts and the Dead sea scroll fragments. Hardly had he returned when the Persian army entered Sippar, and Nabonidus had to flee again. He was captured on entering Babylon, which had itself recently fallen to Cyrus (539 B.C.). According to Berossus, Nabonidus was exiled to Carmania (Kerman), where he died. *See* also BABYLONIA AND ASSYRIA: *History: Late Period.*

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**NABU** (Old Testament NEBO), a major Assyro-Babylonian god. The name is Semitic, but its precise meaning is uncertain—"he who calls" or "he who shines." This latter interpretation is supported by the fact that Nabu is assimilated to the planet Mercury. Nabu cannot be traced farther back than the 1st dynasty of Babylon (19th to 16th centuries B.C.). During that period his name occurs in personal names; in his honour Hammurabi (*c.* 1800 B.C.) erects a throne; Samsu-ditana, the last king of that dynasty, introduces a statue for Nabu into Marduk's temple Esangila at Babylon. The texts leave uncertain whether the location of the throne and statue, or of either of them, is the capital

city, Babylon, or its southern suburb, Borsippa (*q.v.*), where Hammurabi built in honour of Marduk the temple Ezida, which in later times became the centre of Nabu's cult. Not until the 1st millennium B.C. does the relationship between Marduk and Nabu and their relative positions in theology and popular devotion become clear. The Assyrian king Ashurbanipal (669–630) declares that he owes his life to Nabu and Nissaba (a goddess of vegetation and of wisdom), and, in a famous dialogue with Nabu, invokes his aid in battle, names him son of Marduk, and always, in lists of gods, puts him next after Marduk. Sargon II (722–705) had listed Nabu after Ashur, the head of the Assyrian pantheon, and before Marduk. An 8th-century official ends a dedicatory inscription on a statue to Nabu with the words "O posterity, put your trust in Nabu; have confidence in no other god." Some of the titles given to Nabu are as honorific as any given to his father—*e.g.*, "king of all the gods of heaven and earth" (Sargon II), "king of the gods" (Ashurbanipal).

He is patron of the art of writing and a god of vegetation. As the former he is described by Sargon II as "exceedingly wise, scribe who records all things." In an oracle, Ashurbanipal's father Esarhaddon (681–669) refers to him as "lord of the stylus." Ashurbanipal "lays hold of the wisdom of Nabu, his teacher, the god of all scribal wisdom." Nabu's symbols are the clay tablet and the stylus, the instruments proper to him who inscribes the fates of men which the gods, assembled in *ubshukinna*, the chamber of destiny within the precincts of Esangila, have fixed under the presidency of Marduk. Nabu's status as secretary of the gods qualifies him to be the patron of all scribes and students of the art of writing. The writing school at Borsippa continued to flourish until the end of the Neo-Babylonian empire (539 B.C.) and beyond, as is proved by exercises of varied content, dated in the reigns of the Achaemenidae of the 6th and 5th centuries B.C.

Marduk, the father of Nabu, took precedence of him, at least theoretically, in Babylonia. But in popular devotion it was Nabu, the son, the god with the large eyes full open, who knows and sees all, who was chief, especially during the centuries immediately preceding the fall of Babylon. He had a chapel named Ezida in his father's temple Esangila, where at the New Year feast he was installed alongside Marduk. In his own holy city, Borsippa, he was supreme. The theophoric names of the kings Nabopolassar (626–605), Nebuchadrezzar II (605–562) and Nabonidus (556–539), and their inscriptions and pious works, suggest that to them Nabu meant more than his father did. So too with their subjects, if one may judge from the large number of personal names compounded with that of Nabu the omniscient, the mighty, the merciful, who hears prayers and who protects the national boundaries in an evil day. The dialogue between Ashurbanipal and Nabu, and an inscription of Antiochus I Soter (324–262 or 261), make Nabu the giver of long life, the chief object of petition of kings and subjects alike throughout Mesopotamian history.

Goddesses associated with Nabu are Nana, a Sumerian deity (whose name is found abroad in Aramaic, Syriac and Greek documents), Nissaba, and the Akkadian Tashmetum, "queen of Borsippa," "stepdaughter of Marduk" and, as her abstract Akkadian name, a hypostasis, indicates, "lady of hearing and of favour." She plays no independent part among the deities. Her epithets are grandiloquent: goddess of goddesses, queen of the world, giver of life. She is rarely invoked apart from her husband, Nabu.

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**NABUCO DE ARAUJO, JOAQUIM AURELIO BARRETO** (1849–1910), Brazilian statesman, author, abolitionist and diplomat, was born in Recife (Pernambuco), Brazil, on Aug. 19, 1849. His family had long been members of the aristocracy of northeastern Brazil. In 1878, following in the footsteps of his father, he was elected by Recife to the national chamber of deputies. There, he became the dedicated leader of the abolitionist cause. As a result of his tireless efforts with the Brazilian Anti-Slavery society, which he had founded, the emancipation of Brazil's slaves was proclaimed by the imperial regent, Princess Isabel, on May 13, 1888. The ensuing economic disruption of the country stimulated the growing republican movement, which led to the overthrow of the benevolent emperor Pedro II and the establishment in 1889 of the republic. Nabuco, a stanch monarchist, then retired from public life for ten years. In 1900, with the monarchist cause dead, he returned to government service. In 1905 he headed Brazil's first embassy as ambassador to the United States, distinguishing himself as an advocate of Pan-Americanism and a devoted friend of the United States. He died in Washington, D.C., on Jan. 17, 1910. His works include: *Minha formação* (1901), *O abolicionismo* (1883), *Camões e Os lusíadas* (1872), and *Pensées Détachées et Souvenirs* (1906). (J. M. DU.)

**NACHTIGAL, GUSTAV** (1834–1885), German explorer of the Sahara, was born at Eichstedt in Brandenburg on Feb. 23, 1834. He studied medicine at the universities of Halle, Würzburg and Greifswald and practised for several years as a military surgeon. He then went to Tunis as physician to the bey and took part in several expeditions into the interior. In 1868 he was sent on a mission to the sultan of Bornu by the king of Prussia and traveled there via Tibesti and Borku, parts of the central Sahara then unknown to Europeans. From Bornu he went on to Baguirmi and then via Wadai and Kordofan to arrive in Cairo in Nov. 1874. This journey was described in *Sahara und Sudan*, 3 vol. (1879–81); he was awarded the gold medals of the Royal and Paris Geographical societies and became president of the Berlin Geographical society. Nachtigal was German consul general at Tunis, 1882–84, and was then sent by Bismarck to west Africa, ostensibly to inquire into trade. As a result, Togoland and the Cameroons were added to the German empire. Nachtigal died on the homeward voyage, at sea off Cape Palmas, on April 19, 1885.

*See* Heinrich Schiffers, *The Quest for Africa*, pp. 303–310 (1957). (R. M. P.)

**NACOGDOCHES,** a city of eastern Texas, U.S., located near the Angelina river about 130 mi. N. by E. of Houston; the seat of Nacogdoches county. It was named for the Nacogdoche Indians. The site was first visited by the La Salle expedition in 1687 and Mission Nuestra Senora de Guadalupe was founded by the Spaniards in 1716. Fears of the French, however, resulted in its abandonment in 1718. The Spaniard Antonio Gil Ybarbo reoccupied it in 1779, when it was chartered, and rebuilt the Old Stone Fort, which was restored in the 1920s. Nacogdoches was the gateway from the east to Spanish territory and was a place of unrest and violence. It was the scene of smuggling and freebooting activities, such as those of A. Leal and Philip Nolan; revolutionary movements, related first to Mexican independence, and later to that of Texas; and Indian unrest culminating in the expulsion of the Indians after the rebellion promoted by Vicente Cordova in 1838.

Stephen F. Austin State college (*see* TEXAS: *Education*) is located there. A diversified economy based on agriculture and lumbering characterized its history after the coming of the railroad in 1882. A council-manager government was adopted in 1931.

For comparative population figures *see* table in TEXAS: *Population.* (J. L. WR.)

**NADELMAN, ELIE** (1885–1946), Polish-American sculptor, was born in Warsaw, Pol., on Oct. 6, 1885, the son of a master jeweler. He left home at 19 and first saw Greek sculpture, the dominant influence in his art, in Munich. In 1903 he went to Paris, where he studied Rodin's work, whose analyses of plastic forms as intersecting curves anticipated Cubism and had wide effects on contemporary art. His first one-man shows in Paris (1909), London (1911) and New York (1915) were sensational successes. He emigrated to the U.S. in 1917 and became a citizen in 1927. A sensitive portraitist and masterful architectural sculptor, in his last decade Nadelman worked on small-scaled grand-style sculpture fitted to modern domestic living. He died in New York city, Dec. 28, 1946.

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**NADIA,** a district in the Presidency division of West Bengal, India. Area 1,514 sq.mi.; pop. (1961) 1,713,324. It consists of vast alluvial plains, somewhat elevated in the north and low lying

in the southern and central parts. Most of the rivers of the district that carried the Ganges waters in the past are dying because of the eastward shifting of the Ganges. It was expected that the proposed barrage across the Ganges at Farakka would help in the resuscitation of the three main rivers, the Bhagirathi, the Jalangi and the Matabhanga, making them navigable as in the past. The arable lands of the district, deprived of the fertilizing river silt, have lost their fertility. The typical example of unproductive land is the Kalantar tract (120 sq.mi.), which can at the most produce only one crop of rice and that only in years when there is sufficient rainfall. The riverine areas are mostly sandy where nothing but scrub can grow. Both the main varieties of rice, *aus* (autumn rice) and *aman* (winter rice), are grown wherever water is available and soils are loamy. Jute, pulses and oilseeds are the other chief crops. The cottage industries of Nadia, especially cotton weaving, once flourished; great quantities of fine cotton fabrics were purchased annually in the 18th century by the residents of the East India company and exported to Britain. Santipur on the Bhagirathi is still the principal centre of cotton weaving. Krishnagar (*q.v.*) is the headquarters of the district and Plassey, 31 mi. N.W., was the scene of the victory of English forces under Robert Clive over those of the nawab of Bengal, Siraj-ud-Daula, in 1757 caused by the treachery of the nawab's generals Mir Jafar and Rai Durlabh. Nabadwip (*q.v.*) is a cultural and religious centre. Haringhata has a large government dairy unit which supplies milk to Calcutta, an agricultural college and a river-research institute; Ranaghat is mainly a railway town. There are six other colleges, affiliated with Calcutta university. The district is well served by rail and road. (S. P. C.)

**NADIAD,** a town in Kaira district, Gujarat, India, lies 29 mi. S.E. of Ahmedabad, and is a junction on the Western railway. Pop. (1961) 78,952. Situated in the Charotar plain, the richest part of Gujarat, it has an extensive trade in tobacco. There are cotton mills, several small-scale industries, a model farm, an arts and science college and a library. Ancient buildings include Minal Devi's *wav* (step well; 1096), the gates of the town wall and Mohammed Begada's *wav* (1513). The town was a centre of cotton and indigo manufacture in the 17th century. (V. A. M. J.)

**NADIR,** a term used in astronomy for the point in the heavens exactly opposite to the zenith, the zenith and nadir being the two poles of the horizon; that is, the zenith is directly overhead, the nadir directly underfoot.

**NADIR SHAH** (Nadr Quli Beg, Tahmasp Quli Khan) (1688–1747), shah of Persia from 1736 to 1747, was born, as Nadr Quli Beg, at Kubkan in northern Khurasan on Oct. 22, 1688. His father, who belonged to the Afshars, a tribe of Turkmen origin, was of humble birth and calling. After assisting his father and later serving under a local chieftain, Nadr Quli Beg formed and led a band of robbers, showing marked powers of leadership. In 1726, with 5,000 followers, he joined Tahmasp Mirza, who was then gathering forces against Mahmud, the Ghalzai Afghan leader who, in 1722, had usurped the throne. In gratitude for his adherence, Tahmasp gave Nadr Quli Beg the title of Tahmasp Quli Khan. He reformed the Persian forces and in a series of brilliant victories utterly defeated the Ghalzais and enabled Tahmasp to mount the throne of his father. He then attacked and routed the Ottoman Turks who had occupied much of northern and northwestern Persia. While his general was absent quelling a revolt in Khurasan, Tahmasp Mirza rashly attacked the Turks, but he was heavily defeated and was forced to conclude peace on ignominious terms. Enraged at this development, Tahmasp Quli Khan hastened back, deposed Tahmasp and placed the latter's infant son Abbas on the throne. After sustaining a reverse in Mesopotamia, Tahmasp Quli Khan soon revenged himself over the Turks by driving them out of Persia. Then, by threatening Russia with war, he forced it to relinquish the Persian territories it had seized.

In the spring of 1736 Tahmasp Quli Khan cast all pretense aside, had the youthful Abbas III deposed and ascended the throne himself, taking the title of Nadir Shah.

Not content with asserting his strength on land, Nadir Shah created a navy, acquiring a number of warships on the Caspian sea as well as on the Persian gulf. By means of his ships based on Bushire he was able not only to recover Bahrain from the Arabs but also to invade and conquer Oman. In 1738/39 Nadir invaded India. After defeating the Mogul forces at Karnal in Feb. 1739, Nadir and his forces marched on and occupied Delhi; they subsequently returned to Persia with booty of almost incalculable value. In 1741, after an attempt on his life, Nadir suspected his eldest son of complicity and had him blinded, an act which he ever afterward bitterly regretted. Nadir was or had become a Sunni and it is believed that he planned to make himself caliph in place of the sultan of Turkey and so assume the headship of the Muslim world. He forced the majority of his subjects to join the Ja'fari sect, which he endeavoured, unsuccessfully, to have recognized as a fifth sect of the Sunnis.

In 1743, after a costly and abortive attempt to subdue the stubborn Lezgians of Daghestan, Nadir again attacked the Turks, but revolts in Persia forced him to conclude a truce. He renewed hostilities with them as soon as possible, winning a great victory near Yerevan (Erivan). Peace was concluded in Sept. 1746.

By this time Persia, although it had regained its ancient glory, had become utterly exhausted. Many thousands of people had perished in Nadir's ceaseless campaigns and the exactions of his tax-gatherers had drained away the wealth of those who had survived. His furious outbursts of rage, which became more frequent as he grew older, resulted in widespread executions. The consequence was that revolt after revolt occurred. While attempting to crush an uprising in Khurasan, Nadir was assassinated in his camp near Fathabad on June 19, 1747.

Although so brilliantly successful as a soldier, Nadir was no statesman; his only thoughts were for war. Once, when informed that there was no warfare in paradise, he remarked: "How then can there be any delights there?" *See* Iran: *History; see* also references under "Nadir Shah" in the Index.

*See* L. Lockhart, *Nadir Shah* (1938); M. R. Arunova and K. Z. Ashrafyan, *Gosudarstvo Nadir-Shakha Afshara* (1958). (L. Lo.)

**NADOR,** the name of a province of northern Morocco and of its chief town. Nador town, which was built by the Spaniards on a grid plan, is 15 km. (9¼ mi.) from the Spanish *presidio* of Melilla (*q.v.*). Pop. (1960) 17,583. It stretches along the borders of Mar Chica, a lake 25 km. (15½ mi.) long, which is joined to the Mediterranean by a narrow channel.

Nador Province, bordering the sea, comprises the whole of the eastern part of the former Spanish zone. Area 2,362 sq.mi. Pop. (1960) 347,566, overwhelmingly rural. On the west is an imposing mountain mass in the Temsamane tribe country but everywhere else is plain, fringed by low ridges. The wadi Kert drains part of it. In this very dry country it is only by irrigation that limited crops can be regularly cultivated. Everywhere else is steppe covered with esparto grass, which serves as pasture for the sheep bred by the nomads. Southwest of Nador town the Ouichane iron mines are worked by a Spanish company. The province is divided into three *cercles* (administrative subdivisions). (G. L. M.)

**NAEVIUS, GNAEUS** (*c.* 270–201 B.C.), the second in the triad of early Latin epic poets and dramatists, between Livius Andronicus and Ennius. A native of Capua, he seems nevertheless to have been a Roman citizen. He served in the First Punic War. His career as a dramatist, which began in 235, only five years after the first play ever produced in Rome, continued for 30 years. An attack in one of his plays on the noble family of the Metelli, making fate rather than merit responsible for their consulships (*fato Metelli Romae fiunt consules;* the reference is to L. Caecilius Metellus, consul 206) provoked the threatening reply that the Metelli would punish the poet Naevius (*malum dabunt Metelli Naevio poetae*) and led to imprisonment, followed by residence (perhaps exile), at Utica, where he died.

He is reported to have spent his time in prison writing two plays, in which he apologized for his rudeness. An epitaph, attributed to the poet himself, but probably written nearly 100 years after his death, recalls his epic poetry by the Saturnian verse in which it is cast, and his drama by the fine tribute that, since he died, "they have forgotten at Rome how to speak the Latin tongue."

Like Livius, Naevius translated Greek tragedies and comedies. Six such tragedies are known by title, among them two (*Danae*

and *Equos Troianus*) which were produced also by Livius and suggest that Naevius deliberately challenged comparison with the older poet. Of his comedies more than 30 titles are known, many of them of the Latin type (*Corollaria, Nervolaria, Tunicularia*) familiar from Plautine plays. Fragments are scant, but sufficient to show that, far surpassing Livius, Naevius may be regarded as the creator of that apt, forcible and colourful language which is the constant delight of readers of Plautus. His attitude to his originals was more independent than that of Livius: he transferred elements from one play into another, added song where the originals lacked it, and increased the variety of metre. He also added contemporary references and political comment, such as that which proved his undoing. But he broke entirely new ground in writing at least two plays on national subjects (*praetextae*): *Romulus* (perhaps the same as *Lupus*), on the birth of Romulus and Remus, and *Clastidium*, celebrating the victory there of M. Claudius Marcellus over the Insubres in 222 B.C., and probably produced at Marcellus' funeral games in 208.

While Rome was fighting the Second Punic War, Naevius chronicled the events of the first in his *Carmen Belli Poenici*. For his facts he may have relied, apart from his own observation, on oral tradition at Rome; it is uncertain whether the history of Rome by Fabius Pictor, which became a source for the history of the wars, was already available. Force of diction, enhanced rather than impeded by the harsh staccato rhythm of the Saturnian metre, and an over-all plan, which comprised the wanderings of Aeneas (including apparently his sojourn with Dido at Carthage as a cause of the war between Rome and that city), make good the claim of this chronicle to the rank of an epic poem. Naevius undoubtedly had Hellenistic models for the epic treatment of contemporary history, but when it is measured against the *Odusia* of Livius, this poem shows in its conception the same originality as does the creation of the *praetextae*. The *Bellum Poenicum* seems to have exercised considerable influence on the *Annals* of Ennius and on Virgil's *Aeneid*, but this cannot be closely defined, since only about 60 lines of the poem remain.

Remarkable ancient judgments on Naevius are those of Volcacius Sedigitus (*c.* 100 B.C.), who placed him third, after Caecilius and Plautus, in a somewhat arbitrary canon of Roman writers of comedy, and Cicero, who likened his epic, as pleasing despite some lack of polish, to a work of the sculptor Myron.

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**NAGA,** any of a group of tribes inhabiting the Naga hills (*q.v.*) dividing Assam from Burma. Reliable population estimates were not available in the 1960s. Within the group are tribes of mixed origin, varying cultures, and very different physique and appearance, but having enough in common to distinguish them from such neighbouring peoples as the Kachin, Kuki and Kachari. The numerous Naga languages are tonal and agglutinative, belonging to the Tibeto-Burman family; within each language area almost every village has its own dialect.

Political organization has ranged from the autocracy of tabued chiefs (Konyak Naga) through gerontocracy (Ao) to purest democracy (Angami). Patrilineal exogamy is the social rule, with indications of the preexistence of matrilineal and perhaps totemistic systems and of leviratical polyandry. Dual organization (*q.v.*) and communal houses for the unmarried have been reported. Some tribes (*e.g.*, Sema, Chang) practise polygyny; monogamy is more common, divorce being easy and frequent. Inheritance of land passes in the male line. Although most Naga are animists, a substantial minority have been Christianized.

Agriculture is practised by all Naga tribes, some growing rice on elaborately built-up and irrigated terraces (Angami, Tangkhul), others growing it dry, and others using millet, Job's tears or taro as the staple crop, with rice, maize, sorghum, yams and sago as subsidiaries. Millet is often grown on dry terraces among pollarded alders; cotton is grown and cattle are kept, including numbers of gayal, domesticated oxen that have generally displaced the buffalo. Dogs have been reared for food and ceremonial sacrifice as well as for hunting. Naga fishermen are noted for the use of intoxicants to kill or incapacitate the fish.

Manufactures and the arts among the Naga include weaving (on simple tension looms), dyeing, pottery, blacksmith's work and rough wood carving. Material culture shows many links with Indonesia and Melanesia, and the northern tribes make huge wooden xylophones and membraneless drums, often suggestive of dugout canoes with carved figureheads. Music and dancing are popular and are most highly developed among the southern Naga tribes. The prevailing traditional weapon is the throwing-spear, but crossbows are used by some tribes. Guns have been in use for many years and are but one example of progressive Naga acculturation. For political development within the Indian Union *see* NAGALAND.

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**NAGA HILLS** form part of the complex mountain barrier on the borders of Burma and India. Between northernmost Burma and upper Assam the actual frontier follows the crest of the Patkai hills trending southwest to northeast. The Naga hills consist of parallel ranges with the same trend lying on the Assamese side but broaden out southward into the tangle of forested hills culminating in Mt. Japvo (9,890 ft.), near the border with Manipur state, which until 1957 constituted the Naga Hills district of Assam and is now part of Nagaland (*q.v.*). The hills are fold ranges mainly of Tertiary rocks; they receive a heavy monsoon rainfall and are naturally clothed with dense evergreen forest. Shifting cultivation, on the system known to the Burmese as *taung-ya*, has destroyed large areas of forest and it is replaced by bamboo thickets. The sparse population is found mainly in villages on spurs which provide defensive sites. (L. D. S.)

**NAGALAND** was created a separate state within the Indian Union under the Nagaland (Transitional Provisions) regulations promulgated by the president of India on Jan. 24, 1961, and was constituted by the Union government in Sept. 1962. It has an area of 6,236 sq.mi. and a population (1961 est.) of 369,000. The new state occupies a tangle of forested hills and mountains between northernmost Burma and the Brahmaputra valley of upper Assam, and on the south adjoins the state of Manipur. (*See* also NAGA HILLS.) Less than a century ago the tribal Naga (*q.v.*) secure in their almost inaccessible mountain fastness, still practised slavery, head-hunting and human sacrifice, and it was the raids of the head-hunters which led to punitive expeditions and the gradual British occupation of the hills. A frontier district of Assam was formed in 1866; in 1880 it was decided that the Naga hills should be administered as British territory. During the operations against the Kuki of Manipur in 1917–19 a boundary was determined with Burma and on the Burmese side the British provincial government delimited a Naga Hills subdivision as an unadministered part of the Upper Chindwin district. The Naga on the Burmese side were left to run their own affairs provided there was no raiding, but no white men were allowed in the subdivision. On the Indian side a Naga Tribal area was recognized with headquarters at Kohima. Kohima was occupied by the Japanese in March–June 1944.

The religion of the Naga is best described as animism but strong missionary efforts resulted in the conversion of 20%–25% to Christianity. When India became independent in 1947 most of the Naga were in the Naga Hills district of Assam but some were farther north on the Tuensang Frontier division of the North East Frontier Agency (*q.v.*). A strong nationalist movement sought a union of the tribes and independence, and a force of at least 1,500

nationalist rebels was built up against the Indian government. There were at the same time many differences among the Naga. Not only are there about 14 distinct tribes speaking about 30 dialects but new political aspirations took different forms. Following a Naga People's convention held at Kohima in Aug. 1957 the government of India in December constituted the former Naga Hills district and Tuensang division as a "centrally administered area" under the minister of external affairs at Delhi but this proved unacceptable to the Naga; hence the creation of the state of Nagaland in 1961 with a legislative assembly and council of ministers, though temporarily under the governor of Assam. There are three administrative districts: Kohima, Mokokchung and Tuensang.

The former isolation of Nagaland was broken by the construction of the main motor road from Dimapur (Manipur Road station on the Assam railway) to Imphal, the capital of Manipur, which crosses the southwestern corner of the state and serves its capital Kohima. Though road construction has continued, most of the Naga tribes live in isolated valley regions. Their small villages are placed on spurs of the hillsides, near a spring and well-sited in case of attack. Small patches of hillside are cleared, where hill rice is the chief crop; some of the more advanced tribes practise terracing but shifting cultivation is more usual. The torrential rains which characterize much of the region in the wet season are apt to strip the clearings bare of both crops and soil, so the clearings are kept small. But progress has been rapid in education, medical services, agriculture, water supplies and electrification.

(L. D. S.)

**NAGANO, OSAMI** (1880–1947), Japanese admiral who planned and ordered the attack on the U.S. naval base at Pearl Harbor, Dec. 7, 1941. Born in Kochi, he was educated at the naval academy and staff college. In 1913, as a language officer in the U.S., he studied law at Harvard university and took courses at the naval war college. As naval attaché in Washington (1920–23), he attended the Washington naval conference (1921–22). As a member of the Japanese naval general staff he attended the London naval conference of 1930 and was chief Japanese delegate at the London naval conference of 1935–36. Nagano became naval minister in 1936–37 and naval chief of staff in April 1941. His reputation rose after Pearl Harbor, but later reverses caused his dismissal in Feb. 1944. Having admitted personal responsibility for the Pearl Harbor attack, he died on Jan. 5, 1947, while on trial before the international military tribunal.

**NAGANO** is the name of both a landlocked prefecture (*ken*) in central Honshu, Japan, and its capital city. Most of the prefecture is over 2,600 ft. in elevation and 15 peaks, mostly volcanic, are over 9,800 ft. The harnessing of such large rivers as the Tenryu, Kiso, Chikuma and Shinano made it a leading hydroelectric producer. Most activity centres in small mountain basins (Suwa, Matsumoto, Ina, Iida, Zenkoji basins) over 1,600 ft. elevation, where sericulture and apple raising are agricultural specialties. Rich forest land, one-third in national forests, is an important resource. Limited industry is based on sericulture. Area 5,260 sq.mi.; pop. (1960) 1,981,433.

NAGANO CITY in the Zenkoji basin, the capital and largest city (pop. [1960] 160,522) of Nagano prefecture, is about 100 mi. N.W. of Tokyo. Formerly known by the name of Zenkoji, it dates from the 7th century A.D. and grew as a great shrine and post town. Besides administration and education (two universities), Nagano has a commercial function. (J. D. Ee.)

**NAGAPATTINAM** (NEGAPATAM), a seaport on the Coromandel coast (*q.v.*) in Thanjavur (Tanjore) district of Madras, India, lies 267 mi. S. of Madras by rail. Pop. (1961) 59,063. Passenger steamers to Malaya call at this port, but there is no good harbour and vessels anchor three miles offshore. It has a steel-rolling mill (1936); steel trunks, cash boxes and similar goods are also manufactured. The Muslim dargah (tomb) at Nagore, 4 mi. N., and the Catholic church at Velanganni, 6 mi. S., are well-known pilgrimage centres.

Nagapattinam is one of the few places in the Tamil country where Buddhism flourished up to the end of the 15th century, either because from ancient times it was a seaport in direct contact with Ceylon and Burma, or because a colony of Malayan Buddhists, particularly from the Sri Vijaya kingdom (centred at Palembang in Sumatra and which flourished during the 8th century), settled there and erected Buddhist temples during the time of the Cholas. An ancient three-storied tower, the Jaina (China) pagoda, for long a landmark for seafaring men, was demolished by the Jesuits in 1867. Early in the Christian era it was a chief town of the Naga people from whom obviously its name was derived. Later it became a Portuguese settlement and was called the City of Choramandel. It was captured by the Dutch in 1660 and by the British in 1781. Remaining traces of the Dutch include the Dutch church (1774) and the flag staff station.

(G. Kn.)

**NAGASAKI,** a Japanese prefecture (*ken*) on the northwest coast of Kyushu, includes the islands of Tsushima, Iki, Hirado-shima and the Gotō-rettō archipelago. It has a very irregular shape, with rounded Shimabara peninsula in the southeast and Nomo and Nishisonogi peninsulas (which enclose Ōmura bay) in the southwest. Dominated by mountains, it has limited agricultural land that is worked intensively (rice, sweet potatoes and mandarin oranges). Its thriving fisheries support a seafood processing industry. Although coal is mined, there is little industry except in the capital city of Nagasaki (shipbuilding) and the naval base of Sasebo. The city of Nagasaki has one of Japan's largest Christian communities. Area of the prefecture 1,578 sq.mi.; pop. (1960) 1,760,421. (J. D. Ee.)

**NAGASAKI,** capital and largest city of Nagasaki prefecture, western Kyushu, Jap., is the administrative, commercial and cultural nucleus of the prefecture. The second atomic bomb dropped on Japan by U.S. forces in World War II destroyed the innermost portion of the city on Aug. 9, 1945, killing 39,000 persons and injuring 25,000 (*see* ATOMIC ENERGY: *The Atomic Bomb*).

A port city, Nagasaki is located at the head of a narrow, deep-cut bay at the meeting point of the Nomo and Nishisonogi peninsulas. The city is like an amphitheatre in form, the crooked streets and tiered houses clinging to the hillsides that enclose the inner bay. Reclaimed land at bayside and the Urakami basin at the head of the bay provide a little level land.

Nagasaki's early growth was based on its overseas contacts. Subsequent to the arrival of the first Portuguese ships in 1571, it became the principal port for calls by foreign ships. Christianity, introduced by Roman Catholic priests, established a firm foothold in Nagasaki in spite of grievous persecutions. With the enforcement by Japan of foreigner exclusion measures, the city became the sole remaining point of contact with foreigners after 1636. Only the Dutch were permitted to remain in residence on small Deshima (an island on the eastern coast of the bay, now a reclaimed part of the mainland). Through that modest station passed a trickle of books and information that acquainted Japanese authorities with main developments in the west. Scholars also went there to learn Dutch and foreign science and culture. When Japan was emerging from its feudal past in the last half of the 19th century, Nagasaki benefited from nearby coal deposits to become one of the leading east Asian coaling stations. It was the winter port for the Russian Asiatic fleet prior to 1903. The development of oil-burning ships, competition from northern Kyushu coal fields and ports, a limited hinterland and distance from main Kyushu industrial areas later reduced its importance. Nagasaki's limited industrial growth stems mostly from the large shipyards and supplier industries, which are grouped along the western and inner parts of the bay. Pop. (1960) 344,153.

(J. D. Ee.)

**NAGAUR,** a town and district in the division of Jodhpur (formerly the princely state) in Rajasthan, India. The town, headquarters of the district, lies 75 mi. N.E. of Jodhpur on the Northern railway. Pop. (1961) 24,296. Nagaur is said to have derived its name from its traditional founders, the Naga Rajputs, and was held successively by Prithvi Raja, Mohammed Ghori and the chiefs of Jodhpur, except for the periods when it passed to the Bikaner chief as a grant from Akbar, and to another Rathor family from Shah Jahan. The town is surrounded by a wall more than 4 mi. long and about 17 ft. high. Two Hindu temples and

a five-domed mosque are of special interest. There are palaces, a fountain and a mosque, erected by Shah Jahan, in the fort.

NAGAUR DISTRICT, with an area of 6,884 sq.mi. and a population (1961) of 934,948, is mainly a sandy plain lying 1,000–1,500 ft. above sea level. A fine breed of oxen is reared. There is an oil mill at Merta and metal workshops at Nagaur. Marble is quarried and Makrana is a centre of marble supply. Khatu village has important stone works; other main towns are Ladnun and Didwana. (S. M. T. R.)

**NÄGELI** (NAEGELI), **KARL WILHELM VON** (1817–1891), Swiss botanist famous for his investigations on the origin of cells and for his versatility in research, was born on March 26, 1817, at Kilchberg, near Zürich. He studied botany under A. P. de Candolle at Geneva, graduated at Zürich in 1840, then devoted himself to the microscopical study of plants. He became professor in the University of Zürich and of botany in the universities of Freiburg in Breisgau, Ger. (1852), and Munich (1858).

Nägeli extended Robert Brown's discovery of the nucleus to the principal families of cryptogams and asserted that it is present in all plants. He investigated the "mucous layer" (*Schleimschicht*) in cells and showed this to be the living matter of the cell. This discovery was made independently and at the same time by Hugo von Mohl, who called the living substance "protoplasm." Nägeli also investigated the mode of growth in a large number of plants belonging to the algae, mosses, liverworts and angiosperms. He discovered the spermatozoids and antheridia of ferns. He also wrote papers on the anatomy of vascular plants and introduced the concept of "meristem" as opposed to permanent tissue. In addition he studied the structure, development and various forms of starch grains. In his last book Nägeli introduced the idea of a substance which he called "idioplasm" as the definite material basis of heredity. While he was at Munich he corresponded with Gregor Mendel (*q.v.*) but was unimpressed with Mendel's work and, unaccountably, does not seem to have grasped the implications of his discoveries. Nägeli died in Munich on May 10, 1891.

Among Nägeli's more important contributions to science were a series of papers in the *Zeitschrift für wissenschaftliche Botanik* (1844–46); *Die neuern Algensysteme* (1847); *Gattungen einzelliger Algen* (1849); *Pflanzenphysiologische Untersuchungen* (1855–58), with C. E. Cramer; *Beiträge zur wissenschaftlichen Botanik* (1858–68); and finally, *Mechanisch-physiologische Theorie der Abstammungslehre* (1883), his magnum opus on heredity, in which he not once even referred to Mendel's experiments.

*See* C. E. Cramer, *Leben und Wirken von Carl von Naegeli* (1896).

**NAGERCOIL** (NAGARCOIL), a town and headquarters of Kanya Kumari district of Madras, India, lies 8 mi. N.N.W. of Cape Comorin. The nearest railway station is Trivandrum, 53 mi. N.W. Nagercoil is linked with it and with Madras by main road. Pop. (1961) 106,207. Its name means "serpent temple" and the town is a sacred Hindu place of worship. It is also a commercial and a tourist centre, commanding picturesque hill scenery. The London Missionary society maintains a college, printing press, hospital and several schools. Lace weaving and coir making are the chief cottage industries. (G. K. GH.)

**NAGORNO-KARABAKH AUTONOMOUS OBLAST** of the Azerbaijan Soviet Socialist Republic, U.S.S.R., lies in the south of the republic on the northern flank of the Karabakh range (Karabakhski Khrebet), the southeastern end of the Lesser Caucasus. The area, known historically as Artsakh, was acquired by Russia in 1813 and the present autonomous *oblast* was established in 1923. Area 1,699 sq.mi.; pop. (1959) 130,406. It extends from the crest line of the ridge to the margin of the Kura river lowland at its foot. In the north, the valley of the Terter cuts across the *oblast*, terminating the Karabakh range. North of the Terter the Khrebet Murov-Dag rises steeply, culminating in Gora Gyamysh (12,211 ft.), the highest point of the *oblast*. The Karabakh range reaches a maximum height of 8,940 ft. in Gora Bolshoi Kirs. The climate ranges from mild in the lowest areas to cold and severe on the heights, and soils and vegetation show a similar zonality from steppe on chestnut soils, through deciduous forest of oak, hornbeam and beech, to birchwood and finally alpine meadow, usually around 7,500 ft.

The population, mostly Armenian and Azerbaijani, is concentrated in the deep valleys. Only 26,973 (21%) are urban, living mostly in the administrative centre of Stepanakert (19,703), which is on the road passing through the *oblast* from Yevlakh to Nakhichevan A.S.S.R. and the Iran frontier. There is one other town, Shusha, as well as two urban districts. The economy is dominantly agricultural. The raising of cattle and sheep makes use of the high summer pastures. Many pigs are kept. Vineyards, gardens, mulberry groves for silkworms, and beekeeping are all intensively developed in the valleys. Winter and spring wheat, barley, maize (corn) and millet are grown, chiefly on the lowest areas. Some cotton is also cultivated. Industries are concerned with processing agricultural products: the making of silk, wine, butter and cheese, and distilling. There is a large hydroelectric plant on the Terter at Madagiz. (R. A. F.)

**NAGOYA,** a city and capital of Aichi prefecture (*ken*), central western Honshu, Japan, 225 mi. W. of Tokyo, is one of the country's leading industrial centres. It has a deltaic location on the Nōbi plain facing deep-cut Ise bay. Nagoya's modern rise dates from 1610, when a great castle was erected by the Owari branch of the powerful Tokugawa family. Subsequently, political and economic power became centred there. After the collapse of the feudal order, Nagoya continued as the commercial hub of a broad central Honshu area between the spheres of Tokyo and Osaka, earning the title, "central capital."

Its industry is predominantly light because of the long distance from coal sources and the late development (1907) of its port facilities. Among its assets are a central location and abundant hydroelectric power from the rivers of central Honshu. Historically strong in cotton textile production, Nagoya is the economic nerve centre for a nest of industrial satellite cities in Aichi, Gifu and Mie prefectures. Lumber and wood products, vehicles (automobiles and airplanes), machinery and machine tools, ceramics, electric steel, man-made fibres, and chemicals are among the products of its diversified industry.

The city is laid out on a rectangular plan with exceptionally broad main avenues for traffic and fire control. Burned badly in World War II, it put an impressive city reconstruction plan into effect and built many new public and private buildings in the main commercial and residential districts. Several railways, including the main Tokaido line, converge on Nagoya. Its harbour (30 ft. deep) has berthing facilities for 30 ships totaling 135,000 tons and excellent cargo handling and storage installations. Canals link the port and industrial areas. With a population of 1,591,935 (1960), it was the third largest city of Japan. (J. D. EE.)

**NAGPUR,** a city, district and division of Maharashtra, India. The city, headquarters of the district and division, lies 420 mi. E.N.E. of Bombay on the small Nag stream from which it takes its name, and is at the very heart of India. Pop. (1961) 643,186. Its corporation was established in 1952. The city is dominated by the hill and fort of Sitabaldi (1818) overlooking the civil station on the west, the city proper on the east and north, and the suburbs of Sitabaldi and Craddock Town to the south. Northwest of the civil station is the Gorewara reservoir with a dam 2,350 ft. long. There are several fine old reservoirs (tanks), notably Juma Talao, Ambajheri and Telinkheri, and many parks in and around the city. Nagpur is a principal educational centre of Maharashtra and the seat of Nagpur university (1923) with affiliated colleges of arts and science, agriculture, law, technology, medicine, engineering and teacher training, and postgraduate departments in political science, public administration and geology. It is the see of both Anglican and Roman Catholic dioceses, and also has the Jamia-e-Arabia, an institute of Islamic theology.

The city is a major industrial and commercial centre. It is an important road junction and lies on the Bombay-Calcutta railway, and has an airport (Sonagaon, 6 mi.). The principal industry is cotton textiles and the textile mills include the Empress (1877) and Model mills. The city is also the largest handloom centre in the state and a market centre for oranges, cotton and grain. Other industries include potteries, glassworks, dyeing and print-

ing works, leather factories, iron foundries, a rubber factory, oil and flour mills, medical and pharmaceutical works, fruit canning, and the production of copper and brassware, bricks and tiles, and *bidis* (local cigarettes). A state-sponsored dairy and poultry farm has been set up to improve the quality of the stock.

Nagpur is said to have been founded in the 18th century by Bhakta Buland, a Gond prince of the kingdom of Deogarh in the Chhindwara district. Seeing the advantages of civilized life in Delhi he started to build Nagpur as his new capital and his work was continued by his successor Chand Sultan. On his death in 1739, disputes regarding succession arose and Raghuji Bhonsla, the Maratha governor of Berar, helped to restore the elder son to the throne. As dissensions continued Raghuji Bhonsla again intervened in 1743, and control of Nagpur gradually passed from the Gonds to the Marathas. With the Bhonsla dynasty came the vast class of cultivators in Vidarbha. Raghuji's successors lost some territories to the Maratha peshwas and the nizam of Hyderabad and in 1803 to the British after defeats (with their allies of Sindhia) at Assaye and Argaon (Argaum). In 1811 the Pindari raids began and people erected village forts to protect themselves. There was a further clash with the British in 1817 and when Raghuji III died in 1853 without an heir his kingdom was annexed by the British. The raja receives a pension from the Indian government. Nagpur was the capital of the former Central Provinces (later Madhya Pradesh) until the reorganization of the states in 1956.

NAGPUR DISTRICT, with an area of 3,842 sq.mi. and a population (1961) of 1,512,807, is divided into the five *tehsils* of Nagpur, Ramtek, Umrer, Katol and Saoner. It is drained by the Kanhan and Pench rivers in the centre, the Wardha in the west and the Wainganga in the east. There are fertile black cotton soils in the west and north and alluviums in the east. The average annual rainfall is 45 in., with more in the east than in the west. In the west the hills are forested, forests covering 7% of the total area of the district. Kamptee, 10 mi. N.E. of Nagpur city, is a town and cantonment with cotton ginning and pressing, brick and tile works, and *bidi* and paint industries. Kanhan, 2 mi. E. of Kamptee, has a cement-pipe industry, a tea depôt and ferromanganese and sulfuric acid plants. The town of Ramtek, to the northeast, is recognized as Ramgiri of the lyrical poem *Meghadūta,* by Kālidāsa, the noted Sanskrit writer, and is a sacred place with annual fairs. Rice is the chief crop in Ramtek *tehsil* and there are manganese mines around Ramtek town. There is a thermal power station of 60,000 kw. capacity at Khaperkheda. Cotton, millets and wheat are the chief crops in the western part of the district. In the Katol *tehsil,* to the north, oranges and other garden crops are grown. The district produces 100,000 tons of oranges annually, most of which are exported.

NAGPUR DIVISION comprises the districts of Buldana, Akola, Amravati, Yeotmal, Wardha, Nagpur, Chanda and Bhandara. Area 36,868 sq.mi.; pop. (1961) 9,233,742. (D. G. NA.)

**NAGUIB** (NEGUIB), **MOHAMMED** (1901– ), Egyptian soldier who enjoyed temporary political prominence immediately after the military coup in Egypt in 1952. Of partly Sudanese origin, Naguib was born at Khartoum in 1901 and became a professional soldier. He served with distinction in the Palestine campaigns of 1948 and in Jan. 1952 was elected president of the Egyptian Army Officers club. At this time his honesty and patriotism had set him apart from most other prominent Egyptians. He appeared, after the military revolution of July 22–23, 1952, to be the head of the new government, and the greater part of the popularity evoked by the revolution was concentrated upon him. But Naguib had at no time been an effective member of the secret organization, the Free Officers' committee, the leader of which was Gamal Abd-al-Nasser (*q.v.*). In Aug. 1952 Nasser relinquished to Naguib the presidency of the committee, but in the autumn a conflict between them became apparent. In his autobiography, *Egypt's Destiny* (1955), Naguib expressed his dislike for the control exercised by the revolutionary committee and his resentment at being made the symbol of the revolution rather than its effective leader.

In June 1953, when the Egyptian republic was declared, there was a dispute as to whether, on becoming president, Naguib should give up the post of prime minister to Nasser. After much debate the officers agreed to Nasser's becoming deputy prime minister; but both parties were in an intolerable position, and in Feb. 1954 Naguib resigned. In the following months Nasser incurred the hostility of the Muslim Brotherhood and after an attempt on his life in Oct. 1954 the Brotherhood was suppressed. Though not suspected of complicity in the assassination plot, Naguib was believed to have been in touch with the Brotherhood. On Nov. 14, 1954, he was deprived of the presidency and placed under house arrest. Thereafter he disappeared from the Egyptian political scene. *See* also EGYPT: *History.* (H. S. D.)

**NAGYKANIZSA,** a town of southwest Hungary in Zala *megye* (county), 137 mi. S.W. of Budapest by road. Pop. (1960) 34,222 (mun.). It has a sprawling site on either side of the Principális canal which drains into the Drava. Nagykanizsa was for long the second fortress of Hungary and was taken and held by the Turks 1600–90. The fortifications were destroyed in 1702. During the 19th and 20th centuries the town became an important trading centre, especially in grain and cattle; some of its products were well known on the London market. Until World War I it was on the main road and rail route between Budapest, Zagreb and Fiume (Rijeka) and developed as a busy railway junction. The dismemberment of Austria-Hungary lessened this significance. (H. G. S.)

**NAGYKÖRÖS,** a town of central Hungary in Pest *megye* (county), is situated 76 km. (47 mi.) S.E. of Budapest by road. Pop. (1960) 25,861 (mun.). It is an ancient settlement, probably established by the Iazyges in the 5th century as Pession, and later resettled by the Magyars. *Körös* presumably comes from *körisfa,* the Magyar for ash tree, as these flourished locally. The neighbourhood has light, sandy soils which have been skilfully used for vegetable and fruit farming. Before World War I a highly organized long-distance market existed for the products, with regular bulk purchase in western Europe. (H. G. S.)

**NAHA,** largest city of Okinawa Island, Ryūkyū Islands, on the island's southwestern coast, was the capital of Japan's pre-World War II Okinawa prefecture and became the seat of both U.S. military and Okinawan governments after the war. Its port, which can handle ships of 10,000 tons, makes it the commercial centre for the Ryūkyū chain. Destroyed during World War II, it was revived with U.S. support. Pop. (1960) 223,047. (J. D. EE.)

**NAHAS PASHA, MUSTAFA AL-** (1876– ), Egyptian statesman, was born in Cairo on June 15, 1876. In Aug. 1927, he succeeded Zaghlul Pasha Saad as leader of the Wafd, the original Egyptian Independence party. As implacable as his predecessor, Nahas was much less successful in holding his party together. His first term of office as prime minister in 1928 lasted only a few months; he was summarily dismissed by King Fuad. Returned to power in 1929, he remained in office until 1930, when he introduced legislation to curtail the king's powers. When the king withheld his consent, Nahas resigned. Prime minister again in May 1936, when the Italian invasion of Ethiopia presented a favourable opportunity for the negotiation of Anglo-Egyptian differences, Nahas headed an Egyptian delegation in London and in Aug. 1936 signed an Anglo-Egyptian treaty of alliance. King Fuad had died in April 1936, but continued friction between the palace and the Wafd was early apparent. After street brawls between rival youth organizations, King Faruk dismissed the government and dissolved parliament. New elections left Nahas in opposition, and in 1939 an important group of Wafd leaders broke away, claiming to be the true heirs of Zaghlul, and formed the Saadist party. Nahas' next period of power was brought about at the insistence of the British. On Feb. 4, 1942, the British ambassador, with a show of military force, obliged Faruk to accept a government headed by Nahas. Elections in March 1942 gave the Wafd an overwhelming victory, and in the military crisis of the following summer the Egyptian government stood stanchly by the Allies.

In Oct. 1944 Nahas Pasha presided over the meeting of Arab states at Alexandria which gave rise to the Arab league. On his

return to Cairo he was abruptly dismissed by the king.

In opposition, Nahas and the Wafd took the lead in demanding a revision of the treaty of 1936 and greater independence from Great Britain. In 1949, when King Faruk's unpopularity had reached a new height, there were signs of a coming together of the palace and the Wafd. In Jan. 1950 the Wafd, under Nahas' leadership, came back to power. The collaboration of these two long-standing enemies took the brakes off corruption. Despite protests, major scandals were hushed up, while Anglo-Egyptian relations deteriorated swiftly. In Oct. 1951 Nahas called for the unilateral denunciation of the treaty of 1936 and for the proclamation of Faruk as king of Egypt and the Sudan. The Wafd and the king lost most of their remaining authority in the ensuing violent months. In Jan. 1952, when the king once more dismissed Nahas following a day of total disorder in Cairo, Faruk and his old enemy were spent forces. After the military coup of July 1952 Nahas appeared for a time to have believed that he retained his former hold over the Egyptian people. "The Wafd *is* the people," he said, but he was soon undeceived. The freezing of its funds broke the Wafd, and Nahas retired into private life. *See* also EGYPT: *History*. (H. S. D.)

**NAHUEL HUAPÍ, LAKE,** the largest lake and the most popular holiday resort in Argentina's southern lake district, lies at 2,500 ft. in the thickly wooded eastern foothills of the Andes in full view of the snow-covered Andean peaks. The lake is about 40 mi. long and not more than 6 mi. wide, with an area of 212 sq.mi., and is irregular in shape, with many inlets extending into the mountains. It is dotted with islands, on one of which (Isla Victoria) is a forestry research station. The water is deep, clear and cold. Popular tourist activities are boating, fishing and mountaineering. The lake and its surroundings are preserved as a national park. (GE. P.)

**NAHUM, BOOK OF,** in the Bible, the seventh in the collection of the 12 "Minor" Prophets of the Hebrew Old Testament. Nahum was a Judaean prophet from Elkosh, an unknown site, who lived at the end of the 7th century B.C. His vision is mainly concerned with Nineveh, the capital city of the Assyrian empire (i, 1).

**Contents.**—In the outline below, numbering follows the Revised Standard Version, in which i, 15 = ii, 1 in the Hebrew text and ii, 1–13 = Hebrew ii, 2–14.

| | |
|---|---|
| i, 1: | introductory verse |
| i, 2–8: | mainly acrostic hymn to Yahweh |
| i, 12–13: | God's oracle to Judah |
| i, 14a, 11, 14b: | God's oracle to the Ninevite king vowing Assyria to ruin |
| i, 15–ii, 2: | triumphant song announcing the fall of Nineveh |
| ii, 3–10: | description of the fall |
| ii, 11–12: | ironical lament for Nineveh |
| ii, 13: | God's repeated proclamation that he caused this destruction |
| iii, 1–4: | a funeral lament again describing the end of the bloodthirsty city |
| iii, 5–7: | a curse on the dead city |
| iii, 8–17: | ironical satire comparing Nineveh's fate with that of Egyptian Thebes, already sacked by Ashurbanipal, king of Assyria |
| iii, 18–19: | a final funeral lament acclaiming the death of the Assyrian king and his satellites |

The book is an organic construction, moving with strict logical progress. Its component parts, with their message of national importance, are combined in a way that betrays a liturgical rather than a literary whole. The role of oracular utterances in worship is confirmed by I Chron. xv, 22, 27, and it is in this light that the book of Nahum should be understood. The partially acrostic form of the hymn in i, 2–8 is not necessarily an argument against authenticity, although it conforms to a practice attested later in medieval Judaism. This hymn to the omnipotent Yahweh is in fact the essential overture to the religious and ritual drama of the book.

**Date.**—The book must be later than 663 when No-Amon (Egyptian Thebes) was taken by Ashurbanipal (ii, 8–10). But it is debatable whether it was written before or after 612, when Nineveh fell to Nabopolassar and the Babylonians in alliance with Cyaxares and the Medes. The threats against Nineveh, especially in the oracles, have convinced many scholars that the "prophecy" of Nahum fits in most naturally just before 612, when the siege of Nineveh was imminent. Others, however, hold that the book was written after 612 but while the memory of the disaster was still fresh. This theory is supported by the eyewitness account of the destruction of Nineveh (ii, 4–11); the funeral lament (iii, 1–4); the pertinence of the satire (iii, 8–17), which would lose its point before the event; the final lament (iii, 18, 19) over the Assyrian army sleeping the sleep of the dead; the general rejoicing at the defeat of the Ninevite king; the arrival of messengers bringing news of deliverance; and the invitation to celebrate the end of the Assyrian tyranny (ii, 1–13).

**Religious Significance.**—The words "keep your feasts, O Judah, fulfil your vows, for never again shall the wicked come against you, he is utterly cut off" (i, 15) seem to show that the book was composed as a liturgical text for a religious festival celebrating deliverance from the Assyrians. Nahum turns a political accident into an act of providence by attributing it to Yahweh, the only true God and sovereign master of history. Deliverance from the Assyrian yoke is a triumph for faith in Yahweh, to whom alone is due the gratitude of Judah.

Nahum is emphatically not a nationalist in the strict sense of the term but a religious man believing in the salvation given to Israel by providence. He uses hymn, oracles, triumphal song, satire and funeral lament to celebrate and magnify in a thanksgiving ritual the saving intervention of Yahweh; the occasion is perhaps the New Year festival. The brilliant language of the book makes it one of the most beautiful pieces of ancient Hebrew literature.

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**NAIADS,** in Greek mythology, the nymphs of flowing water—springs, rivers, fountains, lakes (from *naiein*, "to flow"). The Naiads, appropriately in their relation to fresh water, were represented as beautiful, light-hearted and beneficent. *See* also NYMPH.

**NAIL,** a small pointed metal shaft used for fastening one object to another. A nail bent into a U shape and sharpened at either end is known as a staple. Both devices are very ancient; copper nails were made in Assyria at least as early as 1700 B.C., and in Egypt nails and staples appear about 1,000 years earlier. Nails were commonly used by the Romans; excavations at Inchtuthil in Perthshire (Scot.) in 1961 revealed a store of nearly seven tons abandoned by the Romans between A.D. 87 and 90. These nails were forged from both iron and steel and were in a remarkable state of preservation, being scarcely distinguishable from the hand-forged nails made in south Staffordshire and Worcestershire (Eng.) until the present century. Nails have been made by machine since the mid-19th century. Today they are mainly of the wire and cut types, although a few are still being cast from malleable iron.

**Wire Nails.**—Nails of this type are manufactured by feeding coiled wire through straightening rollers and into a machine where it is gripped between two dies. These dies are serrated, the serrations being impressed into the wire to prevent its being pushed back in the "heading" process that follows. Sufficient metal to form the head is allowed to protrude from the dies and is then "headed up" by a blow from a heading punch which moves reciprocally from a crankshaft at the rear of the machine. Two side-shafts run from this rear shaft, incorporating cams that provide the timing for the dies and cutters. These cutters are ground to a V shape to form the point. After heading, the feed mechanism advances the wire for the correct length, the cutters come together to form the point, and a cam-operated finger ejects the nail down a chute to the front of the machine. These processes all take place at room temperature. Subsequently the nails are

barreled to brighten them and to remove both the rough edges and the nippings caused in the formation of the point. Further processes such as galvanizing, metal-coating, japanning, sorting or thread-rolling are carried out later where necessary, and the nails are then packed into a variety of unit weights. Wire-nail presses are capable of producing nails at speeds varying from 200 to 250 per minute for the largest to 800 per minute for the smallest. Lengths range from $\frac{3}{16}$ in. to 12 in., although few nails are made longer than 6 in. Shank thicknesses vary from 22 imperial standard wire gauge (0.028 in., 0.711 mm.) to $\frac{1}{8}$ or 0.375 in. (9.53 mm.). Most nails are made from mild steel (*i.e.*, steel that contains a fairly low percentage [.08%–.13%] of carbon) though fairly large quantities are made in copper, brass, aluminum alloy, and to a lesser extent in stainless steel and copper alloys. Further developments, which became prominent in the late 1950s, have been the making of carbon-steel masonry nails, which can penetrate brickwork, and of annular threaded nails, which are used for boat building and are manufactured from Monel nickel-copper alloy and silicon bronze. Other nails, principally those employed for the repairing of shoes, have a square-tapered shank that is swaged from round wire by using four, instead of two, dies.

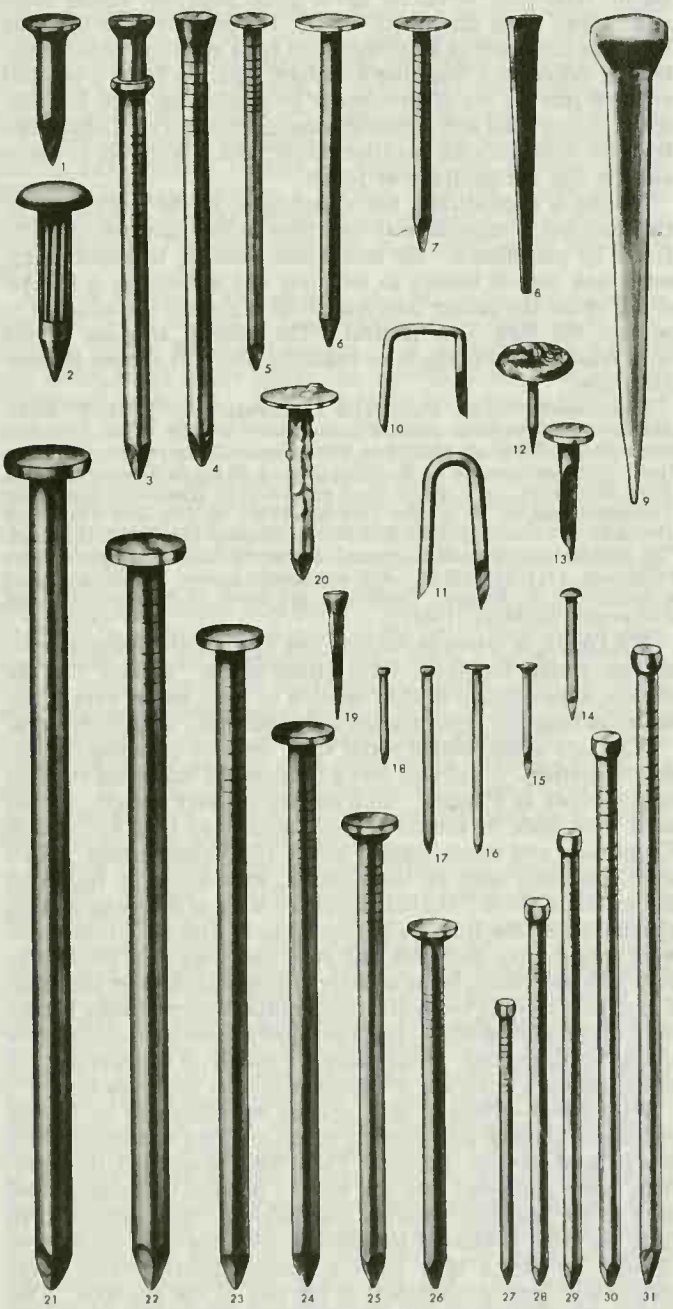

FIG. 1.—TYPES OF U.S. NAILS

(1) Concrete nail; (2) masonry nail; (3) dual-head anchor nail; (4) flooring nail; (5) crating, or box, nail; (6, 20) short and long roofing nails; (7) wallboard nail; (8) cut nail; (9) horseshoe nail; (10) blued double-pointed tack; (11) galvanized flat-point staple; (12) upholsterer's nail; (13) blued carpet tack; (14) brass-plated escutcheon pin; (15) cigar-box nail; (16) 1-in. wire nail; (17) 1-in. brad; (18) $\frac{1}{2}$-in. brad; (19) shoe nail; (21–26) common wire nails, sizes thirtypenny (30*d.*), 20*d.*, 16*d.*, 10*d.*, 8*d.* and 6*d.*; (27–31) finishing nails, sizes 4*d.*, 6*d.*, 8*d.*, 10*d.* and 16*d.*

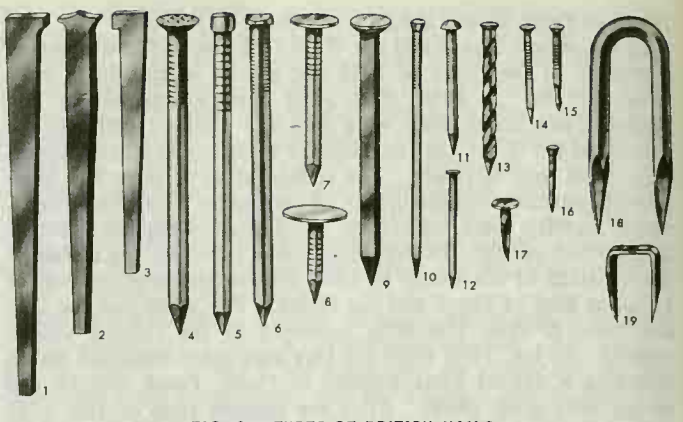

FIG. 2.—TYPES OF BRITISH NAILS

(1) Molder's brad; (2) clasp nail; (3) floor brad; (4) round wire nail; (5) lost-head nail; (6) oval nail; (7) clout nail; (8) clout nail, extra-large head; (9) boat nail; (10) panel pin; (11) escutcheon pin; (12) gimp pin; (13) screwed heel pin; (14) large-head shoe rivet; (15) spearpoint machine rivet; (16) taper tingle; (17) cut tack; (18) presser point staple; (19) telegraph staple

**Cut Nails and Tacks.**—There is still a steady demand for cut nails, principally for building and foundry work, since their comparative roughness provides a greater holding power than an ordinary wire nail. In the manufacturing process, sheets of mild steel are sheared into strips whose width just exceeds the required length of nail. These are fed into the machines either semiautomatically or by hand and the nail blank is cut from the strip, carried down, headed and ejected. The finished nails are not polished.

Cut tacks are made on the same principle, though at higher speeds. Before being packed they are blued by heat treatment to increase resistance to rust.

**Size and Shape.**—It would be difficult to number the different types of nail in use today. Each different length of nail can be made in a wide variety of shapes, in more than a dozen different diameters, in several different metals and in a score of different finishes. The listing of nails by penny sizes, although obsolete in the U.K., continues in the U.S.

**Staples.**—Staple manufacture is commonly regarded as part of the nail industry. Most staples are used to secure fencing or wire netting, and for these purposes they are made from bright and galvanized mild-steel wire. Pieces of wire are sheared diagonally to the correct length and then bent over a mandrel to give the U shape. This process provides a "slice-cut" staple. The "presser point" staple is made by pressing the sides of the point to render them more evenly tapered and in line with one another. The points are then so sharp that the staple can be stuck into the wood by a minimum of pressure, previous to being hammered down. Telegraph staples have three straight sides but are also slice-cut; the material used is rectangular copper-coated wire. A small piece of board may be fixed under the crown to provide insulation. Examples of a rather different type of staple are those that are aligned along a bar after formation and are then glued together in strips for use in stitching and stapling machines.

BIBLIOGRAPHY.—*See* the technical journals *Wire Industry* and *Wire Products;* also a historical work, *White Slaves of England* by R. H. Sherard (1898). (M. F. H.)

**NAIMA, MUSTAFA** (1655–1716), Turkish historian, wrote a history, *Tarih*, of the period 1591–1659. Born in Aleppo, he went at an early age to Istanbul where he entered palace service and held various offices. Protected and encouraged by Hüseyin Pasha, the grand vizier, he was appointed official chronicler (1709). He died during a campaign in the Morea in 1716. His history is

a compilation from the work of his predecessors (Sharihülmenarzade, whose work is lost, Kâtib Chelebi, Hasanbeyzade and others), together with his own comments. In the introduction he states that the aims of a historian should be objective criticism of sources, avoidance of flattery and a straightforward and unadorned style. This advice he himself followed.

The *Tarih* was published in two volumes (1730) and in six volumes (1884).

*See* C. Fraser's partial Eng. trans., *Annals of the Turkish Empire From 1591 to 1659 of the Christian Era* (1832). (F. I.)

**NAINITAL,** a town and district in the Kumaon division of Uttar Pradesh, India. The town, headquarters of the district and division, is 145 mi. E.N.E. of Delhi. It can be reached by road from Kathgodam (23 mi. S.S.E.), the terminus of the railway from Bareilly. Pop. (1961) 16,080 including the cantonment. Founded in 1841, it is a picturesque hill station lying 6,400 ft. above sea level in the Himalayas and is built around a *tal* or lake (area 120 ac.) surrounded by forest-clad hills. It is a popular vacation resort and the summer seat of the state government. There are several public schools, and a college affiliated to Agra university.

Nainital District comprises the lower hills of Kumaon and the adjoining Terai or submontane strip. Pop. (1961) 574,320; area 2,635 sq.mi. The district includes the Gagar and other foothills of the Himalayas, which reach an extreme height of nearly 9,000 ft. in China peak. The Bhabar tract at their base consists of boulders from the mountains, among which the hill streams are swallowed up. Forests cover vast areas of the hill country as well as the Bhabar tract. Beyond this is the Terai, moist and extremely unhealthy. The principal crops are rice and wheat. In the hills a small amount of tea and a considerable quantity of fruits are grown. About 7 mi. E. of Nainital town is Bhowali, noted for its tuberculosis sanatorium, and 7 mi. farther are Bhimtal and Nau-Kuchia Tal. Mukteswar (7,500 ft.), 30 mi. N.E. of Nainital by road, is well known for its veterinary research institute. In 1960 the Uttar Pradesh Agricultural university was set up at Pant Nagar, the first of its kind in the country. (B. Si.)

**NAINSOOK,** a fine, light cotton fabric of plain weave; its texture is similar to that of lawn and cambric. It is usually bleached and finished with a very soft feel for use as lingerie and underwear; nainsook with a crisper finish is used for women's blouses. *See* also Cotton Manufacture: *Varieties of Cotton Fabrics.*

**NAIRN,** a royal and small burgh and the county town of Nairnshire, Scot., on the Moray Firth, at the mouth of the Nairn, 16 mi. E.N.E. of Inverness by road. Pop. (1961) 4,899. The town attracts many summer visitors by its mild and dry climate, good sea bathing and golf courses. Salmon, herring and white fishing are carried on. There is a good harbour, constructed by Thomas Telford in 1820 and enlarged by the building of a dock in 1932. Nairn (originally Invernairn) was made a royal burgh by Alexander I (d. 1124); but his charter, having been lost, was confirmed by James VI in 1589.

**NAIRNE, CAROLINA,** Baroness (1766–1845), Scottish songwriter, who wrote the famous Jacobite songs "Charlie Is My Darling" and "The Hundred Pipers," was born at Gask, Perthshire, on Aug. 16, 1766. She was the daughter of a Jacobite laird, Laurence Oliphant, who was exiled by the rising of 1745 and was not permitted to return to Scotland until 1763. Brought up in a family atmosphere of devotion to the royal house of Stuart and coming in contact with the folksong tradition of the country people on the Gask estate, she became the laureate of Jacobitism, helping to create the myth that the Stuarts' unpopular cause had been the cause of the common people. In 1806 she married the heir to another Jacobite house, Maj. William Nairne, who became the 5th Baron Nairne when his forfeited title was restored in 1824. Her songs remained unpublished until 1821, when she began to contribute them under the pseudonym of "Mrs. Bogan of Bogan" to *The Scottish Minstrel* (1821–24). They immediately became popular, the sly wit of "The Laird o' Cockpen," the gentle pathos of "The Rowan Tree" and the sympathetic passion of "Caller Herrin" appealing to all tastes, so that soon her work became part of the folk tradition from which it had sprung. She was still capable of songwriting as late as her 76th year, when she composed the moving lines, "Would ye be young again," to the traditional tune "Robin Adair." She died on Oct. 26, 1845, while a collected edition of her songs, *Lays from Strathearn* (1846), was still in the press.

*See Life and Songs of the Baroness Nairne,* ed. by Charles Rogers (1869; rev. ed. 1886). (A. M. S.)

**NAIRNSHIRE,** a northeastern county of Scotland, is bounded on the north by the Moray firth, on the east by Moray and on the west and south by Inverness-shire. Its area is 162.9 sq.mi. Its shape is of a compact pentagon, its northern edge being the 9 mi. of coastland; it rises southward for about 20 mi. to its highest and most southerly point at Carn Glas (2,162 ft.).

**Physical Features.**—The middle course of the river Findhorn bisects the southern, hilly half of the county in a valley widening from southwest to northeast (Strath Dearn); the lower third of the river Nairn skirts the northern hill edge and winds over rolling lowland to the sea at Nairn. In the south, remnants of a summit plane at about 2,000 ft. overlook two plateau surfaces, one at 1,500–1,700 ft., and another lower and more extensive plane at about 1,000 ft. All these are planed across Moine Mica schists, with granitic intrusions in the west and again southeast of Strath Dearn which itself contains some Old Red Sandstone. Except for the livestock farms with arable land, and the woodlands of Strath Dearn, this southern area, with between 35 and 45 in. mean annual rainfall, is moorland. It is heathery in the south and grassy with *Molinia* and sedges in the north, and is given over to sheep farming. The lower northern half of Nairn, with less than 30 in. mean annual rainfall everywhere, is a rich farming region. The underlying Old Red Sandstone is masked by thick deposits of boulder clay alternating with glacial sands and gravels. Between the Nairn and Findhorn, and again west of Nairn, long kames (low irregular ridges) may enclose lochans (small lochs) and peaty patches giving rise to moorland stretches. These interrupt the general pattern of livestock farming with arable land which gives way in emphasis to a more intensive arable rotation toward the coast, especially on the warm soils of the 25 ft., 50 ft. and 100 ft. raised beaches. A belt of windblown sand up to 5 mi. wide borders the coast, part of it in the east being forested and the rest unproductive dunes. (A. T. A. L.; A. M. Le.)

**History.**—The county was originally peopled by the Gaelic or northern Picts, and stone circles believed to have been raised by them are found at several places, particularly in the Nairn valley. To the north of Dulsie bridge (18th century) is a monolith called the Princess stone. Mote hills and stones with cup markings are also common. Beyond the occasional finding of Roman coins, there is little evidence of Roman occupation. St. Columba (Colm) and his successors tried to Christianize the Picts, but it was long before this was effected although the saint's name was preserved late in the 19th century in the annual fair called St. Colm's market at Auldearn. The church at Cawdor, where an old Celtic bell is also called St. Colm, is dedicated to St. Adamnan (Evan or Wean), the biographer of St. Columba. By the 10th century the Picts had been subdued with the help of the Norsemen, and Nairn, which was one of the districts colonized by the Scandinavians as part of the ancient province of Moray, soon became an integral portion of the kingdom of Scotland. Hardmuir, between Brodie and Nairn, is the heath where Macbeth is reputed to have met the witches.

Territorially Moray was greatly contracted in the reign of David I (1124–53), and thenceforward the history of Nairn merges in the main in that of the bishopric and earldom of Moray (*q.v.*). The thane of Cawdor was constable of the king's castle at Nairn, and when the heritable sheriffdom was established toward the close of the 14th century this office was also filled by the thane of the time. Cawdor castle dates from the 15th century and is still inhabited. At Auldearn, where once stood a royal castle, the marquess of Montrose defeated the Covenanters in 1645.

**Population and Administration.**—The population was 8,421 in 1961, Gaelic and English being spoken by 130 persons as compared with 410 in 1931. Nairn (*q.v.*; pop. [1961] 4,899), the county town, is the only royal burgh and only small burgh. Nairn

and Moray shires combine to return one member to parliament. There are no county districts. The shire forms a sheriffdom with Inverness, Moray and Ross and Cromarty and a sheriff-substitute from Elgin sits also at Nairn.

**Economy.**—Oats, barley and potatoes are grown and sheep and cattle are reared. There are many dairy farms. The poorer arable land at a higher level is used chiefly for producing winter keep for breeding stock. Other industries include whisky distilling, granite quarrying and brickmaking. There is also a small salmon fishing industry, but sea fisheries have much declined.

The railway from Forres to Inverness crosses the north of the shire. (CH. P.)

**NAIROBI,** the capital city of Kenya, east Africa, lies at the head of the Athi plains, where the Kikuyu escarpment begins, about 300 mi. N.W. of the Indian ocean port of Mombasa. The population increased greatly from 118,976 at the 1948 census to 266,700 in 1962. Under the Kenya constitution (1963) the city area was expanded from 35 sq.mi. to about 266 sq.mi., increasing the population to more than 330,000. The new area, known as the Nairobi area, is an independent administrative unit under the 1963 constitution, outside the regional system and under the administration of the district commissioner, Nairobi area. It supersedes the former extra-provincial district (though its area is not identical) and the Nairobi city council is responsible for the local government of Nairobi area as a municipality. Situated 5,500 ft. above sea level, Nairobi has a pleasantly warm climate, the temperature rarely exceeding 27° C. (80° F.) at midday. The average annual rainfall is about 35 in. of which half falls during March-May.

Originally the site of a water hole used by Masai herdsmen, Nairobi was chosen in the late 19th century as a location for workshops and sidings on the route of the railway from the coast to Uganda. The railhead reached Nairobi in 1899, and the pioneer township attracted trade and settlement. The government was moved there from Mombasa in 1905. Nairobi became a municipality in 1919 and a city by royal charter in 1950; it has a mayor, aldermen and councillors on the English pattern.

Although different racial groups tend to live in their own areas, there are no racial restrictions on residence and public facilities, and services are available to all. Education is conducted through government, city council or private schools and institutions. The Royal college, Nairobi, part of the University College of East Africa, and other establishments offer technical training for students of all races.

Nairobi is the most important urban centre in east Africa. It is the headquarters of the East African Common Services organization and of the East African Railways and Harbours administration. It is also the centre of finance, industry and commerce for a large part of east Africa, and many overseas firms including banks have their east African headquarters in the city. Beside having the Nairobi National park, a game sanctuary of 44 sq.mi., within its boundary, Nairobi is the natural tourist centre for hunting, sightseeing and photographic safaris in east Africa.

The industrial area, to the east of the city, has convenient road access from the city centre, is well served by railway sidings and is near housing estates at Eastlands. Industry is based largely on Kenya's predominantly agricultural economy and includes the manufacture of food and tobacco products, building and furnishing materials, the curing of hides and skins, brewing, and railway and light engineering. Nairobi is the main importing and distributing centre for manufactures from overseas. Near the city are the chief coffee growing areas of the country, and timber, coffee and other primary products of Kenya are exported via Mombasa.

After World War II the city underwent extensive private development and reconstruction, with many multistoried offices, hotels and flats, beside shops, industrial buildings and domestic dwellings. Among notable public buildings are the headquarters of the Common Services organization, Parliament building and the city hall, which was extended in 1957 to form a civic centre and provide international conference facilities. The Kenya National theatre and the adjoining cultural centre (opened in 1960), the East African Conservatoire of Music, the Coryndon Memorial museum (natural history), the McMillan Memorial library, the Sorsbie art gallery and numerous societies and clubs are established in the city.

Nairobi is well served by roads and railways. The main routes are southeast and south to Mombasa and Tanganyika, and northwest via the highlands to Lake Victoria and Uganda. There are regular train and motor coach services to many centres. Nairobi airport at Embakasi, about 9 mi. S.W. of the city, is equipped to deal with the largest aircraft in international service. Wilson aerodrome, within the city boundaries, caters for private, club and charter flying.

*See* J. Smart, *A Jubilee History of Nairobi* (1950). (J. SM.)

**NAISMITH, JAMES** (1861–1939), U.S. physical education director and inventor of the game of basketball, was born at Almonte, Ont., Canada, on Nov. 6, 1861. He was educated at McGill university, Presbyterian theological college at Montreal and the Young Men's Christian Association training college, Springfield, Mass. (now Springfield college) where he also taught physical education. Later he was director of physical education at the Young Men's Christian Association college in Denver (1895–98), obtained an M.D. from the University of Colorado in 1898, and headed the physical education department at the University of Kansas (1898–1937). He died at Lawrence, Kan., Nov. 28, 1939.

With Luther Gulick, his fellow physical education instructor at Springfield, Naismith began experimenting with winter indoor games and originated basketball in 1891. *See* BASKETBALL. (J. D. MCC.)

**NAIVASHA, LAKE,** lies in the highest part of the Kenya rift valley, Africa, where it is flanked eastward by the Kinangop plateau and westward by the Mau escarpment. In this area the floor of the rift is diversified by numerous volcanic cones and craters, including Longonot (9,111 ft.) to the southeast and the Eburru complex to the northwest; but the lake lies on an alluvium-covered flat and is flanked on the north by an extensive papyrus swamp. The level of the lake and consequently its size fluctuate considerably, and from 1917 to 1956 the surface fell by 34 ft. to 6,184 ft. above sea level, thus reducing the area to about 43 sq.mi. The main feeder streams are the Melawa and the Gilgil, and although the lake has no outlet it is only slightly saline. To the south the striking feature of the Njorowa gorge marks the Pleistocene overflow channel. Fish, especially *Tilapia,* are abundant, as are waterfowl. The lake is also a habitat of the hippopotamus. Gustav Adolf Fischer, the German explorer, apparently visited the lake in 1883 and was followed in the same year by Joseph Thomson leading a Royal Geographical society expedition. A 36-mi. road encircling the lake joins the main Nairobi-Nakuru road at junctions north and south of the small town of Naivasha.

*See* A. O. Thompson and R. G. Dodson, *Geology of the Naivasha Area* in *Kenya: Geological Survey* (1963). (S. J. K. B.)

**NAJAF** (AN NAJAF), one of the two Holy Cities of Iraq, the other being Karbala (*q.v.*). Pop. (1957) 88,809. The town is in Karbala *liwa'* (province), lying on a ridge (*najaf*) 7 mi. W. of the Euphrates river and 48 mi. S.S.E. of Karbala, overlooking a marshy lowland (Bahr Najaf). It is revered as containing the tomb of 'Ali, founder of the Shi'ah faith (*see* SHI'ISM). According to one tradition, the first shrine was built by Harun al-Rashid in A.D. 791, but the town's development occurred largely after the 10th century. Najaf retains much of its walled perimeter, with the tomb of 'Ali at the centre; the rest of the town is a tightly built mass intersected by a few reasonably broad streets and a maze of alleys. Special features are the very deep *sirdabs* (underground cellars that provide some coolness in summer), which sometimes communicate outside the house limits, or even the town, hence providing sanctuary for political dissidents. Like Karbala, Najaf has traditionally been a centre of sedition and revolt against the government in Baghdad. (W. B. FR.)

**NAJD** (NEJD), the central region of the kingdom of Saudi Arabia. Najd ("high land" or "high country") consists of uplands sloping eastward from the Hejaz mountains overlooking the Red sea. On the northern, eastern and southern sides it is bounded by the sand deserts of An Nafud, Ad Dahna' and Rub' al Khali. For physical geography, *see* ARABIA: *Geography.*

Riyadh (*q.v.*), the capital of the kingdom, controls the administration of its own district of Al 'Arid and the nearby districts of Al Kharj to the south and Al Mahmal, Al Washm and As Sudayr to the north. A larger measure of administrative autonomy is enjoyed by the outlying districts of Al Aflaj (capital Layla) and Wadi ad Dawasir (capital Al Khamasin) to the south, and Al Qasim (capital Buraydah) and Jabal Shammar (capital Ha'il) to the north.

Tribal affiliations are stronger and more important in Najd than in the more sophisticated and cosmopolitan Hejaz. Until the late 1920s the great Bedouin tribes of Najd (Qahtan, 'Utaybah, Harb, Shammar, Mutayr, Dawasir, Subay' and Suhul) wielded extensive military and political power, but their influence has since declined. Many townspeople of Najd belong to sedentary sections of these tribes or to almost wholly settled tribes such as Bani Tamim. Since the thoroughgoing modernization of Riyadh after World War II, foreigners, including citizens of other Arab countries, have come in increasing numbers to work and live there. Under the rule of al-Sa'ud (the house of Sa'ud), government officials, religious scholars and businessmen from Najd have spread out into all parts of the kingdom.

The earliest history of Najd is imperfectly known. No conclusive evidence has been found to show when Arab tribes first occupied the region or whether they had predecessors. When south Arabian civilization was flourishing in pre-Christian and early Christian times, trade routes from Hadhramaut and Yemen ran across Najd to the Persian gulf. Kinda, a tribe from the south, established a short-lived kingdom in Najd. Christianity penetrated into Al Yamamah, the old name for central Najd (a name now borne only by a single village in Al Kharj), but did not become strong enough to prevent the eastward advance of Islam under the prophet Mohammed and his immediate successors in the 7th century. Najd was at times loosely attached to the Omayyad caliphate of Syria and the later Abbasid caliphate of Iraq. When the Karmatians unified Arabia in the 10th century, Najd formed part of their realm.

After the Karmatian decline, Najd remained for centuries split up into independent tribal domains and oasis states often at war with each other. Backsliding into paganism grew common. About 1741 a religious scholar of Najd, Mohammed ibn 'Abd al-Wahhab, began preaching a return to the original principles of Islam (*see* WAHHABI), and in 1744 Mohammed al-Sa'ud, lord of the town of Ad Dir'iyah, became his chief supporter. By 1785 the reform movement, by proselytizing zeal and military force, had consolidated its hold on all Najd. Expansion beyond Najd included the occupation of Mecca in 1803. The Ottoman sultan commissioned his viceroy of Egypt, Mohammed 'Ali, to check the movement, and after seven years of hard campaigning the viceroy's troops captured Ad Dir'iyah, which they destroyed. Recovering quickly, al-Sa'ud chose Riyadh in 1824 as their new capital. Although the Ottomans gained a foothold in Al Hasa in 1871, their authority did not cross the Dahna into Najd. Civil war involving al-Sa'ud enabled al-Rashid of Ha'il to extend their sway over Najd in the late 19th century, but in 1902 'Abd al-'Aziz al-Sa'ud (known as Ibn Saud; *q.v.*) regained Riyadh and in 1913 drove the Ottomans out of Al Hasa. In 1921 Ibn Saud overthrew al-Rashid in Ha'il and assumed the title of sultan of Najd. After conquering the Hejaz in 1924–25, Ibn Saud ruled it and Najd as a dual monarchy until 1932, when he proclaimed the unified kingdom of Saudi Arabia. The centralization of the government in Riyadh as the sole capital was not fully achieved until about 20 years later. *See* also ARABIA; SAUDI ARABIA.

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(G. S. RE.)

**NA-KHI** (NASI, MOSU, MOSO), an ethnic group of southwest China inhabiting the borderlands of Yünnan, Szechwan and former Hsi-k'ang provinces. Their territory extends from the Salween river valley at about 98° 30′ E. to the west bank of the Ya-lung river at about 102° E. and from about 26° 15′ N. to a few miles north of 29° N. in the Mekong valley. In Chinese records the Na-khi have been grouped with the Lolo tribes under the general name of Wu-man (*see* YI). A Communist Chinese estimate in 1953 placed their total number at 140,000, mostly located in the four districts of Likiang, Chungtien, Wei-hsi and Ninglang. Although the Chinese have called them Mo-hsueh or Mo-so, they call themselves Na-khi. In common with the Tibetans with whom they live intermixed in the north, the Na-khi embrace lamaism (*see* TIBETAN BUDDHISM). However, practitioners of the so-called To-pa religion (Dto-mba) perform sorcery involving an unusual hieroglyphic script for warding off evil spirits. The traditional Chinese marveled at the social freedom of the Na-khi women who unabashedly danced and sang with men in public. Many Likiang Na-khi women were reported in the 1930s to hold positions of economic independence and to control the prosperity of the family. Na-khi grow corn and buckwheat and raise cattle and yaks. The Na-khi are reported in Chinese records to have arrived in northwest Yünnan in A.D. 24, settling in localities from which they had ousted the resident Tibetans. A Na-khi kingdom there was conquered by the Nanchao kingdom in A.D. 778, and Kublai Khan (*q.v.*) passed through their territory to conquer Yünnan in the 13th century.

*See* J. F. Rock, *Ancient Na-khi Kingdom of Southwest China*, 2 vol. (1947), *Na-khi Naga Cult and Related Ceremonies* (1953).

(H. J. WS.)

**NAKHICHEVAN AUTONOMOUS SOVIET SOCIALIST REPUBLIC,** formed in 1924, is an enclave of the Azerbaijan Soviet Socialist Republic of the U.S.S.R., situated between the Armenian S.S.R. and Iran. Area 2,124 sq.mi. Pop. (1959) 141,361. The republic lies to the left of the middle Aras river, which forms the frontier with Iran. From the plain along the river, the land rises to the high wall of the Zangezurski mountains along the border with Armenia, their highest peak being Gora Kapydzhik (12,808 ft.). The area is subject to earthquakes and the shock of 1931 was particularly severe. The climate is continental and dry. Rainfall on the plain is only 8 in. a year, although it rises to 25–30 in. on the mountains, with a spring maximum. Winter temperatures average −7° to −4° C. (20°–24° F.) and summer temperatures 24°–29° C. (75°–80° F.). Vegetation is chiefly of the steppe type and, because of the dryness of the climate, is found almost up to 10,000 ft. Only small groves of dwarf oak and Iberian maple occur in upper parts of valleys.

In 1959 only 27% of the population (38,274) were urban, living in Nakhichevan, the capital (pop. 25,340), Ordubad and Dzhulfa and the two urban districts of Narashen and Paragachai. Agriculture is the main branch of the economy and is remarkably varied. The dry climate makes irrigation necessary on the plain, and many reservoirs have been built. The chief crop is winter wheat, with some spring wheat and barley. Cotton, the main industrial crop, is important. Tobacco, vines, mulberries for silkworms, fruits (apricots, peaches, damsons, quince and apples) are grown, although fruit crops are often badly affected by frosts. Of the livestock kept, sheep are the most important and their wool is used in the Azerbaijan carpet industry. Cattle, goats, horses and donkeys are also reared and there is some beekeeping in the mountains. Industry is limited to salt mining, cotton cleaning, fruit canning, wine making and the bottling of mineral waters.

Nakhichevan town stands on the right bank of the Nakhichevanchai, a few miles above its confluence with the Aras. Its date of foundation is unknown, but archaeological evidence shows that the place was settled long before the Christian era. It is the Naxuana of Ptolemy, and Armenian tradition claims Noah as its founder. In its long history the town has known many masters and was often laid waste. From the 13th to 19th centuries it was the centre of a khanate, owing suzerainty to Persia. In 1828 the town and khanate passed to Russia. Its main importance in the 19th century was as a trading post between Russia and Persia. Industries now include the making of wine, butter, cheese, furniture and bricks, and marble working. The town has a research station of the Azerbaijan Institute of Agriculture and an agricultural technical school. There is a dramatic theatre. Nakhichevan is on the Yerevan-Baku railway which follows the Aras

through the republic, and has motor roads to Yerevan, Dzhulfa on the Iranian frontier, and across the mountains to Yevlakh in Azerbaijan proper. Among notable buildings of the town are the magnificent mausoleums of Yusuf ibn Kutayir (1162) and Momine-Khatun (1186). (R. A. F.)

**NAKHORNPATHOM** is the name of a *changwad* (province) and its capital in Thailand west of Bangkok on the Mae Nam Chao Phraya river delta plain. Area of changwad 841 sq.mi. Pop. (1960) 370,481. Alluvial soils, 49 in. of rain annually, supplementary irrigation from the Nakhon Chai Si river, a Mae Nam Chao Phraya distributary, nearness to the Bangkok market, well-developed transportation facilities and industrious people all contribute to making this one of the most productive and richest *changwads* in Thailand. The chief products are rice, hogs, coconuts, pomelo and other fruits.

The city of Nakhornpathom (pop. [1960] 28,426) is 29 mi. W. of Bangkok on the railroad line connecting Bangkok with Singapore. It is on a hard-surfaced highway extending from Bangkok to peninsular Thailand. At the head of a canal constructed from the Nakhon Chai Si river, it has access to the delta waterways. In addition to being the transportation and commercial centre of the *changwad,* it is a religious and military centre for the entire kingdom. The largest stupa (Phra Pathom) of Thailand, on which construction started in 1860, is there. The new stupa was built on top of an Indian stupa dating from A.D. 500. (T. F. B.)

**NAKHORNPHANOM** is the name of a *changwad* (province) and its capital in Thailand. The *changwad,* in northeastern Thailand adjacent to the Mekong river, has an area of 3,764 sq.mi. Pop. (1960) 436,482. Most of the province is covered with sandy soils which retain only a small percentage of the approximately 85 in. of rain that falls during the wet season (May–September). There is, however, a strip of fertile soil on the flood plain of the Mekong and fair soil in the valleys of the major streams flowing into the Mekong. The city of Nakhornphanom (pop. [1960] 14,799), the political and economic capital of the province, is located on the right bank of the Mekong across from Thakhek, Laos. It is served by a railroad and an all-weather road. (T. F. B.)

**NAKHORNRATCHSIMA** (formerly known as KORAT) is the name of a *changwad* (province) and its capital in Thailand. The *changwad* holds a strategic location in the southwest corner of the northeast geographic region because it is closer and more accessible to Bangkok than any of the other *changwads*. Northeast Thailand is in the Mekong river watershed and contains about one-third of the land and a little less than two-thirds of the country's population. The *changwad* population (1,094,774) in 1960 averaged 145 persons per square mile (area 7,564 sq.mi.). The population is a mixture of Thai, Laotian and Cambodian. Most of the area is in forest and grazing land. The rural population is concentrated chiefly on the flood plains and tributaries of the Mun river where rice can be grown under irrigation on the alluvial soils. Most of the 45 in. of rain falls during the wet season from May to November. The farms produce rice, corn, tobacco, cattle and hogs. The biggest farm problem is the more efficient use of water resources.

The city of Nakhornratchsima (pop. [1960] 41,037) is the transportation, commercial, financial and governmental centre of the northeast. From the city, which is 192 mi. N.E. of Bangkok, a trunk railway line bifurcates toward the north 110 mi. to the Mekong river at Nongkhai, and east 165 mi. to Ubonratchthani. Chief commodities shipped to Bangkok by rail are rice and livestock. A net of all-weather roads connects all the *changwads* and their principal cities in the northeast with this centre. A modern asphalt trunk highway 150 mi. long and air transport connect this capital with Bangkok. One of Thailand's gunnysack factories is in Nakhornratchsima. Ruins indicate that settlement on the Mun river is very old and except for a few short-lived conquests by Cambodia the area has been a part of Thailand since the 14th century. (T. F. B.)

**NAKHORNSAWAN** is the name of a *changwad* (province) and its capital in Thailand. The *changwad,* in central Thailand, has an area of 3,736 sq.mi. Pop. (1960) 647,602. The capital, Nakhornsawan (Paknampho; pop. [1960] 34,947), the chief upcountry river port, is situated at the point where the Nan and Ping rivers join to form the Mae Nam Chao Phraya. Chumsaeng, the second town of importance in the *changwad,* is 19 mi. N.E. by railroad, at the confluence of the Yom river with the Nan. Both towns are collection points for teak logs floated downriver. Nakhornsawan produces rice, beans, corn (maize), cotton, jute and sesame. (G. W. SK.)

**NAKHORNSRITHAMRAT** is the name of a *changwad* (province) and its capital in Thailand. The capital, near the east coast of peninsular Thailand, on a railroad spur, 370 mi. S. of Bangkok by rail, is one of the oldest cities in Thailand. It was founded more than 1,000 years ago. Sometimes called Ligor until the 13th century, it was the capital of a powerful kingdom which dominated the middle of the Malay peninsula. The manufacture of nielloware for which Thailand is known around the world originated there. Pop. (1960) 25,919.

The *changwad* of Nakhornsrithamrat (area 3,926 sq.mi.; pop. [1960] 730,402) has abundant rainfall (110 in.). Its areas of fertile young soils and industrious people make it one of the best agricultural centres in peninsular Thailand. Rice, fruit and coconuts are the chief farm products. Its outport on the Gulf of Thailand is Pakphanang, where Wat Mahathadu, over 1,000 years old, is a famous temple. (T. F. B.)

**NALCHIK,** a town and the administrative centre of the Kabardino-Balkar Autonomous Soviet Socialist Republic, U.S.S.R., stands on the left bank of the Nalchik river, a tributary of the Terek, where it leaves the Caucasian foothills, 320 mi. S.E. of Rostov. Pop. (1959) 87,617. Originally a Russian fortress, the town was established in 1818, but remained unimportant until after the Revolution. There are now light engineering, furniture-making, food-processing, footwear and clothing industries. There are agricultural and horticultural research stations and a pedagogic institute. Nalchik is a popular resort and there are many sanatoriums in the neighbourhood. A branch railway runs to Maiski on the North Caucasus line. Nalchik was held (1942–43) during World War II by the Germans. (R. A. F.)

**NAMANGAN,** a town and former *oblast* of the Uzbek Soviet Socialist Republic of the U.S.S.R. On Jan. 25, 1960, the *oblast* was abolished and its territory divided between the *oblasts* of Andizhan and Fergana (*qq.v.*).

The town of Namangan, in the Andizhan *oblast,* is situated in the northern Fergana valley 125 mi. E. of Tashkent. Pop. (1959) 123,467. It is an important cotton-ginning and textile-manufacturing centre and has a number of light industries, mostly producing foodstuffs (dairy produce, wine, beer and canned meat). By the mid-1960s there were about 50 schools as well as a number of training establishments. Monuments include the Khoja Amni mausoleum (18th century) and the residence of Ahmad Sultan (19th century). Namangan is on the branch line from Kokand to Uch-Kurgan and Tashkumyr which is part of the Fergana circular railway. (G. E. WR.)

**NAMAQUALAND** (NAMALAND; Afrikaans NAMAKWALAND), the area roamed over by the Nama Hottentots before the German occupation of South West Africa, extends from near Windhoek southward into Cape of Good Hope province, S.Af., and from the Namib desert eastward to the Kalahari desert. Since Namagua means "Nama men," many authorities prefer the form "Namaland." The area is divided by the Orange river into Little Namaqualand in South Africa and Great Namaqualand in South West Africa. Near the Orange river an annual rainfall of only 2 in. causes aridity, but farther north the rainfall is about 8 in. on the plateau, and the veld is excellent for sheep and goats. Namakwaland is also the name of a magisterial district in the Republic of South Africa with headquarters at Springbok. Area 18,518 sq.mi.; pop. (1960) 43,825.

*See* also HOTTENTOT. (J. H. WN.)

**NAME (IN LINGUISTICS).** A name may be defined, broadly, as a word or small group of words indicating a particular entity in its entirety without necessarily or essentially indicating any special quality of the entity. The term "common name" is sometimes used roughly as the equivalent of "noun"; the present

article is concerned with what are more specifically "proper names," although a wholly logical distinction has never been established between the two classes. (*See* also NAME [IN LOGIC].)

To illustrate something about the nature and manner of origin of names, a situation may be assumed in which two English-speaking persons are wrecked on an island with several other persons of whose language and individual names they are ignorant. At first they are also ignorant of any individual qualities of the others except for gross external ones, and so they will be likely to speak in such terms as "that fellow with the limp." This may be called a description, serving to distinguish the individual by means of a special quality. In a few days, however, the two will undoubtedly be referring to the other by some handier expression, such as Limpy, and he will at the same time have assumed individuality, so that the word will bring to mind many physical and mental characteristics, that is to say, a whole person. It continues to indicate a special quality, but does not essentially do so, since it calls to mind the complete individual, and has in fact come to be a handy formula for that very purpose. After a while Limpy's foot may heal so that he walks perfectly. His name, however, can remain unchanged, since it has ceased to be primarily a description and refers to him as a whole.

Similarly a place name may be taken, such as Dartmouth, an often-used example. The town was named originally because it stood at the mouth of Dart river, as it still does. But now the word is normally used to name the town without particular reference to its site, and may readily be used for other towns, not so located.

In the effort to escape from this all-inclusive but often no longer descriptive quality of a name, poets and orators often coin epithets. Thus "The Eternal City," though indicating the same entity that Rome does, is purposefully used to direct the mind to a certain aspect. If the name Rome should go out of use and the other become the regular appellation, it would then most likely lose its specific, evocative force as bringing to mind the "eternity" of the city and would become a label to refer to the city in all its aspects, contemporary and ancient, just as Rome now does.

The fact that under proper circumstances Rome will call to mind something other than the Italian city can be taken as demonstrating that a name, like a common noun, may have different applications or meanings. Similarly, it must be recognized that the same entity, by common practice, may have a different name on different occasions: The same man may now be called Jack; now, John; now, Evans; now, Shorty. Even numbers can lose their natural quality of distinguishing a particular aspect. Fifth avenue has come to be just as much a name as Park avenue, evoking all the qualities of the entity. Who thinks of 10 Downing street with any reference to 9 Downing street?

Of concern to theorists, and also a practical matter as regards capitalization in English, is the problem of collective names, plural names, and names derived from collectives and plurals. The problem is usually considered in connection with names for people, but exists with other classes of names; *e.g.*, the Canary Islands. There is much to be granted to the view that no name should exist in the plural (Eskimos) or should be preceded by the indefinite article (an Eskimo). On the contrary, the ordinary practice of linguistic process easily, even if inconsistently, sets up entities composed of what might then be called "subentities," just as a mathematician distinguishes between $a + b$ and $(a + b)$. Present usage in English accepts as names the appellations of legally recognized, well-organized and sharply defined groups, and those of their members. The line of distinction, however, is vague. Differences in the conception of what is to be considered a name (as shown by capitalization) can be readily observed; inconsistencies can be found in the work of a single author and even within a single chapter.

At this point the impossibility of a distinction between names (proper names) and ordinary nouns (common names) becomes evident. If "Englishman" is to be considered a proper name, why should not "man" have the same status? Each specifies, equally, a representative of a class. In fact, "man" indicates a clear and basic biological entity, whereas "Englishman" rests upon the vague and comparatively superficial entity of nationality. The German practice of capitalizing all nouns seems to recognize this impossibility of distinction, and works for consistency and ease in writing; on the other hand, the principles of capitalization, and thus the conception of names, in English and many other languages permit more subtle effects, and seem to reflect a conception that is in harmony with some basic human principle of classification, even if it is not satisfactorily defined by logicians.

All naming thus rests upon the recognition of entities, but in practice a particular entity will be named only if it is important enough to make a name for it useful. Thus, in a large flock the rams and bellwethers may have names but not the ordinary sheep. A (proper) name, as opposed to a (common) noun, may therefore be said, finally, to be assigned to individual entities of sufficient interest and importance. This, in human society, includes all human beings (no completely nameless humans exist) and a vast number of items in their environment (rivers, towns, mountains, houses, etc.).

**Classes of Names.**—Since the individual person is probably the most easily recognizable of all entities and since it is useful to have names for people, personal names are generally conceded to have been the first to be applied. Their tremendous number and great importance make them still of outstanding interest, and most people think of them first when "name" is mentioned. The ramifications of naming are, however, vastly complicated, and it represents a much larger segment of human activity than is usually recognized, as the following rough classification of names may demonstrate.

1. Personal names (*see* below).

2. Quasi-personal names. Here are to be included names for individual animals, for personified objects (*e.g.*, dolls, weapons, ships) and for personified abstractions (*e.g.*, Hope). Also individual wild animals are sometimes named, and primitive peoples often conceive personality as existing in inanimate objects.

3. Names for things not definitely personified but sufficiently important to be individualized. A stone may be usefully named because it marks a boundary, or a tree because it is a good bearer of nuts.

4. Place names (*see* below). These are an obvious extension of (3); they have assumed an importance secondary only to (1).

5. Names of tribes (gentiles, or ethnics), groups, etc. These are an extension of (1), and arise with the recognition of a kind of communal personality. The problem of collectives arises chiefly in connection with this class.

6. Names of institutions (including religions and sects) and corporations. These are an outgrowth of (5), arising with the development of civilization and legal systems.

7. Titles; *i.e.*, the names of books and other works of art. These, developing at comparatively late date, have become of great importance. They may be considered a development of (3) in the direction of the abstract, but what is actually named, even in the case of a statue or painting, is not so much the physical thing as what might be called the artistic or abstract entity.

8. Brand names; *e.g.*, Coca Cola, Vaseline. These are an important modern phenomenon. As with titles, what is named is a kind of exemplar; one buys "a bottle of Coca Cola," or, by compression, "a Coca Cola," much as one buys "a copy of *Hamlet*."

9. Names of events in history; *e.g.*, the Sicilian Vespers, the Renaissance.

10. Names of abstractions not personified; *e.g.*, Stoicism.

With nearly all of these groups the proviso "including legendary, mythological and fictional examples" must be inserted.

## PERSONAL NAMES

The statement by Herodotus (iv. 184), echoed by many later writers, to the effect that the members of a certain African tribe possessed no personal names was based upon hearsay and need be given no credence. Historical and anthropological research has failed to discover any people lacking names. The theory has even been advanced that the first words were the names based upon cries by which individuals "trade-marked" themselves for the

practical purpose of identification. Scholars agree that the use of personal names arose at an extremely early period in human development.

Personal names are derived regularly from ordinary words or from other names. Much less commonly they are derived from the synthesis of essentially meaningless units, such as parts of words, single syllables or mere sounds or letters. This last method is comparatively unimportant, but is of much theoretical interest.

In general every human being receives some name shortly after birth, whether in a matter of minutes or days or weeks, and whether or not this name is considered permanent or temporary. This name is necessarily given by others than the individual receiving it, and these others are generally a parent or both parents, or at least some member or members of the family or group. Since these are well-wishers of the child, the name in any society will ordinarily be a "good" one, whether chosen because of religious feeling, family pride, fashion or mere practicality. Apparent exceptions can be noted, as when a child in some demon-fearing tribe may be given a name such as Filth to deceive the evil spirits into thinking he is not worth troubling. Occasionally (much more rarely than is commonly supposed) the Puritans gave names such as Humility and Tremble; though these names may appear sadistically inspired, they must have seemed excellent to parents of particular religious convictions.

Since a name is generally considered important, its bestowal is often a solemn occasion and a ritual, even, or perhaps especially, among primitive peoples. Such bestowal does not usually prevent the use of a pet name, and this may later displace the "real" name for practical purposes, and sometimes even officially.

Because a newly born child possesses only minimal individuality, few even of its physical traits being determined, fitting descriptive names can rarely be applied, although parental pride may indulge in such a name as the Greek Callias "beautiful." Some peoples have resorted to numbering their children (*e.g.*, the Roman *praenomina*, Quintus, Sextus, etc.), although in such cases the original name is sometimes (though not among the Romans) considered to be only temporary. In contrast to the rarity of truly descriptive names, incident names are common. These are suggested by the time or circumstances of birth, or sometimes of pregnancy. Ben-oni "son of my sorrow" (*Genesis* xxxv, 18) was the name of an infant whose mother died in childbirth; it is another example of an "unpleasant" name, and was also used by the Puritans, perhaps being given on similar occasions. Even among modern peoples incident-naming, particularly with reference to the occasion of birth, is far from uncommon, and many a child is thus called June, or Noël, or even Christmas. Incident-names, but mingling a strong euphemistic quality, are the very numerous saints' names (including even the French Toussaint, "all saints") given, partly at least, because of the day of birth.

As already pointed out, the desire to give a child a "good" name regularly imparts a euphemistic flavour, but many namings are even more definitely so intended and consciously try to start the child out under proper auspices. A baby may be put into what is conceived to be a proper relationship with the tribal totem by being called Wolf, or Son-of-the-Wolf. Even among the Puritans such auspicious names were much commoner than their opposites, *e.g.*, Hope, Constant, Increase, Comfort, Satisfaction. Names that dedicate a child to some god, or in some way connect him with the god, are extremely common (especially in Semitic languages), and many modern names are thus derived; *e.g.*, John from the Hebrew "Jah is gracious," Theodore from the Greek "gift of God," various names beginning in Os- from a Germanic deity.

Comparatively uncommon, but increasing in importance, is the actual manufacture of a personal name from sounds, letters or syllables. Though the practice, or something similar to it, is probably of ancient date, its great development is to be found in the 20th century, especially in the United States for girls' names. Thus have been coined Kathetta, Marilla, Elizene, ClarEtta, D'an, Johnny-D, D-Etta and a host of others.

Inevitably, after the passage of a few generations, names lose touch with their origins, tend to be repeated, and to become "just names." The common practice of naming a child "after" someone, usually some member of the family, is chiefly responsible, along with the power of tradition which makes the use of an established name seem safer and more suitable. With the continuation of this practice, a name, which is by nature and purpose conservative and less subject to linguistic change, which is the inevitable fate of all linguistic forms, may therefore become meaningless to later generations and degenerate into a mere label or tag. This loss of lexical meaning afflicts especially names borrowed from one language into another (*cf.* John, above). In compensation the name acquires a new richness of suggestion as the result of remembered people who have borne it. Thus, today, few know that Thomas means "twin" and was originally applied to one of twins; on the contrary, a boy is so named "after" his father, or someone else, or because "Tom is a good name for a boy." Often the name will be given with both ideas in mind, and perhaps even with the additional thought of Thomas Jefferson and/or all the St. Thomases.

The original name, however given, may be replaced, and such is the regular practice among some peoples. The name may be changed at some definite time, as at puberty, or it may be changed on the occasion of some exploit. Again, a "good" name is sought. The person to be named may now have attained sufficient maturity to choose his own name, or aid in doing so. Since he will by now have attained individuality, the name can often be descriptive, either of appearance or of character, or it may spring from an exploit. Since there is often a close association of names with magic and religion, the new name may have to be "good" in these connections also.

Such full-fledged change of names has not been a noteworthy feature in the tradition from which modern European and American naming has sprung, but the giving of additional names has been of great importance, since the use of family names has developed from it. Such additional names were once known as surnames or nicknames, but modern usage confines the former to mean family names and the latter to mean names of informal or derogatory character. The older term *to-name* has therefore been revived as a technical term, and will be so used here.

In their nature and manner of giving, to-names differ profoundly from names bestowed at birth and names that wholly replace previous ones. They may be bestowed by the person himself or his well-wishers, but more commonly are bestowed by the community. They are often bestowed by people who are good-naturedly making fun of the individual, or even who dislike him. As a result, to-names may be "good" as when the Roman general Scipio is called Africanus because of his victories in Africa. More frequently they are commonplace or mildly derogatory. A few express actual disgust or hatred.

Since the development of multiple and family names, to-names have had little practical function and are not much used, except insofar as individuals, often temporarily as children, may be called by pet names. Even most of the so-called nicknames are only conventionally altered forms of real names, *e.g.*, Bill and Jack, and are scarcely to be considered to-names.

In earlier periods, however, to-names were very widely applied and used, and served much the same purpose that family names now serve. As would be suggested by their generally being commonplace and lacking the "good" quality, to-names seem to have originated for reasons that were primarily practical in the worldly sense. In particular they afforded a good means of distinguishing identically named persons, of whom there are many in most communities. To-names may be actually bestowed or may begin as descriptions (the big John; John who lives at the wood; John, the tanner). Like other descriptions, these pass into names, in English, by shortening, by sloughing off their grammatical apparatus and by being capitalized in writing (Big John, John Atwood, John Tanner). Many such double names look exactly like the modern combination of given and family names, and once really functioned as such, but they differ by not being hereditary. John Atwood's son John, even if he lived in the same place, was not called John Atwood; he might have been called John Priest because of real or imagined piety.

Nearly all to-names, and therefore the family names which de-

velop from them, can be conveniently classified into five groups, according to their manner or origin. (1) They are descriptive of the person's appearance or character; (2) they record an incident or exploit; (3) they identify him by his connection with some other person, usually his father; (4) they give his residence or former residence; (5) they specify his occupation.

Among many peoples and over long periods of time the combination of given name and to-name has functioned satisfactorily and efficiently to identify individuals.

The inherited family name is a comparatively recent development in the European tradition.

Although a few families among the Greeks identified themselves by the patronymic of a real or reputed ancestor, the Etruscans and, learning the custom from them, the Romans are the first Europeans to make regular use of family names. The Roman three-name system was awkward and not highly efficient, but endured until the end of the empire. It then died out, largely because of the opposition of Christianity, under which only the single baptismal name was recognized, though to-names were used for practical distinction.

A modern development of hereditary names began in the middle ages, with royal and noble families. One dynasty of England, for instance, bore the name Plantagenet from a nickname of Geoffrey IV, count of Anjou. Noble families often identified their head by suffixing the name of the estate. This last was in the nature of a to-name as long as it applied only to the titleholder, but it eventually began to be taken by the younger sons and to be considered hereditary. The modern revolution in naming thus seems to stem from feudalism and the family pride associated with it.

Once started, the growth of the use of hereditary names proceeded steadily. The *bourgeoisie* aped the nobility; the lower orders aped both. This desire to be in style was probably an important factor. In addition, the growth in the size of population units and the necessity for more careful keeping of written records presumably aided the process.

The new system was more efficient than the old one. A family name identifies the children before they can achieve any kind of surname except a patronymic. It remains fixed and certain through a man's (but not a woman's) life, whereas he may have one to-name as a young man and have that one forgotten and another put upon him later, or may even bear two to-names at once, perhaps being called one thing by his family and friends and another by people who dislike him. Though to-names are more individualistic and colourful, a family name is correspondingly unlikely to be embarrassing, because everyone realizes that it does not describe the bearer. Moreover, as with all names, the original meaning is generally forgotten. Anyone may be embarrassed because someone bearing the same family name is involved in a scandal, but he is rarely concerned about the actual meaning. The modern triumph of the family name system can thus be adequately explained, both on socio-cultural and practical grounds.

**British and American Naming.**—Since names are a matter of language and tradition, the practices of naming among the English-speaking peoples can be considered together, with certain specification of differences developing since the beginnings of an American tradition.

The Anglo-Saxons, both before and after their Christianization, used a naming system that was also employed by other Indo-European-speaking groups; it is the best attested Indo-European practice, but probably neither the oldest nor the only one. This was a system by which each personal name was formed of two ordinary words; *e.g.*, Hrothgar (Roger), "fame-spear."

As commonly happens with naming, literal significance was not greatly considered, and names were produced, such as Wigfrith, "war-peace," which makes no sense and may be compared to such a modern coinage as Luanda. This system was efficient for the small population groups of the time; if it is assumed that only 100 elements were in use, approximately 10,000 different names were available. To-names were therefore scarcely required, though no doubt they existed. In practice many names were shortened, and nicknames could be used. The only approach to family names seems to have been the practice, at least among royal families, of alliterative naming, or of employing a common initial name-element for all of the sons. Since the Danes and Anglo-Saxons used the same methods of formation, and spoke related languages, the name-pattern of Britain was not greatly affected by the Danish invasion. The chief effect of the Norman conquest was to introduce the use of a few favourite names, themselves of Scandinavian origin but modified by Latin and French influence, and still further modified by transference into English. Thus we may account for the forms and the continuing popularity of William especially, and also of Robert, Richard and Henry (Harry).

Toward the end of the 12th century the church protested against the use of the old heathen names. But even though these objections could not make head against the popularity of the Norman names among the upper classes, the insistence upon the use of biblical and saintly names worked nothing less than a revolution. From this period dates the popularity (and, in some instances, the first recorded English use) of such names as John, James, Michael, Mary, Anne, Elizabeth, Agnes, Catherine and Margaret. Although the number of names in the Christian tradition was considerable, only a few came to be popular. Since at the same time the coinage of new names became almost impossible, the period of the later middle ages threatened to become nomenclaturally poverty-stricken. Only the almost universal use of to-names (and soon, of family names) saved the situation. At the same time there was a great flourishing of variants, so that anyone named Richard might be distinguished from other Richards by being called Dick, Rich, Rick, Hitch, Hitchcock, Dickon or Hud, to mention only a few. Many family names are based on such nicknames.

During the same period of the later middle ages to-names stiffened into family names by becoming hereditary. In the process, however, what might be called the centre of the name-pattern moved considerably in the direction of the commonplace, because to-names were usually given by other people but a man had a good chance of determining what to-name became his family name, or at least of avoiding one he did not want. Thus such personal descriptives as Little, and Reed ("Red"), are preserved, probably because the bearers had no great objection to passing those names on to their children, but such a common derogatory nickname as Fatty, if preserved at all as a family name, is very rare. Names seeming to be derogatory can usually be found to have some other origin, as with Coward, which is from cow-herd or cow-ward.

Geographically, the use of family names began in London and other more developed districts and worked outward. The process was scarcely complete by 1500, even for England, and in the outlying parts of Wales, Scotland and Ireland the use of family names was not universal even in the 18th century.

The chief later British development in family names has been the tendency, basically because of family pride, toward hyphenization (Burne-Jones, Sackville-West).

In modern times the most notable tendency in given (Christian, baptismal, etc.) names has also been toward multiplicity. In English-speaking countries a second given name (middle name) was uncommon before 1700, but by 1850 was ordinary. The use of three given names is fairly common in Great Britain.

Given names, as in any country, are partly controlled by conservative forces (*e.g.*, established religion, family pride), and partly by forces working for change (*e.g.*, fashion, desire for novelty). As important postmedieval influences on naming may be mentioned Puritanism (rejection of the names of nonbiblical saints, emphasis on the Old Testament) and Romanticism (great fondness for Charles, revival of old names such as Alfred, Guy, Guenevere). Any name becoming well known is likely to be more widely used, especially if it carries with it some "good" suggestion, such as piety or patriotism or stylishness. Thus George really became an English name after St. George came to be considered the patron saint of England (about 1360); it grew more popular with the accession of the Hanoverian kings, and in the United States with the emergence of George Washington. Similarly, the Anglo-Saxon name Edward became important because of its use by English kings. Thomas, also, became a characteristically English name because, it would seem, of the popularity of St. Thomas à Becket.

In modern times any popular hero or heroine, even a character in a novel, is likely to give vogue to a name. Such influence, however, is easily overemphasized. It must be remembered that an actor or actress may well assume as a stage name some name that is already becoming fashionable. In that same way, the popularity of Charles may have been aided by the novel *Sir Charles Grandison* (1753), but since the name had already begun to rise in popularity before that time, it may be argued that Richardson actually chose his hero's name for this reason.

**Special American Developments.**—In the United States the chief special developments in the use of family names are (1) the transformation of old names under the influence of frontier illiteracy; (2) the adoption of family names, generally English, by Negroes and Indians; and (3) the adoption of English names or the anglicization of foreign names by non-English-speaking immigrants.

In given names American usage is notable for the strong Puritan use of Old Testament names in early New England (Joseph, Samuel, Benjamin, David, Joel, Ezra, Adlai). Another development is the widespread coinage of women's names (*see* above).

Particularly American also is the use of Jr., as a kind of to-name, and the writing of the signature in the form John Q. Public, as opposed to the British use of J. Q. Public or J. Quincy Public. Hyphenated family names and the use of more than two given names are generally held to be British practices and viewed with little favour.

The second quarter of the 20th century was marked by a considerable change in naming habits in the United States. The proportion of children called by such traditionally common names as John and Mary had declined and many new given names, especially original family names, had become popular. The use of the mother's family name as the child's second given (middle) name has gained considerably.

**Scholarship and Relationships.**—Most scholarship upon personal names has concentrated upon their etymology, manners of origin and method of development. Statistical and historical study of naming as a social phenomenon is little advanced. Although as yet failing to be as useful a tool as the study of place names (*see* below), the study of personal names has been of aid to genealogists and linguists, and occasionally to historians.

## PLACE NAMES

The giving of local names depends, much like that of personal names, upon (1) a sense that a place is an entity which possesses an individuality differentiating it from other places, and (2) a sense that a place is useful and therefore worth naming. The recognition of these requirements necessitates no high degree of intelligence and onomastic reaction is easy. Hence place names arose at a very early period, and occur in all recorded languages.

Originally place names need not have been fully differentiated from common nouns. Just as people now living near a large river say ordinarily "the river," so a primitive tribe thus located, and perhaps knowing no other river, must have spoken. Place naming in a fuller sense would have begun when the people recognized two examples of the same class, and distinguished "the red river" from "the black river," whence eventually Red river and Black river. The original quasi-place name thus became what is now called, by biological analogy, the *generic* (river), and the element used to distinguish between examples of the same class became the *specific* (red, black). This principle, in fact, is not limited to toponomy, or to nomenclature in general—*father* may be any father or *Father* (Jones). In many instances, however, the development proceeded conversely, so that the original common noun became a specific; *e.g.*, from Anglo-Saxon words meaning "the river" several English streams now bear the name Ray or Rea.

The specific-generic principle of place naming, which is highly efficient and so widespread as to be considered universal, rests upon the basic linguistic principle of classification. Ordinary practice in most languages permits the combination of generic and specific into one "word," *e.g.*, Charlestown, and also the omission of either half under the proper circumstances, so that people may say or write either "the Ohio," or "the river," at the same time knowing the full name to be "the Ohio river." In English the specific generally precedes, but it may follow (Lake Mead) or be appended in a phrase (the Bay of Islands).

In spite of the widespread use of the specific-generic principle, different languages naturally differ in their methods of forming place names. Those possessing locative endings are likely to use them liberally. French and Greek employ the article more freely than English does, but Latin lacks an article and so cannot omit it as a mark of a name. The fully developed place name in English generally omits the article; *e.g.*, France, Long Island. The article, however, is used with plurals (the British Isles), and commonly with certain generics, *e.g.*, desert, sea.

This complicated subject of the omission of the article is involved in English with the distinction between evolved and bestowed names. The former begin as mere makeshift identifications; *e.g.*, "the river where the pine trees grow." This can become "the river of the pines," and then "the pine river," and finally "Pine river," or the evolution may be somewhere arrested. At a point sometimes difficult to sense the identification assumes the quality of a name. Bestowed names, on the contrary, arise when a place is consciously labeled by some definite act of naming. Since such a name is likely to be a fully developed one, evolution does not commonly occur, although it may take over to simplify an overcomplicated name, as when El Pueblo de la Reina de los Angeles de la Porciúncula is shortened to Los Angeles.

The giving of place names, as already stated, depends upon entity and use. Primitive peoples, lacking large geographical conceptions, have names for small and obviously useful natural features such as springs, but are not likely to have a sense of the entity of a long river or to have any sense of its usefulness as a whole. Therefore they may not have a single name for it, but may have names for particular pools, reaches and rapids. A mountain is likely to be even harder to conceive as an entity; a range of mountains, still more so. As knowledge increases, larger features are named, often by the process of extending a name in its application; for instance, Italy, Africa and Siberia were originally but small parts of the areas later so denominated. With the development of civilization and geographical knowledge names must be applied to larger and more abstract entities, such as oceans, continents and archipelagos, and eventually to features such as submarine basins, of which earlier peoples were necessarily ignorant.

At the same time a developing civilization gives rise to numerous man-created entities, such as villages, towns, fortresses, provinces and streets, and these also are named. A significant distinction, however, exists between such names and those of natural features. The man-created entities are somewhat less definitely "places" than are natural features, being less surely connected with an actual spot. Towns have changed location, moving the name with them. Primitive villages may bear merely the tribal name, and shift location with the tribal migrations. Even a modern city is often conceived as consisting not of the place, but of the people; its name, then, approaches the status of a collective personal name. In addition, any sovereign or corporate entity such as a city or state possesses a name much as a corporation does. Nevertheless these "habitation-names" are usually considered to be place names, partly because they have a geographically definable location and partly because many of them; such as Liverpool, go back to evolved names of natural features. More doubtful, but sometimes considered to be place names, are the names of such things as bridges, tunnels and individual buildings.

**Types of Specifics.**—The number of specifics is very large, but their usage may be considered under nine heads, and a useful classification of place names thus results, even though the existence of many borderline examples must be recognized. It must also be emphasized that this classification is of kinds of usage, not of the specifics themselves. Thus a specific such as Lincoln might give rise, according to circumstances, to an incident name, a possessive name, a commemorative name or even to something else.

*Descriptive names* employ a specific indicating a long-enduring quality of the generic (Clear brook, Roaring river, Stinking spring, Pliocene ridge). Less purely descriptive, but generally so classi-

fied, are names that identify by means of a possibly impermanent association (Boundary mountain, Mill river, Lone Pine creek). Similar to these latter are the relative descriptive names which identify by indicating a relation to something else (North sea, Ten Mile creek, Fourth crossing). Many counterpart names thus arise, *e.g.*, Big river may not actually be very large, but may be named because it is larger than a neighbouring Little river.

*Incident names* arise from an incident occurring at the place and making it memorable (Massacre lake, Hungry Moose creek). Names of persons are often applied to natural features for this reason, as are also the names of animals. Thus, Crocodile river need not indicate that those beasts were especially numerous there, but merely that a single crocodile happened to impress himself upon early explorers. Nearly all names used by primitive peoples are either descriptive or incident names.

*Possessive names* spring from the idea of ownership, whether legal or informal (Culp's hill, Bakersfield), though the possessive form of the noun need not be maintained. Under this heading may be included most ethnic names (Zululand, Cheyenne river) and many mythological names derived from the names of gods and spirits. These two subclasses, however, are also closely connected with associative-descriptives and with commemorative names. Possessive names appear at an early stage of culture, but probably arise subsequently to the first two classes.

*Commemorative names* are those given consciously "in honour of" someone or something (many religious and patriotic namings); here are to be included most transfer names (Megara from Greece to Sicily; Boston from England to the United States).

*Euphemistic names* are those bestowed with the idea of making a good impression or establishing favourable auspices (Euxine sea, Beneventum, Greenland, Cape of Good Hope). Commemorative and euphemistic names may be considered to arise somewhat later in cultural development than the above-mentioned classes.

*Manufactured names* are those constructed from recombined sounds or letters, out of fragments of old words, from initials, by backward spellings, etc. (Tesnus, from Sunset; Tonolo, from an arrangement of selected letters). Such names are probably of comparatively late origin; no certain example seems to be known before 1600.

*Shift names* result from the mere shift of the specific from one generic to another in the vicinity (White lake, though it may not be white, takes that name because it is near White mountain). The resulting group is called a *name-cluster*.

*Folk-etymologies*, though they may be said merely to transform old names, really produce what are essentially new names, through the mishearing and misinterpretation of an obsolete or foreign word (Picketwire from Purgatoire). Backformation (River Cam from Cambridge) may be considered a phase of folk-etymology.

*Mistake names* arise from failure in transmission, either oral or written (Oregon, from an error on a map). These last three classes differ from the others in that they arise secondarily from other names, and seldom by a conscious process of naming.

The number of names in a given area will be greater because of any factor that increases the number of places easily to be conceived as having entity (*e.g.*, more variegated topography), and also because of any factor leading to more intensive use of land (*e.g.*, denser population). Longer continuous linguistic and cultural tradition is also an important factor, since names established for any reason tend to persist. From such factors, and doubtless from others less easily appraised, spring varying local habits of name giving; thus in some countries every farm and even every field bears a name, but elsewhere such units do not. The density of names thus differs greatly in different areas (according to estimates, South Dakota, .2 to the sq.mi.; U.S., 1; Keos, Greek island, 17; Norway, 40; Bohuslän, Swedish province, 150). Such differences, however, result partly from differences in judgment as to what is to be considered a place name.

Notable periods of naming occur when an uninhabited country is being explored or developed, or when the speakers of a new language are imposing themselves upon a country. In such periods not only are names established for the most important natural features but also for many of the habitation sites that will later become the cities. Because of the general turmoil associated with such a situation, the names are likely to be impermanent. Thus, during the period of the settling of the United States, thousands of names appeared, only to disappear; five once-current European names are recorded for Hudson river, in addition to North river, still in limited use.

Once established firmly, however, place names cling with great pertinacity, and frequently survive, though suffering great change of form, even through periods of shift in population and language. This tenacity renders place names valuable to the study of history and prehistory, and necessitates careful study of the alterations to which they are subject. In general, being a part of language, place names change pronunciation along with the rest of the language. Thus, when the pronunciation of English vowels shifted in the later middle ages, this change occurred in place names as in other words. Certain special factors, however, must be noted. (1) Place names, consisting of specific-generic, are on the average at least twice as long as ordinary words, and so are especially subject to the linguistic forces applicable to long words. (2) Many place names, whether because originally from foreign words or because long-enduring and therefore affected by the obsolescence of native words, are or become meaningless to the ordinary speaker, and thus are peculiarly subject to the processes of folk-etymology. (3) The usage of most place names is highly local, and they are thus susceptible to dialectal variation and even to personal whim. Place names thus tend to depart from the rest of the language and to become unintelligible to the ordinary person, except insofar as they are "re-interpreted" by folk-etymology. By means of earlier recorded forms and by the methods of comparative philology, however, the trained linguist is able to penetrate most of the disguises, and even the most cryptic are not beyond his attempts. As a result the study of place names has proved highly rewarding, and has been assiduously pursued during the 20th century, particularly in western Europe.

**Place Names of Western Europe.**—In this area the "place-name pattern" indicates what is sometimes called a "prehistoric base," *i.e.*, a scattering of names that defy explanation by means of any otherwise recorded language, and are therefore held to represent one that existed at some very remote period. Attempts have been made to elucidate some of these names. Thus to a basic root **kal-* (Calahorra), also supposed to exist in numerous variants, such as **kar* (Carcassonne) and possibly even in **al-* (Alps), has been assigned a large number of names, and the meaning "rock" has been postulated, extended in one direction to mean "mountain," and in another to include "fortress," and even "house" and "village." Such conclusions must still, however, be viewed as highly hypothetical. Iberian and Ligurian were previously coupled with the basic "stratum." The modern tendency, however, is to connect the former with Basque and to restrict it to the Iberian peninsula with some extension into France, and possibly into Britain. Ligurian is now generally considered to represent an early extension of Indo-European, important only in the region of northwestern Italy and southwestern France. After about 1945 much attention was directed toward another possibly early Indo-European stratum to which the term "Illyrian" has been attached.

In contrast to these uncertain early influences is the clear Celtic imprint. As a result of shorter or longer Celtic occupation a recognizable stratum of names extends all the way from central Europe to Ireland and Portugal. As such many names may be noted of rivers (Rhine, Avon), strongholds and sites (Verdun, Vienna, Madrid) and districts (Kent, le Maine). Noteworthy is the derivation from the names of Celtic tribes of about 40 French cities, including Paris.

As comparatively unimportant in the western European name-pattern may be considered the few names left by Greeks, *e.g.*, Nice, Antibes, Ampurias; and by Semites, *e.g.*, Cadiz, Cartagena. The Romans, however, exercised a tremendous influence, and not merely in Italy. Thus arose not only the names of innumerable villages, but also of many important cities; *e.g.*, Saragossa, Aix, Coblenz, Cologne. Direct Roman influence upon names in Britain seems to have been negligible, but indirectly, from Latin words

adopted by the natives, *e.g., castra* and *colonia*, have sprung names such as Lancaster, Chester and Lincoln.

The Germanic migrations affected the pattern strikingly. The appellations of tribes were fixed upon whole regions (Lombardy, Burgundy, Wessex), and even produced the names England and France. In England, where the speech of the invaders supplanted the Celtic speech, the place names became predominatingly Anglo-Saxon, and this Germanic domination was enhanced by the later Scandinavian invasions. In France, Spain and Italy, however, the Germanic influence on names varies, regionally, from moderate to negligible. Naming was active during the period of the revival after the dark ages; the modern languages had then emerged, and most of the new names sprang from them, though a certain Latin influence was still exercised through the Church. Because of the Church influence many religious names appeared; especially noteworthy are the numerous names of towns and villages commemorating saints.

By 1500 the basic European name-pattern was well established, and even most of the smaller names were fixed. Still, naming is a continuous process. Thus, in France, though most cities bear names of medieval or more ancient origin, Le Havre dates only from 1517 and Lorient from 1664. In the British Isles the continuing process is observed with Londonderry, Fort William and Port Sunlight, as well as with the naming of innumerable streets and estates.

Wars and revolutions continue to affect the names, as in the shifts from St. Petersburg to Petrograd to Leningrad. Revivals of nationalism also have strikingly influenced the pattern in Greece and the Republic of Ireland. In Italy the attempts to recall past glories produced such shifts as that from Girgenti to Agrigento.

**Place Names of the United States.**—The place-name pattern of the United States is typical for countries whose development lies mainly in the historical period. The discoverers found a situation such as is to be expected in a region thinly inhabited by primitive tribes. Names were rather sparse; they were descriptive or incident names; according to the principles of entity and use only such features were named as were of interest to a primitive people and were recognizable by them. Europeans adopted some of these names, but since these were generally unintelligible, they were used as mere counters and often misapplied. Thus Connecticut, "at the long estuary," applying only to the river near its mouth, was extended to the whole stream, and then to the colony. At a later period Indian names that had acquired sentimental value were transferred to new sites; a striking example is Wyoming, originally applied to a small valley in Pennsylvania.

Much more commonly the Europeans, of whatever nationality, gave names in their own languages. These were often descriptive (Colorado river, Marblehead, Detroit), or sprang from incidents (Cape Fear, Ranchería de la Espada). Many were commemoratives (Virginia, numerous saints' names in French and Spanish territory), and many of these were transferred from "the old country" (Thames river, Harlem). During more than three centuries, while the country was being explored and settled, thousands of names, and eventually millions, arose by bestowal and evolution. All possible methods of naming were represented; all phases of the history and social development of the American people were enshrined in the names. Enlarged geographical conceptions and an increasing density of population resulted in more and more naming. The necessity of establishing so many names in such a short time, because of the rapidity of settlement, resulted in much repetition and in a great use of transfer names taken in seemingly haphazard fashion from various parts of the world; *e.g.*, Toledo, Athens, Odessa. Nevertheless not a little ingenuity was also displayed, and occasionally some sense of poetry, as in John Frémont's naming of the Golden Gate.

The typically American use of the manufactured name seems to have arisen in an attempt to gain more variety. Although beginning as early as Saybrook (1635), it was a special development of the last half of the 19th century and subsequently. Many manufactured names are *boundary names*, such as Calexico and Mexicali (both from California and Mexico), and Texarkana (from Texas, Arkansas and Louisiana).

Toward the end of the 19th century the "big names" had all been fixed, and the process became one of filling in. Significant dates are the fixing of the last state-name (Wyoming, 1868) and the establishment of the Board on Geographic Names (1890), a federal agency to regulate governmental naming. Place-naming in the United States, however, is still in a comparatively active period because of the constant naming of towns, districts and streets, and the filling-in by the naming of lesser natural features.

**Place-Name Scholarship.**—As a result of the differences in the nature of the problems in Europe and in the United States, the methods and interest of onomatologists have differed greatly. European scholars, lacking historical information, have generally worked by linguistic methods, drawing what help they could from geography, history and anthropology. They have been essentially etymologists. The usual European scholar has little interest in names that have arisen since the middle ages, and are therefore of no etymological interest. Many European scholars have been intensely concerned with the ancillary use of place-name study as a tool for the investigation of prehistory.

American scholars rely mainly on the methodology of history. Not primarily etymologists, they are likely to consider the establishment of the etymology as a mere primary step, of not much significance unless the reason for the application can be established. They are more likely than European scholars to be informed as to the processes of place-naming and more likely to be interested in recent and current naming.

Since the study of place names deals with an important human activity, it is justified in its own right, but it is also of ancillary value to many other studies, such as linguistics, history, geography, archaeology, anthropology and folklore. A zoologist may study place names to establish the former habitat of an animal. Probably the greatest "external" triumphs of the study have been in connection with the establishment of the locations, and something of the social organizations, of various peoples when historical records are lacking. Thus place names make certain a Saxon occupation of the Calais region in France at some time during the period of Germanic migrations. Similarly such study, almost without historical aid, has established that many Norwegians settled in northwestern England (about 900), and is even able to support the assertion that these came in small groups, not in an invading army, had an Irish element mingled with them, and lived on comparatively peaceable terms with the English.

Nevertheless, evidence derived from the study of place names must be used with caution, and is seldom conclusive except when a whole "pattern" can be demonstrated. Individual names may show close resemblance or even be identical as the result of coincidence, as with Georgia in the Caucasus and Georgia, U.S., or Miami (Ohio) and Miami (Fla.), and many others. In the newer countries, such as those of both the Americas, there has been constant transfer of names at a sophisticated level and for what may be called somewhat extraneous reasons. Thus California has been shown to be derived from a Spanish romance. Corinto in Nicaragua resembles the Greek Corinth only by being a port. Odessa in the U.S. may indicate not a settlement of Ukrainians but a wheat-growing district.

Without historical evidence coincidences are often baffling, as with the three widely-separated tribes known to the ancient Greeks as Enetoi. Such cruxes can only be approached by a meticulous combination of linguistic, historical, archaeological, geographical and anthropological techniques.

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**NAME (IN LOGIC).** A *name* is a word, symbol or expression having the kind of meaning which can be explained only by saying that a sentence in which the name is used is intended to be about something which the name denotes. (*See* DENOTATION.)

By some logicians the term *name* is restricted to the narrow category of what are sometimes called *logically proper names; i.e.*, names which denote uniquely, which are simple, in the sense of having no analysis into meaningful parts, and which supposedly have denotation without connotation. But by others the word *name* is used rather in a broader sense than is customary in everyday usage and in linguistics; and it is this broader sense which will be treated in the present article.

Historical changes in the meaning of names (*see* the discussion of particular examples in NAME [IN LINGUISTICS] above), and variabilities and uncertainties of meaning which occur in the natural languages are the concern of the linguist rather than the logician. And many complicating features of the meaning and usage of names in the natural languages, however unavoidable in the actual use and development of a language, are best regarded for purposes of logical analysis as irregularities that have to be removed. This leads ultimately to a formalized language (*see* LOGIC). But we here use for illustration a natural language, English, abstracting from uncertainties of meaning which might be urged as doubts against some of the examples.

Traditionally, names have been classified according to their denotation, as *concrete* names, denoting physically concrete things, *collective* names, denoting collections or classes of concrete things, and *abstract* names denoting abstract entities; or according to the connotation (*q.v.*), as *negative* (if they connote the not having of a specific property) or *positive* (in the contrary case), as *relative* (if, like "father," "friend," "cause," they connote the bearing of a specific relation) or *nonrelative*.

More fundamental, however, is the distinction between *singular* names, or *constants*, which have as a part of their meaning that there is one unique thing denoted, and *common* names, or *general* names, which do not have uniqueness as part of their meaning. (*Proper name* is convenient as a synonym of *singular name*, in view of other meanings of the word *singular;* but by many the term *proper name* is used rather for some more restricted class of names.)

Examples of singular names are the place name "Dartmouth," which denotes the town Dartmouth; the personal name "James Mill," which denotes the man James Mill; the phrase, "the father of John Stuart Mill," which (as would be said even by those logicians who do not class such descriptive phrases as names) denotes the same man James Mill; the personal name "Chiron," which purports to denote a certain centaur; the collective name "mankind," which denotes the class of men; the abstract name "courage," which denotes the property or quality of being courageous. The fact that more than one town has the name of "Dartmouth" and more than one man that of "James Mill" constitutes an equivocacy of these names, but does not prevent them from being singular names, as each one purports to denote uniquely. On the other hand, "Englishman" is a common name since, without equivocacy, it denotes James Mill, and also denotes John Stuart Mill, and Guy Fawkes, and Alexander Pope, etc. "Son of Henry VIII" is a common name, as it is no part of the meaning of the name that there is only one; but "the son of Henry VIII" is a singular name. "Bachelor" is a concrete common name; "centaur" is a concrete common name, though denoting nothing; "throng" is a collective common name; "virtue" is an abstract common name (as both courage and honesty, *e.g.*, are virtues).

In the construction of formalized languages both common names and names denoting nothing have generally been avoided, in the interest of simplicity—except so far as the variables which occur in most formalized languages (*see* LOGIC) may be regarded as partial analogues of the common names. It is an interesting question whether these familiar features of natural language can be reproduced in a formalized language, or whether they have some inherent inconsistency or unsuitability that prevents it. But statements containing either common names or denotationless names can always be reformulated so as to use instead only the constants and variables of the usual formalized languages (an example is the reformulation of "All bachelors are red-haired" as $(x)\,[B(x) \supset R(x)]$ in the language **L** described in SEMANTICS IN LOGIC). (Ao. C.)

**NAMIER, SIR LEWIS BERNSTEIN** (1888–1960), British historian most noted for his work on the 18th century, was born near Lukow, Poland, on June 27, 1888. Arriving in England in 1906, he went to Balliol college, Oxford. He took British nationality before World War I, in which he served first in the army and then in the foreign office, where he remained until 1920. Namier failed to get a teaching post at Oxford, went into business and later devoted his time to research. The appearance of *The Structure of Politics at the Accession of George III* in 1929 revolutionized 18th-century historiography and remains his most considerable work. By massive research over a brief period he aimed to show why men entered politics, and he rejected the simple classification of Whig and Tory in favour of personal, family or regional interests. He was professor of modern history (1931–53) at Manchester and produced various books of essays and two important works: *1848: The Revolution of the Intellectuals* (1946) and *Diplomatic Prelude, 1938–39* (1948). Of an official *History of Parliament*, begun under his editorship, part I, *The House of Commons, 1745–90*, in three volumes, appeared in 1964.

Namier was made an honorary fellow of Balliol in 1948 and was knighted in 1952. He died in London on Aug. 19, 1960. His approach to history attracted many followers but also created opposition among historians who felt that he ignored irrational elements in history and other aspects of society in his preoccupation with the mechanism of politics.

**NAMPA,** a city in the centre of the Boise valley in southwestern Idaho, U.S., 20 mi. W. by S. of the city of Boise. Founded Sept. 8, 1886, on the main line of the Union Pacific railroad at the junction of a branch to Boise, Nampa was a hamlet in the desert until irrigation transformed the area into farms in 1891. The town gained importance through the efforts of W. H. Dewey, an early Idaho settler who made Nampa the hub of two more branch railways and in 1902 undertook a major development of the townsite. His Dewey Palace hotel was a landmark for a generation. A sugar factory, milk condensery and several major vegetable seed producers are the major industries. Nampa is the home of Northwest Nazarene college, a denominational college founded in 1913. The community sponsors the annual Snake River Stampede, one of the leading rodeos in the northwest. The name Nampa is from the name of a leader of the western Shoshone Indians. For comparative population figures *see* table in IDAHO: *Population*. (M. D. B.)

**NAMUR,** a province of Belgium, consists of the three administrative *arrondissements* of Dinant, Namur and Philippeville. It is bounded north by Brabant, east by Liège and Luxembourg (province), south by France and west by Hainaut. Pop. (mainly French-speaking) (1961) 369,432; area 1,413 sq.mi. Namur may be divided into six geographical regions. Forming a "T" across the centre of the province is the lowland of the Sambre-Meuse, with the plateau of Condroz in the southeastern angle and that of Entre-Sambre-et-Meuse in the southwest. South of these plateaus is the low-lying Famenne. Farther south is a small area of the Ardennes. To the north of the Sambre-Meuse valley is a small part of the plateau of Brabant.

The Meuse flows northward from eastern France to its junction with the Sambre at Namur. From the French frontier at Givet to Namur it crosses the Famenne, receiving the Lesse and the Bocq from the east and the Viroin from the west. Its valley there is in places spectacular, especially where the river cuts across bands of compact limestone, forming gorge sections with fine cliffs, alternating with more open valleys, and there are many meanders. The Meuse undergoes a marked change of direction at Namur as it enters the west-southwest to east-northeast line of the furrow flanking the northern edge of the Ardennes, and follows the direction of its tributary, the Sambre, coming in from the west. The valley is cut in Coal Measure shales, with a steep edge to the north. Both Meuse and Sambre have been canalized to stabilize their fluctuating flow.

The Condroz is a plateau of Lower Paleozoic rocks rising to between 600 and 1,000 ft., with a high point (near Durbuy in Luxembourg province) of 1,122 ft. Many parallel ridges are formed mainly of sandstone, with rounded crests. Between them parallel valleys are developed in less resistant Carboniferous limestones. These structural features of the Condroz are continued west of the Meuse in Entre-Sambre-et-Meuse, though the land gradually decreases in altitude toward the French frontier.

Across the south centre of the province the Famenne depression is mostly below 600 ft., forming a trough eroded in weak Upper Devonian shales. In the west the vale is occupied by the Viroin, with its headstreams the Eau Noire and Eau Blanche; in the east the Lesse crosses the Famenne obliquely and receives the Lhomme and the Wamme. In places the limestone has given rise to underground stream-courses, grottoes and resurgences, as in the Grottes de Han in the Lesse valley, and near Rochefort, where there are many caverns; the Salle du Sabbat in the Grotte de Rochefort is 295 ft. high.

Part of the Ardennes uplands, of Lower Devonian sandstones and quartzites, with some Cambrian slates, lies in Namur on either side of a salient of French territory along the Meuse. The highest point in the east is Croix Scaille (1,657 ft.) and in the west in the Forêt de Nismes (1,277 ft.). The Oise rises in the western part of the plateau.

In the north the plateau of Brabant rises gradually southward to a prominent edge (highest point 722 ft.) overlooking the Meuse valley. Though covered with Eocene sands and *limon,* the plateau is underlain by Paleozoic rocks.

Agriculturally Namur province reveals similar diversity. The Ardennes are covered with poor acid soils weathered from shales and slates, with peat moors and bogs in depressions, areas of coniferous plantation, and only a small extent of farmland, mostly under permanent grass. Beef cattle are bred and sent to lowland areas for fattening. Arable farming (oats, rye, trefoil and potatoes) is practised in the valleys. In Condroz and Entre-Sambre-et-Meuse the sandstone ridges are wooded, and the valley floors are used for mixed farming, with oats, winter barley, rye, potatoes and trefoil. Much is under permanent pasture, and dairying to produce milk for the industrial towns, cattle rearing for beef, and horse breeding are important. The Sambre-Meuse valleys, with a milder climate and areas of calcareous loams, clays and alluvial soils, are well farmed. There is mixed farming, though 70% is under pasture; oats, fodder crops and vegetables are grown, and dairying is widespread. The *limon* soils of the Brabant plateau produce wheat and sugar beet. The Famenne has much woodland and pasture.

This section of the Sambre-Meuse valley is part of the "industrial crescent" of southern Belgium. The small Namur coal basin, separated from the coal fields to west and east by barren strata, is now exhausted. Namur town has steel-using and other industries and there are glass and paper works in the vicinity.

Varied relief makes communications difficult, but the Brussels–Arlon–Strasbourg and Liège–Charleroi–Paris lines pass through Namur, and another runs south through Dinant to Reims, France. A line traverses the Famenne (Chimay–Givet–Rochefort). Namur town is an important crossing point of main roads. Both Sambre and Meuse canal systems carry several million tons of freight annually.

Over much of the province the density of population is only about 140 per square mile. The chief town and administrative centre is Namur. With its neighbouring communes of Jambes (13,106) and St. Servais (9,061) the combined population is almost 55,000. Some places in the valleys are tourist centres and market towns, such as Dinant on the Meuse and Rochefort. The centre of the Condroz is Ciney (7,007) and that of Entre-Sambre-et-Meuse is Philippeville, which manufactures tubs, wine casks, clogs and other timber articles. Gembloux (5,875) is the market centre for the northern plateau. (F. J. M.)

**The County and Marquisate of Namur.**—The medieval county of Namur was smaller than the modern province, since the Condroz and much of Entre-Sambre-et-Meuse belonged to the bishopric of Liège. Count Henry the Blind, a descendant of the 10th-century counts of Lomme, had to cede Namur in 1188 to his sister's son Baldwin V of Hainaut (later Baldwin VIII of Flanders), for whom the Holy Roman emperor Frederick I raised it to a marquisate. In 1216 the marquisate passed to Philip (d. 1226), a son of Baldwin's daughter Yolande by her marriage to the Latin emperor of Constantinople, Peter of Courtenay; but in 1263 Philip's brother the Latin emperor Baldwin II ceded it to Guy of Dampierre (*see* FLANDERS, COUNTY OF). Guy gave it in 1297 to his younger son, John I of Namur (d. 1331), whose grandson John III sold it in 1421 to Philip the Good, duke of Burgundy. Thenceforward its history is merged with that of the Burgundian Netherlands. (X.)

**NAMUR** (Flemish NAMEN), chief town of the Belgian province of the same name, lies at the confluence of the Sambre and the Meuse, about 39 mi. (63 km.) S.E. of Brussels by road. Pop. (1961) 32,511. Built on a rocky promontory between the two rivers, Namur is dominated by the citadel, originally the medieval castle of the counts of Namur and improved in the 15th century and by Sebastien Le Prestre de Vauban, the French military engineer, in 1692. It was abandoned as a fortress in 1862 and is now open to the public. Six bridges span the Sambre and two the Meuse. One of the Meuse bridges, the only surviving medieval bridge over the Belgian Meuse, built in the 11th century and rebuilt under Charles V, was demolished in 1962 but was later restored, in its original style, at a higher level.

Despite wars and sieges many fine old buildings survive, including the Meat hall (1588), formerly a meat and fish market, now one of the seven museums in the town. It has important archaeological collections. The diocesan museum has the golden crown and portable altar of the counts of Namur (1217) and the 9th-century Carolingian shrine of Andenne. The cathedral of St. Aubain (1751–63) contains fine paintings, ironwork and brass. The church of St. Loup is notable for its columns of red marble from the St. Rémy quarry in the Ardennes.

Namur is on the railway from Brussels to Luxembourg. Other lines run to Liège and Charleroi. The town has steel-using industries, and manufactures of cement, leather, glue, soap, etc. The tourist trade is important.

A pre-Roman *oppidum* (fortified town), Namur has been, because of its strategic position, the scene of much fighting. It changed hands seven times between 1692 and 1794, passing alternately under French and Allied domination. It went to the kingdom of the Netherlands in 1815 and has been Belgian since 1830. The nine outlying forts erected in 1893 were bitterly contested in World War I when they were destroyed by the Germans. The town was heavily damaged during World War II. (R. M. AN.)

**NANA SAHIB** (*c.* 1820–*c.* 1859), the common designation of Dhondu Pant, a leading figure in the Indian mutiny (*q.v.*), who was adopted by Baji Rao II the last Maratha peshwa in 1827 and made his heir in 1841. On Baji Rao's death in 1851, Nana Sahib inherited his private property and was granted his Bithur *jagir* rent free. But though Baji Rao had pleaded for his life pension to be extended to Nana Sahib, this was refused. Nana Sahib petitioned the governor general and sent an agent, Azim-ullah Khan, to London, but without success. Either resentment of this refusal and Azim-ullah's account of British difficulties in the Crimean War, or perhaps the threats of the sepoys, led Nana Sahib to join the sepoy battalions at Cawnpore (Kanpur) in rebellion in June 1857. A safe conduct given to the British under Gen. Sir Hugh Wheeler by Nana Sahib was brutally broken on June 27 and it was at his palace that the captive British women and children were later massacred. He was proclaimed peshwa in July, but was then defeated by Gen. Henry Havelock and in Dec. 1857 by Sir Colin Campbell. He was driven into the Nepal hills in 1859 where he subsequently died.

*See* R. C. Majumdar, *The Sepoy Mutiny and Revolt of 1857* (1957); P. C. Gupta, *Nana Sahib and the Rising at Cawnpore* (1963).

(J. B. Ha.)

**NAN-CH'ANG,** the capital of the province of Kiangsi, in central eastern China, on the Kan Chiang near the P'o-yang Hu (lake), 160 mi. S.E. of Wu-han. Pop. (1957 est.) 508,000. Nan-ch'ang is situated on the east-west railroad connecting Hangchow in Chekiang province with Chu-chou (Chuchow) in Hunan province. A second railroad station in Nan-ch'ang's left-bank industrial suburb is the terminus for a line going northward to the Yangtze river port of Chiu-chiang (Kiukiang). Nan-ch'ang is the largest city of the P'o-yang (*q.v.*) basin, one of China's chief rice-growing areas. In addition to rice, the city also trades in tea, grown on near-by hillsides, and in cotton, tobacco and hemp. Industries that have developed in the left-bank suburb include factories for the processing of vegetable oils and fats, paper, textiles, machinery and agricultural implements. Kiangsi Agricultural institute and Medical college are located in Nan-ch'ang.

An old walled town, it was formerly situated on the P'o. Over the years the sediments carried by the Kan Chiang built up a delta that pushed the lake shore as far as 20 mi. from the city. The city wall was razed in modern times. The two banks of the city are linked across the Kan Chiang by a bridge and ferries. During the Chinese-Japanese War, the Japanese occupied Nan-ch'ang from 1939 to 1945. (T. Sp.)

**NANCY,** a town of France, formerly the capital of the duchy of Lorraine, now of the *département* of Meurthe-et-Moselle, 93 mi. (150 km.) W. of Strasbourg, on the Meurthe river, 9 mi. (14 km.) S. of its confluence with the Moselle. Pop. (1962) 127,729. The town has two railway stations (rail electrification is under way), large rail yards and repair shops and good highway connections; it is served also by the Marne-Rhine canal and has an airport.

Nancy represents the union of four successive towns. The principal monuments of the Ville-Vieille, the city of the middle ages, are the Porte de la Craffe (1436), restored in the 19th century, with two large towers; and the Porte de la Citadelle (1598) with some remains of fortifications. Near these gates is the palace of the dukes of Lorraine (begun 1502), now housing the Musée Historique Lorrain. The museum's rich collections include materials on Merovingian art and Lorraine folklore. The Chapel des Cordeliers (Franciscans) nearby, the traditional burying place of the dukes of Lorraine, was built in 1480 to celebrate the victory of Duke René II against Charles the Bold.

The Ville-Neuve, south of the old city, was created in 1587 by Duke Charles III; its streets and squares are typical of Italian towns of the 16th century. Among several gates, the St. George and St. Nicholas are outstanding. Principal churches are the cathedral (1703–42) and the church of St. Sebastian (1720–31).

The third town is the work of Stanislaw Leszczynski, former king of Poland, duke of Lorraine (his tomb is in Notre Dame de Bon Secours at Nancy), who destroyed the fortifications between Ville-Vieille and Ville-Neuve and created a handsome, well-planned city with many beautiful examples of 18th-century architecture. The Place Stanislas is surrounded by the theatre, the Museum of Arts and the town hall; its splendid wrought-iron railings edged with gold are well known. Opposite the town hall stands the triumphal arch, leading to the Place de la Carrière, with the Palais du Gouvernement and the Pépinière, a park created in 1765, with a zoo and rose garden. Farther on are the St. Catherine gate, the prefecture and the Place d'Alliance.

Nouveau Nancy, the westernmost city, was built after the Franco-German War of 1870–71. Its principal monuments are Nancy-Thermal, with a hot spring and sporting club; the park of St. Mary; and the barracks, representing Nancy's former importance as a military centre.

The University of Nancy is the continuation of the university of the dukes of Lorraine at Pont-à-Mousson, founded 1572. Activity ceased at the French Revolution, but the university was re-established in the first years of the 19th century (recognized 1854). It is composed of five faculties (law, medicine, science, letters and pharmacy) and several national schools.

Nancy lies at the centre of an important industrial and metallurgical region, distinguished by the textile manufactures of the Vosges, salt mines to the east of the town, iron mines to the south and north and coal mines farther north. Its manufactured products include salt, beer, flour, preserves, macaroni, cotton, velvet, underwear, electric stocks, ironwares, cast-iron pipes, pumps, scales, timber, pasteboard, books, church windows and cut glass.

At the close of the 11th century Nancy was a little town with a castle which enabled it to defy the united assaults of the bishops of Metz and Toul and the count of Bar. In the 12th century the town was surrounded with walls and became the capital of the dukes of Lorraine (*see* Lorraine); in Jan. 1477 Charles the Bold was defeated and killed there by René II and the Swiss. Refortified by Charles III, it was taken by the French in 1633. After the peace of Ryswick in 1697 it was restored to Duke Leopold, who founded academies, established manufactures and set about the construction of the new town. But it was reserved for Stanislaw Leszczynski, the last of the dukes of Lorraine (1736–66), to make Nancy one of the palatial cities of Europe (*see* Stanislaus I). The city, which became French in 1766, was occupied by the allies in 1814 and 1815 and by the Prussians in 1870. After the Franco-German War the population was greatly increased by the immigration of Alsatians and of people from Metz and its district. Although Nancy remained outside the area of actual fighting during World War I, it was bombarded by German airplanes and long-range guns and was seriously damaged. World War II damage was slight, and the city was liberated without difficulty by the U.S. 3rd army in Sept. 1944. (R. Ct.)

**NANDED** (Nander), a town and district in the Aurangabad division of Maharashtra, India. The town, headquarters of the district, lies on the left (north) bank of the Godavari river, 140 mi. N.N.W. of Hyderabad. Pop. (1961) 81,087. It was founded in memory of the Sikh Guru Govind Singh who was assassinated near the town in 1708; a Sikh gurudwara (temple) contains his tomb. Nanded is a market centre for cotton; there are oil mills, cotton ginning and pressing factories and a cotton spinning and weaving mill. There is a training college for Sikhs. The town has good rail and road communications with other towns in the area.

Nanded District is one of the Marathwada districts (Marathi-speaking areas of Hyderabad) that form part of Maharashtra. It is situated on the Bombay and Andhra Pradesh border with an area of 4,800 sq.mi. Pop. (1961) 1,079,674. The district has large forest areas in the north and is traversed by the Godavari river; the Lendi and the Maniad are the other two chief rivers. The railway crosses the centre of the district. Most of the villages are inaccessible during the rainy season.

Agriculture is the main occupation of the people and the land is generally fertile. Cotton is the principal commercial crop, and jowar and wheat are the main food crops. Cattle breeding is an important subsidiary occupation in the villages. Industrially the district is backward. (M. R. P.)

**NANDI,** an east African people of the so-called Nilo-Hamitic group who inhabit the western part of the Kenya highlands. The

name is used also in broad sense for a group living southeast of Mt. Elgon and including the following related peoples: Kipsikis (Kipsigis or 'Lumbwa'); Terik (Nyangori); Keyo (Elgeyo); Tuken (Kamasya); and Sapei (Sebei), totaling about 300,000 (1960s), who now call themselves, as a group, Kalenjin. Except for the Sebei, who live on the Uganda side of Mt. Elgon, all are in Kenya. (*See* NILO-HAMITES.)

Nandi cultivate millet, maize, sweet potatoes and other crops with iron hoes, but their principal interest is their cattle, which, besides providing food and bridewealth payments, are of great ritual importance. Cattle supply both milk and blood, the latter being taken by shooting a blocked arrow into the jugular vein without killing the animal. Some of a man's cattle are distributed among his kinsmen as a precaution against epidemic diseases and raids, which, before the establishment of British administration in 1896, were the chief activity among the Nandi and related peoples.

The people are divided among 17 exogamous, totemic patrilineal clans, which are dispersed throughout Nandi territory. The most important traditional social groups, however, are the age sets to one of which every male belongs from birth. Each set retains power for about 15 years of warriorhood, after which in former days it was ceremonially handed over to the succeeding set. (*See* AGE SET.)

Prior to British administration, political and jural authority resided in local councils of elders. There is a ritual expert (*orkoiyot*) of Masai (*q.v.*) origin who used to sanction warfare, circumcision and planting.

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**NANGRAHAR** (NINGRAHAR; formerly SAMT-I-MASHRIQI or EASTERN PROVINCE), a major province of Afghanistan, is bounded on the east and south by Pakistan, on the north by the main crown of the Hindu Kush mountains (which reach as high as 20,000 ft.) and on the west by the Afghan provinces of Parwan and Kabul. The whole of the northern half of the province consists of the remote and inaccessible land of Nuristan (*q.v.*), which is but loosely integrated into the Afghan state. Formerly known as Kafiristan, it is a land of high mountains and rushing rivers inhabited by a unique people who have been virtually isolated for centuries and who were only conquered and converted to Islam in the last years of the 19th century. The rivers running south from Nuristan flow into two main fertile valleys, the Laghman on the west, fed by the Alinghar and Alishang rivers, and the Kunar in the east, fed by the wide Kunar river which rises across the Pakistan border in Chitral. Both valleys join the Kabul river which flows west to east through the province. Near the junction of the Kunar and Kabul rivers lies Jalalabad (*q.v.*), the capital of the province. Fertile valleys also run into the Kabul river from the Sefid Kuh range in the south, but away from the rivers the main plain around Jalalabad is largely desert. The climate of the province varies with its relief. In the summer the south is hot and dry while Nuristan enjoys a cool and fresh alpine climate; in winter the mountains of Nuristan are buried in snow while the climate of the south is mild and pleasant.

The history of the area is that of the struggle between the tribes themselves, particularly between the people in the valleys and those in the mountains (until 1895 the Nuristanis, from their mountain fastnesses, used to raid the people living in the lower valleys), and the struggle between the local inhabitants and the conquerors and invaders such as Alexander the Great, Babur, and later the British, who passed through it on their way to or from central Asia and northern India. Although the province leads to one of the few possible gateways into India this is not an easy route. The main road from Peshawar to Kabul runs east-west through Jalalabad, parallel to the Kabul river; just before reaching the Afghan frontier it traverses the famous Khyber pass (*q.v.*). Inside Afghanistan, toward Kabul itself, lie the even more formidable Lataband, Gandamak and Jagdalak passes. All these passes have been the scenes of great battles.

The population of the province (1962 est.) was 1,306,570. Besides Jalalabad (46,301) there are no towns of any great size although Kalat-i-Seraj in the Laghman valley and Chigha-Sarai in the Kunar valley are administrative centres. Powerful and warlike Pathan tribes live in the south of the province. South of the Kabul river are the Shinwaris and the Khugianis; north of the river are the Mohmands, half of whom live across the border in Pakistan. Farther up the Kunar valley live the turbulent Safis who were the last of the Afghan tribes to be converted to Islam. The population of the prodigiously fertile Laghman valley is, on the other hand, largely Tadzhik (Tajik). A wide variety of agricultural products is grown in southern Nangrahar, including wheat and rice, tea, sugar cane and many kinds of fruit. In the mountains and on the southern borders of Nuristan various minerals are found in small quantities, notably beryl. There is an airfield at Jalalabad. (X.)

**NANKEEN,** a cotton cloth originally made in China and now imitated in various countries. The name is derived from Nanking, the city in which the cloth is said to have been originally manufactured. The characteristic yellowish colour of nankeen is attributed to the peculiar colour of the cotton from which it was originally made.

**NANKING** (NAN-CHING), capital of Kiangsu province, central eastern China, on the south bank of the Yangtze river, 160 mi. W.N.W. of Shanghai. Pop. (1957 est.) 1,419,000. The city of Nanking dates from the beginning of the Ming dynasty (1368), although it is built on the site of a city which for more than 2,000 years appeared under various names in the history of the empire. The more ancient city was originally known as Kin-ling; under the Han dynasty (202 B.C. to A.D. 23) its name was converted into Tan-yang; by the T'ang emperors (A.D. 618–906) it was styled Kiang-nan and Sheng Chow; by the first sovereign of the Ming dynasty (A.D. 1368–1644) it was created the "southern capital" (Nanking) and was given the distinctive name of Ying-t'ien; and with the accession to power of the Manchu rulers it was officially known as Kiang-ning, though still popularly called Nanking. It was the seat of the imperial court only during the reigns of the first two emperors of the Ming dynasty, and was deserted for Shun-t'ien (Peking) by Yung Lo (Ch'eng Tsu), the third sovereign of that line, who in 1403 captured the town and usurped the crown of his nephew, the reigning emperor.

The T'ai P'ing rebels, who carried the town by assault in 1853, swept away all the national monuments and most of the public buildings it contained, and destroyed the greater part of the magnificent wall which surrounded it. The wall, of which only small portions remain, was about 70 ft. in height, measured 30 ft. in thickness at the base, and was probably 20 mi. in circumference and pierced by 13 gates. Encircling the north, east and south sides of the city proper was a second wall which enclosed about double the space of the inner enclosure. In the northeast corner of the town stood the imperial palace built by Hung Wu (Chu Yüan-chang), the imperial founder of the modern city. After suffering mutilation at the overthrow of the Ming dynasty, this building was burned to the ground on the recapture of the city from the T'ai P'ing rebels in 1864.

The most conspicuous public building at Nanking was the famous porcelain tower, which was designed by the emperor Yung Lo (1403–28) on a previously sacred site to commemorate the virtues of his mother. The building was begun in 1413. In shape the pagoda was an octagon and was about 260 ft. in height. The outer walls were cased with bricks of the finest white porcelain, and each of the nine stories was marked by overhanging eaves of green glazed tiles.

Nanking was formerly one of the chief literary centres of the empire. It was taken by the British in 1842 and made a treaty port by the French treaty of 1858, but was not formally opened. Its proximity to Chen-chiang (Chinkiang), where trade had established itself while Nanking was still in the hands of the rebels, made its opening of little advantage. In 1899 it was voluntarily thrown open to foreign trade by the Chinese government, and in 1909 it was connected by railway with Shanghai, and became the southern terminus of the Tientsin-P'u-k'ou railway.

The nationalist government moved the capital of China to Nanking in 1928 and Nanking remained the legal capital when the government moved to the wartime capital of Chungking after the Japanese invasion. After 1928 Nanking developed rapidly and a number of new buildings such as a modern railway station and several ministries were built by the government and broad boulevards were constructed. Modern airfields and shipping facilities increased the importance of Nanking as a communication centre. Outside the city the famous Sun Yat-sen mausoleum was erected in memory of the founder of the Chinese republic. In Nov. 1937 Nanking fell to the Japanese troops. The "rape of Nanking" which followed was fully authenticated by many neutral witnesses. From 1940 to 1945 Nanking was the seat of the puppet government of Wang Ching-wei. Following the defeat of Japan, the Nationalist government officially returned to Nanking, May 6, 1946, after an absence of eight years.

The Communists seized Nanking in April 1949, and on Oct. 1, 1949, they proclaimed the People's Republic of China with its capital at Peking. Although Nanking ceased to be the national capital, it became the administrative seat of Kiangsu in 1952, when the provincial capital was moved from Chen-chiang to Nanking.

Traditional industries of Nanking included satin, cotton (nankeen cloth), porcelain, paper and ink. Modern industries are concentrated in the riverside suburb of Hsia-kuan (Siakwan) and especially in the left-bank suburb of P'u-k'ou (Pukow), terminus of the trunk railroad to Tientsin. P'u-k'ou has a modern chemical fertilizer plant and a tractor factory. (T. Sd.)

**NAN-NING,** capital city of the Kwangsi Chuang Autonomous Region, south China, 330 mi. west of Canton. Pop. (1957 est.) 264,000. Nan-ning is situated about 30 mi. below the junction of the Li Chiang or Tso Chiang and the Yu Chiang, which form the Yü Chiang, the main southern branch of the Hsi Chiang. The city is served by the Hunan-Kwangsi railroad, which connects the Chinese rail system with North Vietnam.

Nan-ning was opened voluntarily to foreign trade by China in 1907 to offset French influence at Lung-ching (Lungtsin), the former Lungchow, a treaty port near the North Vietnam frontier. Nan-ning is the highest accessible point for steam junks on the Hsi Chiang, except during the low-water season in winter when navigation is seriously affected above Wuchow (Wu-chou). Nanning consists of an old walled city on the left bank of the Yü Chiang and the former foreign commercial settlement just south of the walled town. During the Chinese-Japanese War, the city was temporarily occupied in 1940 by the Japanese.

After the Communist take-over in 1949, the city regained the status of provincial capital, which had been briefly shifted to Kuei-lin (Kweilin), and resumed its historic name of Nan-ning, after having been known officially as Yung-ning from 1913 to the end of World War II.

Nan-ning's traditional orientation toward Canton by the natural route of the Hsi Chiang was sharply altered in 1951 with the coming of the railroad. This line connected Nan-ning with central China and with North Vietnam. During the Indochina hostilities, ending in 1954, Nan-ning was a base of support for the Communist forces of North Vietnam against the French. Nanning's trade was further reoriented in 1955, when a newly completed railroad opened a direct outlet from Kwangsi to the South China sea at the port of Chan-chiang (Tsam-kong).

Nan-ning is the centre of a fertile subtropical agricultural area, whose principal products are aniseed, sugar cane and fruits. It has a flour mill, a sugar refinery and a meat-packing plant. With the recognition of the cultural identity of the Chuang-language minority (of the Thai ethnic group), Nan-ning became the cultural centre of the Chuang people and, in 1958, the capital of the Kwangsi Chuang Autonomous Region, which replaced Kwangsi province. (T. Sd.)

**NANNYBERRY** (*Viburnum lentago*), a handsome North American shrub or small tree of the honeysuckle family (Caprifoliaceae), called also black haw, sheepberry, wild raisin and sweet viburnum, sometimes planted for ornament. It is native to rich soil from Quebec to Hudson bay and southward to New Jersey, Georgia and Colorado. The nannyberry, though usually a shrub, sometimes grows 30 ft. high, with a trunk diameter of 10 inches. It has slender branches, ovate, long-pointed, finely-toothed leaves and bears small white flowers in showy clusters, two to five inches broad. The oval, bluish-black, sweet, edible fruit ripens in late autumn. *See* also VIBURNUM.

**NANSEN, FRIDTJOF** (1861–1930), Norwegian explorer, scientist, artist, statesman and humanitarian, winner of the 1922 Nobel peace prize, was born at Store-Frōen on the outskirts of Christiania (now Oslo), on Oct. 10, 1861. He went to school in Christiania where, in 1880, he passed his entrance examination to the university. He chose to study zoology, because fieldwork would give him the chance of an outdoor life, and also enable him to make use of his artistic talents. Although his scientific work was closest to his heart, he first attained fame as an explorer.

**Explorer.**—As a young man Nansen was a great outdoor athlete, an accomplished skater and skier, and a keen hunter and fisherman. He thus developed an excellent physique which gave him the stamina and endurance needed on his later arctic journeys. He first encountered arctic conditions in 1882 when he joined the sealing ship "Viking" for a voyage to the Greenland waters. On this voyage he saw at a distance Greenland's mighty ice cap, which fired his imagination. It occurred to him that it ought to be possible to cross it, and gradually he developed a plan which he announced in 1887. Instead of starting from the inhabited west coast he would start from the east coast, and by cutting off his means of retreat would force himself to go forward. The expedition of six left Norway in May 1888. In Iceland the group joined a sealing ship bound for East Greenland waters, and after various difficulties the crossing started on Aug. 16. After enduring storms and intense cold, they reached the highest point of the journey (8,920 ft.) on Sept. 5, and struck the west coast at Ameralik fjord on Sept. 26. They were forced to winter at the settlement of Godthaab, where Nansen took the opportunity to study the Eskimos and gather material for his book *Eskimoliv* (1891; Eng. trans., *Eskimo Life,* 1893). The party returned home in triumph in May 1889.

In 1890 Nansen presented before the Norwegian Geographic society a plan for an even more hazardous expedition, and in 1892 he laid it before the Royal Geographical society in London. Having collected evidence showing that the ice of the Polar sea drifted from Siberia toward Spitsbergen, he proposed to build a ship of such a shape that it should be lifted but not crushed when caught by the ice; and to let this ship freeze in off eastern Siberia, in order to be carried from there by the currents. His plan was severely criticized by contemporary arctic explorers; however, the Norwegian parliament granted two-thirds of the estimated expenses, and the rest was raised by subscriptions from King Oscar II and private individuals. His ship "Fram" (*i.e.*, "Forward"; now preserved outside Oslo) was built according to his ideas.

With a complement of 13 men, the "Fram" sailed from Christiania on June 24, 1893. On Sept. 22 she was enclosed by the ice in 78° 50′ N., 133° 37′ E.; she froze in, and the long drift began. She bore the pressure of the ice perfectly. On March 14, 1895, Nansen, being satisfied that the "Fram" would continue to drift safely, left her in 84° 4′ N., 102° E., and started northward with dogsleds and kayaks, accompanied by F. H. Johansen. On April 8 they turned back from 86° 13.6′ N., the highest latitude then reached by man, and headed toward Franz Josef Land. As they approached the northern islands progress was hampered by open water and, because of the advanced season, they wintered on Frederick Jackson Land (named by Nansen after the British arctic explorer) where they stayed from Aug. 26, 1895, to May 19, 1896. They built a hut of stone, and covered it with a roof of walrus hides, and lived during the winter mainly on polar bear and walrus meat, using the blubber as fuel. On their way to Spitsbergen they encountered Frederick Jackson and his party of the Jackson-Harmsworth expedition, on June 17, and returned to Norway in his ship "Windward," reaching Vardo on Aug. 13. The "Fram" also reached Norway safely, having drifted north to 85° 55′. Nansen and his companions on board the "Fram" were given a rousing welcome which culminated on arrival in Christiania on Sept. 9. His two-volume account of the expedition, *Fram over Polhavet*

(Eng. trans., *Farthest North*), appeared in 1897.

**Scientist.**—Nansen's success as an explorer was mainly due to his careful evaluation of the difficulties that might be encountered, his clear reasoning, which was never influenced by the opinions of others, his willingness to accept a calculated risk, his thorough planning and his meticulous attention to detail. Many of these traits can be recognized in his scientific writings. In 1882 he was appointed curator of zoology at the Bergen museum. He wrote papers on zoological and histological subjects, illustrated by excellent drawings. For one of his papers, "The Structure and Combination of Histological Elements of the Central Nervous System" (1887), the Christiania university conferred upon him the degree of doctor of philosophy. This paper contained so many novel interpretations that the committee which had to examine it accepted it with doubt, but it is now considered a classic.

On his return from the "Fram" expedition in 1896 a professorship in zoology was established for Nansen at the Christiania university, but his interests shifted from zoology to physical oceanography, and in 1908 his status was changed to professor of oceanography. During 1896–1917 he devoted most of his time and energy to scientific work. He edited the report of the scientific results of his expedition and himself worked up some of the most important parts. He participated in the establishment of the International Council for the Exploration of the Sea and directed for some time the council's central laboratory in Christiania. In 1900 he joined the "Michael Sars" on a cruise in the Norwegian sea. In 1910 he made a cruise in the "Fridtjof" through the northeastern North Atlantic; in 1912 he visited the Spitsbergen waters on board his own yacht "Veslemoy," and in 1914 he joined B. Helland-Hansen on an oceanographic cruise to the Azores in the "Armauer Hansen." In 1913 Nansen traveled through the Barents sea and the Kara sea to the mouth of the Yenisei river and back through Siberia. He published the results of his cruises in numerous papers, partly in co-operation with Helland-Hansen. His lasting contributions to oceanography comprise improvement and design of instruments, explanation of the wind-driven currents of the seas, discussions of the waters of the Arctic and explanation of the manner in which deep- and bottom-water is formed.

Nansen also dealt with other subjects: for instance, his *Nord i Taakeheimen* (2 vol., 1910–11, Eng. trans., *In Northern Mists,* 1911) gives a critical review of the exploration of the northern regions from early times up to the beginning of the 16th century. Nansen's papers are all stimulating, but he wrote so fluently that he was likely to be verbose and his attention to detail made his presentation cumbersome. His great literary talent is, on the other hand, evident in his popular accounts of his journeys, many of which he himself illustrated.

**Statesman and Humanitarian.**—As Nansen grew older, he became more and more interested in the relations between individuals and nations. In 1905 he took a lively part in the discussion about the dissolution of the union between Norway and Sweden. His attitude may be summarized by his words: "Any union in which the one people is restrained in exercising its freedom is and will remain a danger." On the establishment of the Norwegian monarchy, Nansen was appointed its first minister in London (1906–08). In 1917, during World War I, he was appointed head of a Norwegian commission to the United States, and negotiated a satisfactory agreement with the U.S. government about the import into Norway of essential supplies.

At the first assembly of the League of Nations in 1920 the Norwegian delegation was headed by Nansen, who was to remain one of the outstanding members of the assembly until his death. With his tall and bony frame, his snow-white hair, his flowing mustache, and his broad-brimmed hat at a rakish angle, he made a striking figure in Geneva.

In April 1920 the council of the League of Nations gave Nansen his first great task, appointing him high commissioner responsible for the repatriation from Russia of about 500,000 prisoners of war from the former German and Austro-Hungarian armies. The Soviet government would not recognize the League of Nations but negotiated with Nansen personally, and in Sept. 1922 he reported to the third assembly of the League that his task was completed and that 427,886 prisoners of war had been repatriated.

In Aug. 1921 Nansen was asked by the International Committee of the Red Cross to direct an effort to bring relief to famine-stricken Russia. He accepted, and on Aug. 15 a conference in Geneva, at which 13 governments and 48 Red Cross organizations were represented, appointed him high commissioner of this new venture. On Aug. 27 he concluded an agreement with the Soviet government authorizing him to open in Moscow an office of the "International Russian Relief executive." Nansen's request to the League for financial assistance was turned down, but by appealing to private organizations and by addressing large public meetings he succeeded in raising the necessary funds.

On July 5, 1922, on Nansen's initiative, an international agreement was signed in Geneva introducing the identification card for displaced persons known as the "Nansen passport." In this connection mention can be made of the Nansen International Office for Refugees created in Geneva in 1931 (after Nansen's death): it cared mainly for the "White" Russians, for the Armenians from Turkey and, later, for the Jews from Germany.

In 1922 Nansen was awarded the Nobel peace prize; he used the prize money for the furtherance of international relief work.

Nansen died at his home at Lysaker near Oslo on May 13, 1930.

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**NANTERRE,** a western suburb of Paris in the *département* of Seine, France, is situated on the northwest of Mt. Valérien 13 km. (8 mi.) N.N.W. of Notre Dame cathedral by road, and on the railway from Paris to St. Germain-en-Laye. It is a port on the Seine, the terminus of an oil pipeline from Le Havre, and an industrial centre manufacturing automobiles and accessories, electrical equipment, rolling stock, machine tools, biscuits and perfumes. Pop. (1962) 83,155. Originally Nemetodor, a Gallic place of worship, the settlement was known to the Romans as Nemetodorum. Nanterre is the traditional birthplace of St. Geneviève (*c.* 422–*c.* 500), patron saint of Paris. The tower of St. Geneviève's basilica dates from the 13th century. Burned by the English in 1346, the town was rebuilt with ramparts which were replaced by boulevards in the 19th century. Nanterre was occupied by the Allies in 1815 after a hard-fought struggle against Napoleon's troops, and there were several encounters round Mt. Valérien during the Franco-German War (1870–71).

**NANTES,** a city of western France, capital of the *département* of Loire-Atlantique, is situated at the head of the Loire estuary, 56 km. (35 mi.) from the sea and 395 km. (244 mi.) S.W. of Paris by road. In population (246,227 in 1962), Nantes is the first city of Brittany. The Loire there divides into four branches, forming islands over portions of which the city has spread. Two of the branches have been filled up and made into roads.

The cathedral of St. Pierre, built above a 12th-century crypt, was unfinished till the 19th century. There are two notable monuments in the transept: Michel Colombe's tomb of Francis II, duke of Brittany, and his second wife Marguerite de Foix (1507); and that of Gen. L. C. C. Juchault de Lamoricière, a native of Nantes, by the architect Boitte and the sculptor Paul Dubois (1879). Between the cathedral and the Loire stands the castle of Nantes, founded in the 9th or 10th century. The residence of the dukes of Brittany, it was rebuilt by Francis II and the duchess Anne, and is flanked by huge towers and by a bastion erected by Philippe Emmanuel de Lorraine, duc de Mercoeur, during the time of the Catholic League in Brittany. A fine Gothic façade looks into the courtyard.

Nantes has an archaeological collection in the Dobrée museum, and in the museum of fine arts a splendid collection of paintings, modern French masters being well represented. It is the seat of a prefect, of a bishopric under the archbishop of Tours and of a court of assizes. It has tribunals *de grande instance* and of commerce, a board of trade arbitrators and a chamber of commerce. The original university (founded 1460) was abolished during the French Revolution, but a new one was set up in 1961; there are

many other educational institutions. Nantes is on the railway from Paris to St. Nazaire, and other lines run to Rennes and Bordeaux.

There are four shipyards, four floating docks, and a large tin plate and sheet metal works. Manufactures include steam and electric locomotives, trucks, drilling equipment, generating sets, refrigerating plant, aircraft parts, ships' tackle, machine tools, agricultural machinery, cycles and household goods. Nantes is a centre for food canning and its biscuit factories, sugar refineries and brewery are well known. There are also factories producing fertilizers, compressed fuel, plywood, bottle glass, soap, varnishes and paints, printing ink, shoes, boxes, paper and knitted goods. Farmers in the district are mostly concerned with stock breeding, and the growing of cereals and early vegetables; the local wine, Muscadet, is very fine.

The ports of the Loire estuary run from Nantes through Donges, a tanker base, Paimboeuf and Basse-Indre to St. Nazaire. Sea and river traffic have developed rapidly, exceeding 8,500,000 tons by the mid-1960s. Dredging keeps the channel between Nantes and the sea open to vessels of 28-ft. and 24-ft. draft at average spring and neap tides respectively. There are three miles of wharves on the Pirmil and Madeleine branches of the Loire, all being served by road and rail and having electric cranes. A floating crane handles loads up to 100 tons. The warehouses cover 17 ac. On the river bank is a 550,000-kw. power station using natural gas brought from Lacq by a 300-mi.-long feeder.

**History.**—Before the Roman occupation Nantes was the chief town of the Namnetes and consisted of Condovicnum, lying on the hills away from the river, and of Portus Namnetum, on the river. Under the Romans it became a great commercial and administrative centre, though its two parts did not coalesce till the 3rd or 4th century. In the middle of the 3rd century Christianity was introduced by St. Clair. Clotaire I got possession of the city in 560, and placed it under the government of St. Félix, the bishop who caused the Loire to flow under the walls of the castle. After being several times subdued by Charlemagne, Brittany revolted under his successors, and Nomenoë, proclaimed king in 842, razed the fortifications of Nantes because it had sided with Charles the Bald. The Normans held the town from 843 to 936. About that time began the rivalry between Nantes and Rennes, whose counts disputed the sovereignty of Brittany. Pierre de Dreux, declared duke of Brittany by Philip Augustus, made Nantes his capital, surrounded it with fortifications and defended it against King John of England (1214). During the Breton wars of succession Nantes sided first with John of Montfort, but afterward with Charles of Blois, and did not open its gates to Montfort till his success was assured and his English allies had retired. In 1560 Francis II granted Nantes a communal constitution. Averse to Protestantism, it joined the Catholic League along with the duc de Mercoeur, governor of Brittany, who helped to raise the country into an independent duchy; and it was not till 1598 that it opened its gates to Henry IV, who there signed the Edict of Nantes (*q.v.*), which until its revocation by Louis XIV in 1685 was the charter of Huguenot liberties in France. The city was in 1793 the scene of the *noyades* (mass drownings) instigated by the notorious Jean Baptiste Carrier (*q.v.*), envoy of the committee of public safety. During World War II Nantes was under German occupation from June 1940 until Aug. 1944. From Sept. 1943 Allied bombing caused widespread damage, necessitating much reconstruction later. (X.)

**NANTES, EDICT OF,** the law signed at Nantes, in Brittany, in April 1598 by Henry IV of France whereby he granted a large measure of religious liberty to his Protestant subjects, the Huguenots (*q.v.*).

The Edict of Nantes gave freedom of conscience to the Protestants. It also gave them the right to hold public worship wherever they had held it in 1576 and in the earlier part of 1577; wherever this right had been accorded by the Edict of Poitiers (1577) and by the ratifications of the treaties of Nérac (1579) and of Fleix (1580); and in two towns in each *bailliage* or *sénéchaussée*. The greater nobles, moreover, could hold Protestant services in their houses; and lesser nobles could do the same, but only for gatherings of not more than 30 people. With regard to Paris, Protestant worship was permitted at a distance of five leagues from the city, instead of ten leagues as previously.

The edict granted full civil rights to Protestants: they could trade freely, inherit property, enter universities, colleges and schools and be eligible for official appointments. To deal with disputes arising from the edict, a special chamber, the *chambre de l'édit*, comprising ten Roman Catholics and six Protestants, was established in the *parlement* of Paris; and similar chambers, called *chambres mi-parties*, for the same purpose but with Catholics and Protestants in equal numbers, were set up in the *parlements* of Toulouse, of Bordeaux and of Grenoble (for Languedoc, Guienne and Dauphiné). The Protestant pastors were to be paid by the state and to be released from certain obligations. Finally, the Protestants could keep places that they were still holding in Aug. 1597 as strongholds or *places de sûreté* for eight years, the expenses of garrisoning them being met by the king.

The edict incidentally restored Catholicism in all areas where Catholic practice had been interrupted; and it made any extension of Protestant worship in France legally impossible. Nevertheless it was much resented by Pope Clement VIII and by the Roman Catholic clergy in France. The *parlements* likewise resented it, but that of Paris was forced by the king to register the edict on Feb. 25, 1599. The *parlement* of Rouen, however, delayed registration till 1609. During the minority of Louis XIII and the government of Marie de Médicis (1610–17) the Catholics contrived to apply the edict in the most restrictive sense; and when the cardinal de Richelieu came to power he regarded the political clauses of the edict as a danger to the state. Though the Protestants took up arms to defend their position, the government's forces prevailed, and the Edict of Alès (1629) annulled the political clauses and the right to *places de sûreté*. Louis XIV's revocation of the Edict of Nantes (Oct. 18, 1685) deprived the French Protestants of all religious and civil liberty.

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**NANTEUIL, ROBERT** (1623/30–1678), French line engraver, was born in Reims, the son of a merchant. Having received an excellent classical education, he studied engraving under his brother-in-law, Nicholas Regnesson. He became known by his crayon portraits, and was pensioned by Louis XIV and appointed designer and engraver of the cabinet to that monarch. It was mainly because of his influence that the king granted the edict of 1660, by which engraving was pronounced free and distinct from the mechanical arts, and its practitioners were declared entitled to the privileges of other artists. Nanteuil died at Paris on Dec. 9, 1678.

The plates of Nanteuil, several of them almost life-size, number about 300. In his early practice he imitated the technique of his predecessors, working with straight lines, strengthened, but not crossed, in the shadows, in the style of Claude Mellan, and in other prints crosshatching like Regnesson, or stippling in the manner of Jean Boulanger. He then gradually acquired an individual style, modeling the faces of his portraits with the utmost precision and completeness, and employing various methods of touch for the draperies and other parts of his plates. Among the finest of his mature works are the portraits of Pomponne de Bellièvre, Gilles Ménage, Jean Loret, the duc de la Meilleraye and the duchess of Nemours.

**NANTICOKE,** a city of northeastern Pennsylvania, U.S., on the Susquehanna river 7 mi. W.S.W. of Wilkes-Barre in Luzerne county. Main industries are coal mining and the manufacture of cigars, clothing, silk and rayon yarn and thread and sportswear.

Anthracite coal mining was long the economic mainstay and is still important, but the steady decline of the industry caused serious dislocations, chronic unemployment, and a steady loss in population. For comparative population figures *see* table in PENNSYLVANIA: *Population.*

The city is named after a shad-fishing Indian village on the west side of Nanticoke creek. The town was laid out in 1793 and the first anthracite coal was mined by Col. Washington Lee in 1825. The North Branch canal and the Susquehanna river were important for the transportation of coal before the building of the railroads. Nanticoke was incorporated as a borough in 1874 and secured a charter as a city in 1926. (L. A. Gr.)

**NANTUCKET,** a large island off the coast of Massachusetts, U.S., about 25 mi. S.E. of Cape Cod. Once the centre of the whaling industry, Nantucket has turned to the tourist and recreation industries for support. The island is nearly 15 mi. long and averages 3 mi. in width. The land is quite level with a few low hills, the whole being a terminal moraine of a continental ice sheet. The ever-eroding sea has created 88 mi. of sandy beaches around the island. The encircling ocean also modifies the climate markedly, with warmer winters and cooler summers than the adjacent mainland.

Nantucket was discovered by Bartholomew Gosnold in 1602, granted to the Plymouth company in 1621, and purchased by Thomas Mayhew in 1641. Agriculture was never too successful and the settlers quickly turned to fishing, shipbuilding and trading. Whaling began in earnest in the early 18th century and reached its peak just before the American Revolution, when 125 whalers sailed out of Nantucket's commodious harbour seeking the sperm whale for its valuable oil. British raids during the Revolution, the blockade of the War of 1812 and the general attrition of Nantucket's vessels at sea sapped the commercial strength of the island, although as late as 1830 it was the third commercial port of Massachusetts. New Bedford had surpassed Nantucket as a whaling centre by 1820 and the development of kerosene destroyed the sperm oil industry by 1860. The population of the island shrank from 6,094 in 1860 to a low of 2,797 in 1920. Attempts were made to introduce some manufacturing after the Civil War but none of them prospered. Gradually, as transportation with the mainland improved, first by boat and later by airplane, the island developed a lively tourist industry which brought many visitors and considerable revenue. The year-round population is 3,559 (1960).

The village of Nantucket itself is one of the main tourist attractions with its quaint colonial houses, cobblestoned streets, museums (including a well-known whaling museum) and art galleries. Summer finds the island and its many beaches crowded with vacationers from all over the United States. Nantucket is also the name of the county, coextensive with the island; it comes from an Indian word meaning "the faraway land." (G. K. L.)

**NANTWICH,** a market town and urban district of Cheshire, Eng., 20 mi. S.E. of Chester by road, is situated in the Weaver valley and has been for generations the centre of a prosperous dairy-farming area. Pop. (1961) 10,438. The 14th-century parish church contains much of architectural beauty and interest. The disastrous fire of 1583 destroyed most of the town, one of the few buildings to survive being Churche's mansion, a fine example of black-and-white architecture. A modern civic hall forms the centre for the town's social and cultural activities. The brine springs, so important to the salt industry centuries ago, now provide brine for the open-air swimming pool. Recreational facilities are also enjoyed at Barony park. Joseph Priestley (1733–1804), the discoverer of oxygen, was a Unitarian minister at Nantwich before emigrating to America in 1794. The town is still an important road centre and is connected by bus with the rail centre of Crewe, 4 mi. N.E. The chief industries are clothing, tanning and agriculture. (D. Ll.)

**NAOMI** (Hebrew "pleasant"; Noemi in Douai version), mother-in-law of Ruth in the Old Testament Book of Ruth. She was the wife of Elimelech of Bethlehem and the mother of Mahlon and Chilion. During a famine in Bethlehem, the family went to the country of Moab. After the death of both her husband and her two sons, Naomi returned with her daughter-in-law, Ruth, to Bethlehem in Judah. Ruth was a native of Moab, but she was devoted to her mother-in-law and insisted on remaining with her. As a result of her misfortunes, Naomi was not recognized readily when she returned to Bethlehem. Whereupon she said, "Do not call me Naomi, call me Mara [bitterness], for the Almighty has dealt very bitterly with me." After Ruth and Boaz met, Naomi advised and encouraged Ruth to remarry, which she soon did. Naomi later became the nurse for Obed, the son who was born to Ruth and Boaz. *See* Ruth, Book of.

**NAOROJI, DADABHĀI** (1825–1917), Indian nationalist, was born in Bombay on Sept. 4, 1825, the son of a Parsi priest. He was educated at Elphinstone college, Bombay, where he later served as professor of mathematics and natural philosophy for a short time before turning to a commercial career. Politics soon came to occupy more of his attention, however, especially after commerce took him to England, where he spent much of the rest of his life. The gaekwar of Baroda appointed him chief minister in 1873, but his proposals for administrative reform aroused much opposition and he resigned in 1875. He subsequently returned to England, and stood for election to parliament as Liberal candidate for Holborn in 1886. He was unsuccessful on that occasion, but Lord Salisbury's statement that a British constituency would not elect "a black man" won Naoroji much sympathy. He was elected Liberal member of parliament for Central Finsbury in 1892. He became widely known for his unfavourable opinion of the economic consequences of British rule in India and was appointed a member of the royal commission on Indian expenditure in 1895. He also presided over the annual sessions of the Congress party in 1886, 1893 and 1906. On the last occasion his conciliatory tactics helped to postpone the impending split between moderates and extremists. In his many writings and speeches, and especially in his *Poverty and Un-British Rule in India* (1901), he argued that India was too highly taxed and that its wealth was being drained away to England. He died in Bombay on June 30, 1917.

*See* R. P. Masani, *Dadabhai Naoroji: the Grand Old Man of India* (1939). (Ke. A. B.)

**NAPALM,** the aluminum soap of naphthenic and palmitic acids which, when mixed with gasoline, forms a sticky sirup used in chemical warfare.

In World War I both Germany and the Allies used raw gasoline in flame throwers (*q.v.*), but it burned too quickly to be fully effective. What was needed was a thickener that would slow down the rate of burning and increase the range of the weapon. Napalm did this, and it also greatly raised the temperature at which the fuel burned. Harvard university scientists, in cooperation with the U.S. army chemical warfare service, developed the substance in 1942. (*See* also Chemical Warfare.)

In World War II, Allied forces used great quantities of napalm-thickened gasoline in flame throwers and fire bombs. After the U.S. marines had employed the flame thrower effectively against Japanese bunkers on Guadalcanal, the weapon became popular with army troops. Napalm was also used in incendiary bombs that the air forces rained on Japanese industrial cities. By the end of the war these bombs had burned out 40% of the area of the target cities. During the Korean War (1950–53) napalm was again fired from flame throwers, and was poured into 165-gal. fire bombs that were dropped with devastating effect on enemy troops.

*See* E. W. Hollingsworth, "The Use of Thickened Gasoline in Warfare," *Armed Forces Chemical Journal* (June 1951). (L. P. B.)

**NAPATA,** the capital of the ancient kingdom of Cush in Nubia (*q.v.*) from about 750 B.C. to 590 B.C., was situated just downstream of the fourth cataract of the Nile, near the modern Karima in Northern province in the Republic of the Sudan. It was an area rather than a single town, extending east and south of Karima from Nuri to Kurru. Its main feature is the hill of Barkal, under which lie the ruins of several temples; for it was regarded as a holy mountain, the throne of the god Amon, possibly from as early as the New Kingdom (*see* Egypt: *History: Ancient Period*). A stele of Thutmose III (1504–1450 B.C.) mentioning a fort was found there, and Amenhotep II (1450–1425 B.C.) sent an Asian prisoner to be hanged on its walls. When about 950 B.C. the Libyans seized power in Egypt, a body of the priests of Amon at Thebes went into voluntary exile at Napata. They appear to have egyptianized the native princes of Cush and to have inspired them to enter a degenerate Egypt about 750 B.C. as reformers. Thus

Kashta and his descendants came to constitute the 25th dynasty of Egypt, restoring to a great extent the ancient customs and beliefs which had been abandoned under the New Kingdom. This led to their introducing into Cush the custom of royal burial under pyramids. All their pyramids are at Kurru except the largest, that of King Taharka (688–663 B.C.) which is at Nuri. Taharka also built several Egyptian-style temples at Napata and elsewhere, including perhaps a large copy at Barkal of the temple of Rameses II at Abu Simbel in Nubia. He clashed, however, with the Assyrians in Judaea and was expelled from Egypt. For some time the rulers of Cush thought of reconquering Egypt, but the 26th (Saite) dynasty, originally protégés of the Assyrians, sent an expedition with Greek and Carian mercenaries which sacked Napata in 590 B.C. and caused the transfer of the capital to Meroë (*q.v.*) on the opposite bank; until 315 B.C., however, kings were buried at Nuri, Napata being the religious capital. Royal burials at Barkal on two different occasions even after that have given rise to the hypothesis that Napata may have twice made itself independent of Meroë.

BIBLIOGRAPHY.—F. L. Griffith, articles in *Annals of Archaeology and Anthropology*, vol. ix and x (1922–23); G. A. Reisner, articles in *Journal of Egyptian Archaeology*, vol. iv, v, vi (1917–20); Dows Dunham, *Royal Cemeteries of Kush*, 3 vol. (1950–57); A. J. Arkell, *A History of the Sudan* (1955). (A. J. AL.)

**NAPHTALI** (in the Douai version of the Bible, NEPHTALI), according to Gen. xxx, 8, one of the two sons of Jacob by Rachel's handmaid Bilhah, the other being Dan. This may be no more than a reflection of the fact that geographically the tribes of Dan and Naphtali are closely associated. Naphtali, because of its exposed situation in the north, suffered at the hands of Syria (I Kings xv, 20); it was depopulated by Tiglath-Pileser (II Kings xv, 29). *See* TWELVE TRIBES OF ISRAEL.

**NAPHTHA,** a word originally applied to the more volatile kinds of petroleum, issuing from the ground in the Baku district of the U.S.S.R. and Iran. It is mentioned by Dioscorides, and is the *naphtha,* or *bitumen liquidum candidum,* of Pliny the Elder in the 1st century A.D. By the alchemists, the word was used principally to distinguish various mobile liquids of low boiling point including certain ethers and esters.

The term is now seldom used, either in commerce or in science, without a distinctive prefix, as in the following:

1. Coal-tar naphtha, a volatile commercial product, is obtained by the distillation of coal tar. (*See* COAL TAR.)

2. Shale naphtha is obtained by distillation from the oil produced by the destructive distillation of bituminous shale.

3. Petroleum naphtha is a name sometimes given in the United States to a portion of the more volatile hydrocarbons distilled from petroleum.

*See* FUELS: *Carbonization.*

**NAPHTHALENE,** a hydrocarbon formed when many organic compounds are passed as vapours through a red-hot tube. This accounts for its presence in coal tar (*q.v.*), from the distillates of which it was first isolated by A. Garden in 1819, and also for its formation in modern processes for the high temperature catalytic cracking of petroleum.

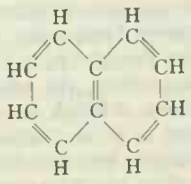
Naphthalene is the most abundant single constituent of coal tar, being present to the extent of about 5%. The amount depends on the type of coal used and increases with rising temperature of carbonization. Naphthalene may be carried with the coal gas through the various purifying chambers and deposited in the service pipes to such an extent as to cause partial blockage. For the technical production of naphthalene the appropriate coal tar distillate, boiling point 170° C. to 230° C., known as middle oil or carbolic oil, is strongly cooled, whereupon the naphthalene crystallizes and may be pressed free from most of the adhering oil. For purification, it is treated with hot caustic soda to remove acidic phenols and then, in the molten state, with a little concentrated sulfuric acid to remove bases and other impurities; it is finally distilled or sublimed.

**Properties and Uses.**—Pure naphthalene crystallizes in lustrous white plates, melting at 80.1° C. and boiling at 218° C. It is almost insoluble in water, sparingly soluble in cold alcohol and in petroleum spirits (mineral spirits, or ligroin), but is readily soluble in ether and in hot alcohol. It is characterized by its volatility, and it readily sublimes. It forms with picric acid a stable crystalline molecular compound, melting point 151° C., the formation of which may be used for the characterization and quantitative estimation of naphthalene. The hydrocarbon has a characteristic odour; as "carbon balls" or moth balls, it was formerly used as a moth repellent but was replaced for this purpose by more efficient insecticides such as paradichlorobenzene, DDT and lindane. Naphthalene has toxic properties, and when administered to rabbits produces a form of cataract, or opalescence of the lenses of the eye.

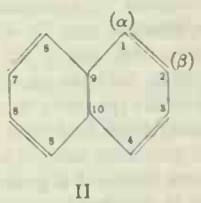
The products obtained by chemical oxidation of naphthalene vary considerably with the conditions and type of oxidizing agent. Chromic acid in acetic acid gives mainly 1:4-naphthoquinone, whereas potassium permanganate in alkaline solution gives phthalonic acid. In acid solution phthalic acid is the chief product, and this is also formed by oxidation with potassium dichromate and sulfuric acid. Phthalic acid was formerly manufactured by oxidizing naphthalene with hot concentrated sulfuric acid in the presence of mercuric sulfate. This process has been superseded by vapour-phase catalytic oxidation with air, using a vanadium pentoxide catalyst; the phthalic acid which is formed is dehydrated to phthalic anhydride, which sublimes into a condenser.

Naphthalene is extensively used as a raw material for the manufacture of dyestuffs and synthetic resins. Phthalic anhydride may be converted into anthranilic acid, an intermediate in the manufacture of indigo; into triphenylmethane dyes; and into anthraquinone and its derivatives, which form the starting material for the preparation of fast vat dyes such as indanthrone and flavanthrone. Phthalic anhydride is also much used for the production of alkyd resins in which it is combined with polyhydric alcohols such as glycerol (*see* RESINS: *Synthetic Resins; Alkyd Resins*). Naphthalene gives rise to a host of substitution products which are important components in the manufacture of azo dyes. These intermediates are principally naphthalene derivatives which contain hydroxyl, amino and sulfonic acid groups in various combinations.

**Constitution.**—The composition of naphthalene was determined by Michael Faraday in 1826. Its molecular formula, $C_{10}H_8$, shows that at least two carbon atoms have no hydrogen atoms attached to them and in 1866 E. Erlenmeyer, Sr., proposed the structural formula I, based on F. A. Kekulé's structure for benzene. It is usually written in the contracted form II.

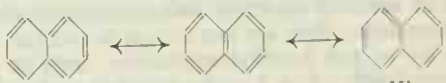


I




II

The oxidation of naphthalene to phthalic acid indicates the presence of one benzene ring. C. Graebe, in 1868–69, obtained from naphthalene a series of degradation products which showed conclusively the presence of two distinct benzene rings. All subsequent work has confirmed the carbon skeleton shown in Erlenmeyer's formula (I). Corresponding with the two Kekulé structures for benzene there are three possible arrangements of the double bonds in naphthalene:



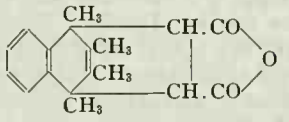
IIa II IIb

The modern view regards naphthalene as a resonance hybrid of which these three are the unexcited forms. L. Pauling and G. W. Wheland recognized 42 canonical structures. Positions 1, 4, 5 and 8 are equivalent to one another (α), and positions 2, 3, 6 and 7 form a second set of equivalent positions (β), so that if a single substituent is introduced into the molecule there are two possible isomers.

The equivalence of the four $\alpha$ positions was proved experimentally by A. Atterberg. Positions 9 and 10 are devoid of hydrogen and cannot be substituted, although this becomes a possibility in fully reduced naphthalene (decahydronaphthalene).

In their chemical reactions some naphthalene derivatives behave as if they had exclusively the Erlenmeyer structure (II). 2-Naphthol, for example, couples with diazo compounds always in position 1, even with displacement of another substituent, and never in the second *ortho* position, 3. But the specificity of such reactions does not necessarily imply bond fixation and can be interpreted on the basis of quantum mechanical calculations which give a figure of 1.725 for the bond order of the 1:2-bond and 1.603 for the 2:3-bond in naphthalene. These differences are reflected in the small but definite differences in bond length shown in the exact X-ray crystallographic measurements by J. M. Robertson and his collaborators.

By contrast with benzene, which has six $\pi$ electrons for its ring, naphthalene has only ten $\pi$ electrons for two rings. Hence if one ring assumes the stable electronic configuration of a fully aromatic structure, the other has the character of an unsaturated side chain linked in two contiguous positions. In this way one can interpret the fact that naphthalene forms addition compounds with much greater facility than benzene. It readily forms a tetrahydride and a tetrachloride and also reacts by addition with alkali metals. It even gives an adduct with maleic anhydride in a Diels-Alder reaction, albeit in small yield. This reaction is much facilitated by alkyl substitution, and 1:2:3:4-tetramethylnaphthalene reacts smoothly to give the anhydride (III) in high yield. Substitution reactions also take place more readily with naphthalene than with benzene.



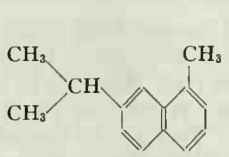
III

For disubstituted naphthalenes there are 10 possible isomers if the substituents are the same and 14 if they are different. With 3 identical substituents the number of isomers is again 14, but if they are all different 84 isomers are possible.

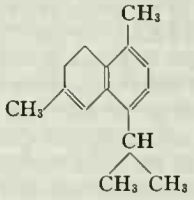
**Chemical Reactions.**—In its chemical behaviour naphthalene shows the aromatic character associated with benzene and its simple derivatives. Its reactions are mainly reactions of substitution, and naphthalene may be readily chlorinated, brominated, nitrated and sulfonated, and it will undergo the Friedel-Crafts reaction. In reactions such as nitration and halogenation, the substituent mainly enters the more reactive $\alpha$ positions, although chlorination and bromination lead to a certain extent to $\beta$ substitution. Reversible reactions subject to steric hindrance lead to substitution in the less hindered $\beta$ positions to an extent which increases with increase in reaction temperature, but varies with the nature of the reagent and sometimes with the solvent. In the sulfonation of naphthalene the $\alpha$-sulfonic acid is formed at low temperatures (below the melting point of naphthalene) whereas the $\beta$-sulfonic acid is formed at high temperatures (optimum temperature, 160° C. to 170° C.). By heating with sulfuric acid, the $\alpha$-acid is converted into the $\beta$-acid.

**Homologues.**—Many of the alkyl derivatives of naphthalene have played an important part in the elucidation of the molecular structures of naturally occurring sesquiterpenes, triterpenes and related compounds. They are also present in coal tar. The simplest two are $\alpha$- and $\beta$-methylnaphthalenes, both of which are coal tar constituents. E. A. Coulson described a process by which they may be isolated by fractional distillation of a suitable tar oil fraction, using a column having a rectifying efficiency corresponding with about 100 theoretical plates. $\alpha$-Methylnaphthalene is a liquid, boiling point 240° C., and $\beta$-methylnaphthalene is a low-melting crystalline solid. Eight of the ten possible dimethylnaphthalenes have been isolated from coal tar and two of them (1:6 and 2:6) from Rumanian petroleum. The best known of these are the 1:6-, 2:3-, 2:6- and 2:7-dimethylnaphthalenes. The 1:6-compound is a liquid; the other three are solids which crystallize in colourless glistening plates. Of the trimethylnaphthalenes, the 2:3:6-, 1:3:7- and 2:3:5- compounds have been isolated from coal tar, and the 1:2:5-, 1:2:7- and 2:3:6- compounds from a Trinidad petroleum distillate. From the high-boiling fractions of aromatic hydrocarbons obtained by high temperature catalytic cracking of petroleum there have been isolated $\alpha$- and $\beta$-methylnaphthalenes; 1:2-, 1:6-, 1:7-, and 2:6-dimethylnaphthalenes; and 1:2:5- and 1:2:6-trimethylnaphthalenes.

The sesquiterpenes are hydrocarbons of the formula $C_{15}H_{24}$, which occur in the essential oils of certain plants. Some of them are hydronaphthalene derivatives; among these are cadinene, which is present in oil of cubebs, and selinene, present in celery seed oil. Closely related to the latter is eudesmol, $C_{15}H_{26}O$, an alcohol which occurs in eucalyptus oil, and cyperone, an unsaturated ketone which is a constituent of oil of *Cyperus rotundus*. Selinene, eudesmol and cyperone (after reduction) may be converted by dehydrogenation with sulfur or selenium into eudalene, or 1-methyl-7-isopropylnaphthalene (IV). Cadinene under similar conditions gives cadalene or 1:6-dimethyl-4-isopropylnaphthalene (V). The structures of these two naphthalene hydrocarbons have been established by synthesis.



IV

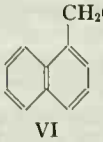


V

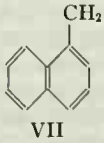
The pentacyclic triterpenes undergo extensive degradation under the conditions of selenium dehydrogenation. Typical naphthalene derivatives which are formed by this procedure are 2:7-dimethylnaphthalene, 1:2:5-trimethylnaphthalene (agathalene), 1:2:7-trimethylnaphthalene (sapotalene), 6-hydroxy-1:2:5-trimethylnaphthalene and 1:2:5:6-tetramethylnaphthalene. (*See* TERPENES.)

To assist the identification of the naphthalene hydrocarbons formed by the dehydrogenation of terpenes, all of the 14 theoretically possible trimethylnaphthalenes have been synthesized as well as all 10 possible dimethylnaphthalenes. Naphthalene homologues may be synthesized either by introducing alkyl groups into simpler naphthalene derivatives or by building up the second ring from a side chain attached to a suitable benzene derivative.

The chloromethylation reaction may be used for the preparation of other types of naphthalene derivatives. Thus, naphthalene itself gives the 1-chloromethyl compound (VI), which may be reduced to $\alpha$-methylnaphthalene or reacted with potassium cyanide to give a nitrile; this is hydrolyzed to $\alpha$-naphthylacetic acid (VII), a substance which has found extensive use as a plant-growth substance. It stimulates root formation in a manner similar to the natural plant growth hormone, heteroauxin, or indoleacetic acid.



VI



VII

**Naphthylamines and Naphthols.**—A very wide range of naphthalene derivatives of these types with their sulfonic acids is manufactured for use in the dyestuffs industry, being used mainly as components for azo dyes (*see* DYES AND DYEING). When their potentialities for this purpose were first recognized, their chemistry was very imperfectly understood. Manufacturing processes in many cases gave rise to mixtures which were difficult to separate, and of which the constituents were poorly characterized and the orientation of their substituents only partly determined. In establishing the chemistry of these derivatives of naphthalene on a firm basis, inestimable service was rendered by the classical researches of H. E. Armstrong and W. P. Wynne, who prepared all

of the theoretically possible mono-, di- and trichloronaphthalenes (26 in all), established their orientations with absolute certainty and provided a series of reference compounds to which the many naphthalene-, naphthylamine- and naphtholsulfonic acids could be related. P. T. Cleve observed, in 1876, that when a naphthalenesulfonyl chloride was distilled with phosphorus pentachloride it was converted into the corresponding chloronaphthalene, and that β-naphthol when treated in the same way gave β-chloronaphthalene. Armstrong and Wynne used this as a diagnostic method and showed that bromo- and nitro- substituents were also displaced by chlorine when the compounds containing them were distilled with phosphorus pentachloride.

Amino groups could be displaced by chlorine by T. Sandmeyer's method, or replaced by hydrogen through the diazo reaction. By such reactions a naphthalene derivative of unknown structure could be converted into a chlorinated naphthalene of known orientation, from which the positions of substituents in the original compound could be deduced.

The preparation of naphthalene derivatives for use as dyestuffs intermediates involves either nitration or sulfonation of naphthalene as the first stage. Nitration leads to α-nitronaphthalene, which crystallizes in yellow needles, melting point 57.8° C.

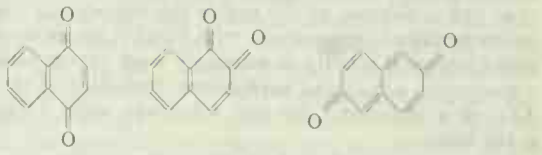
α-Naphthylamine is obtained from α-nitronaphthalene by reduction with iron turnings and water acidulated with hydrochloric acid. After complete reduction, the acid is neutralized and the basic α-naphthylamine is obtained by distillation with superheated steam. It may also be purified by distillation under reduced pressure. It crystallizes in colourless leaflets, melting point 49.2° C. On exposure to air it rapidly acquires a grayish-violet colour and has a somewhat disagreeable odour.

As stated earlier, the position of entry of a sulfonic acid group into the naphthalene molecule is determined by the conditions used. It is very difficult to obtain the pure sulfonic acid by direct sulfonation of naphthalene with sulfuric acid on account of the ease with which it is converted into naphthalene-β-sulfonic acid. The latter acid is, however, readily obtained by sulfonation at high temperatures and is an important intermediate. By fusion of the sodium salt with caustic soda, β-naphthol is formed, and this operation is one of the most important processes in the organic chemical industry. β-Naphthol crystallizes in colourless plates which melt at 122° C. Its ethyl ether, nerolin, has a fragrant odour and is used in perfumery.

β-Naphthylamine is another important naphthalene derivative prepared from β-naphthol. The hydroxyl group is replaced by an amino group by means of the Bucherer reaction, whereby β-naphthol is heated in an autoclave at 150° C. and 6 atm. pressure with an ammonium sulfite solution prepared by saturating concentrated ammonia solution with sulfur dioxide and then adding an equal volume of concentrated ammonia solution. β-Naphthylamine crystallizes from alcohol in colourless lustrous scales of melting point 110° C. Unlike the α-isomeride it is odourless when pure. β-Naphthylamine is probably the agent responsible for causing the bladder cancers to which workers in the dyestuffs industry are sometimes liable. It has been shown experimentally that such bladder tumours can be produced in dogs by administration of β-naphthylamine (*see* CARCINOGENIC CHEMICALS: *Aromatic Amines*).

**Naphthalenecarboxylic Acids.**—Many naphthalenecarboxylic acids have been described, but with few exceptions they are of little importance. They have the usual properties of acids of the aromatic series. Naphthalene-1:8-dicarboxylic acid, naphthalic acid, is obtained by oxidation of the coal tar hydrocarbon acenaphthene. In a similar manner, naphthalene-1:4:5:8-tetracarboxylic acid is formed by oxidative degradation of two of the rings of the tetracyclic hydrocarbon pyrene.

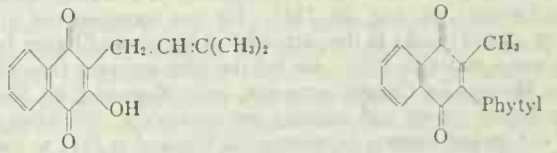
**Naphthoquinones.**—Six different naphthoquinones, $C_{10}H_6O_2$, are theoretically possible, but the only ones which have been prepared are the 1:4- or α- (VIII), the 1:2- or β- (IX) and the 2:6- or *amphi* (X) naphthoquinones. 1:4-Naphthoquinone (VIII) may be obtained by oxidation of naphthalene with chromic acid in acetic acid, but it is better prepared by oxidation of 4-amino-1-naphthol. It crystallizes in yellow tablets, melting point 125° C., is volatile in steam and has a characteristic pungent smell. 1:2-



VIII IX X

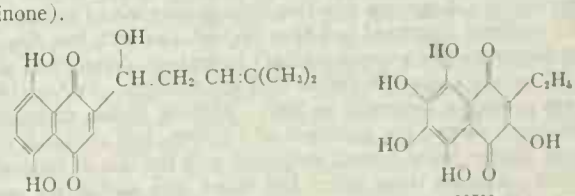
Naphthoquinone, formed by oxidation of 1-amino-2-naphthol, forms golden-yellow needles which decompose at 145° C. to 147° C., and is odourless and nonvolatile. It is somewhat unstable, although more stable derivatives are known; *e.g.*, 3:7-dimethyl-1:2-naphthoquinone. 2:6-Naphthoquinone, also nonvolatile and odourless, forms reddish-yellow crystals. These quinones have the high reactivity associated with quinones of the benzene series, and undergo many reactions of addition. An important example, in the case of the 1:4-quinone, is the Diels-Alder addition of dienes, which furnishes a simple route from the naphthalene series to the anthracene series.

Many derivatives of 1:4-naphthoquinone have been found to occur in nature as pigments. An early known example is juglone, 5-hydroxy-1:4-naphthoquinone, which occurs as the colourless leuco compound in unripe walnut shells. Closely related to this is plumbagin, or 5-hydroxy-2-methyl-1:4-naphthoquinone, a yellow pigment found in roots of *Plumbago* species. It has long been known as the active principle of a medicinal drug obtained from this source. Lawsone, extracted from the leaves of henna (*Lawsonia inermis*), is 2-hydroxy-1:4-naphthoquinone. Phthiocol, or 2-hydroxy-3-methyl-1:4-naphthoquinone, has been isolated from human tubercle bacilli, but it has been suggested that it may be formed during isolation by degradation of vitamin K. Structurally related to phthiocol is lapachol, a pigment occurring in the grain of a number of African woods (*Bignoniaceae*). Lapachol has the structure shown in XI. Introduction of a hydroxyl group into one of the methyl groups of XI gives the structure of lomatiol, the yellow pigment surrounding the nucleus in seeds of Australian *Lomatia*. Vitamin $K_1$, the antihemorrhagic factor isolated from hexane extracts of dried alfalfa (lucerne), is represented by the formula XII. The same type of structure has been assigned to vitamin $K_2$, isolated from decaying fish meal. (*See* also VITAMINS: *Vitamin K*.)



XI XII

Another group of natural naphthoquinone pigments is derived from naphthazarin (5:8-dihydroxy-1:4-naphthoquinone), long known as a synthetic dyestuff. To this group belongs alkannin, a brown-red pigment occurring as the angelic ester in the root of *Alkanna tinctoria*. It is optically active (levorotatory), and its enantiomorph is shikonin, isolated from *Lithospermum erythrorhizon*. These two pigments have the structure XIII. Hydroxydroserone, which occurs with droserone in *Drosera whittakeri*, a plant growing in the Adelaide district of Australia, is also a naphthazarin derivative (3:5:8-trihydroxy-2-methyl-1:4-naphthoquinone).



XIII XIV

In many ways the most remarkable of all these substances is echinochrome A, one of several related pigments which have been

isolated from sea urchin eggs. It functions as a chemotactic principle and is secreted by the egg to the surrounding sea water to induce motility in spermatozoa with which it comes in contact. It shows biological activity in extremely weak concentrations. It is a completely substituted naphthalene derivative of the structure XIV, or a tautomer. *See* also references under "Naphthalene" in the Index.

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**NAPIER, SIR CHARLES** (1786–1860), British admiral, a controversial commander during the Crimean War, was born at Merchiston Hall, near Falkirk, on March 6, 1786. He became a midshipman in 1800 and lieutenant in 1805, serving in the Mediterranean and in the West Indies. After returning to England, he was put on half pay, spent some time at Edinburgh university and later visited the British army in Portugal. Napier served in the Mediterranean in 1811 and on the American coast in 1814. He was appointed to the "Galatea" in 1829, was at the Azores (1831) when they were held by the conde de Villa Flor for the queen of Portugal, and accepted the offer of the Portuguese constitutional leaders to take command of the fleet (Feb. 1833). With it he destroyed the fleet of the Portuguese pretender Dom Miguel on July 5, and was thereupon struck off the English navy list. In 1834 he commanded Portuguese forces in the defense of Lisbon. Napier then returned to England, was restored to his former rank in 1836, and received the command of the "Powerful" (1838) in which he played a leading part in the Syrian expedition of 1840–44. For these services he was knighted in 1840. He was promoted to rear admiral in 1846 and commanded the channel fleet from 1847 to 1849. In the Crimean War he received the command of the Baltic fleet, and hoisted his flag in Feb. 1854. Public expectations were high but when he refused to attack Kronstadt, the Russian naval base, a great outcry was raised against him. He was not again offered a command. He was member of parliament for Southwark from Feb. 1855 until his death at Catherington, Hampshire, on Nov. 6, 1860.

*See* H. Noel Williams, *Life and Letters of Admiral Sir Charles Napier K.C.B.* (1917).

**NAPIER, SIR CHARLES JAMES** (1782–1853), British soldier and statesman, the conqueror of Sind, was born in London, the eldest son of Col. the Hon. George Napier and Lady Bunbury (née Lennox), on Aug. 10, 1782. He was commissioned at the age of 12 and thanks to the patronage of his cousin Charles James Fox was a major by 1806. He led the 50th regiment through Sir John Moore's La Coruña campaign, early displaying his lifelong care for the troops and capacity for leadership. Wounded then and at Coa and Busaco, he returned to England in 1811 to restore to discipline the 102nd regiment and then to command it in operations against the United States (1813).

From 1819 he served in the Ionian Islands. Through Lord Byron he was in touch with Greek patriots, but for financial reasons refused an invitation to command their forces. As military resident of Cephalonia, however, during 1822–30, he used his authority to execute a vigorous program of useful public works. The high commissioner's attempt to introduce a measure of self-government in Cephalonia led to conflict and Napier from 1830 to 1839 was unemployed. Then in 1839, when Chartist agitation was threatening to turn to violence, he was promoted general and given command in northern England. There for two years by sympathy and tact he prevented a dangerous situation from getting out of control.

His northern command had been ill-paid, and with two illegitimate daughters (by a Greek mother) to support, Napier was glad in 1841 to take a lucrative Indian staff appointment. In Aug. 1842 he was posted to command in Sind. Without Indian experience or language, shrewd but impatient of criticism, still militarily ambitious, Napier found himself entrusted with the fate of the amirs of Sind. Though these rulers had stood firm during the early stages of the British disasters in Afghanistan, despite their unjust treatment by Lord Auckland, they were now becoming restless and Lord Ellenborough, the governor general, proposed to impose a new treaty. By this the bases occupied in Sind would be permanently annexed and large northern areas would be transferred to loyal Bahawalpur, if Napier found that the Sind amirs were disloyal. Napier soon convinced himself that some of them were. On Feb. 12, 1843, the amirs signed the new treaty, though even larger areas were annexed than Lord Ellenborough had originally intended and Nasir Khan of Khairpur lost lands only because mistaken for his namesake of Hyderabad. Unhappily Napier believed that "barbaric chiefs must be bullied or they think you are afraid: they do not understand benevolence or magnanimity." His destruction of Imamgarh, his bullying of the aged Rustam Khan into giving the headship to amir Ali Murad and his continued threatening advance had all combined to provoke hostilities. On Feb. 17 Napier won the victory of Miani, the courage, firepower and discipline of British and British-trained Indian troops bloodily overcoming Sindhi valour. In March he won a second victory, at Hyderabad. He was made a G.C.B. and governor of Sind and, as Lord Ellenborough had proposed that all prize money should be paid to the army, Napier secured £50,000 from the plundering of Hyderabad.

As governor Napier established a model police force, began work upon the canals of Sind and upon a mole and water supply for Karachi, and sought to encourage trade. As a general he checked the marauding hill tribes, casting the spell of his leadership over his troops, while in his building program and his general orders he showed his usual care for their well-being. He left Sind in 1847.

There was violent public debate about the rightness of his actions in Sind, particularly between his brother William and Sir James Outram. His return to India in May 1849 to supersede Lord Gough as commander-in-chief was thus a tribute to popular belief in his military genius. He arrived, however, when the Sikh War was over, and left India finally in Feb. 1851 after a quarrel with Lord Dalhousie. He died at Portsmouth on Aug. 29, 1853.

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**NAPIER** (NEPER), **JOHN** (1550–1617), eighth laird of Merchiston, and a distinguished Scottish mathematician who was the inventor of logarithms, was born at Merchiston castle, near Edinburgh, in 1550. At the age of 13, he entered the University of St. Andrews, where he came under the care of the remarkable John Rutherford. His stay at St. Andrews appears to have been short, for he left without taking a degree.

Little is known of his early life, but it is thought that he traveled abroad, as was the custom with the sons of the Scottish nobility. What is certain is that he was back home in 1571, and he stayed either at Merchiston or at Gartness for the rest of his life. The following year, he married Elizabeth, daughter of Sir James Stirling. She died in 1579, leaving him a son and a daughter.

A few years later, he married Agnes, daughter of Sir James Chisholm, and she survived him. From this second marriage there were five sons and five daughters. Napier died at Merchiston on April 4, 1617.

Napier's life was spent amid bitter religious dissensions. He was a passionate and uncompromising Protestant, and in his dealings with the Church of Rome he sought no quarter and gave none. It was well known that James VI of Scotland hoped to succeed Elizabeth I to the English throne, and it was suspected that the help of Philip II of Spain had been sought to achieve this end. Panic-stricken at the peril which seemed to be impending, the general assembly of the Scottish Church, a body with which Napier was closely associated, begged the king to deal effectively with the enemies of the church, and on three occasions Napier was a member of a committee appointed to make representations to the king concerning its well-being, and to urge him to see that "justice be done against the enemies of God's Church."

In Jan. 1594, Napier addressed to the king a letter that forms the dedication of his great work: *A Plaine Discouery of the Whole Reuelation of Saint John.* "Let it be your Majesty's continuall study" he there declared, "to reforme the universall enormities of

your country, and first to begin at your Majesty's owne house, familie and Court, and purge the same of all suspicion of Papists and Atheists and Newtrals, whereof the Revelation foretelleth that the number shall greatly increase in these latter daies." This work occupies a prominent place in Scottish ecclesiastical history, for it is the earliest Scottish work on the interpretation of the scriptures.

Following the publication of this work, Napier seems to have occupied himself with the invention of secret instruments of war, for in the Bacon collection at Lambeth palace, London, there is a document bearing his signature, enumerating various inventions "designed by the Grace of God, and the worke of expert craftsmen" for the defense of his country. These inventions included two kinds of burning mirrors, a piece of artillery and a metal chariot from which shot could be discharged through small holes.

Napier devoted most of his leisure to the study of mathematics, particularly to devising methods of facilitating computation, and it is with the greatest of these, namely logarithms, that his name is associated.

His contributions to this powerful mathematical invention are contained in two treatises: *Mirifici logarithmorum canonis descriptio*, which was published in 1614 (Eng. trans., 1857), and *Mirifici logarithmorum canonis constructio*, which did not appear until 1619, two years after his death (Eng. trans., 1889). In the former, he outlined the steps which led to his invention, these being briefly as follows:

Consider two particles P and Q, the former of which moves along a line segment AZ of finite length, the latter along a line A′Z′ whose length is indefinite. Both particles start with the same velocity, but while Q retains this velocity unchanged, that of P alters in such a way that at any point in its path, say B, the velocity is proportional to the distance it still has to go; *i.e.*, BZ. If, when P is at B, Q is at B′, then A′B′ is defined as the logarithm of BZ. Thus, Napier was able to establish a correspondence between an arithmetical and a geometrical progression, which, it should be noted, is at the root of the modern conception of logarithms. It is clear, however, that the modern conception of logarithms as exponents was quite unknown to Napier. For the development of common logarithms from those of Napier and the part played by Henry Briggs (*q.v.*) in this development, *see* LOGARITHMS: *History of Logarithms*.

In trying to simplify computation, Napier may well have been led to his invention by a consideration of such a relation as $2 \sin A \sin B = \cos (A - B) - \cos (A + B)$, in which the product of two trigonometrical functions can be expressed as the sum (or difference) of two others. The *Descriptio*, besides giving an account of the nature of logarithms, contains a table of natural sines and their logarithms for every minute of the quadrant, to seven figures. These are not what are now called Naperian, *i.e.*, hyperbolic, logarithms, though they are related to them. In this work, Napier confined himself to an account of the use to which logarithms might be put. He promised to explain the method of their construction in a later work. This was the *Constructio*, which also claims attention because of the systematic use in its pages of the decimal point to separate the fractional from the integral part of a number. Decimal fractions had already been introduced by Simon Stevin (*q.v.*) in 1586, but his notation was clumsy. The use of a point as separatrix occurs frequently in the *Constructio*.

Although Napier's invention of logarithms overshadows all his other mathematical work, he has other mathematical contributions to his credit. In 1617, he published his *Rabdologiae, seu numerationis per virgulas libri duo* (Eng. trans., 1667); in this he described ingenious methods of performing the fundamental operations of multiplication and division with small rods (Napier's bones). He also made important contributions to spherical trigonometry, and by his rules of circular parts he was able to resolve all cases of right-angled spherical triangles. He is also credited with certain trigonometrical relations—Napier's analogies—but it seems likely that Briggs had a share in these.

*See* C. G. Knott (ed.), *Napier Tercentenary Memorial Volume* (1915); J. F. Scott, *A History of Mathematics* (1958). (J. F. ST.)

**NAPIER, SIR WILLIAM FRANCIS PATRICK** (1785–1860), Irish-born soldier and historian, remembered for his *History of the War in the Peninsula* . . . (six volumes, 1828–40). The third son of Col. the Hon. George Napier, he was born at Celbridge, near Dublin, on Dec. 17, 1785. Two brothers were also soldiers, Charles James (*q.v.*) and George Thomas (1784–1855), who served with distinction in the Peninsula and was governor of the Cape of Good Hope (1837–43). At 14, William joined the Royal Irish artillery, and in 1803 became a lieutenant at Shorncliffe, under Sir John Moore, who in 1804 made him captain in his own brigade in the 43rd regiment. After serving in Denmark and Spain, in May 1809 he sailed for Portugal. Wounded at the Coa (1810) and Casal Novo (1811), he was made brevet major after Fuentes d'Oñoro (May 1811). In 1812 he married the niece of Charles James Fox. He commanded his regiment at Salamanca (July 1812) and the Nivelle (Nov. 1813), storming a French entrenchment on the Rhune mountains, and, though wounded at the Nive, held his position. Promoted brevet-colonel in Nov. 1813, after the battle of Orthez (Feb. 1814), ill-health, caused by a bullet lodged in his spine, forced him to return to England. He rejoined his regiment in June 1815, and remained in France until 1819, when he retired on half pay.

In 1823 he began his *History*, collecting information from Marshal Soult and Wellington. Widely acclaimed, especially for its vigorous battle scenes and powerful style, it was attacked for inaccuracy and partial judgment, especially of Moore's La Coruña campaign. Napier, always impatient of criticism, defended himself in pamphlets and numerous letters to the press. Although superseded by Sir Charles Oman's *History of the Peninsular War* (1902–30), the book remains a classic of historical writing.

Napier was made knight commander of the Bath (1848) and rose to the rank of general (1859). Although keenly interested in politics, especially in the Reform bill, he refused to enter parliament. As lieutenant governor of Guernsey (1842–47) he reorganized its defenses and encouraged adoption of a new, more equitable, constitution. His *The Conquest of Scind* . . . (two parts, 1844–46), defending his brother, Charles', policy there, was followed by the *History of Sir Charles Napier's Administration of Scinde* . . . (1851), praised by Thomas Carlyle for its narrative style, and by *The Life and Opinions of Gen. Sir C. J. Napier* (four volumes, 1857), but blind devotion to his brother made the last two somewhat biased. He died at Clapham Park, Surrey, on Feb. 10, 1860.

Napier's gallantry, generosity and devoted care for his men, his family and his dependents, his splendid physique in youth, his endurance of pain and his violence in controversy made him a legendary figure. He shared with his brother a hatred of wrong, a nobility of character and an arrogant ambition for glory. His writing can rise to epic heights and his *History* is still valuable.

*See* H. A. Bruce (Lord Aberdare), *Life of Sir William Napier*, 2 vol. (1864); Sir J. W. Fortescue, "The Napiers," in *The Last Post* (1934); also bibliographies to NAPIER, SIR CHARLES JAMES; PENINSULAR WAR.

**NAPIER,** a seaport and pastoral centre in New Zealand, on the east coast of North Island, principal town of Hawke's Bay land district, 199 mi. N.E. of Wellington by rail. Pop. (1961) 24,579 (urban area 32,716). The town is situated on a peninsula known as Scinde Island and by virtue of its sunny climate is a popular resort. It is an important wool centre; the district is pastoral and is renowned for crossbred wools and frozen meats, which are exported chiefly to Great Britain. The harbour caters for overseas vessels and is sheltered by a breakwater. The business area was rebuilt after its destruction by fire following a severe earthquake on Feb. 3, 1931, in which 255 persons were killed.

**NAPIER OF MAGDALA, ROBERT CORNELIS NAPIER,** 1ST BARON (1810–1890), British field marshal who had a distinguished military career in India and commanded the British expedition to Abyssinia in 1867. He was born in Colombo, Ceylon, where his father, an artillery officer, was stationed, on Dec. 6, 1810. After attending the military college of the East India company at Addiscombe, he joined the Bengal Engineers in 1826 and was employed from 1828 to 1845 in various public works duties. When the First Sikh War broke out in 1845 he joined the

army of the Sutlej as commanding officer of engineers and was present at the battles of Mudki, Ferozeshah (where he was wounded) and Sobraon. After the surrender of the Sikh government he took a prominent part in the reduction of the fortified places still holding out. He then returned to civil duty as consulting engineer to the Punjab administration, but his work was interrupted by the Second Sikh War (1848–49) in which he acted first as chief engineer to the force besieging Multan, and then as officer commanding the engineers of the right wing of the army of the Punjab at the battle of Gujrat and in the subsequent pursuit to Attock which ended the campaign. Another period of civil duty in the Punjab was interrupted by his recall to military service for the Hazara expedition (1852) and for the campaign against the Bori clan in Peshawar (1853).

Napier went on leave to England in 1856, returning to India just before the outbreak of the Mutiny in 1857. He became chief engineer to the Lucknow relief force under Sir James Outram and took part in the first relief expedition. Under Napier's direction an active defense was carried on against the incessant enterprises of the sepoys, both above and below ground, and all their efforts were met and baffled. At the moment of the arrival of Sir Colin Campbell's relief force Napier was severely wounded, but recovered in time to take part in the final storming of the city. In May 1858 he went as second-in-command of the Central India force under Sir Hugh Rose with whom he was present at the capture of Gwalior and the action at Jaora Alipur. After Rose's departure, Napier was in command of the final operations in the area.

In 1860 Napier, in command of a division, took part in the expedition to China under Sir Hope Grant; his troops stormed and dismantled the forts north of the Pei-ho river and were engaged in the final advance to Peking which brought about the surrender of the Chinese government. Napier returned to India in 1861 to take up the duties of military member of the governor-general's council and was promoted to major general. He was given the command of the Bombay army in 1865 and in 1867 was promoted lieutenant general and given the command of the expedition to Abyssinia. Despite all the difficulties of administration and terrain, his force, which landed at Zula in Jan. 1868, reached the central plateau, defeated the Abyssinians and in April occupied Magdala, the stronghold of King Theodore II. Two months later Napier's army was on its way back to India, having enforced all the British demands on the country and accomplished one of the most brisk and workmanlike of all minor campaigns. Napier received the thanks of parliament and a pension of £2,000. In 1868 he was created Baron Napier of Magdala and in 1870 became commander in chief in India, a post he held for six years.

Napier ended his military career as governor of Gibraltar (1876–82). He was appointed field marshal in 1883 and became in 1887 constable of the Tower of London, a post which he held until his death in London on Jan. 14, 1890.

*See* H. D. Napier, *Field Marshal Lord Napier of Magdala* (1927).

(E. W. Sh.)

**NAPLES** (Napoli; ancient Neapolis), the former capital of the kingdom of the Two Sicilies and since 1860 the chief town of Napoli province and Campania region, Italy, lies on the northern shore of the bay that bears its name, 74 km. (120 mi.) S.E. of Rome. It is the seat of an archbishopric and is the intellectual and commercial centre of Italy's south. A city of palaces and castles, Naples is also famous for its many churches, which number more than 200. The long and justly famed beauty of its prospect is due to the perfect scale of the bay itself and of the steep and mainly volcanic hills which surround it, terminating in the islands of Capri to the south, and Procida and Ischia to the north, the whole dominated by the volcano Vesuvius, Naples' "terror and pride," on the eastern shore. The city has extended up the hills behind its old centre and along the bay to the west as far as the Collina di Posillipo. Pop. (1961) 1,196,478 (comm.).

**Description and Architecture.**—The central and most ancient part of Naples is built on the flat ground beside the bay to the east of the ridge which runs down Monte Vomero (817 ft.) through Pizzofalcone to the sea, ending in the small island now occupied by the Castel dell'Ovo ("castle of the egg"). In Roman times the island formed part of the villa of Lucullus; Normans and Swabians built the castle, which they used both as a fortress and prison. It is now a military barracks. On the heights of Vomero, a later fortress, the Castel Sant' Elmo, was constructed (originally as Belforte) by Robert of Anjou in 1329 and entirely rebuilt 1537–46; it dominates both the old city to the east and the modern sections to the west of the ridge. These two areas are united (1) by the fashionable Via Chiaia which climbs between Pizzofalcone and Vomero; (2) by a tunnel under the hill, the Galleria della Vittoria (opened in 1929); and (3) by the two thoroughfares, Via Sta. Lucia with Via Chiatamone, and Via Partenope. The former is full of palaces of the nobility, and the latter, on the sea front, is lined with the most fashionable hotels. In a palace near the western end of the Via Chiaia lived the British envoy at Naples, Sir William Hamilton, and there he and his second wife Emma entertained Lord Nelson.

In the old town the narrow streets of the medieval city followed the pattern of ancient Neapolis, traversed by the three *decumani* (axes of orientation) that crossed from east to west and now seen as Via San Biagio, Via dei Tribunali and Via dell' Anticaglia; at right angles to these, still smaller streets ran down to the waterfront and harbour. The wider streets, now used by city traffic, were built after 1860, and much of the characteristic life of Naples is carried on in the narrower ways where cars are still scarce. The medieval city remained mainly within the limits of Neapolis (see *History*, below), bounded by the Valentinian walls (450–550); it expanded only slightly on the south and west until with the coming of the Angevins (1265) it became the capital of a kingdom, when the expansion to the southwest was continued and systematized by the enlargement of the Porto Grande and the erection of the Castel Nuovo (Maschio Angioino) above it. Built for Charles I by Pierre de Chaulnes (1279–82), the castle was reconstructed with five round towers by Alfonso I at which time the entrance was dignified with the graceful marble Triumphal arch (1454–67, probably from a design by Guillem Sagrera), the most distinguished Renaissance work in Naples. Alfonso's court in the castle was visited by many humanists, among them Lorenzo Valla. The Angevin period saw much building in Naples. The Castel Capuano founded by the Norman William the Bad, near the Capuan gate at the eastern end of the Via dei Tribunali, was enlarged and fortified by Frederick II and was frequently used as a royal residence by King Ladislas and by Queen Joan II. Altered many times since, it is now the seat of the courts of justice. Numerous new churches were founded and others rebuilt, all in the Gothic style brought from farther north and gradually adapted by local artists. The original structures of many of these, having subsequently been covered with baroque work of varying merit, have only recently been revealed and restored. In some cases, for example Sta. Maria di Donna Regina, this was done before World War II; in others, such as Sta. Chiara, renovation was made possible after severe war damage.

The *duomo* (cathedral), in the wide street that bears its name, is dedicated to St. Gennaro (St. Januarius, the patron saint of the city) and was built (1294–1323) adjoining the 4th-century basilica of Sta. Restituta which contains the small baptistery of S. Giovanni in Fonte with early mosaics. Both the baptistery and the cathedral were later extensively restored after earthquakes, and much of what is extant is 18th- and 19th-century work, including the facade which incorporates earlier elements. The cathedral contains a number of fine tombs of the 14th and 15th centuries, frescoes by Domenichino in the chapel of S. Gennaro (built 1608–37), and paintings by Luca Giordano and others. In the chapel of S. Gennaro (built 1608–37) are two phials containing his blood (see *Religious and Popular Festivals*, below).

The 19th-century church of S. Giorgio Maggiore also in the Via del Duomo contains parts of the apse of an early Christian basilica. North of the cathedral, behind the baroque church (1649) of Sta. Maria di Donna Regina, is an earlier church of the same name, rebuilt, following an earthquake, for Poor Clares by Queen Maria of Hungary and Naples (1307–20). It contains her tomb, the most magnificent work in Naples of the Sienese sculptor Tino da

LOUIS GOLDMAN—RAPHO GUILLUMETTE

THE BAY OF NAPLES WITH MT. VESUVIUS (RIGHT BACKGROUND) ON ITS EASTERN SHORE

Camaino; in the nuns' choir are a fine series of frescoes attributed to Pietro Cavallini and his pupils. Farther east, just outside the walls, is the church of S. Giovanni a Carbonara containing the huge and florid monument to King Ladislas (1428), the work of Mario and Andrea da Firenze. West of the cathedral are many more churches. In S. Lorenzo Maggiore (recently restored), established by Charles I of Anjou for the Franciscans on the site of a 6th-century church, Boccaccio fell in love with Maria, daughter of Robert of Anjou, whom he immortalized as Fiammetta, in 1334; the graceful apse was built by unknown French architects, and the church contains some fine tombs, including that of Lodovico Aldemorisco (1421), work of the highly individual late Gothic local sculptor Antonio Baboccio. His work may also be seen in the cathedral and the doorway of the little church of S. Giovanni dei Pappacoda (1415). Close to S. Lorenzo is the Franciscan Church of S. Paolo Maggiore (1583–1603) incorporating some elements of the Roman temple of the Dioscuri on whose site it stands.

The main Angevin foundation in Naples was the church and convent of Sta. Chiara (1310–28), established by Queen Sancia of Majorca, wife of Robert the Wise. Largely destroyed by incendiary bombs in 1943, the church has been restored to its original Gothic form. It contains a series of magnificent tombs of the Angevin royal family and nobility, including that of Robert (1343–45), the work of Giovanni and Pacio Bertini, behind the high altar. Adjoining is the convent of the Poor Clares (now Franciscan), with a fine 14th-century cloister decorated with 18th-century Majolica tiles. S. Domenico Maggiore (1289–1324, restored later) also contains fine Gothic and Renaissance tombs and later frescoes. The adjacent monastery, now occupied by public offices, was the centre of the Dominican Order in the kingdom of Naples, and in its schools St. Thomas Aquinas taught, and the humanist Giovanni Pontano and the philosopher Giordano Bruno were pupils. Close by in the little church of S. Angelo a Nilo is the beautiful monument of Rinaldo Cardinal Brancaccio (1426–28) by Donatello, Michelozzo and Pagno di Lapo Portigiani. Many of the finest Renaissance sculptures in Naples (by Antonio Rossellino, Benedetto da Majano, Guido Mazzoni and others) are in S. Anna dei Lombardi (Monteoliveto) farther west.

The city expanded both east and west under the Aragonese (1442–1503) and still more under the Spanish viceroys, when in 1536 the Via Toledo (Via Roma) was built, running north and south between the old city and the hills. Existing monuments were altered or added to, and others were built; the church of the Gesu Nuovo was erected behind the striking facade of an early 17th-century palace, one of many fine buildings erected by the nobility who were encouraged to live in Naples. These palaces include the Palazzo Gravina (now the university's faculty of architecture) in Tuscan style (1513–49); the Palazzo Filomarino, with a fine baroque gateway, the home of Benedetto Croce and now of his foundation, Istituto Italiano per gli Studi Storici (1947); and the Palazzo Santangelo built by Diomede Carafa, friend of Lorenzo de' Medici, in mixed Tuscan and Catalan style (1466). Among the most characteristic monuments of Neapolitan baroque are the *guglie* (elaborate ornamented obelisks) found in the Piazza Gesu Nuovo and elsewhere. Cosimo Fanzago (1593–1678), designer of the elegant church and cloister of S. Martino adjoining Castel Sant'Elmo, was responsible for some of these. The Palazzo Reale (royal palace), built by Domenico Fontana (1600–02) for the Spanish viceroy Ferrante di Castro above the seafront west of the harbour, was restored after a fire in 1837 and again after World War II. The reception rooms now house the Biblioteca Nazionale (national library), and there is a small court theatre with baroque decoration. The large Teatro San Carlo, one of the most famous opera houses in the world (dating from 1737 and rebuilt after a fire 1816), adjoins it on the north; opposite is the Galleria Umberto I (1887–90), a popular arcade. The western facade of the Palazzo Reale faces the large Piazza del Plebiscito and the church of S. Francesco di Paolo (1817–46), which is an imitation of the Pantheon in Rome.

With the establishment of the Bourbon dynasty on the throne (1734), building developments in Naples were on a more spacious scale. The Piazza Dante was built halfway up the Via Toledo. Beyond Pizzofalcone the Spanish viceroys built the street called the Riviera di Chiaia, which runs parallel with the shore for 1½ mi. to Mergellina at the foot of the Collina di Posillipo. During the late 18th and early 19th centuries the city's expansion up the slopes behind this street developed as the fashionable quarter of the day; now known as Rione Amedeo, this has risen still farther up the hills. The Villa Reale (now Villa Comunale, the city's main public park) was built between the Riviera di Chiaia and the sea. Ferdinando Sanfelice, Ferdinando Fuga and Luigi Vanvitelli all contributed to the new and splendid aspect of the city, while wide roads led into it and round it on the slopes above. Later a great embankment and carriageway, the Via Caracciolo, was built along the seafront from the Castel dell'Ovo to Mergellina (1875–81). After the cholera epidemic of 1884, on the advice of Premier Agostino Depretis that "Naples must be disemboweled," a great thoroughfare, the Corso Umberto I (Rettifilo), was cut from the Stazione Centrale (central station) to the Piazza del Municipio, just east of the Palazzo Reale, removing many slums but ignoring the ancient shape of the city. A new working-class quarter, Rione del Vasto, was built beyond the station, while fashionable areas developed on the Vomero as well as on the Posillipo. These further expanded in the 20th century, especially after World War II, when large buildings and wider streets replaced slums north of the Piazza del Municipio.

**Educational and Cultural Institutions.**—The University of Naples was founded by Frederick II in 1224. Under stringent royal control, its existence was sporadic for two centuries and itinerant until 1777 when it was reconstituted and removed to the Jesuits' convent to the rear of the present building. These premises on the Corso Umberto I were enlarged in 1887–1908 but the university's ten faculties are not all centred there. Giambattista Vico taught rhetoric at the university for many years during the early 18th century. The Accademia Pontaniana, founded by Al-

HENRI CARTIER—BRESSON—MAGNUM

A CORRIDOR OF THE CROSS-SHAPED GALLERIA UMBERTO I, A CELEBRATED NEAPOLITAN ARCADE

fonso I in 1442, presided over first by Antonio Beccadelli and then by Giovanni Pontano, was a centre of distinguished scholars and writers in the 15th century; it was restored in 1808. The Conservatorio di Musica (founded 1537) is in the former convent of S. Pietro a Maiella, beside the fine 13th-century church; since 1816 it has consolidated a number of comparatively humble earlier schools of music whose masters and pupils included many practitioners of *opera buffa,* including the Scarlattis, G. Pergolesi, G. Paisiello, D. Cimarosa, and later V. Bellini and G. M. Donizetti. It was in the Teatro Bellini (1877) that Enrico Caruso, a native of Naples, made his modest debut in 1894. The Reale Accademia Ercolanese, founded in 1755 to publish the results of excavations at Herculaneum and Pompeii, later came to include other aspects of learning. The observatory at Capodimonte was founded in 1819. The zoological station in the Villa Comunale, founded in 1872–74 by Anton Dohrn (*q.v.*) of Stettin, is an important international centre for marine biological research and contains an aquarium and many laboratories to study the varied and rich marine flora and fauna native to the area. Among the collections of the Biblioteca Nazionale are papyri from Herculaneum, early manuscripts and palimpsests, manuscripts in Beneventan script and of the Renaissance. Housed in the Castel Nuovo is the large collection of the Società Napoletana di Storia Patria (established 1875), comprising manuscripts and printed works relating to the city and kingdom of Naples. Many old and valuable documents from the Archivio di Stato, established in a former monastery near the university, were destroyed during World War II. The notarial archives, 800,000 original notarial acts dating from 1450, are kept separately nearby. The Historical institute, founded by B. Croce for advanced studies, possesses his excellent library.

*Museums and Art Galleries.*—The Museo Nazionale (National museum), housed in a building at the northern end of the Via Toledo, was built as a barracks in 1585 and used by the university 1616–1777. In 1738 Charles III started building the Palazzo Reale di Capodimonte to house the collections inherited from his mother, Isabella, queen of Spain (Elisabetta Farnese), but these were soon outnumbered by works of art from excavations at Herculaneum, Pompeii, Pozzuoli and other places; the whole collection was moved to the Museo Nazionale which was established and remodeled (1790) to receive it (the paintings, including the Farnese collection, were returned to Capodimonte in 1957; *see* below). The magnificent exhibits are outstanding for the quality and variety of Greek and Roman works of art and include marble and bronze statues and portrait busts, Italo-Greek vases, wall paintings and mosaics, glass and gems, and articles of everyday use.

In its fine park on a hill to the north of the city is the Palazzo Reale, seat of the Museo e Gallerie Nazionali di Capodimonte. This museum and art gallery contains various collections; porcelain and ceramics (including those made in the factory which Charles III established there), ivories, armour and notably the large assembly of pictures of which the Farnese collection was the nucleus. Among many splendid examples of the Italian and Flemish schools are masterpieces by Pieter Brueghel the elder, Simone Martini, Giovanni Bellini and Titian. There are also rooms devoted to the Neapolitan school of the 17th and 18th centuries and to other Italian regional schools. The Museo Nazionale di San Martino in the old Charterhouse beside the Castel Sant'Elmo contains collections mainly connected with the history, art and life of Naples. The 17th-century church of S. Martino is wonderfully decorated with inlaid marbles, and also with frescoes and paintings by Jusepe de Ribera, Luca Giordano and others. There are a number of smaller private museums and collections open to the public.

**Transport and Communications.**—Naples is an important railway centre, being the main junction between Rome and areas to the south. The principal station is the Centrale. From the stations of Piazza Garibaldi and Montesanto local lines run to Pozzuoli and beyond. Corso Garibaldi station serves the Circumvesuviana line to Vesuvius, Pompeii, Sarno, Sorrento, Nola and Baiano. The international airport of Capodichino serves other Italian and European cities, and there are direct flights to New York. Naples is the focal point for frequent bus services to Rome and to neighbouring towns.

*The Port.*—The ancient harbour and its early medieval additions are now mainly filled in. The existing harbour works, creating an inner and an outer harbour, were begun in 1826, while the Molo Angioino (Angevin mole) is now used for passenger traffic. Enormous damage was sustained during World War II but both passenger and cargo areas have been reconstructed with modern port installations including moorings for 70 ships (mostly of heavy tonnage), three large dry docks and a dock for tankers with oil storage facilities. These postwar improvements have made Naples one of the chief Mediterranean ports.

**Industries.**—Naples is a major industrial and commercial centre. Long established occupations include the making of small ornaments such as beads, cameos and figurines from local materials including volcanic tufa; and the manufacture of kid gloves and macaroni. Industrial progress has been much helped by the *Cassa per il Mezzogiorno* (1950) and other credit plans for the development of the south initiated since World War II. There is a flourishing textile industry. Light engineering and the manufacture of railway parts have been established since 1910 at Pogglioreale where there are also enterprises making components for ships and airplanes. The ILVA steel plant at Bagnoli has been joined by a number of allied industries. Factories for food products and tractors, liquid gas, and electrical and mechanical engineering concerns are located in the "Industrial Zone" to the east of the city. Nevertheless by the 1960s many undertakings still employed less than 50 persons. Main exports (including reexports) are foodstuffs, articles of tourist interest, iron and steel, and fuel oils. Raw materials for these industries are the main imports.

**History.**—It is probable that Neapolis ("new town") was founded *c.* 600 B.C. by Greek colonists from Cumae, later refugees from there settling in the suburb Palaeopolis. The Romans captured the city in 328 B.C. and it became a favoured allied state which helped in the wars against Pyrrhus and Hannibal.

As a Roman settlement under the empire, it was enriched with temples, gymnasiums, baths, aqueducts, hippodromes and arenas, and during Cicero's time many upper-class Romans, from a love of Greek manners and literature, were attracted to Neapolis by its schools and gymnasiums or for enjoyment of music and of a mild climate. It was the favourite residence of many of the emperors: Nero made his first appearance on the stage in one of its theatres; Titus assumed the office of its archon and Hadrian became its demarch. Marcus Aurelius lived in Neapolis and frequented its schools. It was also the favourite residence of the poets Statius (*c.* A.D. 45–96) and Silius Italicus (A.D. 25 or 26–101), the former of whom was a Neapolitan by birth. It was chiefly at Naples that Virgil composed his *Georgics*, and he desired to be buried on the hill of Pausilypon, the modern Posillipo, in its neighbourhood, though his traditional tomb is really a columbarium. There are catacombs outside the city, and the earliest Christian foundations date from the 4th century. Naples was conquered by Belisarius (536) and suffered in the Gothic wars, being conquered by Totila in 542. It acknowledged Byzantine suzerainty after 552, gradually returned to prosperity, and became a Byzantine dukedom in the 7th century.

The city preserved its independence (attained in 763) against Lombard incursions. Latin gradually replaced Greek as the language of monuments and of administration. In the 9th century the Neapolitan fleet played an important part in defeating Saracen pirates, and learning flourished during the early 10th century. Threatened for nearly 100 years by the Normans, Naples finally capitulated; it became part of the feudal kingdom of Roger II of Sicily (1139) centred on Palermo, and its importance declined.

The city never willingly recognized the Swabian (Hohenstaufen) line (1191–1266) despite Frederick II's attempts to make it a centre of Ghibelline learning and, faithful to the pope, it welcomed Charles I of Anjou in 1266. He made Naples his capital and, during his reign and those of his Angevin and Aragonese successors, it increased in size, population and prosperity, and became famous for the number and beauty of its palaces and churches. Its attractions drew many scholars to the court, particularly during the reigns of Robert the Wise (1309–43) and Alfonso the Magnanimous (1442–58). After a disputed succession the city welcomed the authority of Ferdinand I (1458–94), and so became a possession of the Spanish Habsburgs. From 1503 to 1734 it was ruled by a succession of Spanish viceroys, of whom Don Pedro Alvarez de Toledo (1532–53), responsible for the street that bears his name and for other improvements, was the most famous. Though heavily taxed and autocratically governed, and despite epidemics (notably in 1656) and unrest (*see* MASANIELLO for the revolt of 1647), the city continued to develop. In 1734 Prince Charles of Bourbon (later Charles III of Spain) captured Naples from the Austrians who had retained it after the War of the Spanish Succession, and made it the capital of an independent kingdom of Sicily. Charles embellished and helped Naples in many ways. In 1799 his son, Ferdinand, was ousted by a French Revolutionary army and the Parthenopean Republic was proclaimed. Napoleon's brother, Joseph Bonaparte, was crowned king of Naples in 1806; he was succeeded in 1808 by Joachim Murat. In 1815 Ferdinand was restored with the title of "king of the Two Sicilies"; most of the new institutions remained, and many Neapolitans of all classes were in sympathy with the movements (including a revolution in 1848) which led up to the union of Italy. In 1860 Francis II was unable to gain support enough to defend the city against Garibaldi, and Naples became part of Victor Emmanuel's Italy, whose destinies it subsequently shared. (*See* also NAPLES, KINGDOM OF.)

The city, especially its harbour, suffered badly from Allied air attacks and from destruction wrought by the retreating Germans during World War II. After the war it continued to increase in size and population. Notable efforts have been made to improve conditions in the city which still retains much of its traditional crowded exuberance and its vivacious character and customs.

**Religious and Popular Festivals.**—The chief religious festival, held in and near the cathedral on Sept. 19 and the seven days following (and again in May), is that of St. Januarius (San Gennaro), patron saint of Naples and the people's intercessor in every need. Crowds flock to witness the liquefaction of his blood relic (*see* JANUARIUS, SAINT), many reading into this the good or bad fortune of the city. The most celebrated festival of the Virgin is that of Piedigrotta at Mergellina (Sept. 7–8). All night long the people go in procession with decorated carts to revel at Mergellina, La Torretta and Fuorigrotta. Fireworks are set off and the annual song festival is inaugurated with compositions by local amateur musicians, whose merits are passionately discussed by the people. The only neighbourhood festival is that of Madonna della Catena at Sta. Lucia on the last Sunday in August. At Pentecost there is a popular visit to the shrine of Montevergine near Avellino. On Jan. 17 the blessing of horses and other animals at the church of S. Antonio Abate is all that is left of a festival formerly including processions and a carnival. Of other popular ceremonials for greater church festivals little is left but traditional food dishes.

NAPOLI PROVINCE.—Including the city and the islands around the bay this occupies an area of 452 sq.mi. Pop. (1961) 2,423,994. Most of the land is highly fertile and devoted to agriculture, or is forested. Its main physical feature is the active volcano Vesuvius (*q.v.*), which last erupted in 1944. Many notable ancient sites (discussed in separate articles) are in the area: Cumae (with the Sybil's grotto); Baiae (a fashionable resort in Roman times); Lake Avernus (Lago d'Averno, regarded in antiquity as the entrance to Hades); Puteoli (Pozzuoli, the main harbour of Rome for trade with the east before the rise of Ostia); and in particular the two famous cities buried in the eruption of Vesuvius in A.D. 79, Herculaneum and Pompeii. Much of the former is still buried under a thick layer of tufa, but most of Pompeii is now excavated and it is possible to visit and study its ancient streets, houses and public buildings. At Herculaneum some two-storied houses and their fittings survive. The whole area was populous with villas in Roman times, including the Villa Jovis of Tiberius on Capri. The poet Torquato Tasso was born at Sorrento; Giacomo Leopardi died in a villa on the slopes of Vesuvius. Among the many modern writers and artists who have favoured the area may be mentioned Norman Douglas in whose writings it features prominently and who spent the latter part of his life on Capri.

Most of the industrial development of Napoli, mainly centred round the bay of Naples, cannot be separated from that of the city itself. Water power is lacking, but there are three centres producing thermoelectricity. The Cassa per il Mezzogiorno is responsible for the Aquedotto Campano, which, using the waters of the Biferno, Torano and Maretto, provides an adequate water supply to the Naples area.

*See* also references under "Naples" in the Index.

BIBLIOGRAPHY.—G. Doria, *Storia di una capitale* (1952); B. Croce, *Storia del Regno di Napoli* (1944); H. Acton, *The Bourbons of Naples* (1956); *The Last Bourbons of Naples* (1961). (S. F. Co.)

**NAPLES, KINGDOM OF,** the name conventionally given, since the end of the 14th century, to the kingdom of Sicily *citra Pharum* (*i.e.*, "on the hither side of the Strait of Messina"); in other words, to the mainland part of the greater medieval kingdom of Sicily, from which the island had been detached to form the separate kingdom of Sicily *ultra Pharum* ("beyond the Strait"). The mainland territory was bounded in the north by the papal states, with a roughly S-shaped frontier running from the mouth of the Tronto river on the Adriatic coast to a point just east of Terracina on the Tyrrhenian coast, so that Abruzzi, Molise and the Terra di Lavoro were its northernmost provinces.

**The Normans and the Hohenstaufens.**—The Byzantines, Lombards, Arabs and indigenous lords who had long been rivals for control over southern Italy and Sicily were displaced in the 11th century by bands of Normans from France. Among these, two brothers were preeminent: Robert Guiscard and Roger I (*qq.v.*). The papacy, which in 1059 had accepted Robert Guiscard

as its vassal for his past and future conquests, looked to the Norman power in the south to prevent the German kings or Holy Roman emperors from extending their dominion over the whole of Italy. In 1130 Roger I's son Roger II (*q.v.*), having united all the Norman acquisitions, assumed the title king of Sicily. An energetic ruler with a splendid capital at Palermo, he welded his heterogeneous subjects—Catholic Italians and Normans, Orthodox Greeks and Muslim Arabs—into a strong state.

Roger II died in 1154, his son and successor William I (*q.v.*) in 1166 and the latter's son William II (*q.v.*) in 1189. The heiress of the Sicilian kingdom was then Roger's daughter Constance, who had in 1186 been married to the German king Henry VI (*q.v.*), son of Frederick I Barbarossa, of the Hohenstaufen dynasty. The consequent accession of Henry to Sicily was resisted by a national party, which set up first Tancred (*q.v.*) of Lecce as king, then Tancred's son Roger as joint king with him; but they were defeated by the Germans in 1194. Installed as king at Palermo, Henry now linked the Sicilian crown to the imperial (his since 1191).

The union of the crowns, dissolved by Henry's death (1197), was reconstituted by his son (*see* FREDERICK II, Holy Roman emperor). Acknowledged in Sicily as king in 1198 (when Constance died), Frederick received the Sicilian crown from Pope Innocent III in 1209 and became German king in 1212 and emperor in 1220. His subsequent disregard of Sicily's feudal dependence on the Holy See and his attempt to override the autonomy of the Italian communes and of the feudatories provoked a formidable conflict. For the kingdom of Sicily itself, his Constitutions of Melfi (1231) and his changes of the Norman dispositions there reflected his absolutist attitude. Though he patronized the arts and developed the economy, the kingdom had to contribute disproportionately to the expenses of his wars. When he died (1250), the Hohenstaufen succession had already been called in question by his second excommunication (1245).

Frederick's heir, the German king Conrad IV, died in 1254. Then Manfred (*q.v.*), a bastard son of Frederick II, assumed the regency for Conrad's son Conradin. In 1258, on a false report of Conradin's death, Manfred had himself crowned king of Sicily, which he then tried to make independent of pope and emperor alike. The papacy, meanwhile, had been offering the Sicilian crown to others: Henry III of England accepted it in 1254 for his son Edmund, but this scheme came to nothing. At last, in 1265, Charles of Anjou, count of Provence and brother of Louis IX of France, accepted the crown as a vassal of the papacy (*see* CHARLES I). At the battle of Benevento (1266) Manfred was defeated and killed.

**The Angevins.**—So as to be nearer to his Guelph allies of northern and central Italy and to Rome, Charles made Naples his capital instead of Palermo. A revolt linked with Conradin's attempt to assert his claims (1268) was savagely put down. Charles, however, had further ambitions—in Italy, in the Balkans and in the Arab Mediterranean—and subjected his kingdom to oppressive taxation. Discontent was exploited by exiles abroad, in particular the physician Giovanni di Procida and Ruggiero di Lauria (*q.v.*), at the court of Peter III of Aragon, who had married Manfred's daughter Constance. When the revolt known as the Sicilian Vespers (*q.v.*) broke out at Palermo in 1282, Charles was taken by surprise. Rebellion spread over all Sicily and into Calabria.

Peter III's landing in Sicily began a war in which the Ghibelline states of Italy took the Aragonese side while the papacy and France took the Angevin. The Aragonese navy had several successes; *e.g.*, in the battle off Naples in 1284, in which Charles I's son, the future Charles II (*q.v.*), was taken prisoner. Charles I died in 1285, and Charles II had to accept humiliating terms before being restored to Naples. Yet he finally expelled the Aragonese from the mainland; and at the peace of Caltabellotta (1302) it was agreed that the island should revert to Angevin rule on the death of Peter III's son, who took the misleading style of Frederick III (*q.v.*). Hostilities, however, were resumed, and warfare punctuated by truces went on until Joan I of Naples in the 1370s waived her rights to Sicily and accepted Frederick's grandson, the rightly numbered Frederick III, as her vassal.

When the Sicilian crisis arose, Charles I issued the *capitoli* or articles of San Martino (1283), which extended the jurisdiction and immunities of barons and clergy and strengthened feudalism. The capital city, moreover, with its administration monopolized by an urban aristocracy and with its swollen population largely destitute and often workless, became another privileged entity whose particular interests were allowed to overshadow those of the nation as a whole. While the parliament remained under the control of the feudatories, municipal life stagnated, since there was no way for an active middle class to make its influence felt. Poor in natural resources, the country based its economy on agriculture and livestock. Foreigners—mostly Florentines, Venetians, Genoese, Catalans and Marseillais—competed between themselves for what trade there was and dominated the markets.

Conditions improved under Charles II's son Robert (*q.v.*), who succeeded to the crown in 1309. Against the emperor Henry VII (*q.v.*) he took the Guelph side. Successfully defended by his troops, the Guelph communes in Tuscany finally put themselves under his protection; and the Avignon pope, John XXII, later made Robert his vicar for the papal states. A capable ruler, Robert enhanced the prestige of his capital at home and abroad.

Robert died in 1343, leaving the crown to his granddaughter Joan I (*q.v.*). Two years later dynastic strife broke loose. The Angevin princes of the branch of Taranto (sons of Robert's brother Philip) procured the murder of Joan's husband Andrew, an Angevin of the Hungarian branch (grandson of Robert's brother Charles Martel). Suspected of complicity in the murder, Joan fled to Avignon. Louis I of Hungary, Andrew's brother, twice tried to win the kingdom for himself (1348 and 1350–52), but the brutality of the Hungarians provoked a reaction in Joan's favour. She and her second husband, Louis of Taranto (*see* LOUIS, kings of Naples), were recognized as sovereigns of the kingdom in 1352.

Avid for power, Louis of Taranto quarreled with his queen. The tranquillity which the grand seneschal Niccolò Acciaiuoli had worked to promote was shattered. When the schism of the papacy began (1378), Joan supported the antipope Clement VII. Pope Urban VI therefore declared the crown forfeit and offered it to another Neapolitan Angevin, Charles of Durazzo (*see* CHARLES III of Naples). Joan turned for help to Louis of Anjou-Provence (a brother of the French king Charles V), but Charles of Durazzo took Naples, imprisoned Joan and had her put to death (1382).

Anarchy followed Charles's death (1386), the kingdom being alternately ravaged by the mercenaries of rival kings and embroiled in the conflicts of other Italian states. There was an interval of resurgence while Charles III's son Ladislas (*q.v.*) was king, from 1400 to 1414. An able soldier with no political scruples, Ladislas subdued the great feudatories, expelled his rival Louis II and, by exploiting the Italian situation, made himself master of the papal state, from which he invaded Tuscany. Premature death cut short his plans. His sister and successor Joan II (*q.v.*), who reigned till 1435, was dominated by *condottieri*, favourites and barons one after another. She first adopted Alfonso V of Aragon as her heir (Alfonso I of Naples), then put up Louis III of Anjou-Provence against him. The court could get no obedience from the provinces, over which the Angevin and Aragonese factions fought ruinously. Finally the Aragonese took Naples in 1442, driving René I (*q.v.*), Louis III's brother and titular successor, into exile.

**The Aragonese.**—Alfonso, whose predecessors had from 1409 united the crowns of Aragon and Sicily, fulfilled an ancient Aragonese aspiration when he conquered Naples; but in 1443 he decided that, whereas Aragon and Sicily would pass to his brother John, the Neapolitan succession should go to his bastard son Don Ferrante, or Ferdinand I (*q.v.*). The Neapolitan barons helped him to win the approbation of Pope Eugenius IV, who had hitherto been against him. Alfonso's policy of war and expenditure in Italy was designed to strengthen his son's position and to open up new vistas for Aragonese diplomacy and commerce. The result, however, was to aggravate the disequilibrium in the kingdom.

Succeeding Alfonso in 1458, Ferdinand I was soon faced with a

baronial revolt in favour of René or the latter's son John of Calabria. Centralization and modernization antagonized the barons; and they revolted again in 1485–87, with the intention, this time, of putting his younger son Frederick (born in 1451) on the throne. Ferdinand prevailed by trickery and ruthlessness.

Meanwhile Charles VIII (*q.v.*) of France had inherited the Angevin claims to Naples. In 1494 he invaded Italy to conquer the kingdom. Alfonso II of Naples, Ferdinand I's elder son and successor, abdicated in favour of his son Ferdinand II (*q.v.*), or Ferrandino, in 1495; but the kingdom, torn by faction, could not withstand the French, and Charles was crowned king. The formation of the League of Venice obliged Charles to withdraw from Naples, and Ferdinand II was restored to his throne a few months before his death (1496). The crown then passed to Frederick (Alfonso II's brother), under whom the kingdom enjoyed a few years of security. Finally, however, Louis XII of France and Ferdinand II of Aragon, by the treaty of Granada (1500), agreed to divide the kingdom between themselves, on the pretext of forestalling a Turkish occupation. Frederick gave himself up to Louis XII in 1501 and was pensioned off in France, where he died in 1504. The French and the Spaniards soon came to blows over the partition. Gonzalo de Córdoba's victories at Cerignola and on the Garigliano river (1503) decided the issue in Spain's favour.

**The Spanish Viceroyalty.**—The Spanish kings ruled Naples through viceroys. After the failure of the last French effort to recover the Angevin inheritance (1528, when the siege of Naples had to be abandoned), the major defensive concern of the viceroys was against the Turks and the Barbary pirates. Internally, they applied themselves to breaking the political power of disloyal feudatories. Pedro de Toledo, viceroy from 1532 to 1553 for the emperor Charles V, was especially successful, but his attempt to reinforce absolutism by introducing the Spanish Inquisition was foiled by a vigorous opposition.

Pedro de Toledo and his successors enhanced the importance of the capital, whose population grew to excess. While the aristocracy was still predominant in the *seggi,* or municipal administration of Naples, a popular element was brought in, so that the system became rather more democratic. The parliament of the kingdom, whose sole function was to vote supplies of money, was last convened in 1642; thereafter the viceroys treated the *seggi,* on whose loyalty they relied, as representatives of the kingdom.

The rising of Masaniello (*q.v.*) in July 1647 was provoked by taxation and by the high cost of living, but was really organized and directed by Giulio Genoino, a lawyer who wanted the people's voice in the administration to be made equal to the nobility's. It failed, but insurrection broke out again: while the provinces rose against baronial oppression, the city of Naples, turning at last against Spanish rule, proclaimed a republic. As neither the papacy, nor Savoy nor France could undertake its effective protection, the republic had to offer sovereignty to the duc de Guise (Henry de Lorraine), but the Spaniards took prompt countermeasures, supported by those who wanted to see order restored. By spring 1648 the rebellion was crushed.

The second half of the 17th century was a period of stagnation for the kingdom. The last lights of Renaissance culture in southern Italy had gone out with Tommaso Campanella (*q.v.*) and with the economist Antonio Serra (*Breve trattato . . . ,* 1613). Society was paralyzed by the rivalries of pressure groups and by corruption; and the Spanish monarchy, which drained the country of money and soldiers to prop its power in Europe, made matters worse by its administrative experiments. There was, however, a slow reawakening of intellectual life as the currents of European thought touched Naples, Cartesianism being the most vital factor.

**The Spanish Succession and the Austrian Interlude.**—When the War of the Spanish Succession (*q.v.*) was breaking out a group of nobles, led by Gaetano Gambacorta, principe di Macchia, in reaction against the absolutism of Spain and its middle-class supporters, plotted to offer the crown to an Austrian Habsburg (1701). This conspiracy came to nothing; but the Austrians overran the kingdom in 1707, and by the peace treaties of Utrecht and Rastatt (1713–14) it was ceded to the emperor Charles VI. Sicily was at the same time ceded to Victor Amadeus II of Savoy; but a few years later, in accordance with the Quadruple alliance of 1718, it was transferred to Austria likewise, in exchange for Sardinia. The Austrians undertook some measures of rehabilitation and were to some extent open to the influence of the Neapolitan intelligentsia, whose great spokesmen now were Giambattista Vico and Pietro Giannone (*qq.v.*).

**The First Bourbon Period.**—On the outbreak of the War of the Polish Succession (*q.v.*) in 1733, France, Spain and Sardinia-Savoy agreed that the Spanish infante Don Carlos de Borbón (*see* CHARLES III, king of Spain) should have Naples and Sicily if they could be conquered. Don Carlos defeated the Austrians in the battle of Bitonto (1734) and was finally recognized in his possession of the two kingdoms by the peace of Vienna (1738). He had also the Presidi, that is, the former Habsburg possessions on the Tuscan coast. Welcome to the Neapolitans because it brought independence to the kingdom, he made his reign glorious by careful reform of the political and administrative system and by splendid building. His most able minister was the great Bernardo Tanucci.

In 1759, on succeeding unexpectedly to the Spanish throne, Charles abdicated his Italian possessions to his third son, who became king as Ferdinand IV of Naples (III of Sicily; *see* FERDINAND I of the Two Sicilies). There was a council of regency, on which Tanucci sat, till the new king came of age in 1767. Next year Ferdinand married the Austrian archduchess Maria Carolina, an ambitious woman who easily took control of her pleasure-loving husband's government. By ousting Tanucci and putting the Englishman John Acton at the head of affairs, she opened the way for British and Austrian influence to replace Spanish.

The backwardness of the kingdom, where the aristocracy and the clergy were still highly privileged and the lower classes lived in degrading poverty, was meanwhile being denounced by progressive thinkers such as Antonio Genovesi (*q.v.*); and the Neapolitan government, in the paternalistic spirit of "enlightened despotism," sponsored a vigorous program of legislation to rectify these injustices and to modernize the state. The expulsion of the Jesuits (1767) was another symptom of the current tendency.

The monarchy was halted in its course of reform by the example of the French Revolution, which released a flood of republican and democratic ideas. These ideas appealed strongly to those—middle-class intellectuals, nobles and churchmen alike—who had seen the Bourbon reforms as designed rather to increase the king's power than to benefit the nation. "Patriots" began to conspire and were countered by persecution. Having entered the War of the First Coalition against France in 1793 (*see* FRENCH REVOLUTIONARY WARS), Ferdinand had to withdraw from it in 1796, after the Franco-Sardinian treaty of Paris; but the French intervention in Rome alarmed him, and the British admiral Nelson's victory in the battle of the Nile encouraged him to take part in the War of the Second Coalition in 1798. His army, under the Austrian Karl von Mack, advanced against the Roman republic but was defeated at Civita Castellana by the French under J. E. Championnet, who then pursued it toward Naples. In Naples, while the local Jacobins were preparing to revolt on the arrival of the French, the populace rose to defend its king; but Ferdinand took panic and fled with his entourage and his treasure to Palermo, having ordered the burning of the fleet built up in the past decade.

**The Republic and the First Bourbon Restoration.**—The French entered Naples, and on Jan. 24, 1799, the Parthenopean republic was proclaimed. The republicans, however, who had ingenuously welcomed the French as liberators, were idealists out of touch with the actual life of the people. With no army of their own, they were caught between the royalist-popular counter-revolution and the exorbitant demands of the French. Appointed vicar of the kingdom by Ferdinand, the cardinal Fabrizio Ruffo landed in Calabria and mustered an army of all sorts, including brigands and convicts. The city of Naples, abandoned by the French, fell to Ruffo on June 13, 1799, after desperate resistance by the "patriots." The castles which still held out were won over by a capitulation whereby their defenders were promised freedom to remain at home unmolested or to embark for Toulon. On June 24, however, Nelson's fleet arrived, and Nelson, in agree-

ment with Palermo, repudiated the capitulation, despite Ruffo's protests. The patriots' ships were attacked, many prisoners were taken, and Francesco Caracciolo (*q.v.*) was hanged. After Ferdinand's return to Naples (July 1799), special tribunals sentenced the leading republicans to death. The jurist Mario Pagano, the physician Domenico Cirillo, the priest Francesco Conforti, the writer Luigia Sanfelice and the noble Ettore Carafa, conte di Ruvo, were among the victims of a reaction which estranged open-minded intellectuals from the Bourbon dynasty.

After the Franco-Austrian peace of Lunéville, Ferdinand had to accept Napoleon's harsh terms in the treaty of Florence (March 1801), whereby he surrendered the Presidi to France, agreed to grant a general amnesty and consented to a French occupation of parts of his territory. When the War of the Third Coalition broke out (1805) he entered into secret dealings with Austria and Great Britain. The exasperated Napoleon, having defeated the Austrians at Austerlitz, sent his brother Joseph (*see* BONAPARTE) to conquer Ferdinand's kingdom. Ferdinand fled to Sicily again, and the French overran the mainland. The capital was taken easily, as the *bourgeoisie,* remembering the troubles of 1799, formed its own militia to hold the populace down (Jan. 1806).

**The Decennio.**—Napoleon first annexed the kingdom to his empire, then declared it independent, with Joseph as king (March 30, 1806). When Joseph was transferred to Spain (1808), Napoleon gave Naples to his brother-in-law Joachim Murat (*q.v.*).

The Decennio, as the decade of French rule is called by Neapolitan historians, brought great reforms. Feudalism was abolished; seignorial domains were broken up and ecclesiastical property was confiscated and sold (thus promoting the growth of the agrarian middle class); the laws were unified, with the introduction of the Code Napoléon; army and navy were brought into being on modern lines; brigandage was suppressed; and the administration was reorganized. Neapolitans brought up on the principles of the 18th century but conscious of traditional values collaborated with French officials in the public service.

Murat was deservedly popular as king; but discontent was fomented by clandestine propaganda spread from Sicily by Lord William Bentinck, the British envoy there, who had saddled Ferdinand with a constitution and so could represent him as standing for liberalism. Moreover, Napoleon's tutelage was oppressive and suspicious. To win genuine independence, Murat negotiated secretly with Great Britain and with Austria, concluding a treaty with the latter in Jan. 1814, after Napoleon's defeat at Leipzig. During the Hundred Days, however, he rallied to Napoleon's cause, took up arms against Austria and, on March 30, 1815, from Rimini, appealed to the Italians to join him in a fight for the national independence of the peninsula. Defeated by the Austrians at Tolentino (May 2), he abandoned his kingdom and retired to France.

**The Second Bourbon Restoration.**—By his Treaty of Casalanza with the Austrians (May 20, 1815), Ferdinand IV recovered the kingdom of Naples. On the recommendation of the congress of Vienna, he unified Naples and Sicily to form the kingdom of the Two Sicilies, of which he was styled Ferdinand I (1816). Though he had assured conservative Austria that he would not allow any institutions incompatible with the absolutism about to be reimposed on the Austrian north of Italy, he took no measures to undo the reforms of the Decennio when he returned to Naples in June 1815. On the contrary, he sought to integrate and to develop its achievement and retained much of its personnel in his service.

Sicily proved obstinately hostile to the centralizing policy of unification with Naples: the Sicilian barons, who had resented the viceroy Domenico Caracciolo's antifeudal program in the 1780s, had in 1812, with Bentinck's connivance, transformed their own parliament and forced the king to accept a constitution on the English model, so that autonomists and liberals were now combined in opposition to the Bourbons. On the mainland, the pathetic failure of Murat's audacious landing in Calabria (Oct. 1815) and his subsequent execution, far from discouraging his partisans, increased their numbers and created a Murat cult which looked backward to the Decennio and forward to the united Italy envisaged by him at Rimini. Even stronger in opposition to the Bourbons were the Carbonari (*q.v.*), who were in existence in the kingdom in 1810 and whose ranks, reinforced by men returning from Germany and Switzerland, now included nobles, priests, bourgeois and, particularly, army officers. The Bourbon government antagonized them by its measures against secret societies, by its favouritism toward its own trusty friends and by its wide concessions to the church in the concordat of 1818 with the papacy.

Revolution began on July 1, 1820, with a demonstration by a cavalry regiment at Nola. It spread quickly, under the leadership of Gen. Guglielmo Pepe (*q.v.*). The rebels demanded the democratic and unicameral Spanish constitution of 1812 (*see* SPAIN: *History*); Ferdinand granted it on July 7 and swore to it on July 13. The Sicilians, on the other hand, rose for their own constitution of 1812, which was aristocratic and bicameral; and the Neapolitan parliament, consisting entirely of mainland deputies, resorted to armed force against Sicilian separatism. At the congress of Troppau (*q.v.*) Austria's call for intervention by the powers against revolutionary threats to the European order was agreed to despite British and French objections, but a decision on Naples was postponed for the congress of Laibach (*q.v.*) in 1821.

Granted leave by his parliament to go abroad, Ferdinand attended the congress of Laibach and promptly broke his oath to the constitution. With his consent and the mandate of the Holy alliance, Austria undertook to restore his absolute monarchy. Pepe's forces were defeated at Rieti, and on March 23, 1821, the Austrians entered Naples. They were to stay there, as the watchdogs of the Bourbons, till 1827, when King Francis I obtained their recall and engaged a Swiss bodyguard instead.

Reprisals were taken against the liberals; and the kingdom was dominated by the police for the rest of Ferdinand's reign and throughout Francis I's (1825–30; *see* FRANCIS I). Resentment bred an outcrop of tenuously connected sects of malcontents, a reemergence, under various names, of the Carbonari. A new revolt, in the Cilento, was put down by force (1828).

Francis I's son and successor Ferdinand II (*q.v.*) began his reign with measures expressly intended to amend things. Trade and industry increased; agricultural production was encouraged; the lot of the workers was improved; better budgets allowed a reduction of taxes; laws were brought up to date; and public works were undertaken. Ferdinand however allowed no political reflection of this economic progress, though he issued an amnesty on his accession and was ready to employ, as administrative experts, men who had previously been exiled or imprisoned. In foreign affairs he was inclined to neutrality, as he saw that alliances might compromise his precious independence.

Ferdinand II's attitude was thus quite irreconcilable with the spirit of the Italian Risorgimento (*see* ITALY: *History*), which was affecting his kingdom through various channels. Periodicals and intellectual groups sprang up to satisfy the revived taste for literature, history, philosophy and the arts; and liberalism and nationalism thrived in the new atmosphere. Vincenzo Gioberti (*q.v.*), who had a Neapolitan precursor in Vincenzo Cuoco (1770–1823), captivated the majority of would-be reformers with his book *Del primato,* which appealed to tradition and called for an Italian federation of the existing states under papal presidency. Others held less moderate views: Giuseppe Mazzini, who wanted a unitary republic of Italy, had converts in the kingdom; and the backward areas were sprinkled with revolutionary cells plotting to subvert the economic and social order, as for instance Benedetto Musolino's Calabrian association Giovane Italia (not to be confused with Mazzini's Giovine Italia). Gradually the old political world of Naples was undermined by a more or less clandestine and heterogeneous opposition: liberal constitutionalists (mainly former Carbonari), led by Carlo Poerio; Giobertians, led by the historian Carlo Troya; and democrats of all sorts, including extremists. Successive revolts proved that repression was not enough to stifle the revolutionary ferment. A violent rising at Cosenza in 1844 was put down rigorously; but its example prompted Mazzini to encourage the ill-fated expedition of the brothers Attilio and Emilio Bandiera (*q.v.*) to Calabria in 1845.

Rejoicings at Pope Pius IX's early marks of sympathy for the Italian cause (1846–47) were paralleled by overt attacks on

Bourbon tyranny: Luigi Settembrini published his *Protesta del popolo delle due Sicilie* in July 1847. There followed the great year of European revolutions. Sicily, still obstinately separatist, was in revolt from Jan. 12, 1848; and alarm for the mainland induced Ferdinand II to grant a constitution on Jan. 29. Modeled on the French constitution of 1830, this was promulgated on Feb. 11. A constitutional guard was formed; the kingdom joined the Italian customs union; and finally, under pressure from the people, war was declared against Austria on April 7 (*see* ITALIAN INDEPENDENCE, WARS OF). Pepe was sent with an expedition to Lombardy while the fleet sailed for Venice.

Elections took place in April 1848. The democrats were agitating in the press for a parliamentary revision of the constitution and for other controversial measures. There were riots in Naples, and the peasants' seizure of national, communal and private lands exposed the activity of socialist and communist cells. Parliament was to have met on May 15; but on May 13 the radicals demanded that the king's oath should acknowledge the parliament's right to revise the constitution. The king refused, and barricades were put up (May 14). Ferdinand would not open parliament unless the barricades were dismantled, but the rebels stood firm until troops had mastered them by force (evening of May 15). When Troya resigned from the ministry, Ferdinand replaced him with the reactionary principe di Cariati (Gennaro Spinelli). Eventually the king dissolved parliament, announced fresh elections, recalled his troops from Lombardy and broke off relations with Sardinia-Piedmont (July). The democrats were now openly opposing the liberals and working for a republic. The provinces were still in commotion. When the elections returned as many radicals as before, Ferdinand postponed the opening of parliament from July 1848 to November and then to Feb. 1849.

After both Pius IX and Leopold II of Tuscany had been driven by revolution to take refuge at Gaeta, Ferdinand dissolved the parliament and shelved the constitution (March 1849); and the Austrian victory at Novara gave a free hand to reaction in Italy. Sicily, which in summer 1848 had declared the Bourbon dynasty deposed, was subdued by Carlo Filangieri (*q.v.*) in April–May 1849. Sentences of death (commuted by Ferdinand to penal servitude), imprisonment, banishments and dismissals were widespread: Carlo Poerio, Silvio Spaventa, Francesco de Sanctis and Luigi Settembrini were victims of the reprisals. The liberals, having identified themselves with the cause of Italian national unity, were wholly discredited, and vigorous absolutism was brought back. Believing that he had thus won tranquillity for his subjects, Ferdinand devoted himself again to public works and to economic improvement. Foreign liberals, such as Gladstone in the British press (1851) and Cavour at the Paris conference (1856), inveighed against the kingdom as morally bankrupt and politically anachronistic. Carlo Pisacane, a former officer of the Bourbon army who had fought for the Roman republic and had absorbed Mazzinian and socialist ideas, landed at Sapri with a small force in 1857 but was defeated and killed by the local police and townspeople. Next year, yielding to French and British pressure, Ferdinand released into exile some of his political prisoners. In May 1859, on his deathbed, while the French and the Sardinians were beginning their campaign in Lombardy, Ferdinand adjured his heir, Francis II (*q.v.*), to stay neutral and to eschew innovations.

On his accession to the throne, Francis II appointed as prime minister the moderate Carlo Filangieri, who advised him to reinstate the constitution and to accept the alliance offered to him by Victor Emmanuel II of Sardinia. Francis hesitated, while his kingdom was shaken with the reverberation of Sardinian successes in Lombardy and central Italy. The Swiss regiments, hitherto the mainstay of royal absolutism, mutinied in July 1859 and were disbanded; Filangieri resigned in March 1860; and Palermo rose in revolt on April 4.

Sicily, the hotbed of antidynastic feeling, had already been infiltrated by emissaries of the Comitato d'Azione, an organization under Mazzinian influence whose aim was to unify Italy by means of revolution, instead of waiting for Cavour to do so by internationally acceptable means. These emissaries, notably Francesco Crispi (*q.v.*) and Rossolini Pilo, prepared the ground for Giuseppe Garibaldi (*q.v.*), who landed with his Thousand at Marsala on May 11, 1860, declared himself for "Italy and Victor Emmanuel" (to the chagrin of the Mazzinians), defeated the Bourbon troops at Calatafimi on May 15 and was in Palermo (which the Bourbons had recovered since its revolt) by the end of the month.

Francis on June 25, 1860, signed a proclamation promising a general amnesty for political offenders and a liberal ministry; and on July 1 he restored the constitution; but the amnesty only exposed Naples to the return of exiles who were either converts to Cavour's plan for a unitary Italian monarchy under the house of Savoy or partisans of Lucien Murat, Joachim's heir. Garibaldi's victory at Milazzo (July 20) put an end to Bourbon resistance throughout Sicily, except in the citadel of Messina; and Great Britain, France, Russia and Sardinia ignored Francis II's plea that the invasion should be halted at the straits. Cavour, who, unlike Victor Emmanuel II, had at first objected to the expedition both because its democratic sponsors had opposed his cession of Nice and Savoy to France and because its revolutionary aspect might have compromised his plans, now began to abet it. On Aug. 18, Garibaldi crossed the straits and took Reggio di Calabria. As his forces advanced northward, Bourbon rule collapsed, province by province. Francis fled to Gaeta on Sept. 6; and, Garibaldi, having entered Naples in triumph on Sept. 7, assumed the dictatorship on Sept. 8. The Neapolitan fleet refused to follow the king.

The revolutionaries with Garibaldi's forces might now have proclaimed a republic; and if they had marched on Rome, France and Austria would have intervened. To forestall this and at the same time to seize a role for Sardinia in the liberation of southern Italy, Cavour exploited the pretext furnished by the disorderly conduct of the foreign volunteers who were rallying to defend the papal states. The Sardinian army began to overrun the papal states on Sept. 11, 1860; and on Oct. 12 it crossed the frontier into Neapolitan territory. A Bourbon counteroffensive against the Garibaldians was defeated in a desperate and hard-fought battle on the Volturno river (Oct. 1–2).

In Naples, meanwhile, Cavour's followers, in favour of annexation by Sardinia, were disputing with anti-annexationists, whom Mazzini and Carlo Cattaneo arrived to reinforce. Plebiscites, held on Oct. 21, 1860, one for the mainland and one for Sicily, came out in favour of annexation. On Oct. 26, at Caianello near Teano, Garibaldi saluted Victor Emmanuel as "king of Italy," a title confirmed by the Italian parliament at Turin in Feb. 1861.

The French naval squadron that had been protecting the heroic defenders of Gaeta was withdrawn, at British insistence, in Jan. 1861; and on Feb. 13 Francis and his family sailed for Rome, whereupon Gaeta surrendered. The citadel of Messina capitulated on March 12, that of Civitella del Tronto on March 20. The 700-year-old kingdom was no more.

*See* also references under "Naples, Kingdom of" in the Index.

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(E. PO.)

END OF VOLUME FIFTEEN

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